Savannah River Site™

ENVIRONMENTAL REPORT FOR 2017

SRNS-RP-2018-00470

The cover photos are courtesy of local photographers who graciously gave SRS permission to display their work.

Front Cover—Large photograph. The iconic Blue Peter Tree at the Aiken Training Track, Aiken, SC. The bottom left photograph was taken at the Brick Pond Park in North Augusta, SC. *These two photographs are courtesy of Larry Gleason.* The bottom right photograph was taken at the Brick Pond Park in North Augusta, SC. *This photograph is courtesy of Mike Baggett.*

Back Cover—The Canoe and Kayak Club of Augusta on the Savannah River, downstream of Augusta, GA. *This photograph is the courtesy of George Reeves.*

For more information about this report contact:

Teresa Eddy
Savannah River Nuclear Solutions, LLC
Building 730-4B, Savannah River Site
Aiken, SC 29808
Telephone: 803-952-8253
E-mail address: teresa.eddy@srnl.doe.gov

or go to the SRS Environmental Report webpage at
http://www.srs.gov/general/pubs/ERsum/index.html
and under the SRS Environmental Report for 2017, complete the electronic
Customer Satisfaction Survey.

SRNS-RP-2018-00470

Savannah River Site

Environmental Report for 2017

Prepared by
Savannah River Nuclear Solutions, LLC
Savannah River Site
Aiken, SC 29808

Dedication

The Savannah River Site 2017 Annual Site Environmental Report is dedicated to the memory of Gail R. Whitney. Gail managed the Department of Energy's oversight of the Savannah River Site's Environmental Monitoring Program. At the time of her death in February, she had already made a valuable and significant contribution to this year's report. Her technical knowledge and passion for the program was evident to all those who worked with her. Gail was respected by her peers at the Savannah River Site and across the Department of Energy complex. Her constant drive to ensure the quality of the environmental monitoring program impacted the surrounding environment and community. Additionally, her dedication to the program helped those she touched, achieve their greatest potential.

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SRS Annual Site Environmental Report Core Team

(Left to right, front row) Lori Brown, Lori Coward, Karen Vangelas, Michele Wilson, Sadika O'Quinn. (Left to right, back row) Catherine Thomas, Ted Millings, Timothy Jannik. Absent from the photograph are Martha Thompson, Teresa Eddy, and Maatsi Ndingwan.

Chapter Authors and Contributors

Ch. 1 Introduction

Karen Vangelas, SRNS, Chapter Lead

Ch. 2 Environmental Management System

Ted Millings, SRNS, Chapter Lead

Michael Harmon, SRNS

Earl Joyner, SRNS

Lance Cramer, Centerra-SRS

David Werth, SRNS

Natasha McCants, AREVA Federal Services, LLC

Ch. 3 Compliance Summary

Michele Wilson, SRNS, Chapter Lead

Rob Backer, SRNS

Sarita Berry, SRNS

Charles Bishop, SRNS

Tracy Bryant, SRNS

Kim Cauthen, SRNS

Leighanne Clifton, SRNS

Lori Coward, SRNS

Lance Cramer, Centerra-SRS

Katie Davis, SRNS

Keith Dyer, SRNS

Greta Fanning, SRNS

Jim Fudge, SRNS

Ginger Humphries, SRNS

Rod Hutto, SRNS

Keith Liner, SRR

Jeffry Lintern, SRNS

Shelia McFalls, SRNS

Ted Millings, SRNS

Angela Pizzino, SRNS

Tammy Robinson, U.S. Forest Service-Savannah River

Carlton Shealy, SRNS

Daniel Skiff, SRR

Keith Stephenson, SRARP

Kim Wolfe, SRNS

Ch.4 Nonradiological Environmental Monitoring Program

Lori Coward, SRNS, Chapter Lead

Jeffry Lintern, SRNS

Greta Fanning, SRNS

Dennis Jackson, SRNL

Karen Vangelas, SRNS

Ch. 5 Radiological Environmental Monitoring Program

Martha Thompson, SRNS, Chapter Lead

Kevin Baird, SRNS

Eric Doman, SRNS

Timothy Jannik, SRNL

Karen Vangelas, SRNS

Ch. 6 Radiological Dose Assessment

Timothy Jannik, SRNL, Chapter Lead

Kenneth L. Dixon, SRNL

Evaleigh Bell, SRNL

Ch. 7 Groundwater Management Program

Sadika O'Quinn, SRNS, Chapter Lead

Peter Avioli, SRNS

Ch. 8 Quality Assurance

Lori Brown, SRNS, Chapter Lead

Lori Coward, SRNS

Siobhan Kitchen, SRNS

Dennis Knapp, SRNS

Sherrod Maxwell, SRNS

Ted Millings, SRNS

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DOE-SR	**DOE-NNSA**
Jeffrey Bentley	Christina Edwards
James Demass	Jack Cheney (Tritium)
Avery Hammett	Drew Grainger**
Lauren Hill	
Angelia Holmes	
Julie Mao*	
Chun Pang	
Mark Spurlock	

* Julie Mao, a 2018 DOE Summer Scholar, is a graduate student studying environmental policy at Duke University. She is graduating in May 2019.

** Drew Grainger is a contractor to DOE-NNSA.

To Our Readers

Highlights

The U.S. Department of Energy (DOE) Order 231.1B (Environment, Safety, and Health Reporting) requires Annual Site Environmental Reports to assess field environmental program performance, site-wide environmental monitoring and surveillance effectiveness, and to confirm sites are complying with environmental standards and requirements.

Annual Site Environmental Reports are prepared in a manner that addresses likely public concerns and to solicit feedback from the public and other stakeholders. Savannah River Site (SRS) began publishing Annual Site Environmental Reports in 1959.

Readers can find the SRS Annual Environmental Report on the World Wide Web at the following address:

http://www.srs.gov/general/pubs/ERsum/index.html

The Savannah River Site Environmental Report for calendar year 2017 is an overview of environmental management activities conducted on and in the vicinity of SRS from January 1 through December 31, 2017. This report includes the following:

- A summary of implemented environmental management systems that facilitate sound stewardship practices, as well as the compliance with applicable environmental regulations and laws intended to protect air, water, land, and other natural and cultural resources that SRS operations have impacted.
- A summary of the results of nonradiological parameters. These results are compared to permit limits and applicable standards.
- A summary of the results of effluent monitoring and environmental surveillance of air, water, soil, vegetation, biota, and agricultural products to determine radioactivity in these media. SRS compares the results with historical data and background measurements, and to applicable standards and requirements in order to verify that SRS does not adversely impact the environment or the health of humans or biota.
- A discussion of the potential doses to members of the public from radioactive releases from SRS operations compared to applicable standards and regulations, and from special-case exposure scenarios.
- An explanation of the quality assurance and quality control program, which ensures that samples and data SRS collects and analyzes are reported with utmost confidence.

The report addresses three general levels of reader interest:

1) The first is a brief summary with a "take-home" conclusion. This is presented in the "Highlights" text box at the beginning of each chapter. There are no technical tables, figures, or graphs in the "Highlights."

2) The second level is a more in-depth discussion with figures, summary tables, and summary graphs accompanying the text. The chapters of the annual report represent this level, which requires some familiarity with scientific data and graphs.

3) The third level includes links to supplemental and technical reports and websites that support the annual report. The links to these reports may be found in the chapters or on the SRS Annual Environmental Report webpage. Many of the reports mentioned in Chapter 3, *Compliance Summary*, are submitted to meet compliance requirements and are not available on the SRS Annual Environmental Report webpage or through direct links. These reports may be obtained through a Freedom of Information Act request.

When a regulation or DOE Order requires reporting on a fiscal year (FY) basis, the information in the ASER is reported in FY. This allows for consistency with existing documentation. FY reporting is typically found in chapter 2, *Environmental Management System*, and chapter 3, *Compliance Summary*.

The SRS Environmental Report webpage contains reports from multiple years with the 2017 report being the latest. The report folders feature:

- The full report with hyperlinks to all supplemental information or reports
- Maps with environmental sampling locations for the various media samples. These figures are identified as "Maps Figure" within the text of the report
- Annual reports from SRS organizations

Savannah River Nuclear Solutions (SRNS), LLC develops this report as the management & operations contractor to the Department of Energy at SRS. In addition to SRNS, the contributors to the annual report include Savannah River Remediation (SRR), LLC; Parsons Government Services; U.S. Department of Energy, Savannah River Operations Office (DOE-SR); Chicago Bridge & Iron AREVA MOX Services, LLC; Centerra-SRS; Ameresco Federal Solutions, Inc.; Savannah River Ecology Laboratory (SREL); and U.S. Forest Service-Savannah River (USFS-SR). Links to their websites may be found on pages 1–4 through 1–6 of this report.

The SRS Annual Environmental Report is available on the World Wide Web at the following address:

http://www.srs.gov/general/pubs/ERsum/index.html

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Acronyms and Abbreviations

A

ARP	Actinide Removal Process
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers

B

BAT	Best Available Technology
BJWSA	Beaufort-Jasper Water & Sewer Authority
BLLDF	Barnwell Low-Level Disposal Facility
BWRE	Bulk Waste Removal Efforts

C

C&D	Construction and Demolition
CA	Composite Analysis
CAA	Clean Air Act
CB&I	Chicago Bridge & Iron Company N.V.
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMP	Chemicals, Metals, and Pesticides
COC	Contaminant of Concern
CX	Categorical Exclusion

CWA	Clean Water Act
CY	Calendar Year

D

DCS	Derived Concentration Standard
DOE	United States Department of Energy
DOE-SR	United States Department of Energy-Savannah River Operations Office
DOECAP	DOE Consolidated Audit Program
DWPF	Defense Waste Processing Facility

E

EA	Environmental Assessment
ECHO	Enforcement and Compliance History Online
EDAM	Environmental Dose Assessment Manual
EEC	Environmental Evaluation Checklist
EIS	Environmental Impact Statement
EM	Environmental Management
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPP	Environmentally Preferable Purchasing
ESA	Endangered Species Act
ESPC	Energy Saving Performance Contracting
ETP	Effluent Treatment Project

F

FERC	Federal Energy Regulatory Commission
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FY	Fiscal Year

G

GHG	Greenhouse Gas
GTCC	Greater-Than-Class C

H

HWMF	Hazardous Waste Management Facility

I

I&D	Industrial and Domestic
ICRP	International Commission on Radiological Protection
IMNM	Interim Management of Nuclear Materials
ISO	International Organization for Standardization
ISMS	Integrated Safety Management System

L

LED	Light-Emitting Diode
LLRW	Low-Level Radioactive Waste

M

MACT	Maximum Achievable Control Technology
MAPEP	Mixed Analyte Performance Evaluation Program
MBTA	Migratory Bird Treaty Act
MCL	Maximum Contaminant Level
MCU	Modular Caustic Side Solvent Extraction Unit
MDN	Mercury Deposition Network
MEI	Maximally Exposed Individual
MEK	Methyl Ethyl Ketone
MFFF	Mixed Oxide Fuel Fabrication Facility
MOX	Mixed Oxide
MWMF	Mixed Waste Management Facility
Mrem	Millirem

N

NADP	National Atmospheric Deposition Program
NA-MRF	North Augusta, SC Material Recovery Facility
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NNSA	National Nuclear Security Administration
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NQA	Nuclear Quality Assurance

NRC	Nuclear Regulatory Commission
NTN	National Trends Network
NWP	Nationwide Permit

O

ODS	Ozone-Depleting Substances
ORPS	Occurrence Reporting and Processing System

P

PA	Performance Assessment
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethylene
pH	Potential of Hydrogen

Q

QA	Quality Assurance
QC	Quality Control

R

RCRA	Resource Conservation and Recovery Act
RESRAD	RESidual RADioactivity
RICE	Reciprocating Internal Combustion Engine
RM	River Mile
RPD	Relative Percent Difference
RSL	Regional Screening Levels

S

SA	Supplement Analysis
SARA	Superfund Amendment and Reauthorization Act of 1986
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SDU	Saltstone Disposal Unit
SDWA	Safe Drinking Water Act
SEER	Seasonal Energy Efficiency Ratio
SNF	Spent Nuclear Fuel
SPCC	Spill Prevention, Control, and Countermeasure
SRARP	Savannah River Archaeological Research Program
SREL	Savannah River Ecology Laboratory
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions, LLC
SRR	Savannah River Remediation LLC
SRS	Savannah River Site
SRSCRO	Savannah River Site Community Reuse Organization
SSP	Site Sustainability Plan
STP	Site Treatment Plan
SWDF	Solid Waste Disposal Facility
SWPF	Salt Waste Processing Facility
SWPPP	Stormwater Pollution Prevention Plan

T

TCE	Trichloroethylene

TCCR	Tank Closure Cesium Removal
TLD	Thermoluminescent Dosimeter
TRI	Toxic Release Inventory
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facilities
TSS	Total Suspended Solids

U

U.S.	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS-SR	United States Forest Service-Savannah River
USGS	United States Geological Survey
UST	Underground Storage Tank

V

VEGP	Vogtle Electric Generating Plant
VOC	Volatile Organic Compound
VSDS	Visual Survey Data System

W

WIPP	Waste Isolation Pilot Plant
WTP	Water Treatment Plant

Sampling Location Information

Note: This section contains sampling location abbreviations used in the text and on the sampling location maps. It also contains a list of sampling locations known by more than one name. (See next page.)

Location Abbreviations	Location Name/Other Applicable Information
4M	Fourmile
4MB	Fourmile Branch (Fourmile Creek)
4MC	Fourmile Creek
BDC	Beaver Dam Creek
BG	Burial Ground
BLTW	Burke and Screven Counties Wells (Georgia)
EAV	E-Area Vaults
FM	Four Mile
FMB	Fourmile Branch (Fourmile Creek)
GSTW	Burke and Screven Counties Wells (Georgia)
HP	HP (sampling location designation only; not an actual abbreviation)
HWY	Highway
JAX	SRS Boundary Wells
KP	Kennedy Pond
L3R	Lower Three Runs
MCQBR	McQueens Branch
MHTW	Burke and Screven Counties Wells (Georgia)
MPTW	Burke and Screven Counties Wells (Georgia)
MSB	SRS Boundary Wells
NSB L&D	New Savannah Bluff Lock & Dam (Augusta Lock and Dam)
PAR	"P" and "R" Pond
PB	Pen Branch
RM	River Mile
SC	Steel Creek
SWDF	Solid Waste Disposal Facility
TB	Tims Branch
TC	Tinker Creek
TNX	Multipurpose Pilot Plant Campus
TR	Burke and Screven Counties Wells (Georgia)
U3R	Upper Three Runs
VEGP	Vogtle Electric Generating Plan (Plant Vogtle)

Sampling Locations Known by More Than One Name
Augusta Lock and Dam; New Savannah River Lock & Dam
Beaver Dam Creek; 400-D
Fourmile Creek-2B; Fourmile Creek at Road C
Fourmile Creek-3A; Fourmile Creek at Road C
Lower Three Runs-2; Lower Three Runs at Patterson Mill Road
Lower Three Runs-3; Lower Three Runs at Highway 125
Pen Branch-3; Pen Branch at Road A-13-2
R Area downstream of R-1; 100-R
River Mile 118.8; U.S. Highway 301 Bridge Area; Highway 301, US 301, Georgia Welcome Center at Highway 301
River Mile 129.1; Lower Three Runs Mouth
River Mile 141.5; Steel Creek Boat Ramp
River Mile 150.4; Vogtle Discharge
River Mile 152.1; Beaver Dam Creek Mouth
River Mile 157.2; Upper Three Runs Mouth
River Mile 160.5; Demier Landing
Steel Creek at Road A; Steel Creek-4; Steel Creek-4 at Road A; Steel Creek at Highway 125
Tims Branch at Road C; Tims Branch-5
Tinker Creek at Kennedy Pond; Tinker Creek-1
Upper Three Runs-4; Upper Three Runs-4 at Road A; Upper Three Runs at Road A; Upper Three Runs at Hwy 125
Upper Three Runs-1A; Upper Three Runs-1A at Road 8-1
Upper Three Runs-3; Upper Three Runs-3 at Road C

Chapter 1 Introduction

The Savannah River Site (SRS) Annual Site Environmental Report is the primary document that the U.S. Department of Energy (DOE) uses to inform the public of environmental performance and conditions at SRS. This report meets the requirements of DOE Order 231.1B, *Environment, Safety, and Health Reporting*. The annual site environmental report also is the principal document that demonstrates how the Site complies with the requirements of DOE Order 458.1, *Radiation Protection of the Public and the Environment.*

This document summarizes SRS's environmental information and data to achieve the following:

- **Highlight significant Site programs**
- **Report environmental occurrences and responses**
- **Describe SRS's compliance with environmental standards and requirements**
- **Describe SRS's Environmental Management System and sustainability performance**
- **Provide the results from monitoring material containing residual radioactivity before its release from SRS**

Chapter Background

This chapter presents the following:

- A brief history of SRS, along with a summary of its current missions
- Highlights of SRS organizations and their primary responsibilities
- Description of the physical characteristics and attributes of the environment in and around SRS
- Updates of SRS's primary mission and annual programs

1.1 HISTORY

SRS is a DOE site in the western region of South Carolina, along the Savannah River. The Atomic Energy Commission constructed SRS in the early 1950s to produce materials used to create nuclear weapons during the Cold War. Over the next decades, five nuclear reactors produced these materials. Several of the support facilities continue to operate, although the reactors ceased operating by 1988. The main activities onsite today involve treating and processing waste, environmental cleanup and remediation, tritium processing, and protecting nuclear material. Today, SRS missions fall into three general areas, described in the next section.

1.2 MISSIONS

The SRS mission is to operate safely and efficiently and to protect public health and the environment, while supporting the nation's nuclear deterrent programs. SRS has the following three main mission areas:

Environmental Stewardship—SRS reduces the environmental legacy of nuclear materials and radioactive waste through initiatives such as restoring groundwater, deactivating and decommissioning excess contaminated facilities, and disposing of radioactive waste.

National Security—SRS enhances national security by creating safe, innovative solutions to manage nuclear materials. These include disposing of nuclear materials, managing the tritium supply, and maintaining and evaluating the nuclear stockpile.

Clean Energy—SRS accelerates developing technology, providing sustainable energy through public and private research and development partners. You will find more information on SRS's website.

1.3 ORGANIZATION

The DOE Environmental Management (DOE-EM) program and the National Nuclear Security Administration (NNSA) oversee the Site missions. These two DOE Program Offices direct the Savannah River Operations Office (DOE-SR). To execute SRS's missions, two federal agencies, two state universities, and several contractors participate in various supporting roles. Figure 1-1 shows the relationship of these contractors with DOE. You will find a description of each entity on the following pages.

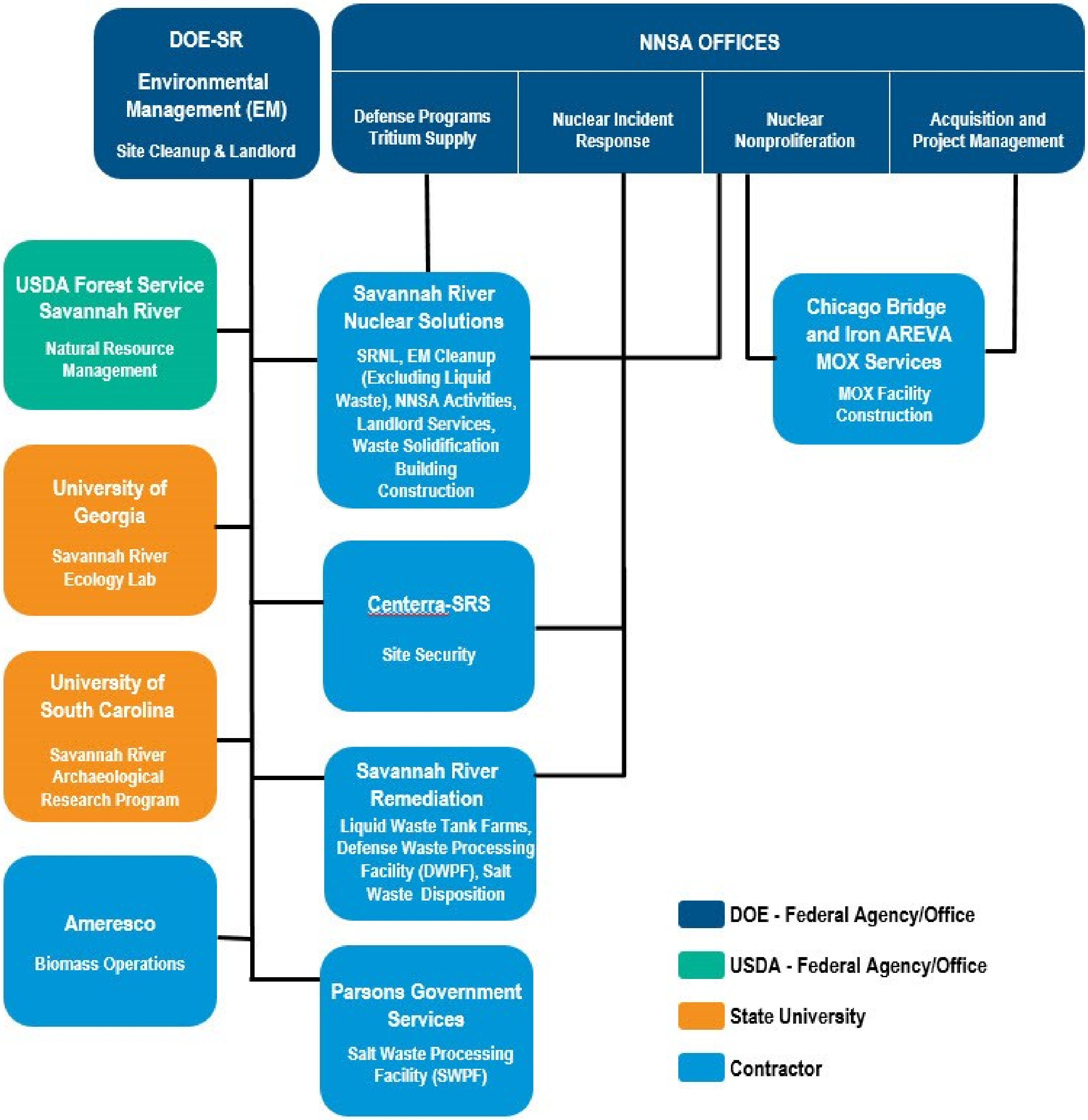


Figure 1-1 SRS Organization

The DOE-EM mission is to safely clean up the environmental legacy waste consisting of nuclear materials and radioactive waste remaining from five decades of developing nuclear weapons and government-sponsored research. DOE-SR is responsible for overseeing EM operations and landlord services supporting all mission areas at SRS. You will find more information on the DOE-SR website.

NNSA is responsible for the defense programs and nuclear nonproliferation elements of the national security mission. NNSA is also responsible for emergency operations related to SRS tritium facility functions and the national Radiological Assistance Program. You will find more information on the NNSA website.

Savannah River Nuclear Solutions, LLC (SRNS), a joint venture of Fluor Corporation, Newport News Nuclear, and Honeywell International, Inc., is the SRS management and operations contractor. SRNS is responsible for nuclear materials facilities, solid waste management facilities, tritium programs, Site infrastructure, and waste site remediation and closure projects. You will find more information on the SRNS website.

Savannah River National Laboratory (SRNL), which SRNS operates, is the only EM-applied research and development laboratory. SRNL creates practical, high-value, cost-effective technological solutions in all three SRS mission areas as well as throughout the DOE complex, with other Federal agencies, and within the private sector. You will find more information on the SRNL website.

Savannah River Remediation LLC (SRR) is responsible for treating and disposing of radioactive liquid waste and operationally closing waste tanks. SRR is composed of a team of companies led by AECOM with partners Bechtel National, CH2M, and BWX Technologies. Critical subcontractors for the contract are AREVA, Atkins, and AECOM Technical Services. You will find more information on the SRR website.

Parsons Government Services, Inc. is responsible for designing, constructing, and commissioning the Salt Waste Processing Facility (SWPF). When completed, SWPF will separate radioactive salt solutions currently stored in below-ground tanks at SRS. SWPF will transfer separated solutions to the Defense Waste Processing Facility (DWPF) or the Saltstone Facility for more processing. You will find more information on the Parsons website.

Chicago Bridge & Iron AREVA MOX Services, LLC is responsible for designing, constructing, starting up, and operating the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF). The MFFF will convert plutonium that could be used to make weapons to a form that can be used in a commercial nuclear power plant. You will find more information on the Chicago Bridge & Iron Areva MOX Services website.

Centerra-SRS is the protective force that safely ensures that criminal or terrorist acts do not disrupt the Site and its employees or compromise sensitive information or nuclear materials. You will find more information on the Centerra website.

Ameresco Federal Solutions, Inc. constructed and now operates biomass steam-generating plants in K and L Areas and the steam and electricity cogeneration plant near F Area. Ameresco supplies steam to SRS. You will find more information on the Ameresco website.

The Savannah River Archaeological Research Program (SRARP) is a research unit of the University of South Carolina that provides the technical expertise to manage SRS cultural resources. SRARP identifies, evaluates, and protects SRS archaeological sites and artifacts, conducting compliance-based research, offering public outreach programs, and preparing documents and reports for state and federal regulators. You will find more information on the SRARP website.

University of Georgia Savannah River Ecology Laboratory

The Savannah River Ecology Laboratory (SREL) is a research unit of the University of Georgia. For more than 65 years, the lab has independently evaluated the environmental risk associated with DOE activities. This mission includes educating graduate and undergraduate students through advanced hands-on research and providing outreach to public schools and communities surrounding the Site. You will find more information on the SREL website.

U.S. Department of Agriculture Forest Service Southern Region

The U.S. Department of Agriculture (USDA) Forest Service-Savannah River (USFS-SR), under an interagency agreement with DOE-SR, manages SRS's natural resources. This includes managing timber; maintaining and improving habitat for threatened, endangered, and sensitive species; maintaining secondary roads and Site boundaries; performing prescribed burns and protecting the Site from wildland fires; and evaluating the effects of its management practices on the environment. You will find more information on the USFS-SR website.

1.4 SITE LOCATION, DEMOGRAPHICS, AND ENVIRONMENT

SRS borders the Savannah River and encompasses about 310 square miles in the South Carolina counties of Aiken, Allendale, and Barnwell. SRS is about 12 miles south of Aiken, South Carolina, and 15 miles southeast of Augusta, Georgia (Figure 1-2). The Savannah River flows along the Site's southwestern border. On Figure 1-2, the capital letters within SRS borders identify operational areas referenced in this report.

Based on the U.S. Census Bureau's 2010 data, the population within a 50-mile radius of the center of SRS is about 781,060 people. 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.

1.4.1 Water Resources

Water resources potentially impacted by SRS activities include the Savannah River, streams located on Site, and the underlying groundwater. The Savannah River bounds SRS on the southwest for 35 river miles. The upriver boundary of SRS is about 160 river miles from the Atlantic Ocean. The nearest downriver municipal facility that uses the river as a drinking water source (Beaufort-Jasper Water and Sewer Authority's Purrysburg Water Treatment Plant) is about 90 river miles from the Site. Commercial fishermen, sport fishermen, and boaters also use the river. The river is not currently used for any large-scale irrigation projects downriver of the Site.

The groundwater at SRS migrates through the subsurface, primarily discharging into the Savannah River and its tributaries. SRS uses groundwater for both industrial processes and drinking water.

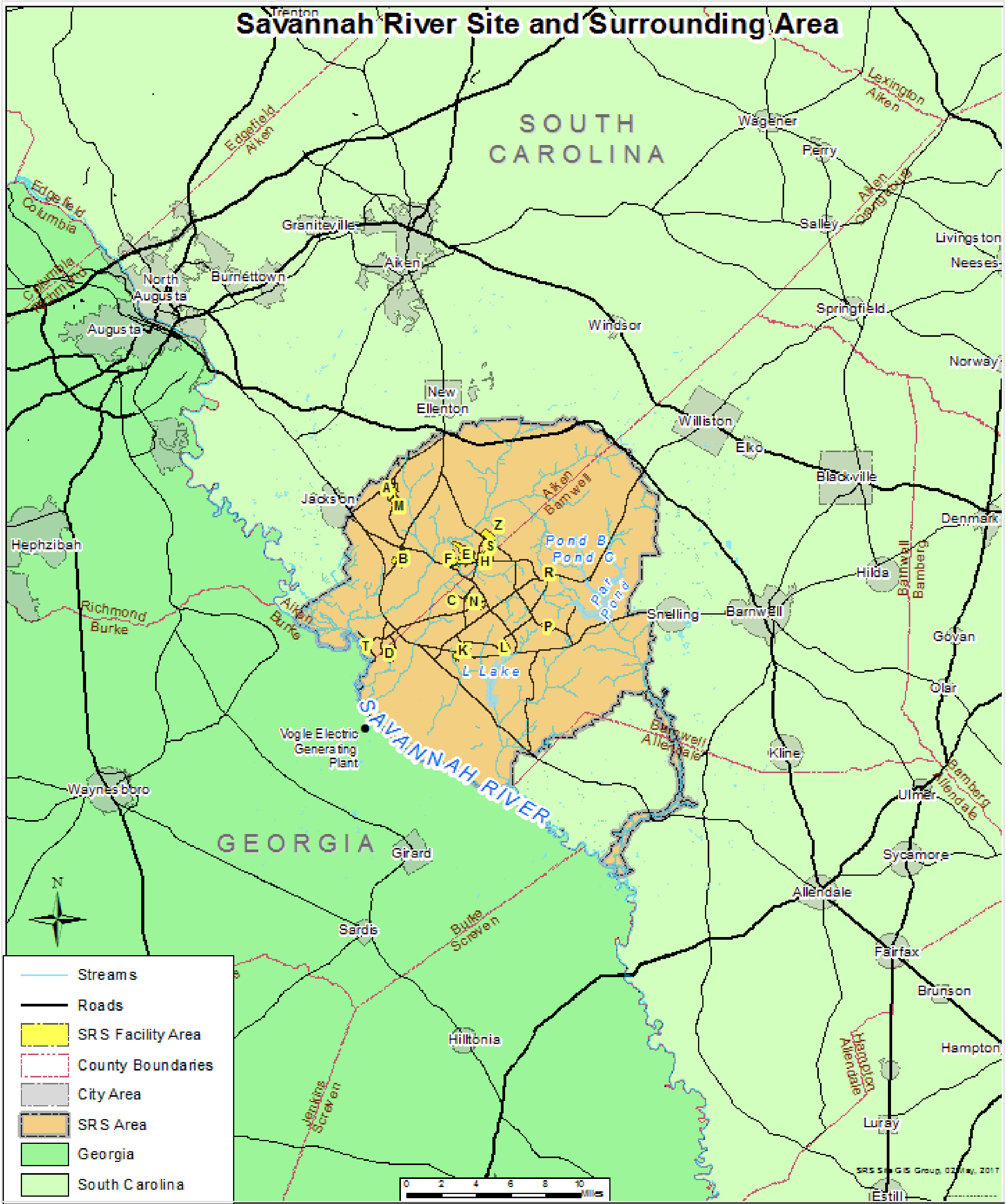


Figure 1-2 The Savannah River Site and Surrounding Area

1.4.2 Geology

SRS is located on the southeastern Atlantic Coastal Plain, in an area named the Aiken Plateau. The center of SRS is about 25 miles southeast of the geologic fall line that separates the Coastal Plain from the Piedmont. The Aiken Plateau slopes gently to the southeast and is generally well drained although many poorly drained depressions exist. Carolina Bays, poorly drained elliptical depressions, are common on the Aiken Plateau. All major streams on SRS originate on Site, except for Upper Three Runs, which begins above the Site. All onsite streams drain into the Savannah River (Denham, 1995)

With nearly three centuries of available historic and contemporary seismic data, the Charleston and Summerville areas remain the most seismically active region affecting SRS. However, levels of earthquake activity within this region are usually low, with magnitudes generally less than or equal to 3.0 on the Richter Scale.

1.4.3 Land and Forest Resources

About 10% of SRS's land is industrial; the remaining 90% consists of natural and managed forests that the USFS-SR plants, maintains, and harvests. SRS consists of four major forests: 1) mixed pine-hardwoods, 2) sandhills pine savanna, 3) bottomland hardwoods, and 4) swamp floodplain forests. These forests, as well as Carolina Bays, are accessible to the public when visiting the Crackerneck Wildlife Management Area and Ecological Reserve near Jackson, South Carolina. Carolina Bays provide important wetland habitat and refuge for many plants and animals. More than 345 Carolina Bays exist on SRS.

1.4.4 Animal and Plant Life

SRS is home to many varieties of plants and animals, including

- More than 100 species of reptiles and amphibians
- Approximately 50 species of mammals
- Nearly 100 species of fish
- Nearly 600 species of aquatic insects
- Approximately 1,500 species of plants, of which at least 40 are of state or regional concern

SRS also maintains habitat for more than 250 species of birds, some of which are migratory and do not make SRS their permanent home. Additionally, the Site provides habitat for federally listed as threatened or endangered animal and plant species, including the wood stork, the red-cockaded woodpecker, the pondberry, the gopher tortoise, and the smooth purple coneflower.

Eastern Box Turtle, one of more than 100 species of reptiles and amphibians that call SRS home

1.5 DOE-EM PRIMARY SITE ACTIVITIES

1.5.1 Nuclear Materials Stabilization

In the past, the mission of the F- and H-Areas facilities was to produce materials for nuclear weapons and isotopes for both medical and National Aeronautics and Space Administration applications. Central to these facilities were the canyons, where the radionuclides were chemically separated from nuclear fuels. The end of the Cold War in 1991 shifted that mission to stabilizing nuclear materials and providing safe interim storage or disposal. F Canyon completed its production mission in 2002 and was deactivated in 2006.

Since 2003, H Canyon has recovered highly enriched uranium from various sites across the DOE complex. DOE now uses H Canyon to blend down highly enriched uranium into low enriched uranium (LEU) fuel. Blending down or down blending, as it is sometimes referred, mixes the uranium with natural uranium to not only make it undesirable to use in nuclear weapons, but to also make it useable for commercial nuclear reactors. You will find more information on H-Area Nuclear Materials Disposition on SRS's website.

1.5.2 Nuclear Materials Consolidation and Storage

The K-Area Complex is NNSA's facility to safely store non-pit plutonium, pending disposition. The principal operations building formerly housed K Reactor, which produced nuclear materials to support the United States for nearly four decades during the Cold War. DOE has revitalized this robust structure to safely store nuclear materials. Additionally, NNSA uses the K-Area Complex to perform inspections to confirm that the plutonium is stored safely and to dilute plutonium in preparation for disposal as transuranic waste at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico.

You will find more information on Nuclear Materials Management on SRS's website.

1.5.3 Spent Nuclear Fuel Storage

SRS supports the DOE National Security mission by safely receiving and storing spent fuel elements from foreign and domestic research reactors, pending disposition. Currently, SRS stores spent nuclear fuel at the L-Area Complex. You will find more information in the L-Area Complex fact sheet on SRS's website.

Personnel with Spent Fuel Project in L-Area Complex

1.5.4 Waste Management

SRS manages radiological and nonradiological waste created by legacy operations, as well as newly generated waste created by ongoing Site operations.

1.5.4.1 Radioactive Liquid Waste Management

Processing nuclear materials for national defense, research, and medical programs generates radioactive liquid waste. SRS safely stores approximately 35 million gallons of radioactive liquid waste underground in waste tanks located in the F- and H-Area Tank Farms. SRS waste tanks have been safely storing radioactive liquid waste for decades. Closing the liquid waste storage tanks is a high priority for DOE EM. To do this, SRS must first remove the waste from the tanks, which is mostly salt waste, and then process and treat the waste before disposing of it. In 2017, SRS procured the Tank Closure Cesium Removal (TCCR) system to remove the cesium in the salt waste. This system will allow SRS to expedite treating the salt waste and accelerate tank closures. SRS completed the TCCR design and fabrication.

SRS uses cylindrical tanks, known as Saltstone Disposal Units (SDUs), to dispose of the low-activity liquid waste. In 2017, SRS completed construction of and performed operational testing on SDU-6, a new design for the cylindrical SDUs, 16 months ahead of schedule and $25 million under budget. In fiscal year (FY) 2017, the Saltstone facilities processed and disposed of 170,000 gallons of waste.

SRS uses DWPF to process high-activity waste from the Tank Farms. Since DWPF began operating in March 1996, it has produced more than 16 million pounds of glass, immobilizing 60.9 million curies of radioactivity and pouring more than 4,100 canisters. In FY 2017, DWPF produced 52 canisters with more than 190,000 pounds of glass, immobilizing approximately 926,000 curies of radioactivity. SRS replaced Melter 2 in 2017. This melter poured 2,819 canisters, or approximately 11 million pounds of glass, in its lifetime. SRS installed and completed start up testing of Melter 3, the replacement melter, by the end of 2017.

You will find more information in the Radioactive Liquid Waste: Operational Tank Closure and Liquid Waste Facilities fact sheets on SRS's website.

1.5.4.2 Solid Waste Management

Solid wastes managed at SRS include the following types:

- Low-level radioactive solid waste, including ordinary items, such as coveralls, gloves, and hand tools, contaminated with small amounts of radioactive material
- Transuranic (TRU) waste, which contains alpha-emitting isotopes with an atomic number greater than that of uranium (92)
- Hazardous waste (nonradiological), which is any toxic, corrosive, reactive, or ignitable material that could affect human health or the environment
- Mixed waste, which contains both hazardous and radioactive components
- Sanitary waste, which, like ordinary municipal waste, is neither radioactive nor hazardous

All low-level radioactive and hazardous wastes that SRS generates are treated, stored, and disposed of to meet environmental and regulatory requirements. The Site also emphasizes minimizing waste and recycling to reduce the waste volume that SRS must manage.

SRS packages TRU waste and transports it in U.S. Department of Transportation-approved containers for underground disposal at WIPP, DOE's geologic repository. SRS began shipping TRU waste to WIPP in May 2001 and, through 2014, has made more than 1,650 shipments. SRS made nine TRU shipments in 2017. In

2017, the Site completed a Resource Conservation Recover Act-approved closure of TRU Pad 2. All remaining legacy TRU waste associated with TRU Pad 2 is packaged and ready for SRS to ship to WIPP.

DOE conducts annual reviews to ensure that Site operations are within DOE's performance standards. The annual reviews for the E-Area Low-Level Waste Facility Performance Assessment (PA) and the Saltstone Disposal Facility PA, showed that SRS continued to operate these facilities in a safe and protective manner.

You will find more information on the Solid Waste Management page on SRS's website.

1.5.5 Waste Site Remediation and Closure

Past operations at SRS have released hazardous and radioactive substances to soil, which subsequently have ended up in the groundwater. Area Completion Projects is responsible for and focuses on reducing the footprint of legacy waste at SRS's contaminated waste sites and obsolete facilities. Area Completion Projects cleans up contamination in the environment by treating or immobilizing the source of the contamination, mitigating contamination transport through soil and groundwater, and slowing the movement of contamination that has already migrated from the source. Cleanup includes capping inactive waste sites, installing and operating efficient groundwater treatment units, and using natural remedies, such as bioremediation (using naturally occurring microbes).

In 2017, SRS continued a 5-year project to restore 90 acres located near the former coal-fired power plant in D Area. The restoration includes consolidating ash that had been deposited over decades and constructing an engineered cover system. To date, SRS has constructed two highly engineered grassy hills over a portion of the site. SRS continues to construct the third multilayer protective landfill cover and has made significant progress on the last of the three basin covers. You will find more information on the Area Completion Projects page on SRS's website.

Construction of the Multi-Layer Protective Landfill Cover at the D-Area Ash Basin

1.5.6 Environmental Monitoring

SRS has an extensive environmental monitoring program that has been in place since 1951, prior to the start of Site operations. In the 1950s, onsite environmental monitoring program data were reported in Site documents. Beginning in 1959, SRS made offsite environmental surveillance data available to the public. SRS reported onsite and offsite environmental monitoring separately until 1985, when it merged data from both programs into one publicly available document, the *U.S. Department of Energy Savannah River Plant Environmental Report for 1985.*

SRS continues to conduct an extensive environmental monitoring program to determine impacts, if any, from SRS to the surrounding communities and the environment, both on and offsite. In addition to the onsite environmental monitoring the Site conducts, SRS also monitors a 2,000-square-mile area beyond the Site boundary. This area includes neighboring cities, towns, and counties in South Carolina and Georgia. SRS collects thousands of samples of air, rainwater, surface water, drinking water, groundwater, food products, wildlife, soil, sediment, and vegetation. These samples are checked for radionuclides, metals, and other chemicals that could be in the environment because of activities at SRS.

The potential radiation doses to the public from SRS operations were well below the DOE public dose limit. Chapter 6, *Radiological Dose Assessment*, contains more information on the public dose limit. You will find overview information on monitoring and radiation dose in the Environmental Monitoring fact sheet on SRS's website.

1.6 NNSA PRIMARY SITE ACTIVITIES

Tritium Facility

NNSA operates tritium facilities at SRS to supply and process tritium, a radioactive form of hydrogen gas that is a vital component of nuclear weapons. SRS also plays a critical role in NNSA's nonproliferation missions, helping the United States meet its commitments to security and disposing of plutonium and uranium.

1.6.1 Tritium Processing

SRS has the nation's only facility for extracting, recycling, purifying, and reloading tritium. SRS replenishes tritium by recycling it from existing warheads and by extracting it from target rods irradiated in nuclear reactors that the Tennessee Valley Authority operates. SRS purifies recycled and extracted gases to produce tritium suitable for use. SRS tritium facilities are part of the NNSA's Defense Program at SRS. You will find more information on Defense Programs on SRS's website.

MFFF Facility under Construction

1.6.2 Nuclear Nonproliferation

When construction is complete, the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) will convert surplus weapons-grade plutonium to a form compatible with generating electricity in commercial nuclear power reactors. The plutonium in the MOX fuel cannot be used for nuclear weapons. You will find more information on the NNSA website.

1.7 SPECIAL ENVIRONMENTAL STUDIES

SRS provides a unique setting for environmental research with 90% of SRS being in a natural state. Several organizations at SRS—the University of Georgia Savannah River Ecology Laboratory (SREL), U.S. Forest Service-Savannah River (USFS-SR), Savannah River Archeological Research Program (SRARP), and Savannah River National Laboratory (SRNL)—conduct research to support a better understanding of human impact on both plants and animals.

SREL, USFS-SR, and SRARP provide annual reports on the environmental studies and research they conduct on SRS. These annual reports are on the SRS 2017 Annual Environmental Report webpage. These reports present and discuss environmental studies and research that occurred during the reporting year and directly affected environmental sampling or dose calculations. Special environmental studies and research directly impacting the environmental monitoring program and dose calculations are presented and discussed in their respective chapters.

Chapter 2 Environmental Management System

The Savannah River Site (SRS) Environmental Management System (EMS) supports the U.S. Department of Energy (DOE) commitment to implement sound stewardship policy and practices to protect the air, water, land, and other natural, archaeological, and cultural resources that SRS construction, operations, maintenance, and decommissioning potentially affect.

The EMS plans and evaluates SRS activities to protect public health and the environment, prevent pollution, and comply with applicable environmental and cultural resource protection requirements. SRS activities demonstrate the Site's commitment to minimize waste, manage water, foster renewable energy, reduce greenhouse gases, acquire sustainable services, remediate with a focus on sustainability, and observe best management practices, all vital components of environmental management. The SRS Site Sustainability Plan contains more information on DOE and SRS goals and the progress toward achieving those goals.

2017 Highlights

DOE sets goals for carrying out its mission in an environmentally sustainable manner that supports a policy of national energy security and addresses global environmental challenges. SRS continues to make substantial progress in meeting the goals for the Site. Below are the highlights of the program:

- **Pollution Prevention and Waste Minimization**—SRS recycled 53.7% (645 metric tons) of nonhazardous solid waste.
- **Water Management**—SRS continued to reduce potable water use, contributing to a 29% reduction since 2000.
- **Renewable Energy Intensity**—SRS derived 100% of steam and 41% of electricity from renewable energy sources.
- **Greenhouse Gas Reduction**—SRS continued to reduce greenhouse gas emissions. The Site has reduced emissions by 69% since 2008.
- **Transportation and Fleet Management**—More than 83% of the current fleet of light-duty vehicles are hybrid, electric, or vehicles that use E85 (ethanol) fuel.
- **Sustainability Award**—SRS won the 2017 DOE Sustainability Award for implementing a sustainable cover system in its basins. The cover system controls the chemistry of the basin water by inhibiting algae growth.

Chapter 2—Key Terms

Environmental impacts *are any positive or negative change to the environment caused by an organization's activities, products, or services.*

Environmental objectives *define the organization's environmental goals.*

Environmental sustainability *is interacting responsibly with the environment to conserve natural resources and promote long-term environmental quality. It includes reducing the amount of waste produced, using less energy, and developing processes that maintain the long-term quality of the environment.*

2.1 SRS EMS IMPLEMENTATION

2.1.1 Introduction

DOE has chosen the International Organization for Standardization (ISO) Standard 14001 as the framework to employ its Environmental Management Systems (EMS). The ISO 14001 standard defines an EMS as part of a system that manages an organization's environmental aspects (including activities, products, or services), fulfills compliance obligations, and addresses risks and opportunities. An organization can use an EMS to frame the "Plan-Do-Check-Act" approach to achieve continuous improvement, as depicted in Figure 2-1. The SRS EMS also complies with Executive Order No. 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*; Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*; and DOE Order 436.1, *Departmental Sustainability*, which require federal facilities to use environmental management systems.

The EMS has two areas of focus: environmental compliance and environmental sustainability. The environmental compliance area consists of regulatory compliance and monitoring programs that implement federal, state, and local requirements, agreements, and permits. The environmental sustainability area promotes and integrates initiatives such as energy and natural resource conservation, waste minimization, green remediation, and the use of sustainable products and services.

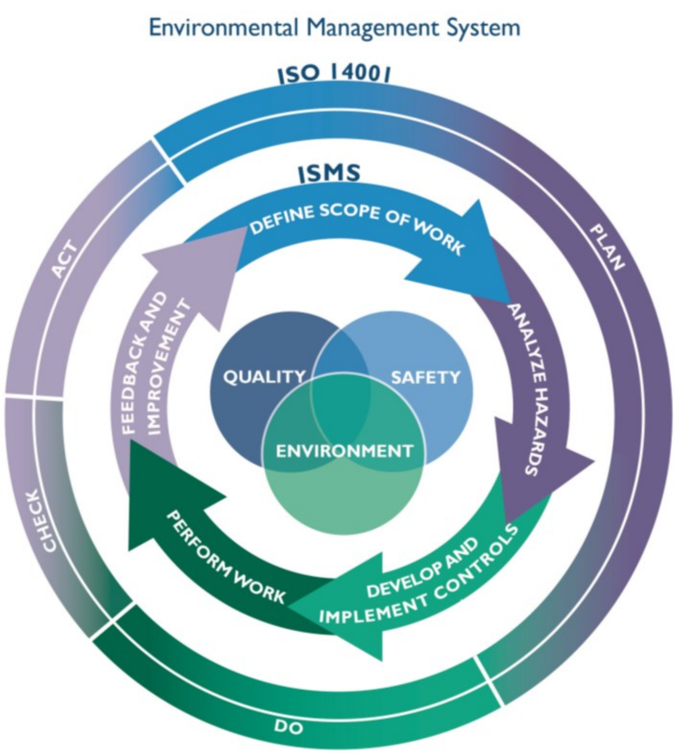


Figure 2-1 Integrated Safety Management System Continual Improvement Framework within the ISO 14001 Environmental Management System

SRS trains all employees annually on the EMS policies and requirements. Additionally, the Site generates regular and routine employee communications as a reminder of the SRS commitment to sustainability and the environment.

The SRS Integrated Safety Management System (ISMS) is a process that integrates safety into management and work practices at all levels so that the Site accomplishes its missions, while protecting the public, the worker, and the environment. The ISMS execution comprises five functions: 1) defining scope of work, 2) analyzing hazards, 3) developing and implementing controls, 4) performing work, and 5) providing feedback and improvement. SRS implements ISO 14001 and accomplishes the EMS goals using the ISMS approach in programs and procedures. As evidenced by Figure 2-1, the ISO 14001 EMS approach, Plan-Do-Check-Act, is similar to ISMS, which allows SRS to integrate EMS into ISMS.

The EMS integrates environmental protection initiatives—such as identifying safety and health hazards, and the quality processes in place to manage them—into SRS daily operations. This linked approach to planning, executing, evaluating, and modifying ensures that SRS operates with minimal adverse impact on the environment.

SRS also uses the EMS as a platform to implement the Site Sustainability Plan (SSP), as well as carry out programs with environmental goals and objectives that contribute to SRS meeting its sustainability goals. SRS EMS and SSP goals and objectives, along with the status of the Site's progress toward meeting these goals, are available on the SRS website. These documents, combined with Site policies and procedures, ensure SRS remains a leader in protecting the environment and is a steward of conserving energy and water.

Each EMS must have a formal audit performed by a qualified party outside the control or scope of the EMS every three years. Savannah River Nuclear Solutions (SRNS) and Savannah River Remediation (SRR) conform to the ISO 14001, and Centerra and Chicago Bridge & Iron (CB&I) AREVA MOX Services are ISO 14001 certified.

SRS contractors had the following audits for ISO 14001 compliance:

- SRNS and SRR had an external conformance audit in March 2015
- Centerra conducted ISO 14001 reregistration in January 2015 and had a review audit in January 2016
- Chicago Bridge & Iron AREVA MOX Services had an external conformance audit in April 2016

All the above-mentioned SRS contractors have performed their ISO 14001 conformance audits within their specified schedules and did not need to have one in 2017.

2.1.2 Goals and Objectives

The Site uses the SRS Site Sustainability Plan to implement the environmental goals outlined in DOE's Strategic Sustainability Performance Plan (SSPP). The objectives, which DOE sets annually, include the following:

- Reducing total energy use
- Increasing renewable energy use
- Reducing water use
- Purchasing environment-friendly, or "green," products and services
- Reducing solid waste generation
- Increasing the number of sustainable buildings
- Reducing fleet and petroleum use
- Using energy-compliant electronic devices

SRS Environmental Management System Goals

Appendix A presents the goals for 2017, identifies the strategies for implementation, and provides the status of SRS's progress toward achieving them. This chapter contains additional information on how SRS is moving forward in supporting DOE environmental objectives.

2.2 SUSTAINABILITY ACCOMPLISHMENTS

The following topics summarize the major accomplishments the SSP discusses. Updated annually, the SSP outlines the strategies in place and the progress made toward accomplishing national goals related to improving energy, water and fuel efficiency, and using sustainable products and services as required by DOE Order 436.1, E.O. 13423, and the DOE SSPP. Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*, outlines each of the topics below. Additionally, Appendix A of this document outlines the 2017 EMS goals and objectives related to sustainability.

2.2.1 Greenhouse Gas Reduction

By reducing greenhouse gas (GHG) by 69%, SRS has surpassed the 50% goal to reduce Scope 1 and 2 from a fiscal year (FY) 2008 baseline. Scope 1 GHG emissions consist of direct emissions from sources that DOE owns or controls, such as onsite combustion of fossil-fuels and fleet fuel consumption. Scope 2 GHG emissions consist of indirect emissions from sources that DOE owns or controls, such as emissions from generating electricity, heat, or steam DOE purchased from a utility provider. Scope 3 GHG emissions are from sources DOE does not own or directly control but are related to DOE activities such as employee travel and commuting.

The following inventoried sources at SRS currently generate Scope 1 and 2 emissions:

- Purchased electricity
- Wood (biomass)
- Fuel oil
- Propane
- Gasoline
- Diesel
- E85 (ethanol)
- Jet fuel
- Fugitive emissions

Biomass Cogeneration Facility

SRS continued to substantially reduce Scope 1 and 2 GHGs during FY 2017 due to the Biomass Cogeneration Facility and operating three additional biomass facilities, one each in A Area, L Area, and K Area. DOE tracks GHG data from various impact sources (such as Site energy use, alternative workplace arrangements and space optimization, and vehicle and equipment use). By 2025, DOE must reduce Scope 3 GHG emissions by 25% compared to the FY 2008 baseline. SRS currently meets that goal with a 26% reduction in FY 2017. The Site has accomplished this by such efforts as utilizing webinars and conference calls to reduce business travel and by promoting employee carpooling.

2.2.2 Sustainable Buildings

Using FY 2015 as a baseline, DOE must reduce by 25% the amount of energy per square foot (energy intensity) used in an identified class of buildings. The annual goal is to reduce intensity by 2.5%. DOE expects sites to aggressively strive toward the overall DOE 25% reduction goal, particularly when cost-effective and prudent to do so. As of FY 2017, SRS has reduced its energy intensity by 20% from the FY 2015 baseline. Thus, SRS is well ahead of the energy-reduction goal.

In February, the National Nuclear Security Administration (NNSA) designated the Tritium Engineering Building “green” and awarded it a High Performance Sustainable Building status, meaning it met performance requirements related to energy, waste, water reduction, and occupant health and comfort.

Improving energy efficiency has been ongoing at the Site for many years, and additional benefits have come from a wide variety of strategies used to reduce energy and manage utilities, including the following:

- Upgrading utility systems
- Minimizing boiler use for winter heating
- Operating the Biomass Cogeneration Facility
- Operating biomass steam plants in A Area, K Area, and L Area
- Deactivating and decommissioning many facilities, including entire areas, which often comprise multiple buildings, land, and associated waste disposal and decontamination challenges
- Consolidating employee-occupied building space into fewer buildings

- Using more setback equipment in facilities (such as lighting timers, lighting sensors, and thermostats)
- Upgrading various small-scale light fixtures

SRS conducted many activities in FY 2017 that reduced energy intensity. Operating the Biomass Cogeneration Facility had the most impact. The following are some additional notable accomplishments supporting this program:

- Conducted a required energy and water audit for 40 facilities, identifying ongoing opportunities for improvement
- Removed 20 unoccupied and aging trailers, reducing energy consumption and reducing 28,000 square feet of footprint
- Installed energy-efficient lighting, such as light-emitting diodes (LEDs), as existing fluorescent lighting failed in facilities
- Replaced 16 heating and cooling units with new, higher Seasonal Energy Efficiency Ratio (SEER) units, which are more efficient and save energy
- Replaced roofs on eight buildings with cool roof technology, which uses light-colored tiles or shingles to reflect sunlight and heat, decreasing the need for air conditioning

SRNS also manages energy efficiency at a facility level with the Peak Alert process, which reduces purchased power. Actions that will reduce the demand for energy include raising the thermostat (summer), lowering the thermostat (winter), and turning off lights when it is safe to do so. SRS used Peak Alerts to manage 17 peak events during FY 2017: 11 during cool months and 6 during warm months.

2.2.3 Renewable Energy

Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*, Clean Energy goal for FY 2017 requires at least 10% of an agency's total electric and thermal energy come from renewable and alternative energy sources. This goal increases to 25% by FY 2025. Additionally, DOE's Renewable Electric Energy goal requires that renewable electric energy account for at least 10% of a total agency electric consumption in FY 2017, working toward 30% of total agency electric consumption by FY 2025. SRS has exceeded the clean energy generation goal with renewable energy sources producing 100% of steam and 41% of electricity. SRS no longer uses coal to generate energy. Using clean and renewable energy at the Site is a high-level priority. The Biomass Cogeneration Facility is in its fifth year of fully operating and has played a significant role in supporting these renewable and alternative energy goals.

2.2.4 Water Use Efficiency and Management

Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*, stipulates that by FY 2025, DOE as an agency will reduce the gallons of potable water used per square foot of building area (also known as potable water consumption intensity) by 36%, relative to a FY 2007 baseline. DOE had an FY 2017 target goal to reduce this ratio by 20%.

The Site has been significantly decreasing its potable water use over many years. In 1996, for example, the Site installed a new SRS primary domestic water system. The new system, along with replacing old and leaky piping, saved the Site several hundred million gallons of water annually. SRS also installed water meters on the main supply lines and periodically conducts a water balance to monitor use and help detect leaks.

Compared to the current baseline (FY 2007), SRS has reduced potable water consumption intensity through FY 2017 by 17%. Over a longer timeframe, since FY 2000, the Site has reduced potable water use by 29%. It will be more difficult for SRS to make future decreases to potable water usage since it has already achieved large decreases in the programs that have the biggest impact. Potable water use fluctuates from year-to-year based on various factors, such as the number of employees and the amount of potable water used for nonpotable purposes.

During FY 2017, SRS continued to benefit from the use of WaterSense® products and other water-conserving products, including low-flow toilet flush valves, low-flow urinal flush valves, and low-flow faucets. In recent years, the Site has replaced several hundred faucets and flush valves with reducers or low-flow units.

2.2.5 Fleet Management

The primary goal for DOE fleet management is to use less petroleum and more alternative fuel, as Figure 2-2 demonstrates. SRS has met and exceeded these goals since FY 2000. Figure 2-3 shows SRS FY 2017 performance in meeting key fleet management goals.

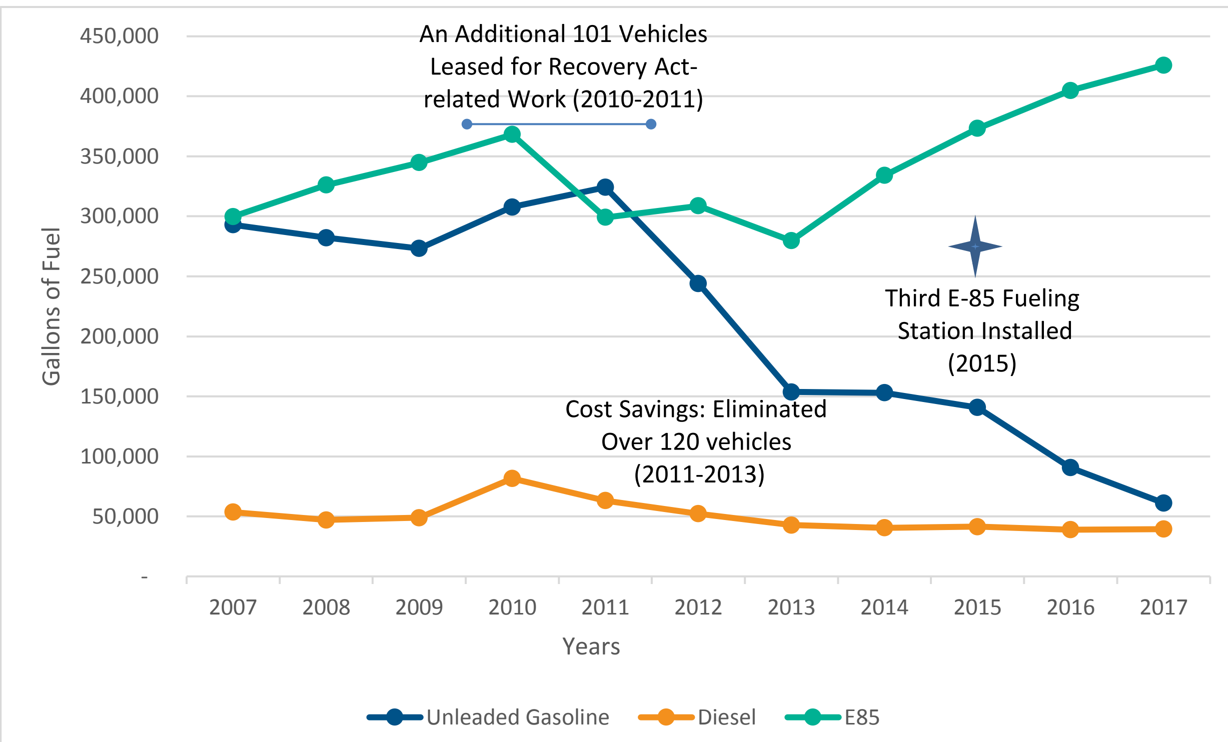
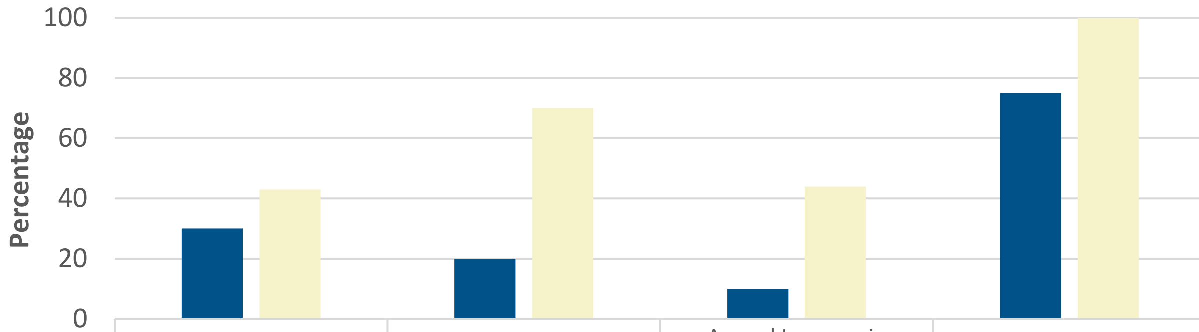


Figure 2-2 GSA Fuel Consumption by Type, FY 2007 to FY 2017



	Fleet-wide Per-mile GHG Emssions (% Reduction by FY 2025)	Reduction in Annual Petroleum Consumption (% Reduction Against FY 2005 Baseline)	Annual Increase in Alternate Fuel Consumption (% Increase Against FY 2005 Baseline)	Percent Light duty Vehicle Aquisitions being Alternate Fuel—FY 2017 Goal
Goal	30	20	10	75
FY 2017	43	70	44	100

Figure 2-3 SRS Performance in Meeting Fleet Management and Transportation Goals

SRS installed two E85 fueling stations in October 1999 and added a third in FY 2015. In FY 1999, the year prior to installing the fueling stations, the Site consumed more than 700,000 gallons of unleaded gasoline and no E85 alternative fuel. In FY 2017, the Site consumed approximately 63,000 gallons of unleaded gasoline, 44,000 gallons of diesel fuel, and 298,000 gallons of E85 alternative fuel. SRS has reduced its fleet-wide per mile greenhouse gas emissions goal by 43%, exceeding the Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*, goal of a 30% reduction by FY 2025. In FY 2017, SRS exceeded the goal of annually maintaining a 20% reduction of petroleum use and a 10% increase in alternative fuel compared to the FY 2005 baseline with a 70% reduction in petroleum and a 44% increase in alternative fuel, respectively.

SRS continues to implement the Site Vehicle Allocation Methodology Plan completed in 2016. The Vehicle Allocation Methodology helps organizations eliminate fleet vehicles that are unnecessary, oversized, or not fuel-efficient. SRS updates its plan at least every five years. In FY 2017, SRS leased 22 new light-duty vehicles, all of which used E-85 alternative fuel, and increased the number of alternate fuel vehicles in the light duty to fleet to 441 (83%), out of an approximately 530-vehicle fleet. This acquisition of 100% alternative fuel vehicles in FY 2017 exceeded the goal of 75% of the vehicles using alternative fuel. Of the passenger vehicles that are unleaded vehicles, 90% are hybrid fuel and electric vehicles, which exceeds the FY 2025 Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*, goal of having 50% of the passenger vehicle acquisitions being zero emission or plug-in hybrid electric vehicles.

2.2.6 Sustainable Acquisition

SRS Procurement has established sustainable practices related to purchasing environmentally preferable products (EPP) to meet the DOE goal of 95% of new contract actions for products and services are to meet sustainability acquisition requirements. For FY 2017, SRS reviewed 16,908 contracts with 100% of them meeting all requirements. The EPP procurements have led to several practices, as outlined below:

- The SRS Chemical Management Center reviews and approves chemical acquisitions. This review monitors using hazardous chemicals and, where appropriate, recommends EPPs.
- Electronic stewardship has led to procuring and leasing desktops, laptops, and monitors that meet Electronic Product Environmental Assessment Tool (EPEAT) standards and copiers that are ENERGY STAR®-compliant.
- EPP substitutions have been procured under various new and existing contracts, including bulk janitorial supplies (for example, cleaners, paper products) and safety items (for example, earplugs, filters).

SRS implemented a system to monitor and track EPP procurements. This new business system will enable SRS to develop an EPP baseline and track spending on EPP items and materials.

2.2.7 Pollution Prevention and Waste Reduction

In accordance with the Pollution Prevention Act of 1990, SRS's primary objective is to prevent or reduce pollution at the source whenever practical. Environmentally safe and cost-effective reuse or recycling will divert pollutants and wastes that source reduction cannot prevent from entering the waste stream. Pollution prevention is the SRS preferred approach to reducing waste, mitigating health risks, and protecting the environment. The Pollution Prevention Program provides SRS a safe, effective, and environmentally responsible strategy to implement specific waste-reduction techniques based on current and projected information on waste generation, waste characteristics, and costs associated with managing waste. Pollution prevention is a key component of the SRS EMS.

The goal for FY 2017 was to divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, for recycling or reuse. SRS uses the North Augusta Material Recovery Facility (NA-MRF) for typical office and municipal-type waste recycling and another vendor to shred and recycle sensitive office paper. In FY 2017, SRS recycled about 53.7% of this stream, 645 metric tons of the 1,202 metric tons of waste that it shipped. Table 2-1 provides a breakdown of recycled amounts from key items in the onsite program.

SRS continues to work with NA-MRF to improve the process to attain and improve upon a 50% recovery rate. In addition, SRS uses NA-MRF to recycle most of the waste from its area cafeterias and building kitchenettes. The Site segregates the main cafeteria's waste due to there being very little material suitable for recycling or composting. SRS continues to monitor this waste stream for opportunities to recycle materials. In FY 2017, SRS successfully implemented concrete and asphalt recovery, recycling more than 21,000 metric tons of rubble from scraping and paving a major road on site. The Site otherwise would have treated the rubble as waste and sent it to the on-site construction and demolition landfill. SRS is storing this recovered material for beneficial reuse, such as improving secondary roads onsite.

Table 2-1 SRNS Recycling and Sustainability in FY 2017 by Amount

Items Recycled Onsite in FY 2017	Amount Recycled
Silver Fixative	55 gallons
Batteries (nickel-cadmium, lithium-ion, mercury)	5,956 pounds
Lead Salvage	12,064 pounds
Light Bulbs/Mercury-containing Equipment	13,633 pounds
Brass Casings	25,643 pounds
Batteries (lead acid)	52,522 pounds
Furniture	222,680 pounds
Scrap Metal	710,961 pounds
Used Tires	11 tons

MOX restores 95% of used methyl ethyl ketone (MEK) to virgin quality solvent. MEK is a solvent used to clean painting equipment that MOX uses during construction. In 2017, MOX used an onsite distillation system to recycle approximately 1,100 gallons of MEK, making it available for reuse. This approach of recycling instead of discarding generated 20% less hazardous waste.

SRS piloted "Clean Sweep" collections for unwanted nonaccountable scrap electronics for two administrative buildings. Eligible Items included computer peripherals (for example, monitors, keyboards); audio-visual equipment; printing and duplicating equipment such as plotters, printers, and scanners; and other electronic items, such as desktop telephones and computer cables. Not only did the two events reduce office clutter, they also collected more than 2,700 pounds of scrap electronics for recycling.

2.2.8 Energy Saving Performance Contracting

SRS has used Energy Saving Performance Contracting (ESPC) to engage Ameresco Federal Solutions for several projects that conserve energy and water. ESPC funds energy- and water-saving building improvements with future energy savings. Ameresco Federal Solutions, tasked with the DOE's largest-ever ESPC project, operates the Biomass Cogeneration Facility located on SRS. This facility produces steam and electricity on a 24-hour, full-time basis.

The ESPC scope included the following in 2017:

- Ameresco continued operating the Biomass Cogeneration Facility, which includes three biomass boilers for steam and electricity
- Ameresco also operated steam-only biomass plants for heating buildings in two other areas at SRS

2.2.9 Electronics Stewardship

SRS is implementing many electronics stewardship strategies to reduce energy use and waste, and their associated costs. In FY 2017, SRS continued exemplary performance and met sustainable electronics purchasing and disposal goals. SRS purchased Electronic Products Environmental Assessment Tool (EPEAT) and registered ENERGY STAR®-qualified products for all eligible laptops, desktops, and monitors. Ninety-seven percent of the eligible electronics SRS acquires meet EPEAT standards. All eligible computers and imaging equipment have automatic duplexing enabled. Likewise, 100% of eligible desktops, laptops, and monitors have power management enabled. Used electronics are either recycled or reused in an environmentally sound manner by donating to schools and nonprofit organizations or by recycling through authorized recycling companies. In FY 2017, SRS recycled 78,730 pounds of scrap electronics. SRS is also extending the "workstation refresh cycle"—the time a computer is used before being replaced—reducing the number of computers being retired and the amount of scrap electronics being generated.

2.2.10 Climate Change Resilience

SRS ensures that federal operations and facilities can continue to protect and serve citizens in a changing climate. SRS uses global climate model projections and data as the starting point to assess the impact of climate change to Site buildings and outdoor workers. SRS continues to assess the effects of climate change on preserving forests, maintaining water levels in Site ponds and lakes, and the ability of a Site energy plant to "dump" heat to the environment.

2.3 EMS BEST PRACTICES

2.3.1 2017 Department of Energy Sustainability Award

SRS received the 2017 Department of Energy Sustainability Award for "Saving Our Water: SRS Saves Well Water Usage, Ensures Regulatory Water Discharges and Avoids Expensive Treatment System." The project, initiated in 2015, added a floating cover to a water basin at SRS. The result has been an annual decrease of 55 million gallons of well water use and discharges that meet permit conditions for the receiving stream. The cover consists of more than 700,000 rhombus-shaped balls. These small, dark shade plastic balls nestle together no matter which way they turn, acting like a sun-blocking tarp as they float in the basin. Additional information on the award-winning project is available on the 2017 ASER webpage.

2.3.2 South Carolina Environmental Excellence Program (SCEEP)

In 2017, MOX Services renewed it membership in SCEEP. Membership is active for three years. MOX Services was recognized by the South Carolina Department of Health and Environmental Control (SCDHEC) for its membership in the South Carolina Environmental Excellence Program (SCEEP) since 2011. SCEEP is a voluntary SCDHEC program that recognizes South Carolina facilities that demonstrate excellence in environmental performance through pollution prevention, energy and resource conservation, and continued efforts in environmental improvement.

2.3.3 Sustainability Campaign

SRS continued to implement its "One Simple Act of Green" environmental awareness campaign. The program empowers SRS employees with the information, tools, and programs needed to reduce our footprint on the environment. Employees practice simple acts, such as turning off lights when leaving a room or workspace, which promote positive actions toward environmental stewardship.

A sustainability booth was presented at the 2017 SRS Safety Expo in October, which approximately 3,000 Site employees and community members attended. This booth highlighted sustainable practices and efforts onsite, including reusing asphalt road millings, waste reduction, LED lighting, E-85 alternative fuel use, and rhombus-shaped balls used with the floating basin cover.

MOX Services TEEM (Targeting Environmental Excellence at MOX) is an elite group of MOX employees selected by their peers who volunteer their time to identify ways to reduce MOX's environmental footprint. TEEM championed two sustainability campaigns in 2017:

- Last Out Lights Out—MOX reduced its electricity consumption by 7% as compared to the same quarter of the previous year. This campaign aimed to curb wasteful electricity use by deploying "lights out" messages in MOX facilities.
- Call for Awareness—MOX obtained the top five slogans, posters, and quotes on reducing MOX's environmental footprint. This campaign encouraged employees to participate in spreading awareness through compelling visuals that better grab people's attention on environmental stewardship, one of MOX's core values.

2.3.4 Earth Day

SRS hosted an Earth Day celebration onsite for its employees on April 20. The 2017 Energy Department Sustainability Award was presented to SRR for "Saving Our Water," the project that implemented the innovative basin cover and biological digester described in section 2.3.1. Additionally, the Site planted two southern magnolias to observe Earth Day.

SRS Personnel Observe Earth Day by Planting a Southern Magnolia

2.3.5 Excess Equipment and Materials

SRS is partnering with the Savannah River Site Community Reuse Organization (SRSCRO) to turn excess equipment and material into money to benefit the counties of Aiken, Allendale, and Barnwell in South Carolina and Richmond and Columbia counties in Georgia. Surplus material includes the following:

- Small items such as office equipment, valves, and glassware for laboratory experiments

- Large items of potentially much greater value such as electrical turbines, diesel powered pumps, and fire engines
- Tons of metal

SRSCRO is the interface organization that takes in items that the Site no longer needs. The SRSCRO sells these items and uses the proceeds for the economic good of numerous businesses throughout the large region surrounding SRS. In FY 2017, SRS shipped $29.5 million in usable assets for reuse and recovery. Based on SRSCRO's 2017 annual report, the program generated by this partnership generated $794,832 in gross revenue during the fiscal year.

2.3.6 Challenges and Barriers to Implementation

SRS has made significant accomplishments in conserving and managing resources over many years. However, the cost effectiveness of achieving new goals is becoming significantly more difficult. Economic paybacks are typically long, due to low energy costs and the high cost of implementing sustainability upgrades in SRS's many aging nuclear production and support (for example, administrative, shops, laboratories, warehouses) facilities. Additionally, the Site will have increases to energy and greenhouse gas emissions as additional processing facilities, such as the MOX Fuel Fabrication Facility and the Salt Waste Processing Facility, begin operating. This is a major challenge to meeting the future goals.

Chapter 3 Compliance Summary

The Savannah River Site (SRS) implements programs to meet the requirements of applicable federal and state environmental laws and regulations, and U.S. Department of Energy (DOE) Orders, notices, directives, policies, and guidance. Our goal is to comply with regulatory requirements and eliminate or minimize any environmental impacts. SRS continues our commitment to protect human health and the environment.

2017 Highlights

Permitting

SRS managed more than 375 operating and construction permits. SRS received five Notices of Violation (NOVs). More information on the NOVs can be found below and in Sections 3.3.6.5, 3.3.7.1.1, 3.3.7.2, 3.5, and 3.8.

Remediation (Environmental Restoration and Cleanup)

SRS completed the cleanup of 408 of the 515 waste units containing or having contained solid or hazardous waste by the end of fiscal year (FY) 2017. An additional 10 waste units are currently under remediation.

Tank Closure (Radioactive Liquid Waste Processing and Dispositioning)

- SRS procured the Tank Closure Cesium Removal (TCCR) system to expedite treating salt waste and accelerate tank closure. SRS completed the TCCR design and fabrication.
- The Defense Waste Processing Facility (DWPF) filled 52 canisters with approximately 190,000 pounds of glass waste mixture, immobilizing 926,000 curies of high-level radioactive waste.
- The Saltstone facilities processed 170,000 gallons of low-activity waste.
- SRS completed construction and operational testing of SDU-6 16 months ahead of schedule and $25 million under budget.

Radioactive Waste Management

- The annual reviews for the E-Area Low-Level Waste Facility Performance Assessment (PA) and the Saltstone Disposal Facility PA showed that SRS continued to operate these facilities in a safe and protective manner.

Resource Conservation and Recovery Act (RCRA)

- SRS submitted TRU Pad 2 Closure Certification to SCDHEC in September.
- SRS submitted the Solvent Storage Tanks (SSTs) S33-S36 Closure Plan in May.

2017 Highlights (continued)

Resource Conservation and Recovery Act (RCRA) (continued)

- SRS reached 15 consecutive years without a violation by assuring that all 19 underground storage tanks containing usable petroleum fuel remained in compliance.

Air Quality and Protection

SRS received three of the five NOVs for not complying with air permits:

- Not conducting a relative accuracy test and certifying a new flow transmitter at the 291-F Stack
- Not complying with the requirements of 40 CFR 63 Subpart DDDDD at the 784-7A boiler facility
- Not complying with work practice requirements for a nonfriable asbestos project related to packaging, transporting, and disposing of 160 linear feet of asbestos- containing waste

Water Quality and Protection

SRS received two of the five NOVs for not complying with water permits, as described below:

- SRS sampled drinking water monthly to ensure it met SCDHEC and U.S. Environmental Protection Agency (EPA) standards. All samples obtained and tested in 2017 met drinking water quality standards. SRS received an NOV on February 9, 2017 for failing to collect all the required monthly drinking water samples in December 2016.
- SRS monitored 28 industrial outfalls as the National Pollutant Discharge Elimination System (NPDES) permit required. Outfall L-7A had a fecal coliform exceedance in October, which resulted in one of the five NOVs. Except for the exceedance associated with the NOV, all analyses results complied with the NPDES permit and contributed to a 99.9% compliance rate.

All 34 SRS Industrial storm water outfalls covered under a Stormwater Pollution Prevention Plan (SWPPP) complied with plan requirements. The SWPPP describes how SRS prevents contamination and controls sedimentation and erosion.

Radiation Protection of the Public and the Environment

SRS air and water discharges containing radionuclides were well below the DOE public dose limit of 100 mrem per year. (Chapter 5, *Radiological Environmental Monitoring Program*, provides details of the air and water discharges; Chapter 6, *Radiological Dose Assessment,* explains the public dose.)

Environmental Protection and Resource Management

- SRS conducted 504 National Environmental Policy Act (NEPA) reviews to identify potential environmental impacts from proposed federal activities. SRS identified 452 of these as categorical exclusions that did not require action from the Site under NEPA.
- SRS continued to comply with many other federal laws, including the Emergency Planning and Right-to-Know Act (EPCRA), the Superfund Amendments and Reauthorization Act (SARA) Title III, the Endangered Species Act (ESA), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the National Historic Preservation Act (NHPA), and the Migratory Bird Treaty Act (MBTA).

2017 Highlights (continued)

Release Reporting

SRS did not have any releases exceeding the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Reportable Quantity.

External Environmental Audits and Inspections

SCDHEC conducted audits, inspections, and site visits of various SRS environmental programs to ensure regulatory compliance. The Federal Energy Regulatory Commission (FERC) performed a dam safety inspection in October.

3.1 INTRODUCTION

Complying with environmental regulations and DOE Orders is integral to SRS operations. The rest of this chapter summarizes how SRS complies with applicable environmental regulations and programmatic requirements.

3.2 FEDERAL FACILITY AGREEMENT

The 1993 *Federal Facility Agreement (FFA) for the Savannah River Site*, a tri-party agreement between DOE, EPA and South Carolina, integrates CERCLA and RCRA requirements to achieve a comprehensive remediation strategy and to coordinate administrative and public participation requirements. The FFA governs remedial actions, sets annual work priorities, and establishes milestones for cleanup and tank closure. SRS conducts remediation and closure activities identified in the FFA in accordance with applicable regulations, whether they are from the state, the federal government, or both.

3.2.1 Remediation (Environmental Restoration and Cleanup)

SRS has 515 waste units subject to the FFA, including RCRA/CERCLA units, Site Evaluation Areas, and facilities covered by the SRS RCRA permit. At the end of FY 2017, SRS had completed the surface and groundwater cleanup of 408 of these units and was in the process of remediating an additional 10 units. Appendix C, *RCRA/CERCLA Units List*; Appendix G, *Site Evaluation List*; and Appendix H, *Solid Waste Management Units Evaluation* of the FFA list all of SRS's 515 waste units. The *Federal Facility Agreement Annual Progress Report for Fiscal Year 2017* explains the status of FFA activities at SRS for FY 2017.

CERCLA requires reviews every five years for sites that have hazardous substances remaining at levels that do not allow for unrestricted use of the area after a remedy is completed. Remedies are evaluated to determine if they are functioning as designed and are still protecting human health and the environment.

The *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Groundwater Remedies* was issued to the public on February 2, 2017. SCDHEC and EPA approved the *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Engineered Cover Systems* in December 2017 and January 2018, respectively. This report was issued to the public on February 21, 2018. SCDHEC and EPA approved the *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with*

Geosynthetic or Stabilization/Solidification Cover Systems in January 2018 and February 2018, respectively. This report was issued to the public on March 27, 2018. DOE submitted the *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Operating Equipment* to EPA and SCDHEC in December.

The FFA also governs how the Site closes the ash basins associated with the D-Area coal-fired powerhouse closure. The ash basins located adjacent to the inactive D-Area powerhouse hold ash, a byproduct of generating power at SRS.

SRS completed both the 488-2D basin and the 488-4D landfill closures in November 2016. The Site started construction on the 488-1D basin in July 2016 and had made significant progress by the end of 2017. In 2017, SRS continued progress on a five-year project that is consolidating the coal ash that covers 90 acres near the former coal-fired powerhouse in D Area. During the year, SRS continued constructing the cover system and made significant progress on the last ash basin (488-1D) and coal pile runoff basin (Figure 3-1).

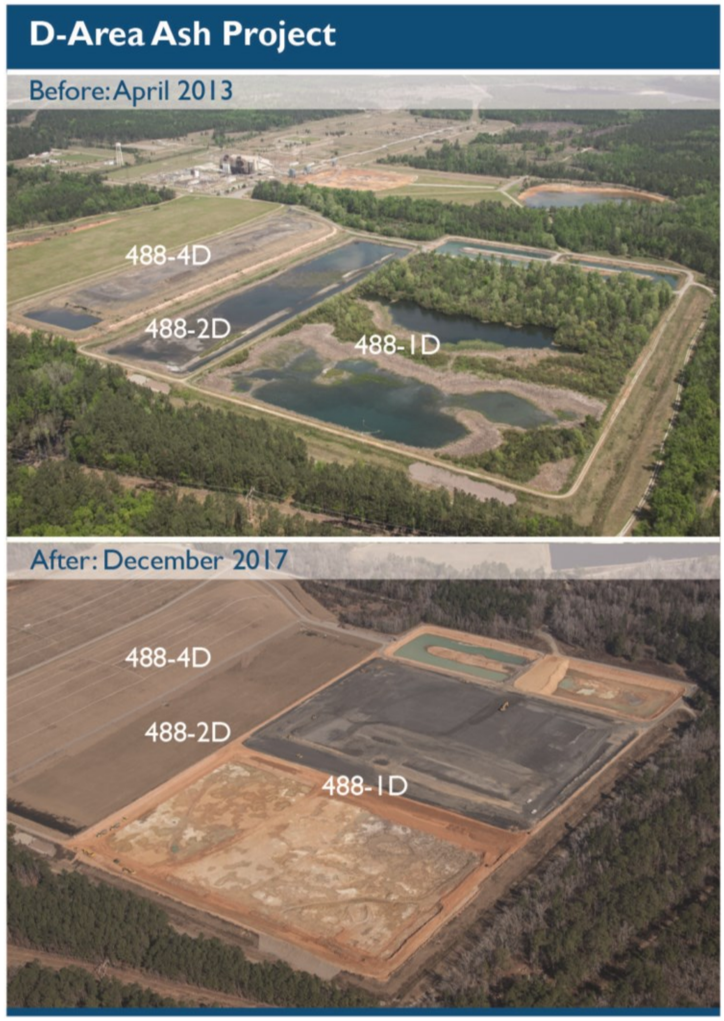


Figure 3-1 D-Area Ash Project

For decades, pipes carried a hazardous watery ash-laden solution from the powerhouse to the basins. Now, consolidating the ash into two large mounds underneath a protective cap and grassy cover is eliminating the risk to human health, ecology, and groundwater in the area.

The EPA and SCDHEC submitted comments on *The Removal Action Report for the 488-2D Ash Basin and the 488-4D Ash Landfill* (Revision 0) in 2017. The revised document was submitted to the regulators in October. SCDHEC made additional comments, but EPA approved the report.

3.2.2 Tank Closure (Radioactive Liquid Waste Processing and Dispositioning)

SRS generates liquid radioactive waste as a byproduct of processing nuclear materials (legacy liquid waste). The waste is stored in underground waste tanks grouped into two tank farms (F-Tank Farm and H-Tank Farm). While the waste is stored in the tanks, a sludge settles on the bottom of the tank and a liquid salt waste resides on top of the sludge. The waste removed from the tanks feeds the sludge and salt waste processing programs, as Figure 3-2 depicts.

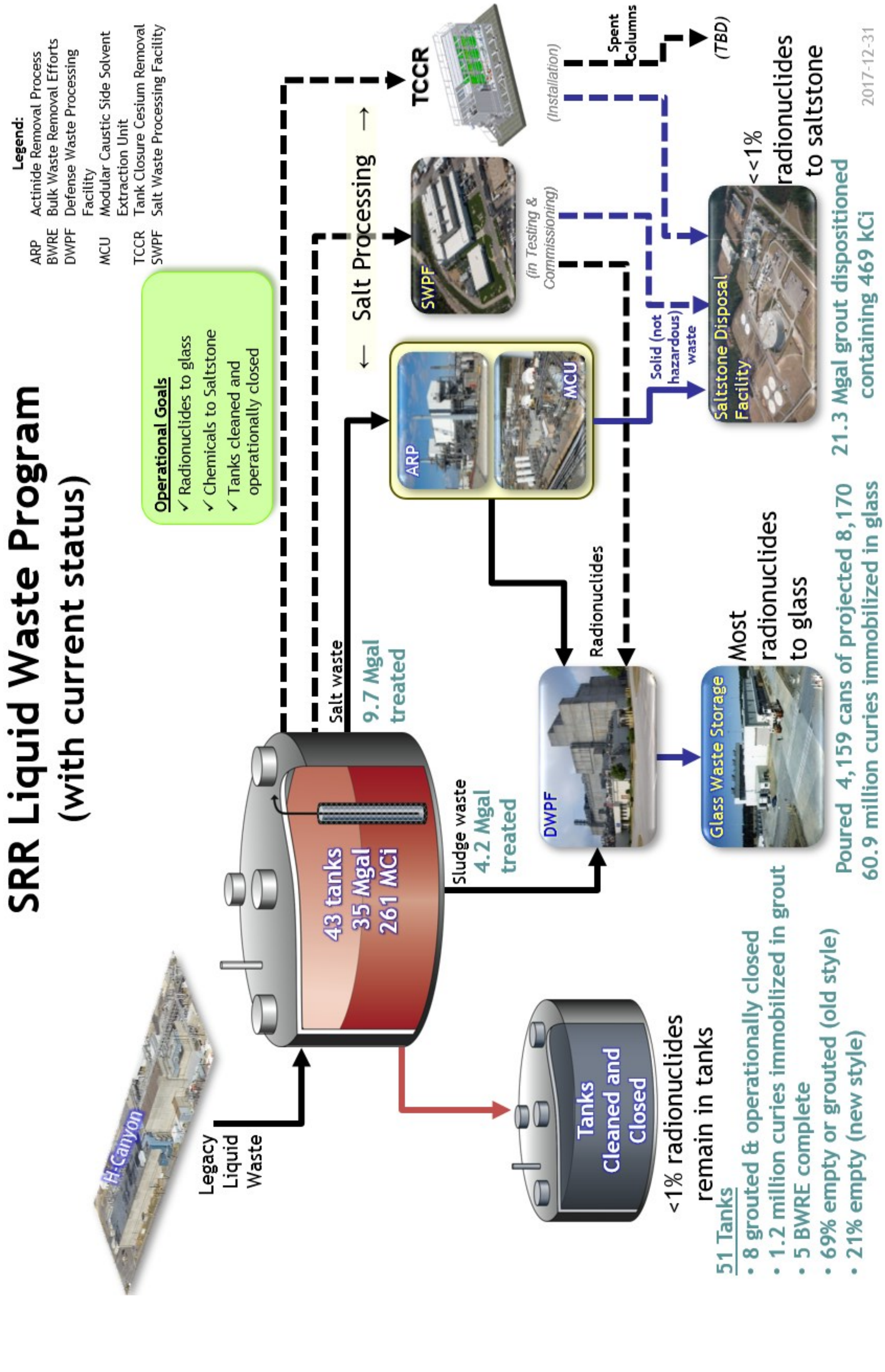


Figure 3-2 Pathway for Processing and Dispositioning Radioactive Liquid Waste at SRS

3.2.2.1 Tank Closure

SCDHEC permits the F-Tank Farm and H-Tank Farm under the industrial wastewater regulations through the provisions of the FFA, Section IX, *High-Level Radioactive Waste Tank System(s).* The FFA contains enforceable closure schedules for the liquid waste tanks. In addition, tank closures are subject to DOE Order 435.1, *Radioactive Waste Management*; federal regulations; and Section 3116 of the Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005.

NDAA Section 3116(a) is legislation that allows the secretary of energy, in consultation with the Nuclear Regulatory Commission (NRC), to determine that certain waste from spent fuel reprocessing is not high-level radioactive waste and does not need to be disposed of in a deep geologic repository. The NRC, in coordination with SCDHEC, monitors the disposal actions DOE takes to assess compliance with the performance objectives of 10 CFR Part 61, Subpart C. Additionally, EPA may participate in NRC monitoring activities. *Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site* and *Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site* demonstrate that the stabilized tanks and ancillary structures in the F-Tank Farm and H-Tank Farm meet the necessary criteria and will not need to be permanently isolated in a deep geologic repository.

During 2017, DOE supported the NRC in NRC's F- and H-Tank Farm monitoring role under Section 3116 of the NDAA by providing routine documentation (for example, groundwater monitoring reports, PA maintenance plan) as the NRC requested. There were no NRC on-site observation visits for F- and H-Tank Farms during 2017. Prior to SRS closing the tanks, they undergo an extensive waste removal process that includes specialized mechanical cleaning and isolation from the waste transfer and chemical systems. Once these activities are complete, DOE receives regulatory confirmation that the tanks are ready to be stabilized by grouting.

The first step in this process is Bulk Waste Removal Efforts (BWRE). Preparation for BWRE is typically a multiyear engineering and modification process to install specialized equipment that meets strict nuclear safety standards. DOE began the Tank 15 BWRE in 2016 and declared it complete in September 2017, six weeks ahead of the FFA deadline. SRS met all the tank closure commitments the FFA required for FY 2017. The next step in closing Tank 15 is to remove the residual waste, known as the heel, using mechanical and, if necessary, chemical cleaning methods. This process will continue in 2018.

You will find more information on tank closure on the Tank Farms at the Savannah River Site web page.

3.2.2.2 Salt Processing

Several processes are being used at SRS to disposition the salt waste from the liquid waste tanks, as Figure 3-2 shows. The Actinide Removal Process and Modular Caustic Side Solvent Extraction Unit (ARP/MCU) is an interim salt waste processing system. SCDHEC permitted ARP/MCU under South Carolina industrial wastewater regulations. The salt form of the liquid waste comprises more than 90% of the volume and contains about half of the radioactivity in the tank farms. The ARP/MCU process removes actinides, strontium, and cesium from the salt waste taken from the liquid waste tank farms. In FY 2017, MCU processed about 397,000 gallons of salt solution. The higher activity portion of the salt waste—a very small stream—is sent to the Defense Waste Processing Facility (DWPF). The remaining portion is a low-activity salt solution sent to the Saltstone facilities. The Salt Waste Processing Facility (SWPF) will replace the ARP/MCU process, as Figure 3-2 shows. SRS completed SWPF construction in 2016. During 2017, the facility underwent testing and commissioning in preparation for startup of operations. SRS procured the Tank Closure Cesium Removal (TCCR) system to treat salt waste, increase salt processing capability, and to expedite tank closure. TCCR design and fabrication were completed in 2017.

More information is available in the Salt Processing fact sheet on the SRS web page.

3.2.2.3 Salt Disposition

After ARP/MCU interim processing, the low-activity salt solution is sent to the Saltstone Production Facility for processing into grout. The grout waste is then disposed in the Saltstone Disposal Facility (SDF). SCDHEC permits the SDF to operate under South Carolina solid waste industrial landfill regulations. SRS disposes of treated low-level salt waste in the SDF based on the secretary of energy's determination pursuant to Section 3116 of the NDAA legislation. The basis for this determination is found at *Section 3116 Determination for Salt Waste Disposal at the Savannah River Site.* NDAA Section 3116(b) requires that NRC, in coordination with SCDHEC, monitor the disposal actions DOE takes to assess if it is complying with the objectives of 10 CFR Part 61.

Salt Disposal Unit 6 (SDU-6)

In FY 2017, Saltstone facilities processed and disposed of 170,000 gallons of waste. In 2017, SRS continued to use cylindrical Saltstone Disposal Units (SDUs) for disposal. SRS completed construction and the operational testing of SDU-6 in May, 16 months ahead of schedule and $25 million under budget. The mega-vault, a 32.8 million-gallon concrete rubber-lined tank, is expected to begin operating in 2018. DOE approved 13 months of construction to ready the site for SDU-7, the second mega-vault to be built.

More information on SDUs is available in the Saltstone Disposal Units fact sheet on the SRS web page.

3.2.2.4 Sludge Waste Processing—Vitrification of High-Activity Waste

SCDHEC permits DWPF to operate under South Carolina industrial wastewater regulations. The sludge waste comprises less than 10% of the volume of waste stored in the tanks and contains about half of the radioactivity, as shown in Figure 3-2. DWPF receives the high-activity portion of both the sludge and salt wastes, where it is combined with frit and sent to the plant's melter. In the melter, electricity is used to heat the waste/frit mixture to nearly 2,100 degrees Fahrenheit, until molten. This molten glass-waste mixture is poured into stainless steel canisters to cool and harden. This process, called "vitrification," immobilizes the radioactive waste into a solid glass form suitable for long-term storage and disposal. SRS stores these canisters temporarily in the Glass Waste Storage Buildings, in preparation for final disposal in a federal repository.

DWPF Melter 2 reached the end of its operational life in February, lasting nearly seven times longer than its design life. Melter 2 poured 2,819 canisters, or 16 million pounds of glass, in its lifetime. Melter 2 was removed and moved to an onsite underground vault for safe storage. Savannah River Remediation LLC (SRR) replaced Melter 2 with Melter 3 over the summer after a specialized robot cleaned the melt cell. The robot was a commercially available machine the Savannah River National Laboratory (SRNL) modified to remove the radioactive debris on the melt cell floor left over from Melter 2 operations and removal. Installing Melter 3 into DWPF was complex and took several months. Extensive testing of the melter-related components, as well as supporting systems, was completed to ensure melter startup would be safe and comply with regulations. On December 29, Melter 3 topped off a half-filled canister that was left over from Melter 2 operations.

In FY 2017, DWPF produced 52 canisters with more than 190,000 pounds of vitrified glass, immobilizing approximately 926,000 curies of radioactivity. Since DWPF began operating in March 1996, more than 16 million pounds of vitrified glass have been produced, and 60.9 million curies have been immobilized.

More information is available in the Waste Solidification fact sheet on the SRS web page.

Melter 3 Arrives at DWPF

3.2.2.5 Low-Level Liquid Waste Treatment

The F- and H-Area Effluent Treatment Project (ETP) treats low-level radioactive wastewater from the tank farms. ETP removes chemical and radioactive contaminants from the water before releasing it into Upper Three Runs Creek, an onsite stream that flows to the Savannah River. The point of discharge is a South Carolina NPDES-permitted outfall. ETP processed 5.4 million gallons of treated wastewater in FY 2017. SCDHEC permitted the ETP under the South Carolina industrial wastewater regulations. ETP remained in compliance with the industrial wastewater permit and the NPDES permit throughout 2017.

3.3 REGULATORY COMPLIANCE

This section summarizes how SRS complies with the applicable federal and state environmental laws and regulations.

3.3.1 Atomic Energy Act/DOE Order 435.1, *Radioactive Waste Management*

SRS waste and materials management is complex and includes numerous facilities that DOE Orders and federal and state regulations govern. All radioactive waste management (LLW, HLW and TRU) is governed by DOE Order 435.1 to protect the public, workers and the environment. Only low-level waste is disposed of at SRS, at the E-Area Low-Level Waste Facility and the Saltstone Disposal Facility. Low-level waste is radioactive waste not classified as high-level or TRU waste.

As required by DOE Manual 435.1-1, *Radioactive Waste Management Manual*, DOE prepares performance assessments (PAs) to evaluate the potential impacts of low-level radioactive waste disposal and closure activities (for example, Tank Farms) to the workers, the public, and the environment. The PAs provide the technical basis and evaluation needed to demonstrate compliance with DOE Order 435.1. The order also requires a composite analysis (CA) to assess the combined impact of multiple low-level waste disposal facilities and other interacting sources of radioactive material after closure.

SRS performs a comprehensive annual PA review for disposal facilities. This review ensures any developing information does not alter the original PA conclusions and that there is a reasonable expectation the facility will continue to meet the performance objectives of the DOE Order. In addition, SRS performs an annual CA review to evaluate the adequacy of the 2010 SRS CA and verify that SRS activities were conducted within the bounds of the 2010 analysis. The FY 2016 annual reviews for the disposal facilities and the CA determined that SRS continues to comply with the performance objectives of DOE Order 435.1. Based on the reporting and approval cycle for the PA and CA annual reviews, there is a one-year lag in reporting this information in this document.

TRU waste is another category of radioactive waste that SRS generates. DOE Orders define TRU waste as waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes (elements with atomic numbers greater than uranium) per gram of waste with radiological half-lives greater than 20 years. At SRS, examples of TRU waste include clothing, tools, rags, residues, debris, and other items associated with trace amounts of plutonium. SRS TRU waste is sent to the Waste Isolation Pilot Plant (WIPP), a deep geologic repository located near Carlsbad, N.M. for permanent disposal. Many different federal and state agencies (EPA, NRC, DOE, and the State of New Mexico), along with multiple regulations, govern TRU waste management and disposal. SRS manages TRU waste under DOE Orders and federal and state hazardous and toxic waste regulations. SRS sent nine TRU shipments to WIPP for disposal in 2017.

3.3.2 Resource Conservation and Recovery Act (RCRA)

RCRA establishes regulatory standards for generating, transporting, storing, treating, and disposing of solid waste; hazardous waste, such as flammable or corrosive liquids; and underground storage tanks. SRS has a RCRA hazardous waste permit, multiple solid waste permits, and multiple underground storage tank permits (Table 3-3).

3.3.2.1 Hazardous Waste Permit Activities

The EPA authorizes SCDHEC to regulate hazardous waste and the hazardous components of mixed waste. SCDHEC issued a RCRA hazardous waste permit to SRS.

In May, SRS submitted a closure plan for the RCRA-permitted Solvent Storage Tanks. The plan called for environmental media sampling, viewing the tank contents, and removing as much of the tank contents as possible before grouting the tanks in place.

Solvent Storage Tanks

On May 25, SRS submitted the third revision to the TRU Pads RCRA Permit Application. It included the following:

- An allowance for loaded/closed TRU shipments to be staged outside of regulated TRU Pads for less than seven days to prepare for shipment to WIPP (as approved by SCDHEC in a Temporary Authorization issued to SRS in March)
- A clarification that container labels should be both legible and visible
- An update of emergency contact information
- An update of fire protection information
- An update of the EPA acceptable test methods used for waste analysis
- Minor editorial changes in the permit application

SRS completed a RCRA-approved closure of TRU Pad 2 in 2017. The RCRA Closure Certification Report was submitted to SCDHEC on September 5.

3.3.2.2 Solid Waste Permit Activities

SRS has solid waste permits for the 632-G Construction and Demolition Debris Landfill, the 288-F Industrial Solid Waste Landfill, the 488-4D Industrial Solid Waste Landfill (closure is being done under the FFA [see section 3.2.1]) and the Z-Area Saltstone Industrial Solid Waste Landfill (see section 3.2.2.3). Except for the 488-4D facility, which is undergoing closure, all the solid waste landfills are active and operated in compliance with their permits in 2017.

3.3.2.3 Underground Storage Tank Permits

Subtitle I of RCRA regulates 19 underground storage tanks (USTs) containing usable petroleum products. These tanks require an annual compliance certificate from SCDHEC. A SCDHEC inspection and audit on October 25 found that all 19 tanks complied, marking 15 consecutive years without a violation.

3.3.3 Federal Facility Compliance Act (FFCA)

The Federal Facility Compliance Act (FFCA) was signed into law in October 1992 as an amendment to the Solid Waste Disposal Act. It adds provisions to apply certain requirements and sanctions to federal facilities. A Site Treatment Plan (STP) Consent Order (95-22-HW, as amended) was obtained and implemented in 1995, as required by the FFCA. The consent order required annual updates to the STP. SCDHEC executed *A Statement of Mutual Understanding for Cleanup Credits in October 2003*, allowing SRS to earn credits for certain accelerated cleanup actions. Credits can then be applied to the STP commitment schedules. Following a revision to the STP in 2011, DOE now prepares and submits an annual STP update to SCDHEC every five years.

In November 2017, SRS received comments on the *Savannah River Site Treatment Plan, 2016 Update* from SCDHEC. The update will be finalized in 2018.

SRS and SCDHEC held STP Cleanup Credit validation meetings in January, May, August, and November. A total of 144 Cleanup Credits were earned and validated during FY 2017.

3.3.4 Toxic Substances Control Act (TSCA)

SRS complies with Toxic Substances Control Act (TSCA) regulations when storing and disposing of lead, asbestos, and organic chemicals, including polychlorinated biphenyl compounds (PCBs). SRS disposes of routinely generated nonradioactive PCBs at an offsite EPA-approved disposal facility within the regulatory defined period of one year from the date of generation. SRS also generates radioactive waste contaminated with PCBs. Low-level radioactive PCB bulk product waste is disposed of onsite. PCB waste that is contaminated with TRU requires disposal at WIPP, located in New Mexico. SRS made nine shipments to WIPP in 2017, but none of the shipments contained PCBs.

SRS completed the 2017 annual PCB document log on May 9, 2018 and submitted the 2017 annual report of onsite PCB disposal activities to EPA on July 9, 2018, meeting applicable requirements.

3.3.5 South Carolina Infectious Waste Management Regulation

SRS is a large-quantity generator of infectious waste registered under the SCDHEC Infectious Waste Management Program. SRS contracts with a vendor for monthly pickup of infectious waste. It made 13 shipments in 2017. Once offsite, the waste is treated and disposed of in accordance with the SCDHEC regulations. In 2017, SRS managed all infectious wastes in compliance with the state regulations. SCDHEC did not inspect the SRS Infectious Waste Management Program.

3.3.6 Air Quality and Protection

3.3.6.1 Clean Air Act (CAA)

EPA has delegated regulatory authority for all types of air emissions to SCDHEC. SRS is required to comply with SCDHEC Regulation 61-62, *Air Pollution Control Regulations and Standards*. SRS currently has the following six air permits regulating activities on the Site:

- Part 70 Air Quality Permit (TV-0080-0041)
- 784-7A Biomass Boiler Construction Permit (TV-0080-0041a-CG-R1)
- 784-7A Oil Boiler Construction Permit (TV-0080-0041a-CF-R1)

- Ameresco Federal Solutions, Inc. ("Ameresco") Biomass Facilities Permit (TV-0080-0144)
- Mixed Oxide Fuel Fabrication Facility (MFFF) (TV-0080-0139-CA-R1)
- Building 235-F D&D Construction Permit (TV-0080-0041-C1)

Under the CAA, SRS is considered a "major source" of nonradiological air emissions and, therefore, falls under the CAA Part 70 Operating Permit Program. The Part 70 Operating Permit regulates stationary sources with the potential to emit five tons or more per year of any criteria pollutant (six of the most common air pollutants: ozone precursors, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead). These major stationary sources are subject to operating and emission limits, as well as emissions monitoring and record-keeping requirements.

The EPA sets the National Ambient Air Quality Standards air pollution control standards, and SCDHEC regulates them. The Part 70 Operating Permit requires SRS to demonstrate compliance through air dispersion modeling and by submitting an emissions inventory of air pollutant emissions every three years.

The current CAA Permit expired on March 31, 2008. SRS submitted a complete renewal application of the current permit prior to the expiration date. SCDHEC granted an application shield, effective on September 21, 2007, allowing the Site to continue operating under the expired permit. In 2017, the Site continued to operate under the expired Part 70 Air Quality Permit.

3.3.6.2 Accidental Release Prevention Program

The CAA Amendments of 1990, Section 112(r) requires any facility that maintains specific hazardous or extremely hazardous chemicals in quantities above specified threshold values to develop a risk management plan. SRS has maintained hazardous and extremely hazardous chemical inventories below each threshold value; therefore, SRS has not been required to develop a risk management plan. Additionally, no reportable 112(r)-related hazardous or extremely hazardous chemical releases occurred at SRS in 2017.

3.3.6.3 Ozone-Depleting Substance (ODS)

The CAA mandates air quality standards to protect the stratospheric ozone. Releases of chemical gases widely used as refrigerants, insulating foams, solvents, and fire extinguishers cause ozone depletion. Some of these ODSs include chlorofluorocarbons, hydrofluorocarbons, and halons. SRS complies with the standards for emissions reduction and the systematic reduction of ODSs to ensure no ODS is knowingly or willfully released into the atmosphere. SRS reported no exceedances in 2017.

3.3.6.4 Air Emissions Inventory

SCDHEC Regulation 61-62.1, Section III (*Emissions Inventory*), requires compiling an air emissions inventory to locate all sources of air pollution and to define and characterize the various types and amounts of pollutants. The schedule for submitting the inventory is either every year or every three years, depending on the emission thresholds in the regulations.

SRS submitted the 2015 emissions inventory electronically on March 31, 2016. SRS emissions have dropped below the threshold that requires an annual air emissions inventory. Therefore, SCDHEC concurred that SRS' interpretation of the rule was correct, and SRS could now be on a three-year submittal cycle. SRS will submit the next required inventory for 2017 before March 31, 2018. The most recent information on the EPA National Emission Inventories is available on the website.

3.3.6.5 National Emission Standard for Hazardous Air Pollutants (NESHAP)

NESHAP is a CAA-implementing program that sets air quality standards for hazardous air pollutants, such as radionuclides, benzene, Reciprocating Internal Combustion Engines (RICE) emissions, and asbestos.

SRS received three NOVs under NESHAPs programs in 2017.

- An NOV dated March 10, 2017 under 40 CFR 61, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities and SC R.61-62.1, Section II, Permit Requirements. The flow meter associated with the stack at F-Canyon failed on May 31, 2016. The flow meter was replaced on October 26, 2016, but SRS did not perform a relative accuracy test to certify the accuracy of the new flow meter it installed. Subsequently, SCDHEC issued the NOV that required SRS perform a relative accuracy test. SRS completed the test, and SCDHEC accepted the test results in April 2017. No fines or civil penalties were associated with this NOV.
- An NOV dated July 25, 2017 for violating the Part 70 (Title V) Operating Permit 0080-0041, 40 CFR 63 Subpart DDDD, and SC R. 61-63 Subpart DDDDD as a result of a SCDHEC inspection on August 1, 2016 at the 784-7A Boiler facility. SCDHEC noted that SRS did not comply with the record keeping, monitoring, and work practice standards contained in the permit. SRS began implementing corrective actions immediately after the 2016 inspection. The NOV required SRS to take immediate corrective action to ensure it was complying with the work practice standards, monitoring, and record-keeping requirements of the regulations. No fines or civil penalties were associated with this NOV.
- An NOV dated December 15, 2017 under 40 CFR 61, National Emission Standards for Hazardous Air Pollutants and SC R.61-86.1 Standards of Performance for Asbestos Projects. SRS did not comply with the disposal requirements for nonfriable asbestos while performing an abatement project in building 735-A. An internal inspection on October 26, 2017 identified work had been performed without following proper disposal requirements. SRS removed approximately 160 linear feet of cove base from building 735-A and had not labeled it and disposed of it correctly. SRS made a verbal disclosure to SCDHEC on November 20 and a written follow-up on November 30. No fines or civil penalties were associated with this NOV.

3.3.6.5.1 NESHAP Radionuclide Program

SRS complies with the NESHAP Radionuclide Program by performing all required inspections and maintaining monitoring systems. Subpart H of the NESHAP regulations requires SRS to determine and report annually (by June 30) the highest effective dose from airborne emissions to any member of the public at an offsite point. SRS transmitted the *SRS Radionuclide Air Emissions Annual Report for 2016* on June 13, 2017 to EPA, SCDHEC, and DOE Headquarters.

During 2017, SRS estimated the maximally exposed individual (MEI) effective dose equivalent to be less than 1% of the EPA standard of 10 millirem (mrem) per year. Chapter 6, *Radiological Dose Assessment*, contains details on this dose calculation.

3.3.6.5.2 NESHAP Nonradionuclide Program

In 2013, NESHAP emission standards applicable to stationary RICE equipment—such as portable generators, emergency generators, and compressors—became effective. These regulations impact numerous pieces of SRS's RICE equipment. RICE equipment must also comply with the New Source Performance Standards. In January and July 2017, SRS submitted the semiannual compliance reports, demonstrating it was complying with the regulations.

3.3.6.5.3 NESHAP Asbestos Abatement Program

Work involving asbestos at SRS falls under SCDHEC and federal regulations. These activities—operation and maintenance repairs, removing asbestos, and demolishing buildings—require an asbestos notification, a renovation permit, or a demolition permit.

SRS issued 150 asbestos notifications and conducted 72 permitted renovations and demolitions involving asbestos in 2017. Table 3-1 summarizes these removals. Certified personnel removed and disposed of friable (easily crumbled or pulverized) and nonfriable asbestos. Both disposal sites for nonradiological asbestos waste are SCDHEC-approved landfills for the disposal of regulated and nonregulated asbestos.

SRS maintains a SCDHEC Temporary Storage Containment Area License that facilitates removing and disposing of waste generated from nonradiological operations and maintenance activities and minor and small projects. Additionally, SRS maintains a SCDHEC Asbestos Group License that allows Savannah River Nuclear Solutions, LLC (SRNS) and SRR to operate as a long-term, in-house asbestos abatement contractor for DOE-Savannah River.

Table 3-1 Summary of Quantities of Asbestos Materials Removed in 2017

Asbestos Type	Nonradiological, Friable	Nonradiological, Nonfriable	Radiologically Contaminated Asbestos
Linear Feet Disposed	60	413	63
Square Feet Disposed	180	7,359	111
Cubic Feet Disposed	12	10	7
Disposal Site	Three Rivers Solid Waste Authority Landfill	SRS Construction and Demolition Landfill	SRS E-Area Low-Level Waste Facility

3.3.7 Water Quality and Protection

3.3.7.2 Clean Water Act (CWA)

Except for Ameresco, which has its own CWA National Pollutant Discharge Elimination System (NPDES) permit, SRS operated pursuant to the following CWA permits in 2017:

- Land Application Permit (ND0072125)
- General Permit for Storm Water Discharges Associated with Industrial Activities (Except Construction) (SCR000000)

- Permit for Discharge to Surface Waters (SC0000175)
- Permit for Discharge to Surface Waters (SC0047431)
- General Permit for Stormwater Discharges from Construction Activities (SCR100000)
- General Permit for Utility Water Discharges (SCG250000)
- General Permit for Discharges from Application of Pesticides (SCG160000)
- General Permit for Vehicle Wash Water Discharges (SCG750000)
- General Wastewater Construction Permit (SCG580000)
- General Construction Permit for Water Supply Distribution Systems (151218)
- General Permit for Land Disturbing Activities at SRS

Information on these permits is available at the EPA's Enforcement and Compliance History Online (ECHO) database.

3.3.7.1.1 National Pollutant Discharge Elimination System (NPDES)

SCDHEC administers the NPDES program, which protects surface waters by limiting releases of pollutants into streams, reservoirs, and wetlands. As explained in the previous section, SCDHEC issued multiple NPDES permits to SRS to govern different types of discharges to surface water. A major goal of the NPDES program is to control or eliminate discharges of toxic pollutants, oil, hazardous substances, sediment, and contaminated storm water to protect the quality of our nation's water. To achieve this goal, SRS is required to prepare the following plans:

- Best Management Plan to identify and control the discharge of hazardous and toxic substances
- Storm Water Pollution Prevention Plan (SWPPP) to address the potential discharge of pollutants in storm water
- Spill Prevention, Control, and Countermeasure (SPCC) plan to minimize the potential for discharges of oil, including petroleum, fuel oil, sludge, and oily wastewater

SRS has two NPDES permits for industrial activities that discharge to surface water: one covering D Area (Permit No. SC0047431 NPDES Permit for Discharge to Surface Waters) and the other for the remainder of the Site (Permit No. SC0000175 NPDES Permit for Discharge to Surface Waters). Throughout the year, SRS monitors a total of 28 NPDES-permitted industrial wastewater outfalls across the Site on a frequency specified by the permits. Monitoring requirements vary from as much as once a day at some locations to once a quarter at others, although typically they are conducted once a month. For each outfall, SRS measures physical, chemical, and biological parameters and reports them to SCDHEC in SRS monthly discharge monitoring reports, as required by the permit. Chapter 4, *Nonradiological Environmental Program*, provides additional information about sampling required to remain compliant with SRS's NPDES permits.

The following are highlights under the NPDES program:

- In October 2017, the SRS NPDES program had a permit exceedance at the L-7A outfall. SCDHEC issued a NOV in December 2017 to SRS for exceeding the fecal coliform permit limit for the L-7A outfall. No fines or civil penalties were associated with this NOV.
- In September 2016, SCDHEC conducted the annual compliance evaluation inspection (CEI) and issued a satisfactory rating, the highest grade possible. SCDHEC sent the results from the outfall

sampling phase of the CEI in September 2017, and all the analytical results met applicable permit requirements.

- In December 2017, SRS met with SCDHEC NPDES permitting personnel to discuss the renewal application of NPDES Industrial Wastewater Outfall H-16 and the initial application of Outfall H16-8H.
- The 2017 update to the SRS SWPPP contains information on the 34 SRS industrial storm water outfalls and outfall facilities.
- SCDHEC did not require construction storm water monitoring on any of the active construction projects underway at SRS during 2017.
- Constructing, operating, and closing industrial wastewater treatment facilities are permitted under the NPDES program. Facilities permitted are broad in scope and include those involved with groundwater remediation, radioactive liquid waste processing, and nuclear nonproliferation. In 2017, SCDHEC issued a construction permit for the tank closure cesium removal system and for an additional recovery well and associated piping for the M-1 Air Stripper remediation system. SCDHEC also concurred with SRS's proposal to adjust the expiration of the construction permit for the Waste Solidification Building to January 2022.

You will find the results from sampling of both industrial and storm water outfalls in the 2017 Environmental Monitoring Program Data Report (SRNS 2018) and a summary of the sampling and results in Chapter 4 of this report.

3.3.7.1.2 Section 404(e) Dredge and Fill Permits

Wetlands make up 48,973 acres, or 25%, of the total SRS area. SRS wetlands account for more than 80% of the wetlands across the entire DOE complex. Permits under Section 404 are required when work will be conducted in a wetland area. The Nationwide Permits (NWPs) program (general permits under Section 404[e]) are within the jurisdiction of the U.S. Army Corps of Engineers. Permits issued under the NWPs program are for projects that have minimal impact on the aquatic environment.

SRS wetlands staff reviewed 463 Environmental Evaluation Checklists (EECs) and 70 Site Use applications for potential wetland impacts in 2017. During this time, SRS had four open permits under the NWPs program, as follows:

- SRS completed dam construction on an unnamed tributary to Fourmile Branch for the Mixed Waste Management Facility Groundwater Interim Measures project in 2000 under NWP 38, *Hazardous Waste Cleanup*. However, mitigation for the impact to wetlands was pending approval from the U.S. Army Corps of Engineers to use wetland mitigation credits from the SRS wetland mitigation bank.
- The University of Georgia's Savannah River Ecology Laboratory (SREL) installed water sampling equipment in Tims Branch and adjacent wetlands to research uranium transport.
- SRNL installed three shallow wells in wetlands adjacent to Steel Creek to monitor a contaminated groundwater plume originating from legacy operations in P Area.
- The U.S. Forest Service installed a prefabricated plastic floating dock on PAR Pond.

3.3.7.2 Safe Drinking Water Act (SDWA)

SCDHEC regulates drinking water facilities under the SDWA. SRS uses groundwater sources to supply drinking water to onsite facilities. The A-Area drinking water system supplies most Site areas. Remote facilities, such as field laboratories, barricades, and pump houses, use small drinking water systems or bottled water. All 2017 bacteriological samples for drinking water were collected and met the state and federal drinking water quality standards.

SCDHEC requires SRS to collect 10 bacteriological samples each month from the domestic water system that supplies drinking water to most areas at SRS. SRS usually exceeds this requirement by collecting 15 samples each month from various areas. Bacteriological analyses are performed on all samples. The sample results consistently meet SCDHEC and EPA drinking water quality standards, confirming the absence of harmful bacteria. In February 2017 SRS received an NOV for the 2016 noncompliance. The December 2016 noncompliance was for SRS collecting only 7 samples instead of the required 10 samples. Results for the seven bacteriological samples taken in December of 2016 met drinking water quality standards. No fines or civil penalties were associated with this NOV.

SRS samples domestic water systems for lead and copper on a three-year, rotating cycle. Based on this cycle, SRS will sample the A-Area water system for lead and copper in 2019.

3.3.8 Environmental Protection and Resource Management

3.3.8.1 National Environmental Policy Act (NEPA)

The NEPA process identifies the potential environmental consequences of proposed federal activities and the alternatives to support informed environmentally sound decision-making regarding the design and implementation of the proposed activities.

The NEPA program complies with DOE Order 451.1B. SRS initiates the required NEPA evaluation by completing an environmental evaluation checklist (EEC) for new projects or changes to existing projects. SRS uses the EEC to review the proposed action, identify any potential environmental concerns, and determine the appropriate level of NEPA review required for the proposed activity.

SRS conducted 504 NEPA reviews in 2017 (Table 3-2). Categorical exclusion (CX) determinations accounted for 90% of completed reviews. Additional information on SRS NEPA activities is on the SRS NEPA web page.

The following major NEPA reviews were either completed or in progress in 2017:

- Final Environmental Impact Statement for the Disposal of Greater-than-Class-C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste *(DOE/EIS-0375) (In progress).* DOE is evaluating disposal of GTCC low-level radioactive waste (LLRW) and GTCC-like LLRW in a geologic repository, in intermediate-depth boreholes, and in enhanced near-surface disposal facilities. SRS is an alternative location for these disposal facilities.
- Supplement Analysis of the Mark-18A Target Material Recovery Program at the Savannah River Site *(DOE/EIS-0220-SA-02, DOE/EIS-0279-SA-06).* This SA evaluates whether the proposed action requires supplementing the existing *Final Environmental Impact Statement: Interim Management of Nuclear Materials at the Savannah River Site (IMNM EIS)* (DOE/EIS-0220) and the *Savannah River Site Spent Nuclear Fuel Management Environmental Impact Statement (SRS SNF EIS)* (DOE/EIS-0279). Based on the analysis prepared for the IMNM EIS and SRS SNF EIS, the impacts of

this action are very small. The Proposed Action would therefore not constitute a substantial change relevant to environmental concerns reported in the IMNM EIS and SRS SNF EIS. Therefore, neither a supplement to the IMNM EIS, a supplement to the SRS SNF EIS, nor a new EIS is required.

- Finding of No Significant Impact for the Final Environmental Assessment for the Acceptance and Disposition of Spent Nuclear Fuel Containing U.S.-Origin Highly Enriched Uranium from the Federal Republic of Germany *DOE/EA-1977).* DOE prepared this *Spent Nuclear Fuel from Germany EA* to evaluate potential environmental impacts of receiving, storing, processing, and disposing of certain spent nuclear fuel (SNF) from a research and development program of the Federal Republic of Germany (Germany). DOE is considering the feasibility of accepting this SNF containing U.S.-origin highly enriched uranium (HEU) at SRS for processing and disposition. Based on the analysis in the *Spent Nuclear Fuel from Germany EA*, DOE determined that the proposed action is not a major federal action significantly affecting the quality of the environment within the context of NEPA, and thus does not require the preparation of an environmental impact statement. This Finding of No Significant Impact (FONSI) does not constitute a decision to select any alternative, and it is not a decision to proceed with the project.

The *Environmental Assessment for the South Carolina Army National Guard Proposal to Construct and Operate Training Facilities and Infrastructure on 750 Acres at the Department of Energy Savannah River Site* (DOE/EA-1999) is in progress.

Table 3-2 Summary of 2017 NEPA Reviews

Type of NEPA Review	Number
CX Determinations[a]	452
"All No" Environmental Evaluation Checklist (EEC)	39
Previous NEPA Review[a]	9
Environmental Impact Statement (EIS)	1
Supplement Analysis (SA)	1
Interim Action	0
Revised Finding of No Significant Impact (FONSI)	0
Environmental Assessment (EA)	2
Total	**504**

Note:

[a] Proposed actions that require no further NEPA action

3.3.8.2 Emergency Planning and Community Right-to-Know (EPCRA)/Superfund Amendment Reauthorization Act (SARA) Title III

EPCRA requires facilities to notify state and local emergency planning entities about their hazardous chemical inventories and to report releases of hazardous chemicals. The Pollution Prevention Act of 1990 expanded the EPCRA-mandated Toxic Release Inventory (TRI) report to include waste management. SRS complies with the applicable EPCRA reporting requirements and incorporates the applicable TRI chemicals into its pollution prevention programs.

As required by Section 312, *Chemical Inventory Reporting*, of EPCRA, SRS completes an annual Tier II Chemical Inventory Report for all hazardous chemicals exceeding specified quantities present at SRS during the calendar year. SRS submitted the 2017 hazardous chemical storage information to state and local authorities on February 14, 2018. The report included 60 reportable chemical categories, compared to 58 in the previous year.

As required by Section 313, *Toxic Chemical Release Inventory*, of EPCRA, SRS must file an annual TRI report each year by July 1 for the previous year. SRS calculates chemical releases to the environment for each regulated chemical and reports those above each threshold value to EPA. SRS submitted the 2017 Toxic Release Inventory Report on June 21, 2018 for each of the following regulated chemicals: ammonia, chromium compounds, lead compounds, mercury compounds, naphthalene, nickel compounds, nitrate compounds, nitric acid, sodium nitrite, and sulfuric acid. Details are on the EPA Toxic Release Inventory Program website.

3.3.8.3 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The objective of FIFRA is to provide federal control of pesticide distribution, sale, and use. The EPA must register all pesticides used in the United States. Use of each registered pesticide must be consistent with use directions contained on the package's label. SRS must comply with FIFRA and, on a state level, the South Carolina Pesticide Control Act.

SRS must also comply with the South Carolina NPDES General Permit for discharges from the application of pesticides. This permit authorizes applying pesticides to surface water in accordance to limitations set forth in the NPDES general permit.

SRS procedures implement the FIFRA requirements for pesticide application, application record keeping, storage, and disposing of empty containers and excess pesticides. General use pesticides (ready-to-use products that are available for public use) are applied at SRS per the label instructions. SRS applies restricted-use pesticides on a very limited basis, following label requirements and using state-certified pesticide applicators. Application records for general use and restricted use pesticides are generated and maintained for each application.

3.3.8.4 Endangered Species Act (ESA)

The ESA designates and protects wildlife, fish, and plants in danger of becoming extinct. This federal law also protects and conserves their critical habitats. Several federally listed animal species exist at SRS, including the wood stork, the red-cockaded woodpecker, the shortnose sturgeon, and the Atlantic sturgeon; as well as plant species, including the pondberry and the smooth coneflower.

In addition, SRS is home to the gopher tortoise, a candidate for protection under the ESA. SRS is one of the first DOE sites to conduct experimental translocations of gopher tortoises, where they are captured, transported, and released to another location. Conservation organizations use protocols developed during the SRS translocation studies to establish viable populations elsewhere in the species' range.

South Carolina has enacted legislation that lists additional plants and animals not on the federal list to encourage conservation of these species. Those found on SRS include the Carolina gopher frog and the

U.S. Forest Service personnel prepares to mount on tree a nesting box for red-cockaded woodpeckers

swallow-tailed kite. While the bald eagle is no longer on the federally listed endangered or threatened species list, nesting bald eagles and wintering golden eagles remain protected by the Bald and Golden Eagle Protection Act. Bald eagles nest on SRS and are considered year-round residents. Golden eagles use SRS as a wintering habitat. The U.S. Forest Service-Savannah River (USFS-SR) manages programs onsite to enhance the habitat and survival of these species.

The USFS-SR actively manages more than 65,000 acres in the red-cockaded woodpecker habitat management area by removing vegetation mechanically, chemically, and by prescribed fires. These methods create and improve habitat by restoring the natural fire regime, improving native plant diversity in the understory, and enhancing native pine stands. Additionally, the USFS-SR inserts artificial cavities into living pine trees to supplement the available cavities for roosting and nesting. From 1985 through FY 2017, active red-cockaded woodpecker clusters increased from 3 to 105 due to successful habitat restoration. As of 2017, the USFS-SR managed 112 cluster sites for the red-cockaded woodpecker, with an average expected population growth rate of 5% each year. The growth rate over the past five years at SRS has been an outstanding average growth rate of 9.5%.

During FY 2017, while implementing the *United States Department of Energy Natural Resources Management Plan for SRS*, USFS-SR developed two SRS watershed management plans for standard USFS-SR project plans, resulting in two biological evaluation reviews for timber, research, and wildlife-related management. The biological evaluations determined that forest implementation plans are not likely to adversely affect federally listed endangered or threatened species due to beneficial, insignificant, or discountable effects.

3.3.8.5 National Historic Preservation Act (NHPA)

The NHPA requires all federal agencies to consider the impacts to historic properties in all their undertakings. SRS ensures compliance with the NHPA through several processes. SRS uses the Site Use Program, the *Cold War Programmatic Agreement,* and *SRS's Cold War Built Environment Cultural Resource Management Plan* to ensure it is complying with NHPA. The Savannah River Archaeological Research Program (SRARP) provides cultural resource management guidance to DOE to ensure fulfillment of compliance commitments. SRARP also serves as a primary facility to investigate archaeological research problems associated with cultural development within the Savannah River valley. The results are used to help DOE manage more than 2,000 known archaeological sites at SRS.

SRARP evaluates and documents all locations being considered for activities, such as construction, to ensure that archaeological or historic sites are not impacted. In FY 2017, 191 acres of land on SRS were investigated for cultural resource management, including 29 field surveys and testing. Eighteen newly discovered sites were recorded, and eight previously recorded sites were revisited.

The 2017 SRARP annual report will be available after DOE review.

3.3.8.6 Migratory Bird Treaty Act (MBTA)

The MBTA prohibits taking, possessing, importing, exporting, transporting, selling, purchasing, bartering, or offering for sale any migratory bird or its eggs, parts, and nests, except as authorized by the U.S. Department of the Interior under a valid permit. To support migratory bird monitoring, a one-day Christmas Bird Count is conducted annually in December. The 2017 count found 105 species. A one-day bald eagle survey is conducted every year in January. The 2017 eagle survey found 11 eagles.

Killdeer nest enclosed within barricade to protect fledglings

In 2017, 11 active bird nests were discovered on large mobile equipment, on structures, or on the ground in areas actively used by SRS personnel. Nest locations were barricaded until fledglings left the nests or adult birds abandoned the nests. Bird species consisted of Northern Mockingbird (*Mimus polyglottos*) (three nests), Eastern Bluebird (*Sialia sialis*) (two nests), Killdeer (*Charadrius vociferus*) (one nest), Barn Swallow (*Hirundo rustica*) (three nests), Northern Rough-winged Swallow (*Stelgidopteryx serripennis*) (one nest), and Great Crested Flycatcher (*Myiarchus crinitus*) (one nest).

Also in 2017, USFR-SR staff found an osprey (*Pandion haliaetus*) nest on a platform they built in 2014. This marked the third year that ospreys nested on the platform after their nest had been moved from a power pole at the L-Lake Dam.

3.3.9 Release Reporting

Federally permitted releases to the air, water, and land must comply with legally enforceable licenses, permits, regulations, or orders. If an unpermitted release to the environment of an amount greater than or equal to a reportable quantity of a hazardous substance (including radionuclides) occurs, EPCRA, CERCLA, CWA, and the CAA require a notice be sent to the National Response Center and applicable state agencies.

SRS did not have any reportable CERCLA releases in 2017.

3.3.10 Permits

SRS had 376 construction and operating permits in 2017 that specified operating levels to each permitted source. Table 3-3 identifies the number of permits by the permit type. These numbers reflect permits for all organizations at SRS, except Ameresco.

Table 3-3 SRS Permits

Type of Permit	Number of Permits
Air	6
U.S. Army Corps of Engineers (USACE—Nationwide Permits)	4
Asbestos Demolition/Abatement/Temporary Storage of Asbestos Waste	72
Asbestos Abatement Group Permit	1
Asbestos Temporary Storage of Waste	1
Domestic Water	96
GA Department of Natural Resources Scientific Collecting Permit	1
Industrial Wastewater	64
NPDES Permits	11
Construction Storm Water Grading Permit	7
RCRA Hazardous Waste	1
RCRA Solid Waste	4
RCRA Underground Storage Tank	7
Sanitary Wastewater	89
SC Department of Natural Resources Scientific Collecting Permit	2
SCDHEC 401	0
SCDHEC Navigable Waters	0
Underground Injection Control	10
Total	**376**

3.4 MAJOR DOE ORDERS FOR ENVIRONMENTAL COMPLIANCE

SRS complies with the following major DOE Orders in addition to state and federal regulations for environmental compliance:

- DOE Order 451.1B, *Administrative Change 3, National Environmental Policy Act Compliance Program*. See the NEPA section of this chapter.
- DOE Order 436.1*, Departmental Sustainability*. See Chapter 2, *Environmental Management Systems.*
- DOE Order 458.1, *Administrative Change 3, Radiation Protection of the Public and the Environment*. See Chapter 5, *Radiological Environmental Monitoring Program*; and Chapter 6, *Radiological Dose Assessment,* of this report.
- DOE Order 435.1, *Change 1, Radioactive Waste Management*. See Radioactive Waste Management Section in this chapter.
- DOE Order 231.1B, *Environment, Safety and Health Reporting*, requires the preparation of this Annual Environmental Report.
- DOE Order 232.2, *Administrative Change 1, Occurrence Reporting and Processing of Operations Information*. This order requires DOE to use the designated system called *Occurrence Reporting and Processing System (ORPS).* The ORPS ensures that the DOE complex and the National Nuclear Security Administration are informed of events that could adversely affect the health and safety of the public and workers, the environment, DOE missions, or DOE's credibility. Of the 110 ORPS-

reportable events at SRS in FY 2017, there were zero ORPS reportable events within ORPS Group 5 (Environmental) and three ORPS reportable events within ORPS Group 9 (Noncompliance Notification). (DOE ORPs reports are compiled on a fiscal year basis, and this annual report is for the calendar year (CY) 2017. SRS received a total of five NOVs or Noncompliance Notifications in CY 2017, as previously discussed in this chapter.)

- DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*. This order requires DOE to provide oversight related to protecting the public, workers, environment, and national security assets effectively through continuous improvement.

3.5 REGULATORY SELF-DISCLOSURES

SRS made three regulatory self-disclosures in 2017. SRS made two notifications regarding the asbestos regulations and one notification regarding the fecal coliform exceedance at outfall L-7A. Two of the self-disclosures resulted in NOVs previously discussed in this chapter.

3.6 ENVIRONMENTAL AUDITS

SCDHEC, EPA, and the United States Army Corps of Engineers (USACE) inspected and audited the SRS environmental program for regulatory compliance. Table 3-4 summarizes the results of the 2017 audits and inspections.

Table 3-4 Summary of 2017 External Agency Audits/Inspections of the SRS Environmental Program and Results

Audit/Inspection	Action	Results
632-G C&D Landfill, 288-F Ash Landfill, 488-4D Ash Landfill Inspections	SCDHEC conducted four quarterly inspections of the 632-G and 288-F landfills and three of four quarterly inspections for 488-4D (SCDHEC decided not to inspect again until post-closure).	No issues were identified.
Federal Energy Regulatory Commission (FERC) Inspection	FERC evaluated PAR Pond Dam; Steel Creek Dam (L Lake); and Ponds B, C, 2, 4, and 5 in May 2016. FERC issued its report to DOE on March 8, 2017. FERC also performed another inspection in October 2017, but the reports have not been issued.	The March 2017 FERC report (May 2016 inspection) stated the dams are adequately operated and maintained, and identified recommendations for improvements.
Comprehensive Groundwater Monitoring Evaluation	SCDHEC inspected groundwater facilities associated with the F- and H-Area Seepage Basins, M-Area Settling Basin, Metallurgical Laboratory Basin, Mixed Waste Management Facility, and Sanitary Landfill on September 18-19. A records review of groundwater-related files was also completed.	Inspectors identified the grout column at well RWM018 has fallen below ground surface. The grout column was brought up to grade on September 20. SCDHEC noted no other issues.
Industrial Wastewater Construction Permit Inspections	SCDHEC inspected Liquid Waste Tank 12H and associated appurtenances on January 11 to support closing the tank.	No issues were identified.
Environmental Laboratory Certification On-site Evaluations	SCDHEC inspected the Waste Treatment Plant Lab at the Central Sanitary Waste Treatment Facility for recertification of the lab on March 7 and for the addition of analytical methods on December 13.	The Waste Treatment Plant Lab was recertified for three years, and the additional analytical methods were approved for use.

Table 3-4 Summary of 2017 External Agency Audits/Inspections of the SRS Environmental Program and Results (continued)

Audit/Inspection	Action	Results
SCDHEC Sanitary Survey of SRS Drinking Water Systems	SCDHEC conducted the biannual inspections of the wells, tanks, and treatment systems supporting the A-Area and ATTA drinking water systems on March 23.	No issues were identified. A-Area and ATTA water systems complied with State Primary Drinking Water Regulations.
Interim Sanitary Landfill and the F-Area Railroad Crosstie Pile Landfill Post-Closure Inspection	SCDHEC conducted an annual review of the landfills.	No issues were identified.
Air Compliance Inspection	No inspections or outside audits were conducted by SCDHEC in 2017.	
RCRA Compliance Evaluation Inspection (CEI)	SCDHEC inspected seven facilities and reviewed hazardous waste program requirements (i.e., notifications and reports to SCDHEC, plans, training records, internal inspections, and waste documentation) during its August 29-30 CEI.	SCDHEC did not observe any deficiencies during the inspection.
Underground Storage Tank (UST) CEI	SCDHEC inspected 19 USTs.	No issues were identified.
Z-Area Saltstone Solid Waste Landfill Inspections	SCDHEC performed monthly inspections of the Saltstone Disposal Facility (SDF). This included reviewing facility procedures and performing walk downs of the SDF.	No issues were noted.

3.7 KEY FEDERAL LAWS COMPLIANCE SUMMARY

Federal laws are implemented by the Code of Federal Regulations or state regulations if the federal agency has delegated the program to the state. You can find additional information online at epa.gov. Table 3-5 summarizes SRS's 2017 compliance status with applicable key federal environmental laws.

Table 3-5 Status of Key Federal Environmental Laws Applicable to SRS

Regulatory Program Description	2017 Status
The Atomic Energy Act/DOE Order 435.1 grants DOE the authority to develop applicable standards (documented in DOE Orders) to protect the public, workers, and environment from radioactive materials.	The FY 2016 annual reviews for the SRS Performance Assessments showed that radioactive low-level waste operations were within the required performance envelope, and the facilities continued to comply with performance objectives.
The Clean Air Act (CAA) establishes air quality standards for criteria pollutants, such as sulfur dioxide and particulate matter, and for hazardous air emissions, such as radionuclides and benzene.	SRS continues to operate under a CAA Permit that expired on March 31, 2008. SRS received three NOVs, with no fines assessed, for air monitoring and asbestos noncompliance.
The Clean Water Act regulates liquid discharges at outfalls (e.g., drains or pipes) that carry effluent to streams (NPDES, Section 402). It also regulates dredge and fill operations in waters of the United States (Section 404) and water quality for those activities (Water Quality Criteria, Section 401).	The SRS NPDES program maintained a 99.9% compliance rate. SCDHEC issued a Notice of Violation (NOV) to SRS in December for exceeding the fecal coliform permit limit for the L-7A outfall. There were no fines or penalties.
The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) establishes criteria for liability and compensation, cleanup, and emergency response requirements for hazardous substances released to the environment.	SRS continues to comply with CERCLA and the requirements of the FFA.
The Emergency Planning and Community Right-to-Know Act (EPCRA), also referred to as SARA, Title III, requires SRS to report hazardous substances and their releases to EPA, state emergency response commissions, and local planning units.	SRS complied with all reporting and emergency planning requirements.

Table 3-5 Status of Key Federal Environmental Laws Applicable to SRS (continued)

Regulatory Program Description	2017 Status
The Endangered Species Act (ESA) prevents the extinction of federally listed endangered or threatened species and conserves critical habitats.	SRS continued to protect these species and their habitats as outlined in the Natural Resource Management Plan for SRS.
The Federal Facility Agreement (FFA) for the Savannah River Site between the EPA, DOE, and SCDHEC integrates CERCLA and RCRA requirements to achieve a comprehensive remediation of high-level radioactive waste tanks at SRS.	SRS met all the commitments contained within the FFA.
The Federal Facility Compliance Act (FFCA) requires federal agencies to comply with federal, state, and local solid and hazardous waste laws.	SRS continues to comply with the FFCA.
The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates restricted-use pesticides through a state-administered certification program.	SRS continues to comply with FIFRA requirements.
The Migratory Bird Treaty Act (MBTA) protects migratory birds, including their eggs and nests.	SRS continues to comply with the MBTA.
National Defense Authorization Act, Section 3116(a) (NDAA) allows the secretary of energy, in consultation with the Nuclear Regulatory Commission (NRC), to determine that certain waste from reprocessing is not high-level radioactive waste requiring deep geologic disposal if it meets the criteria set forth in Section 3116. Section 3116(b) addresses monitoring by NRC and SCDHEC.	SRS provided routine documents as requested by the NRC to support monitoring SRS facilities in accordance with NDAA 3116(a). NRC did not conduct on-site monitoring observation visits to F- and H-Tank Farms in 2017.

Table 3-5 Status of Key Federal Environmental Laws Applicable to SRS (continued)

Regulatory Program Description	2017Status
The National Environmental Policy Act (NEPA) requires federal agencies to identify potential environmental consequences of proposed federal actions and alternatives to ensure informed, environmentally sound decision-making regarding design and implementing programs and projects.	SRS is in compliance with NEPA.
The National Historic Preservation Act (NHPA) protects historical and archaeological sites.	The Savannah River Archaeological Research Program (SRARP) provides cultural resource management guidance to DOE to ensure continued compliance with the NHPA.
The Resource Conservation and Recovery Act (RCRA) governs the management of hazardous and non-hazardous solid waste and underground storage tanks (USTs) containing petroleum products, hazardous materials, and wastes. RCRA also regulates universal waste and recyclable used oil.	SRS continues to manage hazardous, nonhazardous solid waste, and USTs in compliance with RCRA.
The Safe Drinking Water Act (SDWA) protects drinking water and public drinking water resources.	All drinking water samples taken in 2017 met drinking water quality standards. SCDHEC issued an NOV to SRS in February 2017 for failing to collect the required samples in December 2016.
The Toxic Substances Control Act (TSCA) regulates polychlorinated biphenyls (PCBs), radon, asbestos, and lead and requires users to evaluate and notify EPA when new chemicals are used and significant new uses of existing chemicals occur.	SRS managed all TSCA-regulated materials in compliance with all requirements. The 2017 annual PCB report was submitted on July 9, 2018.

3.8 ENVIRONMENTAL COMPLIANCE SUMMARY

SRS was not involved in any environmental lawsuits during 2017. SRS received five NOVs in 2017; one was for a December 2016 water noncompliance. Table 3-6 summarizes the NOVs SRS received from 2013–2017.

Table 3-6 NOV Summaries, 2013–2017

Program Area	Notice of Violation (NOV)				
	2013	2014	2015	2016	2017
Clean Air Act (CAA)	0	0	1	0	3
Clean Water Act (CWA)	2	0	0	1	2
Resource Conservation and Recovery Act (RCRA)	0	0	0	0	0
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	0	0	0	0	0
Others	0	0	0	0	0
Total	**2**	**0**	**1**	**1**	**5**

Chapter 4 Nonradiological Environmental Monitoring Program

The Savannah River Site (SRS) nonradiological environmental monitoring program is twofold in that it confirms that the Site is complying with state and federal regulations and permits, and it monitors any effects SRS has on the environment, both onsite and offsite. SRS monitors permitted point-source discharges from onsite facilities for nonradiological parameters to ensure compliance with regulations and permit requirements. SRS collects and analyzes environmental media such as air, water, sediment, and fish for nonradiological parameters to evaluate the effect of Site operations on the environment.

2017 Highlights

Effluent Releases

- Nonradiological effluent releases for all categories except industrial wastewater were below permit limits and applicable standards.
- Only 2 of approximately 3,210 analyses at SRS industrial wastewater outfalls exceeded National Pollutant Discharge Elimination System (NPDES) permit limits, a 99.9% compliance rate.
- All SRS industrial stormwater outfalls under the NPDES permit were compliant.

Onsite Drinking Water

All SRS drinking water systems complied with South Carolina Department of Health and Environmental Control (SCDHEC) and U.S. Environmental Protection Agency (EPA) water quality standards.

Surveillance Program

- SRS industrial wastewater and industrial stormwater discharges are not significantly affecting the water quality of onsite streams and the Savannah River.
- Sediment results from SRS streams, stormwater basins, and the Savannah River were consistent with the background control locations and were comparable with historical levels.
- Fish flesh sample results indicated most measured metals were not detectable. Zinc, found in 139 (99%) of the samples, was at levels consistent with the background control location. Mercury, detected and quantified in 79 (56%) of the samples, was consistent with 5-year trends for catfish, bream, mullet, sea trout, and red drum. Mercury levels in bass are in the range expected based on comparison with results for 2013 through 2016.

4.1 INTRODUCTION

> **Chapter 4—Key Terms**
>
> ***Effluent*** *is a release of treated or untreated water or air from a pipe or a stack to the environment. Liquid effluent flows into a body of water, such as a stream or lake. Airborne effluent (also called emission) discharges into the air.*
>
> ***Effluent monitoring*** *is the collection of samples or data from the point a facility discharges liquids or releases gases.*
>
> ***Environmental surveillance*** *is the collection of samples beyond the effluent discharge points and from the surrounding environment.*
>
> ***Outfall*** *is a place where treated or untreated water flows out of a pipe or ditch.*

Environmental monitoring programs at SRS examine both radiological and nonradiological constituents that SRS activities could release into the environment. Chapter 5 *Radiological Environmental Monitoring Program* discusses the radiological components of this monitoring program.

The nonradiological monitoring program collects and analyzes air, water, sediment, and fish samples from numerous locations throughout SRS and the surrounding area. The program is divided into two focus areas: 1) effluent monitoring, and 2) environmental surveillance. The objective of the effluent monitoring program is to demonstrate permit compliance, and the focus of the environmental surveillance program is to assess the environmental impacts of Site operations on the surrounding area. SRS determines sampling frequency and analyses based on permit-mandated monitoring requirements and federal regulations.

SRS conducts nonradiological environmental monitoring on the following categories:

- Atmospheric (airborne emissions and precipitation with a special focus on mercury deposition)
- Water (wastewater, stormwater, sludge, onsite drinking water, and river and stream water quality)
- Stream and river sediment
- Fish

Figure 4-1 shows the types and typical locations (for example, upstream and downstream of SRS influence) of the nonradiological sampling SRS performs.

This chapter summarizes the nonradiological environmental monitoring programs and data results. Sections 8.4 *Environmental Monitoring Program QA Activities* and 8.5 *Environmental Monitoring Program QC Activities* summarize the quality assurance and quality control activities that support the sampling and analysis reported in this chapter. The *2017 Environmental Monitoring Data Report* (SRNS 2018) documents all data associated with the SRS sampling this chapter describes. Appendix Table B-1 of this document summarizes the nonradiological surveillance sampling media and frequencies.

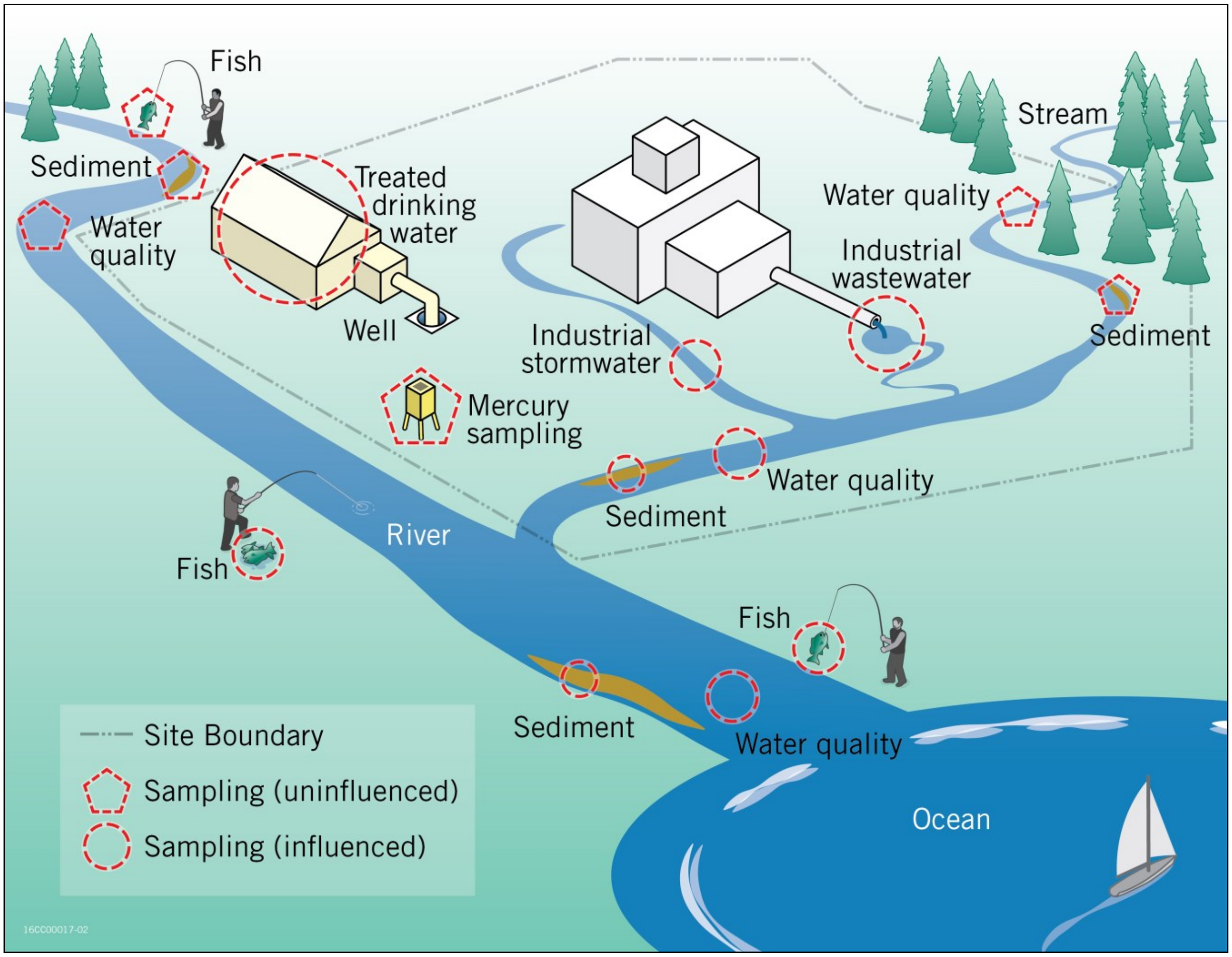


Figure 4-1 Types and Typical Locations of Nonradiological Sampling

4.2 CALCULATED AIR EMISSIONS

Airborne contaminants can present a risk to public health and the environment. Thus, identifying and quantifying these contaminants is essential to a nonradiological monitoring program. SCDHEC regulates nonradioactive air pollutant emissions from SRS sources. The regulations list pollutants, compliance limits, and methods to use to demonstrate compliance.

SRS uses nonradioactive volatile chemicals (e.g. gasoline, toluene), fuels, and combustion products that can adversely affect the environment if released into the air in sufficient quantities. However, the Site uses most of these materials in very small quantities, and the environmental impact from their potential release is negligible. Because of the nature and quantity of potential air emissions, SRS is not required to sample or monitor the ambient air for chemical pollutants. Following SCDHEC requirements, SRS uses process data to calculate emissions.

Many of the applicable regulatory standards are source-dependent (that is, applicable to certain types of industries, processes, or equipment). The SCDHEC-issued Title V operating permit provides the source-specific limits for facility operation, source sampling, testing, monitoring, and reporting frequency. SRS demonstrates it is complying with these regulations by performing air dispersion modeling and submitting to SCDHEC an annual emissions inventory of air pollutant emissions. SRS uses SCDHEC and EPA approved calculations that include source-operating parameters, such as hours of operation, process throughput, and EPA-approved emission factors, to determine facility source emissions. SRS then compares the total actual annual emissions for each source to the emission limits contained in applicable permits. Chapter 3 *Compliance Summary*, Section 3.3.6.4 *Air Emissions Inventory* discusses emissions reporting.

4.3 WATER MONITORING

SRS nonradiological water monitoring includes collecting water and sediment samples and performing measurements on various water sources onsite and from the Savannah River. The sample results enable SRS personnel to evaluate whether there is long-term buildup of pollutants downstream of discharge points and determine whether SRS is complying with permit requirements. SRS also collects and analyzes fish from the Savannah River to evaluate metal uptake in the flesh. SRS monitors groundwater, as Chapter 7 *Groundwater Management Program* discusses.

4.3.1 Wastewater and Stormwater Monitoring

Nonradiological surface water monitoring primarily consists of sampling water discharges (industrial wastewater and industrial stormwater) associated with SRS NPDES-permitted outfalls. SRS monitors nonradiological liquid discharges to surface waters through the NPDES program, as mandated by the Clean Water Act. The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

A Technician Prepares a Water Sample

SCDHEC administers the NPDES permit program and is responsible for permitting, compliance tracking, monitoring, and enforcing the program. The permits SCDHEC issues to SRS provide specific requirements for sampling locations, parameters to be tested, monitoring frequency, and analytical and reporting methods.

SRS collects NPDES samples in the field according to 40 CFR 136, *Guidelines Establishing Test Procedures for the Analysis of Pollutants*. This document lists specific methods for sample collecting, preserving, and acceptable analytical methods for the type of pollutant. SRS upgraded field equipment used in the NPDES program, as discussed in Section 8.4 *Environmental Monitoring Program QA Activities*.

In 2017, SRS monitored 28 industrial wastewater outfalls for physical and chemical properties, including flow, dissolved oxygen, potential of hydrogen (pH), ammonia, biochemical oxygen demand, fecal coliform, metals, oil and grease, volatile organic compounds, and total suspended solids (TSS). Figure 4-2 shows these locations. The permits specify how often SRS is to monitor the outfalls. Typically, SRS took samples at the locations once a month, although some locations required monitoring as frequently as once a day and others as infrequently as once a quarter. As specified by permits, SRS collected either composite or grab samples. SRS reported results to SCDHEC in required monthly discharge monitoring reports. In addition, SRS collected quality control samples as an internal check to ensure representative data. Section 8-5 *Environmental Monitoring Program QC Activities* summarizes the quality control sample results.

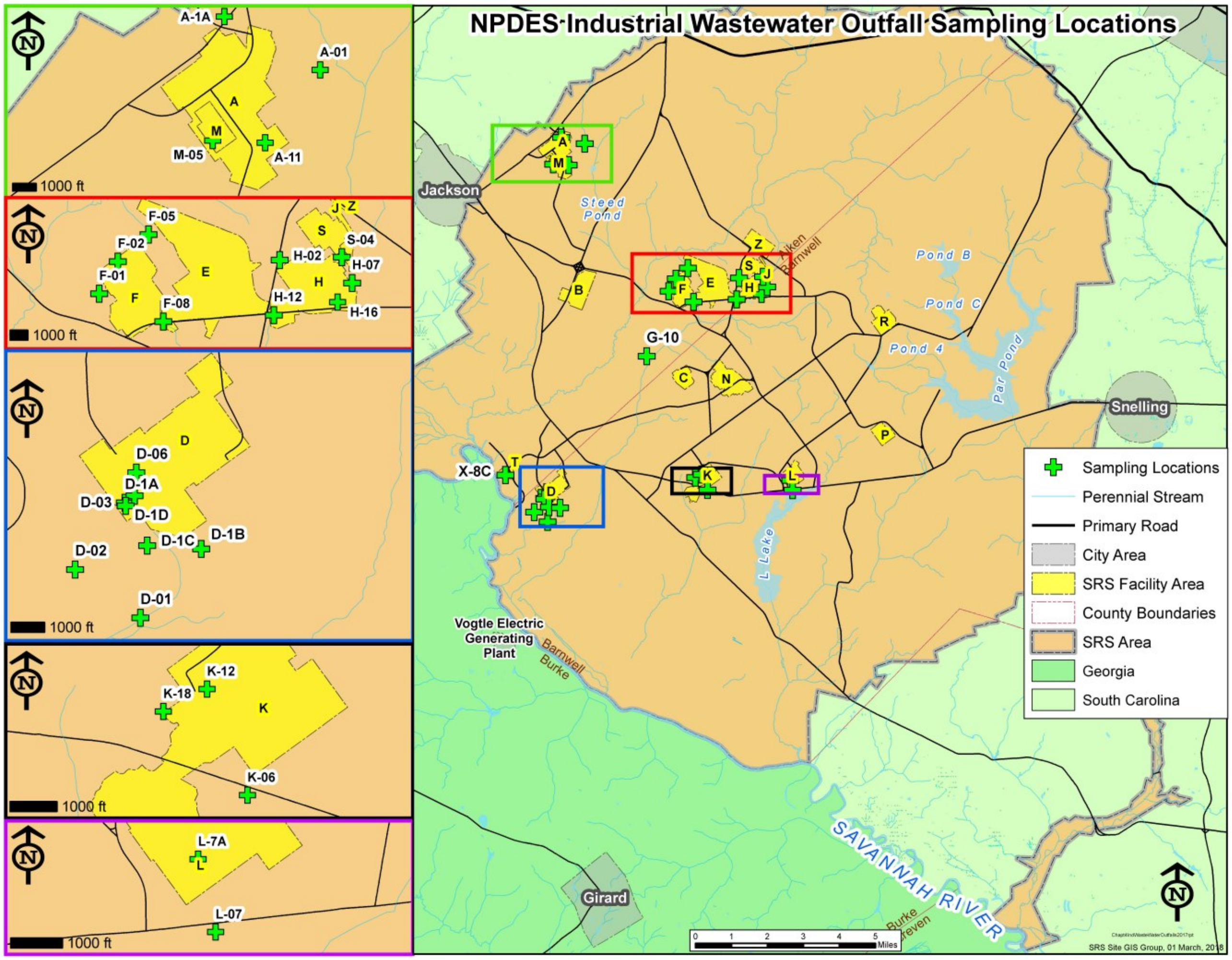


Figure 4-2 NPDES Industrial Wastewater Outfall Sampling Locations

In 2017, SRS monitored 34 industrial stormwater outfalls for ammonia, chemical oxygen demand, cyanide, *Escherichia coli* (*E. coli*), metals, nitrite, nitrate, pH, and TSS. In addition, sampling personnel visually assessed the water in these outfalls for color, odor, clarity, solids, foam, and oil sheen. Figure 4-3 shows these locations. SRS monitored the outfalls on the frequency the permit specified, varying from quarterly to annually. It used grab-sample techniques to collect the stormwater samples.

SRS can collect stormwater samples only during a qualifying rain event. To collect a sample, two conditions must be met: 1) at least 72 hours must have elapsed since the previous flow event, and 2) the sample should be collected during the first 30 minutes of the initial flow. SRS continued to use wireless technology to send immediate text notifications of rain events and to start automated samplers at specific locations. This allowed SRS to comply with the SCDHEC permit requirements of sampling within 30 minutes of rain flow.

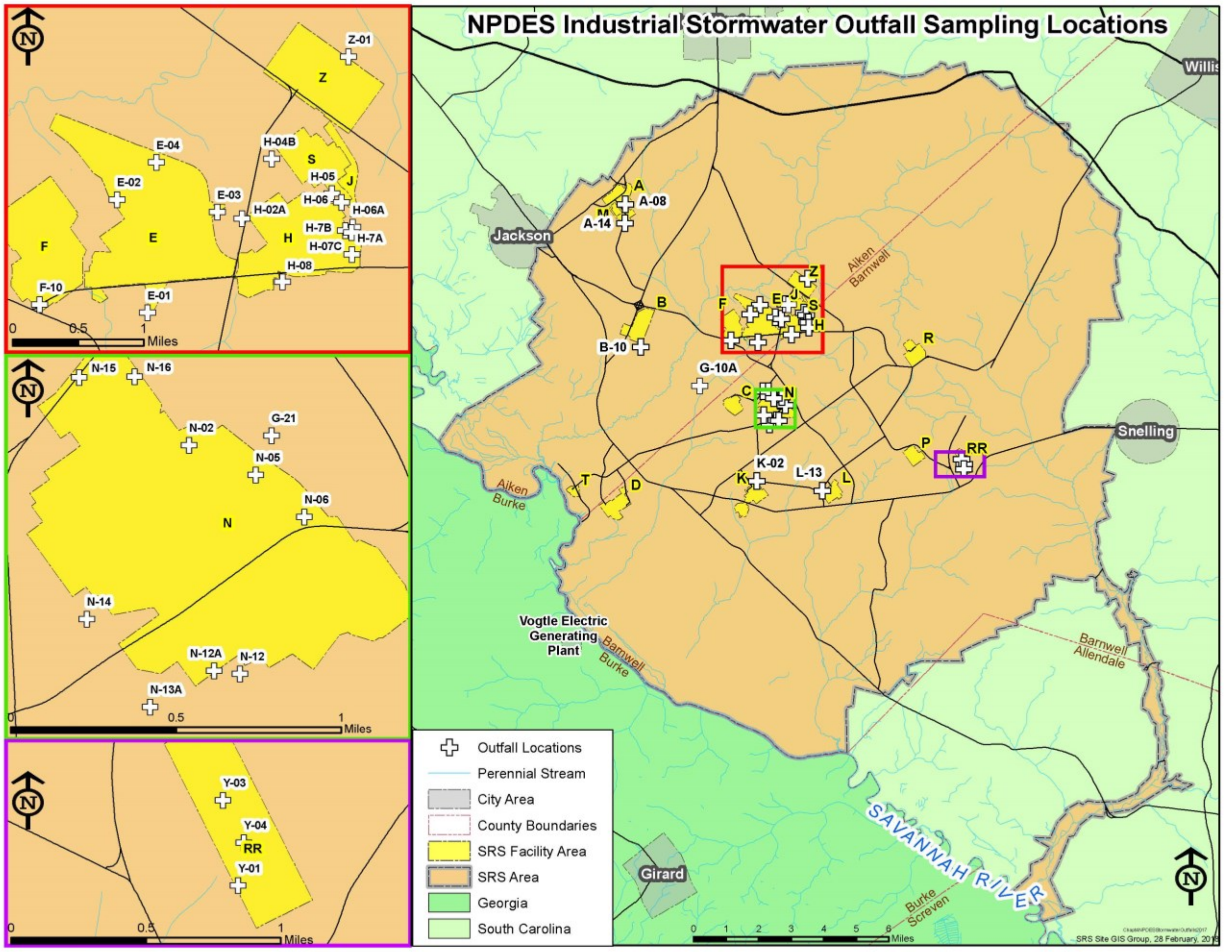


Figure 4-3 NPDES Industrial Stormwater Outfall Sampling Locations

4.3.1.1 Wastewater and Stormwater Results Summary

SRS reports NPDES industrial wastewater analytical results to SCDHEC through monthly discharge monitoring reports. Only 2 of the approximately 3,210 analyses performed during 2017 exceeded NPDES permit limits, which is a 99.9% compliance rate. SRS had one permit limit exceedance for daily maximum flow at K-12 Outfall (due to 4.5 inches of recorded rainfall from Hurricane Irma) and one permit exceedance for daily maximum of fecal coliform at L-7A Outfall. On December 20, SCDHEC issued a Notice of Violation (NOV) for the fecal coliform exceedance at L-7A Outfall but did not assess a penalty. Chapter 3 *Compliance Summary*, Section 3.3.7.1.1 *National Pollutant Discharge Elimination System* provides additional information regarding the NOV.

SRS monitored all industrial stormwater outfalls according to permit requirements. Zinc average results at Outfalls N-12 and N-06, and copper average results at Outfall N-12A exceeded benchmark limits, triggering corrective actions. To absorb the metals, SRS installed oyster shells on the upstream side of small check dams in the stormwater ditches leading to Outfall N-12A in August and to Outfall N-06 in September. The monitoring results are being used to evaluate and optimize the performance of this treatment method.

Outfall N-12 has been reclassified because the discharge source has been eliminated and will now require visual inspection only.

Sample results from the other stormwater outfalls demonstrated compliance with permit requirements.

Workers Install Oyster Shells to Absorb Metals in Stormwater Runoff

4.3.2 Onsite Drinking Water Monitoring

SRS uses groundwater sources to supply drinking water to onsite facilities. The A-Area treatment plant supplies most of the drinking water at SRS. The Site also has four smaller drinking water facilities, each of which serves fewer than 25 people. These systems are not required to be sampled for lead and copper due to the small number of people served.

SCDHEC requires SRS to collect 10 bacteriological samples each month from the A-Area treatment plant to ensure that domestic water from that system meets SCDHEC and EPA bacteriological drinking water quality standards. SRS exceeds this requirement by collecting 15 samples each month from various areas. These samples consistently meet SCDHEC and EPA drinking water quality standards, confirming the absence of harmful bacteria.

SRS samples domestic water systems for lead and copper on a three-year, rotating cycle. The A-Area water system is not due for lead and copper sampling again until 2019.

4.3.3 River and Stream Water Quality Surveillance

South Carolina Regulation 61-69, *Classified Waters,* classifies SRS streams and the Savannah River as "freshwaters." Freshwaters as defined in Regulation 61-68, *Water Classifications and Standards*, (SCDHEC 2014) support the following:

- Primary and secondary contact recreation and as a drinking water source after conventional treatment in accordance with SCDHEC requirements
- Fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora
- Industrial and agricultural uses

SRS surveys river and stream water quality to identify: 1) any degradation that could be attributed to the water discharges regulated by Site NPDES permits, and 2) materials that may be released inadvertently from sources other than routine release points.

SRS samples 10 streams onsite and 5 Savannah River locations for various physical and chemical properties, including dissolved oxygen, pH, temperature, hardness, metals, nitrate, nitrite, pesticides and herbicides, phosphorus, total organic carbon, and total suspended solids. Figure 4-4 shows the sampling locations. In May, sampling for the upstream location on Upper Three Runs Creek, U3R-1A, was moved upstream to U3R-0. The sample location was changed to alleviate the potential impacts to water quality results from the planned bridgework along the stream. The river and stream sampling locations are

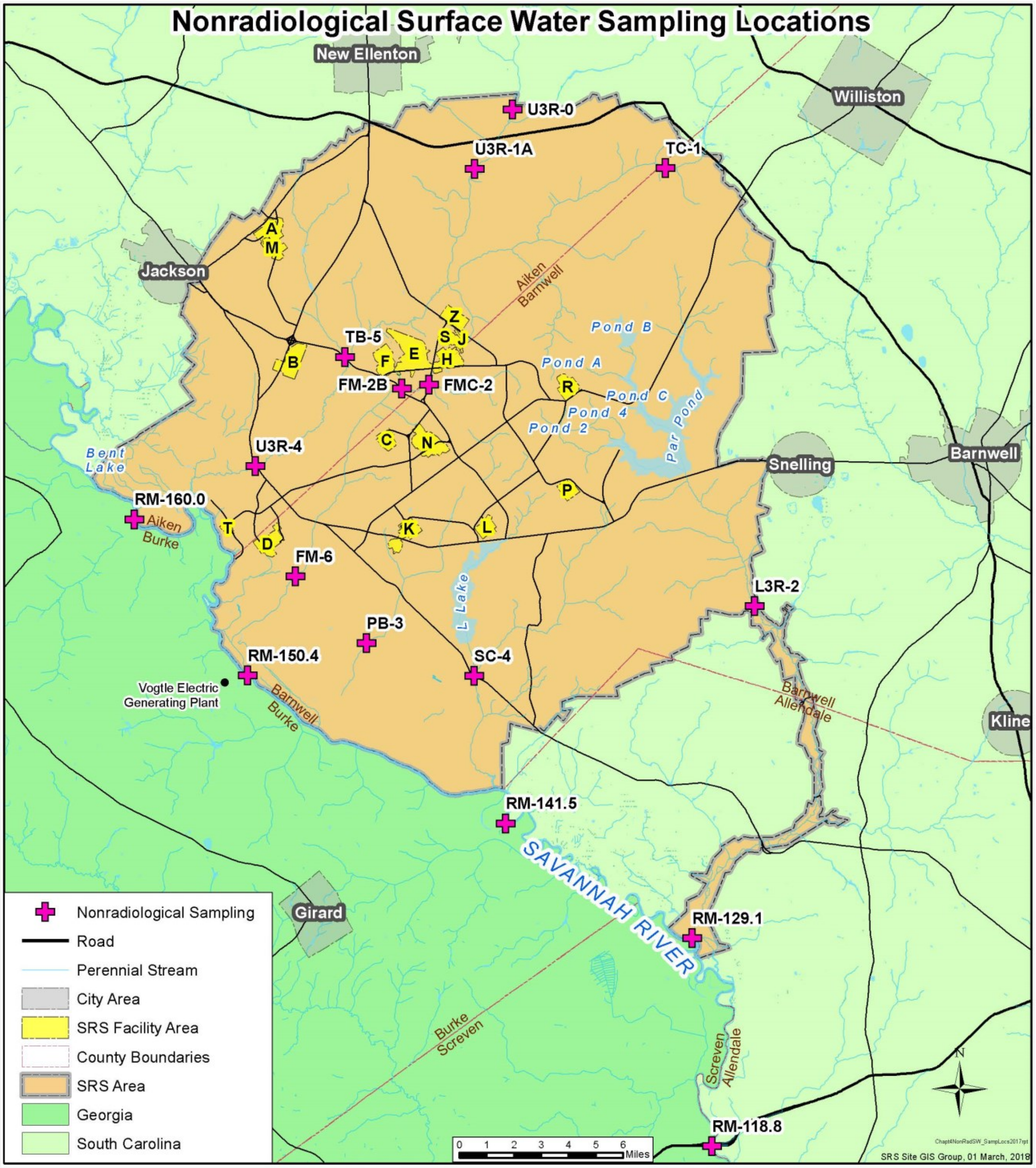


Figure 4-4 Nonradiological Surface Water Sampling Locations

upstream, adjacent to, and downstream from the Site. SRS compares results to background levels of chemicals from natural sources and from contaminants produced by municipal sewage plants, medical facilities, and other upstream industrial facilities to assess the environmental impacts of Site operations on the surrounding area. The water quality locations are sampled monthly and quarterly by the conventional grab-collection technique. SRS collects quality control samples throughout the year, as documented in Section 8.5 *Environmental Monitoring Program QC Activities*. SCDHEC also collects samples at several onsite stream locations; most of them are colocated with SRS sample locations as a quality-control check of the SRS program.

4.3.3.1 River and Stream Water Quality Results Summary

SRS performed 5,400 individual analyses on samples collected from the 15 stream- and river-water quality locations during 2017, with 5,059 (93.7%) meeting South Carolina Freshwater Quality Standards. Averages for each river and stream location met standards for dissolved oxygen, pH, temperature, chromium, mercury, nickel, nitrate, nitrite, and zinc. No sample results showed detectable levels of pesticides, herbicides, or polychlorinated biphenyls (PCBs). Appendix Table C-1 summarizes the analytical results. These results continue to indicate that SRS discharges are not significantly affecting the water quality of onsite streams or the Savannah River.

4.3.4 Sediment Sampling

SRS's nonradiological sediment surveillance program measures the nonradiological contaminant concentrations that are deposited and accumulate in stormwater basins, stream systems, and in the Savannah River. One of the important contaminants measured is mercury. Mercury is a contaminant that could pose a health risk to humans through various exposure pathways, including drinking water and eating fish. Mercury enters bodies of water naturally through volcanic activity and mineral weathering of rocks over time, as well as through industrial and urban sources such as coal-burning power plants. Mercury that is released into the air may eventually settle or be washed into water, where it deposits onto streambeds and wetlands. The other nonradiological parameters measured are aluminum, arsenic, barium, cadmium, chromium, copper, cyanide, iron, lead, magnesium, manganese, nickel, selenium, silver, and zinc. Many of these are trace metals that occur naturally in soils and sediments.

The nonradiological sediment program collects sediment samples at various stream, stormwater basin, and Savannah River locations (Figure 4-5). The locations vary from year-to-year, depending on the rotation schedule agreed upon with SCDHEC. SCDHEC duplicates sampling at various locations onsite as a quality control check of the SRS program.

4.3.4.1 Stream and River Sediment Results Summary

In 2017, SRS sampled 15 onsite stream locations, 4 stormwater basin locations, and 9 Savannah River locations. The laboratory analyzed the samples for various inorganic contaminants (metals and cyanide) to determine if there was a human health risk from exposure to sediments. The Site used EPA Regional Screening Levels for Residential Soil for comparison.

In 2017, all mercury results for river and stormwater basin sediment samples were below the lowest levels the laboratory could detect. Three samples from onsite stream locations contained detectable mercury levels that ranged from 0.0085 mg/kg at L3R-2 to 0.27 mg/kg at L3R-1A. All mercury results were well below the EPA Regional Screening Level for resident soil (Figure 4-6).

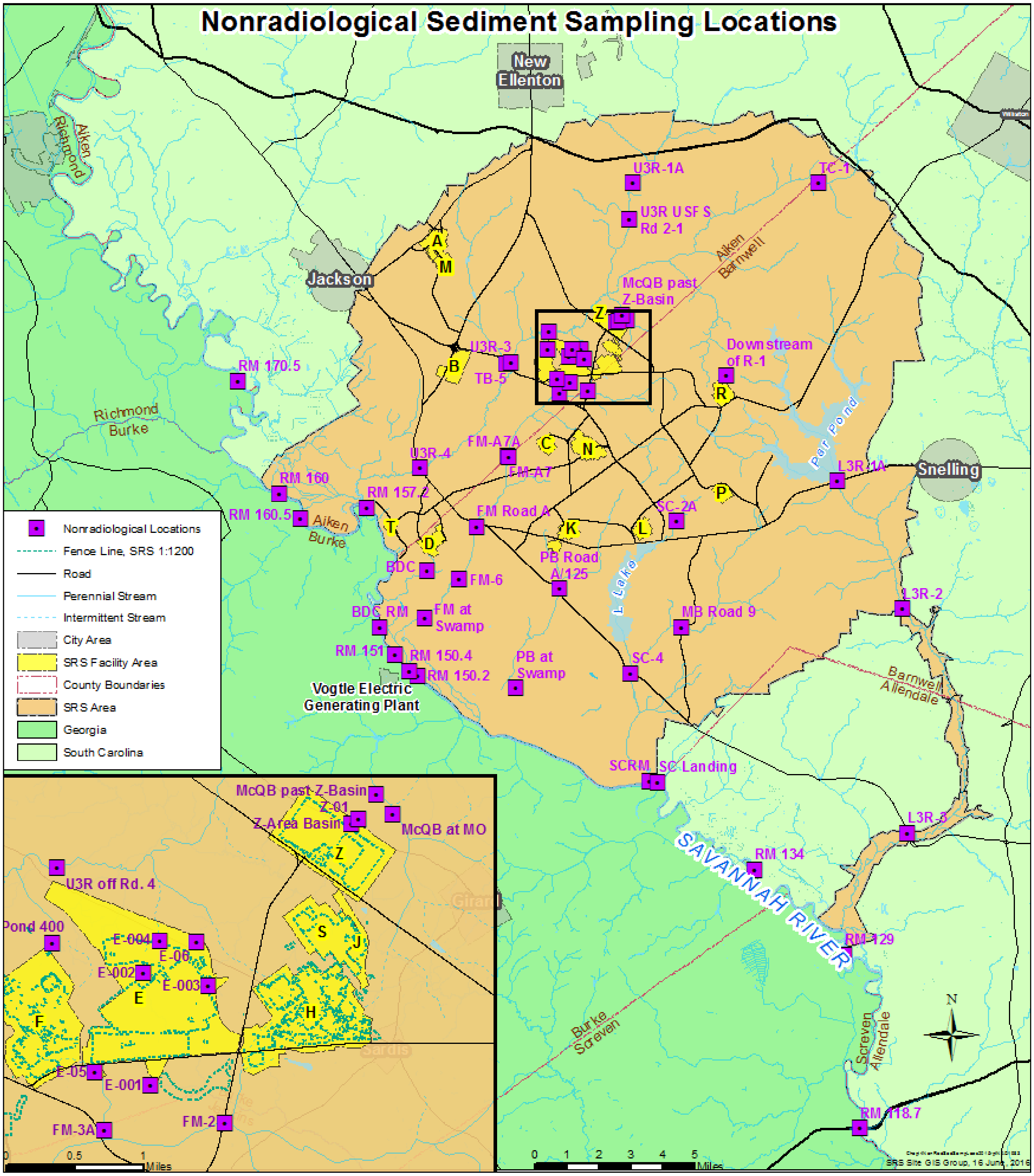


Figure 4-5 Nonradiological Sediment Sampling Locations

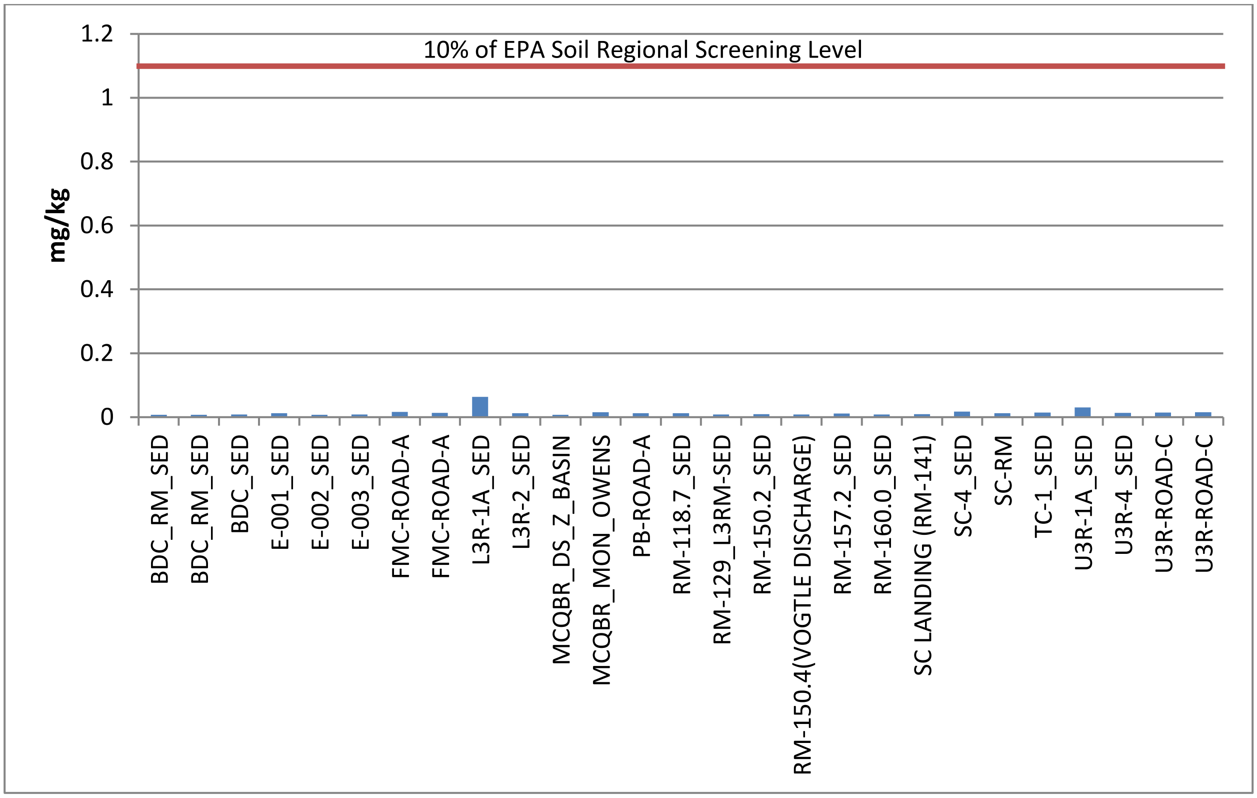


Figure 4-6 Mercury in Sediment Locations

All measured analytes except silver were detected in at least one sample at levels greater than the practical quantitation limit but were consistent with the concentrations seen in the background control locations (river location River Mile [RM]-160 and stream location Upper Three Runs U3R-0) and comparable to those of the previous five years. Appendix Table C-2 summarizes the analytical results.

4.3.5 Fish Monitoring

SRS samples aquatic species to identify and evaluate any effect of Site operations on contaminant levels in fish. The Site collects freshwater fish (bass, catfish, and panfish) at six locations on the Savannah River from above SRS at Augusta, Georgia to the coast of Savannah, Georgia. SRS collects freshwater fish at the mouth of the streams that flow through the Site. Saltwater fish (red drum, sea trout, and mullet) are collected at the Savannah River mouth near Savannah. SRS analyzes samples of the edible flesh for metals uptake. SRS performs

Fish Sample Collected from SRS creek mouth

nonradiological analyses for mercury, arsenic, cadmium, chromium, copper, lead, manganese, nickel, zinc, and antimony.

4.3.5.1 Fish Results Summary

In 2017, SRS performed 1,405 individual analyses on 145 fish flesh samples. The majority (60%) of the results were nondetected (less than the method detection limit). Appendix Tables C-3 and C-4 present summaries of the analytical results. Sixteen percent, or 221 results of the 1,405 individual analyses, were detected and quantified, with the majority being for mercury (79) and zinc (139).

A review of the 2017 zinc data indicates the results for the SRS creek mouths are comparable with the results for the control location at the New Savannah Bluff Lock and Dam. Review of mercury data for the period 2012 through 2017 (Figure 4-7) indicates lower concentrations in catfish and panfish than in bass. Mercury data for bass collected in 2017 are within the expected range based on the previous four-year period (2012–2016).

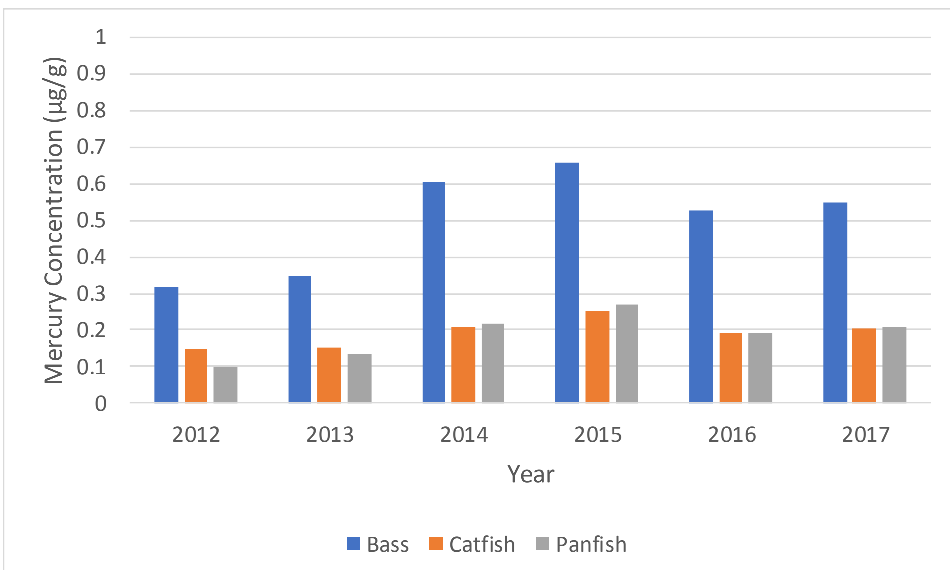


Figure 4-7 Average Mercury Concentration of Fish Species in the Savannah River Adjacent to the Savannah River Site

4.4 PRECIPITATION CHEMISTRY AND DEPOSITION

The SRS nonradiological air monitoring program includes collecting samples and data to calculate air emissions from Site sources and for the National Atmospheric Deposition Program (NADP). The NADP monitors the geographic distribution of specific airborne contaminants to better understand their effects on the environment. The NADP publishes data one year after analyzing all samples from their network of collection locations. Thus, this section reports 2015 data, which is publicly available.

SRS sponsors a collection station to support the NADP. This station, located near the center of SRS at the Savannah River National Laboratory (SRNL) Central Climatology facility, collects weekly precipitation (rain, sleet, and snow) samples and submits them to NADP laboratories for chemical analysis. Since 2001, this station has been part of the Mercury Deposition Network (MDN) of the NADP. The MDN provides data on the geographic distributions and trends of mercury in precipitation. Mercury is emitted into the atmosphere and surface waters from natural sources, including volcanoes and wildfires. It also occurs naturally in some soils. Yet most of the attention on mercury in the environment has focused on anthropogenic sources: coal combustion, medical waste incineration, and chlorine production, among others. The MDN is the only network providing a long-term record of mercury concentrations in North American precipitation. All monitoring sites follow standard procedures and have uniform precipitation collectors and gauges. Beginning in 2012, the National Trends Network (NTN) added the station at SRS. This network tracks changes in acid rain.

Sample analysis associated with the NTN network includes free acidity (pH), conductivity, calcium, magnesium, sodium, potassium, sulfate, nitrate, chloride, and ammonium. In addition to supporting national-scale observations relating to trends in precipitation chemistry, results from this surveillance provide specific information related to the chemistry of precipitation at SRS.

4.4.1 Precipitation Chemistry and Deposition Results Summary

The 2016 average (volume-weighted) concentration of total mercury in precipitation was 8.3 ng/L, and the wet deposition rate was 10.9 $\mu g/m^2$. These observations were consistent with historical observations associated with this surveillance and are consistent with other observations from the southeastern United States. Data from 2017 will be available in the fall of 2018. The NAPD provides additional information on the MDN, as well as the location and data from surrounding stations.

In 2016, the average pH of precipitation was 5.08. Appendix Table C-5 presents the precipitation results that the NTN reported for 2016. These observations are consistent with other observations from other locations in the southeastern United States. The NAPD provides additional information on the NTN.

Chapter 5 Radiological Environmental Monitoring Program

The purpose of the Savannah River Site (SRS) Radiological Environmental Monitoring Program is two-fold in that it monitors any effects SRS has on the environment, and it demonstrates the Site is complying with applicable U.S. Environmental Protection Agency (EPA), South Carolina Department of Health and Environmental Control (SCDHEC), and U.S. Department of Energy (DOE) regulations and standards. As part of this program, the Site collects thousands of samples throughout the year and analyzes them for radionuclides that could be present from releases due to SRS operations. Samples are collected both onsite and in the communities surrounding SRS. State and federal regulations drive some of the monitoring SRS conducts. DOE Orders 231.1B, *Environment, Safety and Health Reporting*, and 458.1, *Radiation Protection of the Public and the Environment*, also address environmental monitoring requirements.

2017 Highlights

Air Pathway—All air contaminants SRS released were below applicable permit and regulation limits. Elevated actinides at F Canyon resulted in a DOE Order 458.1 Derived Concentration Standard (DCS) exceedance. Radiological results for surveillance media associated with the airborne pathway were within expected historical levels when compared to background, except for actinides and cesium-137, which appeared occasionally.

Water Pathway—Water contaminants SRS released were all below applicable permit limits and standards. Radiological results for surveillance media associated with the liquid pathway were within expected historical levels when compared to background.

Wildlife Surveillance—SRS monitors animals harvested during the annual onsite hunts to ensure the total dose to any hunter from ingesting the meat is below the SRS Annual Administrative Game Animal Release Limit of 22 mrem/yr. SRS monitored the deer, feral hogs, turkeys, and coyotes harvested during the hunts and released 402 animals. Based on field measurements, SRS released all animals to the hunters.

Creek Plantation Comprehensive Survey—Every five years, SRS assesses the residual contamination from radionuclides deposited on sediments at Creek Plantation in the 1960s due to SRS operations. The comprehensive survey conducted in 2017 confirmed the previous observation that cesium-137 (Cs-137) is the primary man-made radionuclide detected at Creek Plantation, based on soil, vegetation, and external gamma exposure measurements. Cs-137 concentrations continue an overall downward trend.

5.1 INTRODUCTION

Environmental monitoring at SRS examines both radiological and nonradiological constituents that the Site could release to the environment. This chapter discusses radiological monitoring at SRS; Chapter 4, *Nonradiological Environmental Monitoring Program*, presents the nonradiological monitoring.

The SRS Radiological Environmental Monitoring Program monitors radiological contaminants from both air and liquid sources, as well as collects and analyzes environmental samples from numerous locations throughout the Site and the surrounding area. SRS measures tritium in most sample media as it a significant contributor to potential dose to the public. The Radiological Environmental Monitoring Program has two focus areas: 1) effluent monitoring, and 2) environmental surveillance. SRS determines sampling frequency and analyses based on permit-mandated monitoring requirements, federal regulations, and DOE Orders.

In accordance with DOE Order 458.1, SRS evaluates the effluent monitoring program by comparing the annual average concentrations to the DOE derived concentration standards (DCSs). DOE's *Derived Concentration Technical Standard* (DOE 2011) establishes numerical standards for DCSs to supporting implementing DOE Order 458.1. DCS compliance is demonstrated when the sum of the ratios of each radionuclide's observed concentration to its corresponding DCS does not exceed 1.00. This sum is referred to as the "sum of fractions." The DCSs are applicable at the point of discharge, and SRS uses them to screen existing effluent treatment systems to determine if they are appropriate and effective. SRS uses the same DCSs as reference concentrations to conduct environmental protection programs. All DOE sites use these DCSs.

The SRS surveillance program samples the types of media that may be impacted based on Site releases as measured in the effluent monitoring program. Figure 5-1 shows the liquid and airborne pathways, as well as the types of media sampled through those pathways.

SRS conducts environmental monitoring of the following:

- Air (stack emissions and ambient air)

Chapter 5—Key Terms

Actinides *are a group of radioactive metallic elements with an atomic number between 89 and 103. Within this chapter, laboratory analysis of actinides generally refers to the elements uranium, plutonium, americium, and curium.*

Derived concentration standard (DCS) *is the concentration of a radionuclide, measured at the discharge point, in air or water effluents that—under conditions of continuous exposure for one year (that is, annual ingestion of water, submersion in air, or inhalation)—would result in a dose of 100 mrem (1 mSv). This assumption of direct exposure to discharge point effluents is extremely unlikely and ensures that the DCSs are highly conservative.*

Dose *is a general term for the quantity of radiation (energy) absorbed.*

Effluent monitoring *collects samples or data from the point a facility discharges liquids or releases gases.*

Environmental monitoring *encompasses both effluent monitoring and environmental surveillance.*

Environmental surveillance *collects samples beyond the effluent discharge points and from the surrounding environment.*

Exposure pathway *is the way that releases of radionuclides into the water and air could impact a person.*

- Rainwater
- Vegetation
- Soil
- Surface water (stream, river, and stormwater basins)
- Drinking water
- Stream and river sediment
- Aquatic food products
- Wildlife
- Food products (milk, meat, fruit, nuts, and green vegetables)

Sampling results provide the data needed to assess the exposure pathways for the people living near SRS, as documented in Chapter 6, *Radiological Dose Assessment*.

Appendix Table B-2 of this document summarizes the radiological surveillance sampling media and frequencies. *The 2017 Environmental Monitoring Program Data Report* (SRNS 2018) documents all raw data associated with SRS.

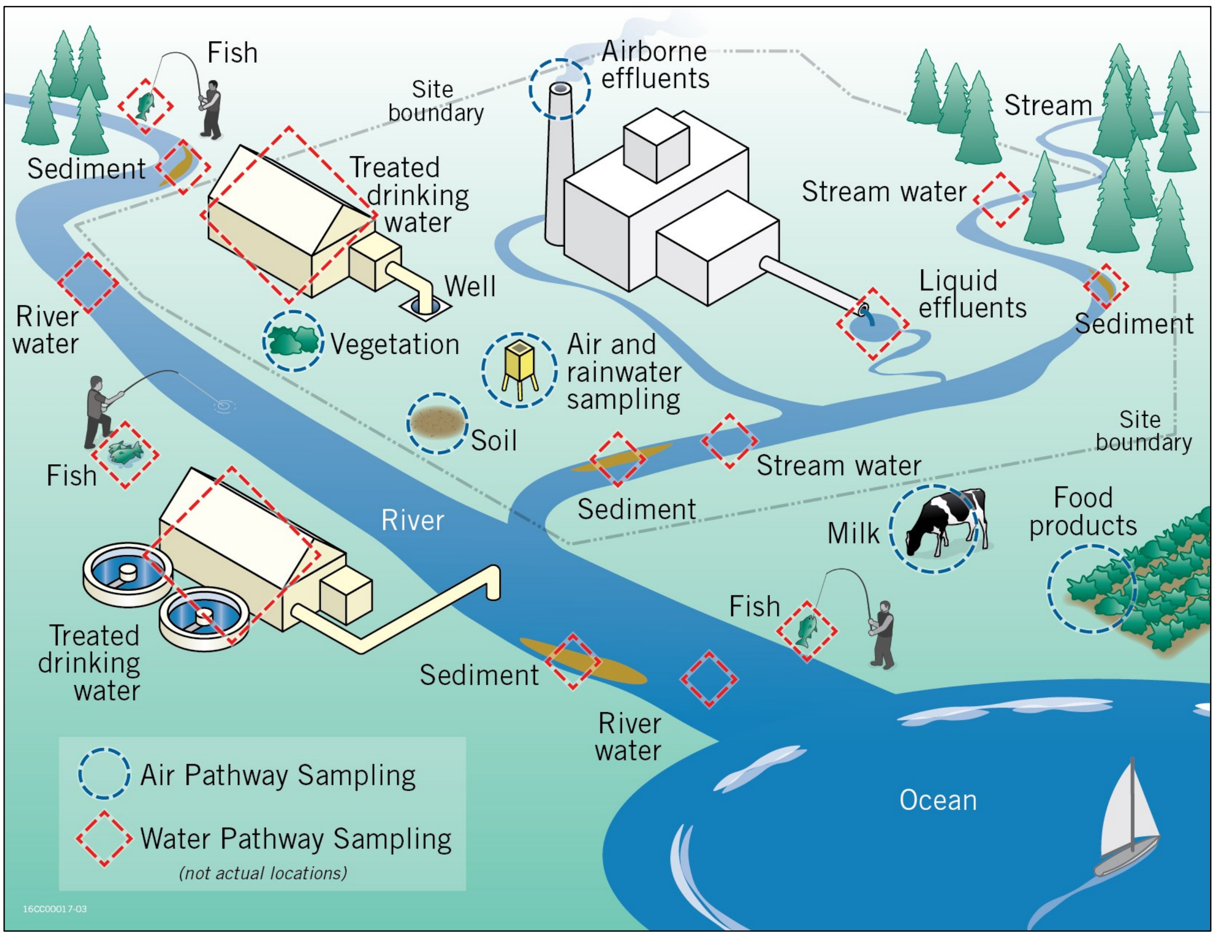


Figure 5-1 Types and Typical Locations of Radiological Sampling

5.2 SRS OFFSITE MONITORING

Offsite monitoring involves collecting and analyzing samples of air, river water, soil, sediment, vegetation, milk, food products, fish, and other media from many locations. SRS analyzes these samples for radioactive contaminants to monitor any effects the Site has on the environment and to assess long-term trends of the contaminants in the environment. SRS collects samples beyond the Site perimeter in Georgia and in South Carolina at 25 and 100 miles from the Site. Additionally, SRS collects samples at several population centers in Georgia and in South Carolina.

SRS monitors the Savannah River at River Mile (RM) 141.5, locations downriver of each SRS stream entry point, and above the Site at River Mile 160 as a control location. Media-specific chapter figures and Environmental Maps show offsite environmental sampling locations. Chapter 7, *Groundwater Management Program,* provides information on SRS groundwater monitoring. Table 5-1 summarizes SRS offsite radiological sampling performed in Georgia and South Carolina, excluding samples collected in the Savannah River.

Table 5-1 SRS Offsite Radiological Sample Distribution by State

Environmental Sampling Media	Approximate Number of Samples (Number of Locations)	
	South Carolina	Georgia
Air Filters	26 (1)	52 (2)
Silica Gel	26 (1)	52 (2)
Ambient Gamma Radiation Monitoring[a]	77 (57)	16 (4)
Rainwater	12 (1)	24 (2)
Food Products	20 (20)	5 (5)
Milk	16 (4)	16 (4)
Soil[a]	96 (51)	2 (2)
Grassy Vegetation[a]	51 (51)	2 (2)
Drinking Water	24 (2)	0 (0)
Total	**348 (188)**	**169 (23)**

Notes:
General: This table excludes groundwater monitoring locations and samples that Chapter 7, *Groundwater Management Program*, discusses, as well as samples collected from the Savannah River.

[a] The approximate number of samples and number of locations in South Carolina include the five-year comprehensive Creek Plantation study.

5.3 AIR PATHWAY

The media in this section supports the air pathway dose assessment discussed in Chapter 6, *Radiological Dose Assessment*.

5.3.1 Air Monitoring

SRS monitors the air to determine whether airborne radionuclides from SRS emissions have reached the environment in measurable quantities and to ensure that radiation exposure to the public remains below regulatory limits. SRS performs effluent monitoring of airborne radionuclides at the point of discharge from operating SRS facilities. This monitoring complies with radiation dose limits that the Environmental Protection Agency (EPA) and DOE established to protect the public. SRS conducts additional air sampling at surveillance stations onsite, along the SRS perimeter, and within communities surrounding SRS. Radionuclides in and around the SRS environment are from both SRS operations and from events not related to the Site. The events not associated with SRS include 1) natural sources, 2) past atmospheric testing of nuclear weapons, and 3) offsite nuclear power plant operations. Tritium in the elemental (hydrogen gas) and oxide (water vapor) forms make up most of the radionuclide emissions from SRS to the air. The amount of tritium released from SRS varies yearly, based on mission activities and on the annual production schedules of the tritium-processing facilities.

5.3.2 Airborne Emissions

EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) program establishes the limits for radionuclide emissions, detailing the methods for estimating and reporting radioactive emissions from DOE-owned or operated sources. South Carolina Department of Health and Environmental Control (SCDHEC) issues Clean Air Act Part 70 Air Quality Permits to regulate radioactive airborne pollutant emissions for each major source of airborne emissions on SRS. Each permit has specific limitations and monitoring requirements.

SRS quantifies the total amount of radioactive material released to the environment by the following methods:

- Data obtained from monitored air effluent release points (stacks or vents)
- Calculated releases of unmonitored radioisotopes from the dissolution of spent fuel
- Estimates for unmonitored sources based on approved EPA calculation methods

SRS monitors the emissions from process area stacks at facilities that release, or have the potential to release, airborne radioactive materials. SRS typically uses laboratory analyses of samples to determine concentrations of radionuclides in airborne emissions. Airborne effluent samples are collected on filter papers for particulates, on charcoal sampling media for gaseous iodine, and in a bubbler solution for airborne tritium. Depending on the processes involved, SRS may also use real-time instrumentation to monitor instantaneous and cumulative releases (of tritium, for example) to the air.

The dissolution of spent nuclear fuel in the H-Canyon facility releases krypton-85, carbon-14, and tritium. These emissions are calculated and included with the monitored releases.

Each year, SRS calculates radionuclide release estimates (in curies [Ci]) from unmonitored diffuse and point sources. Point sources include stacks or other exhaust points, such as vents. In contrast, emissions from diffuse sources are not actively ventilated or exhausted. Diffuse emissions may not originate from a single location but are released over a larger area. SRS diffuse sources include research laboratories, disposal sites and storage tanks, and deactivation and decommissioning activities. The emissions calculated from unmonitored releases use the methods contained in Appendix D of EPA's NESHAP regulations (EPA 2002). Because these methods employ conservative assumptions, they generally overestimate actual emissions. Although SRS does not monitor these releases at their source, it uses onsite and offsite environmental surveillance to assess the impact, if any, of unmonitored releases.

Air Emission Stack in L Area

In 2017, SRS fully implemented analytical compositing of airborne source samples within the air effluent program, where reasonable to do so. Compositing increases analytical accuracy by reducing the minimum detectable concentrations (MDCs) in airborne effluent samples.

5.3.2.1 Airborne Emissions Results Summary

The continuous airborne effluent particulate sampling system for the F-Canyon stack was out of service from late October through the end of December. The stack flow transmitter was inoperable. The facility continued to obtain filter paper samples for analysis and to estimate the stack releases during this time. Conservative estimates for the F-Canyon stack are incorporated into this year's releases based on guidance in the *American National Standard Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*, American National Standards Institute (ANSI) N13.1-1969.

Appendix Table D-1 presents SRS radioactive release totals from monitored and unmonitored (calculated) sources, while Table 5-2 provides a summary. During the past 10 years, as Figure 5-2 shows, the total annual tritium release has ranged from about 15,200 to 40,400 Ci per year, with an annual average tritium release of 26,400 Ci. The 2017 tritium emissions of 15,200 Ci, the lowest in 10 years, is also significantly below this 10-year average. Compared to the 21,700 Ci of tritium released in 2016, SRS tritium releases decreased about 30% in 2017. This continues the general 10-year trend of tritium releases to the air decreasing. As stated previously, the amount of tritium released from SRS fluctuates due to changes in SRS missions and in the annual production schedules of the tritium-processing facilities. In addition, the reduction in tritium may be attributed to legacy tritium continuing to decay and diffuse from old process equipment, as well as the ultimate disposal of some legacy contaminated components.

In 2017, tritium accounted for more than 73% of the total radiation SRS operations released to the air. Tritium processing facilities are responsible for 76% of SRS tritium releases, while the spent nuclear fuel dissolution in H Canyon accounted for less than 1% of SRS tritium releases. Tritium releases from the separations areas comprise the combination of releases from the tritium processing facilities and the dissolution in H Canyon. Appendix Table D-1 and Figures 5-2 and 5-3 show the tritium releases from the separations areas, reactors and spent nuclear fuel facilities, and unmonitored sources.

Appendix Table D-2 summarizes the 2017 air effluent-derived concentration standards (DCSs) sum of the fractions. The raw data includes the specific radionuclide average concentrations and associated DOE DCSs for each monitored discharge point within the facilities (SRNS 2018). The radionuclide dose assessment includes concentrations for other periods, including any time between stack samples, unidentified alpha and unidentified beta results, and emissions estimated using calculations (that is, unmonitored diffuse and point) (Jannik, Bell, and Dixon, 2018). The raw data (SRNS 2018) also contains calculated concentrations for tritium from the reactor areas and the tritium-processing facilities, and for krypton-85, carbon-14 and tritium from the H-Canyon facility during the dissolving process. These calculated concentrations are based on the annual releases in curies and the annual stack flow volume.

Table 5-2 SRS Radiological Atmospheric Releases for CY 2017 (measured in curies)

Release Type	Totals (in Curies)
Tritium	1.52E+04
Krypton-85 (^{85}Kr)	5.45E+03
Noble Gases ($T_{1/2}$ < 40 days)[a,b]	0.00E+00
Short-Lived Fission and Activation Products ($T_{1/2}$ < 3 hr)[b,c]	3.19E-08
Fission and Activation Products ($T_{1/2}$ > 3 hr)[b,c]	3.12E-02
Total Radio-iodine[d]	3.06E-03
Total Radio-strontium[e]	1.25E-03
Total Uranium	2.96E-04
Plutonium[f]	1.06E-03
Other Actinides	2.49E-04
Other	4.00E-02

Notes:

[a] SRS did not release any radioactive noble gases in CY 2017, other than Kr-85 (considered in krypton-85)

[b] ICRP 107 Half-life data, *Nuclear Decay Data for Dosimetric Calculations (2008)*

[c] IAEA Common Fission and Activation Products

[d] Includes iodine-129 and iodine-131

[e] Includes unidentified beta releases

[f] Includes unidentified alpha releases

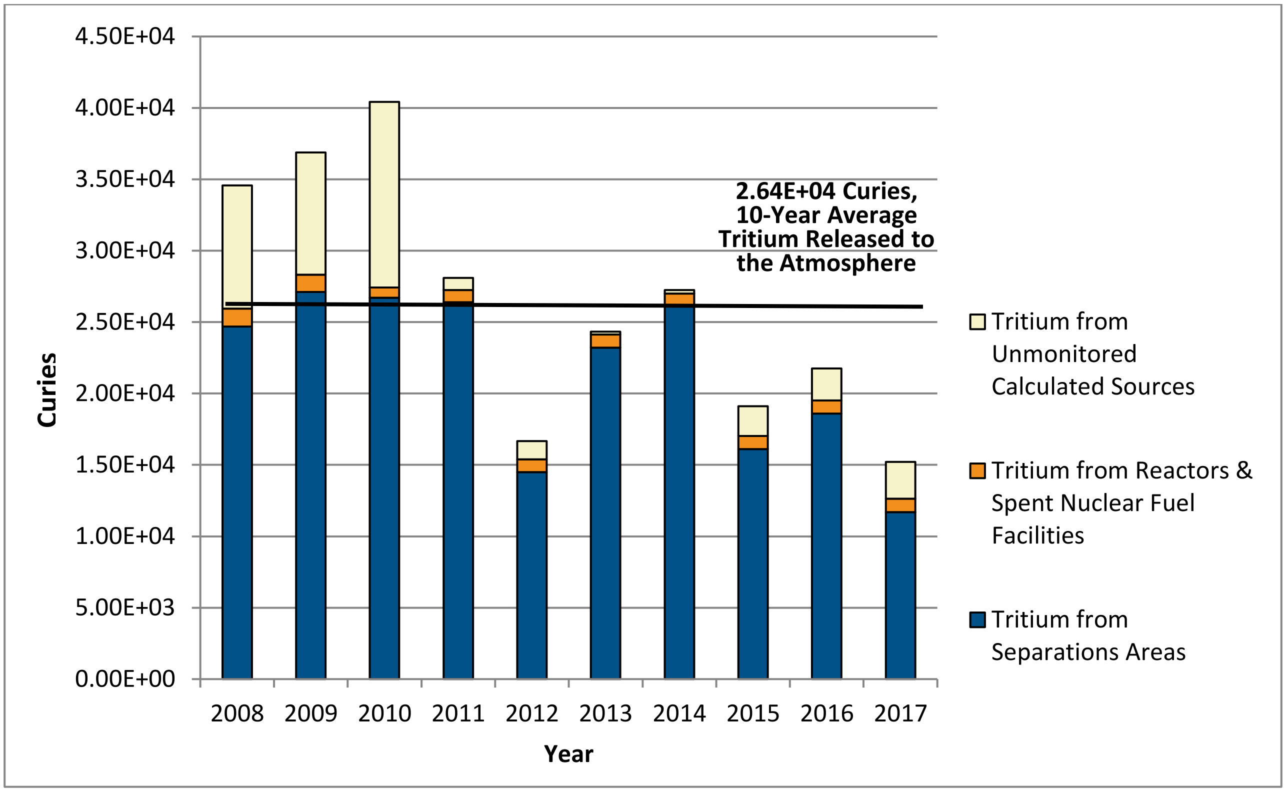


Figure 5-2 10-Year History of SRS Annual Tritium Releases to the Air

Most SRS stacks and facilities release small quantities of radionuclides at concentrations below the DOE DCSs. F-Canyon stack analytical results have been elevated in 2017. This has led to a DCS exceedance with plutonium-239 as the primary contributing radionuclide. SRS continues to investigate possible causes for the exceedance and to identify mitigative actions, as discussed in section 5.3.3.1.

Because of the nature of several SRS facilities operations, tritium oxide releases exceeded DOE's tritium air DCS. However, DOE recognizes that tritium oxide, which is essentially water vapor, cannot be filtered or removed from the effluent. Therefore, DOE Order 458.1 specifically exempts tritium from Best Available Technology considerations but not from environmental As Low As Reasonable Achievable requirements, as implemented by Site procedures. The facilities that exceeded the tritium oxide air DCS are C Area, K Area, L Area, and the tritium processing facilities. However, tritium releases are maintained as low as reasonably achievable to comply with DOE Order 458.1.

Additionally, the offsite dose from all airborne releases remained well below the DOE and EPA annual air pathway dose limit of 10 mrem (0.1 mSv). Chapter 6, *Radiological Dose Assessment*, discusses this further.

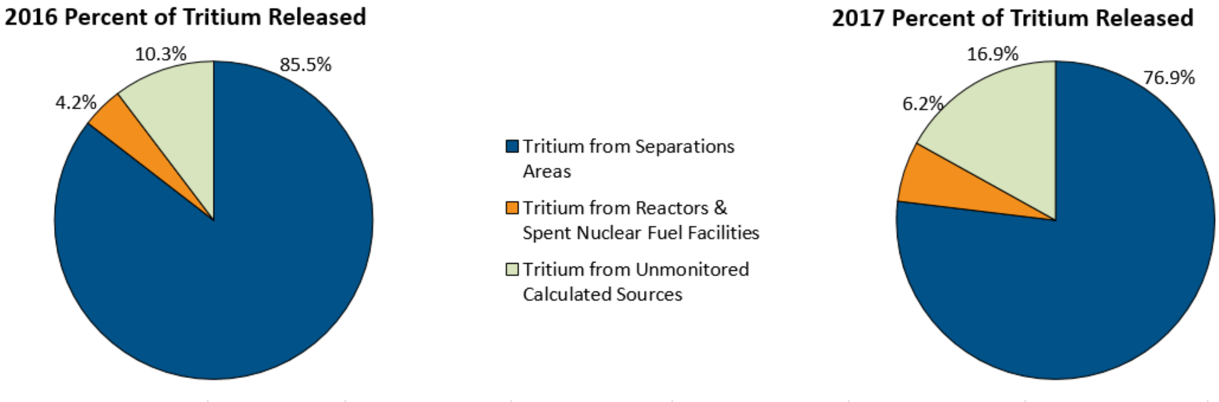


Figure 5-3 Percent of Tritium Released to the Air for 2016 and 2017

5.3.3 Air Surveillance

Beyond the operational facilities, SRS maintains a network of 14 air sampling stations (Figure 5-4 and Environmental Maps, *Radiological Air Surveillance Sampling Locations*) in and around SRS to monitor concentrations of tritium and radioactive particulate matter in the air and rainwater. The air contains radionuclides in various forms (gaseous, particulate matter, water vapor). Rainwater can redeposit particulate matter from the air onto the ground, and the radionuclides can eventually be absorbed into vegetation or soil.

The sampling stations are at locations on and off the Site. Onsite stations are at the center of the Site and around the perimeter. Offsite, sampling stations are 25 miles from the Site in population centers and at a control location, the U.S. Highway 301 Bridge at the Georgia Welcome Center in Screven County. SRS operations are not likely to affect the control location. SRS placed air-sampling stations near the Site boundary and beyond to be representative of the atmospheric distribution of airborne releases into the environment. Each air sampling station is set up to collect the media that Table 5-3 lists.

Table 5-3 Air Sampling Media

Media	Purpose	Radionuclides
Glass-Fiber Filter	Airborne particulate matter	Gamma-emitting radionuclides, gross alpha/beta emitting radionuclides
Charcoal Canister	Gaseous states of radioiodine	Iodine-129, gamma-emitting radionuclides
Silica Gel	Tritiated water vapor	Tritium
Rainwater	Tritium in rainwater	Tritium

SRS selected the radionuclides presented in Table 5-3 based on known SRS airborne emission sources. Background levels in the air consist of naturally occurring radionuclides (for example, uranium, thorium, and radon) and radionuclides from global fallout due to historical nuclear weapons testing related to the Cold War (for example, strontium-90, and cesium-137). Compositing samples, as discussed in section 8.4, began in 2017.

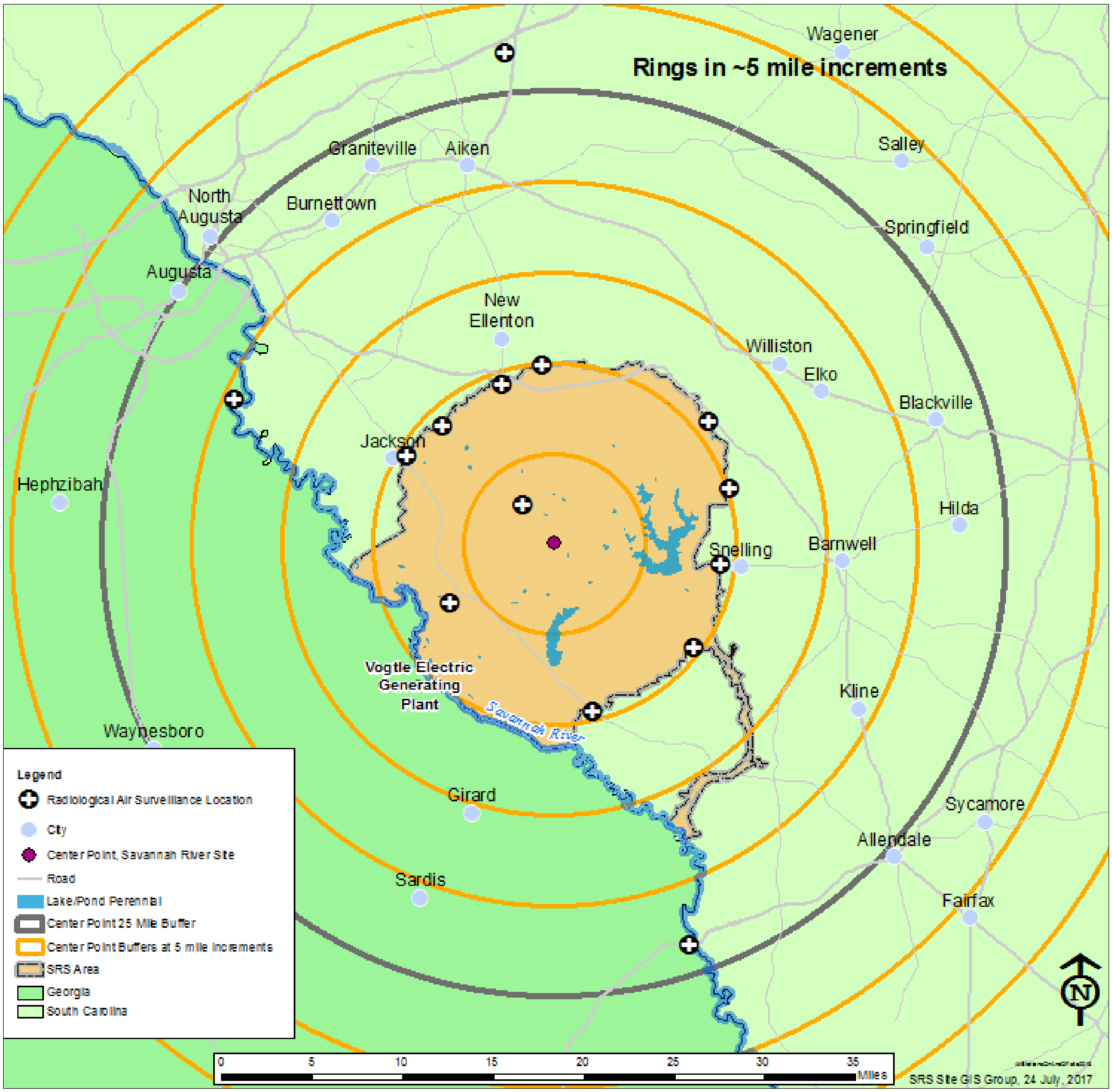


Figure 5-4 Air Sampling Locations Surrounding SRS up to 25 Miles

5.3.3.1 Results Summary

Due the elevated releases at the F-Canyon stack, SRS analyzed additional samples from potentially impacted Site boundary air surveillance stations. Because wind direction will impact the movement of contaminants released to the air, the Site evaluated weather patterns to identify the air surveillance stations that the contaminants potentially impacted. SRS does not typically observe DOE-added actinides, such as plutonium-239 and americium-241, at the air stations. However, results of the additional analyses showed a detectable amount of some actinides, but not at levels that provide any significant dose to the public. The Savannah River National Laboratory (SRNL) performed modeling to investigate, and SRS will continue to monitor the nearby air surveillance station for actinides.

All charcoal canisters analyzed annually for radioiodines and gamma-emitting radionuclides showed no detections of iodine-129 or cobalt-60. However, cesium-137 was detected in 5 out of 28 samples tested. These detections were all near the detection limit. No detections of cesium were observed on the glass fiber filters associated with these samples. Air passes through the glass fiber filter before passing through the charcoal canisters. SRS is investigating sampling methods and equipment that may contribute to these results.

Except for the results discussed above, all other onsite surveillance air sampling media (Table 5-2) were within the trend levels for the previous 10 years. All offsite location results were near the levels observed at the control location at the U.S. Highway 301 Bridge. The composite sample actinide results were within expected levels and the range of historical results of analytes from noncomposited filters.

Appendix Tables D-3 and D-4 summarize tritium results and the comparison to the background control location at the U.S. Highway 301 Bridge. The 2017 results for tritium in air showed detectable levels in 39 of the 364 samples (11%).

The 2017 results for tritium in rainwater showed detectable levels in 15 of the 182 rainwater samples (8%). Concentrations from all locations were below the EPA drinking water standard of 20 pCi/mL. While there are no regulatory standards for tritium in rainwater, SRS uses the EPA drinking water standard as a benchmark. As in previous years, the 2017 values were highest near the center of SRS and decreased with distance from the Site (SRNS 2018). Appendix Table D-4 summarizes the results of tritium in rainwater.

Equipment Setup within Air Monitoring Station

5.3.4 Ambient Gamma Surveillance

Since 1965, SRS has been monitoring ambient (surrounding) environmental gamma exposure rates with thermoluminescent dosimeters (TLDs), which are passive devices that measure the exposure from ionizing radiation. The Site uses data from the TLDs to determine the impact of Site operations on the gamma exposure to the public and the environment and to evaluate trends in exposure levels. Other uses include support of routine and emergency response dose calculations.

An extensive TLD network in and around SRS monitors external ambient gamma exposure rates (Environmental Maps, SRS Thermoluminescent Dosimeter [TLD] Sampling Locations). The SRS ambient gamma radiation-monitoring program has four subprograms: 1) Site perimeter stations, 2) population centers, 3) air surveillance stations, and 4) onsite perimeter stations co-located with Georgia Power's Vogtle Electric Generating Plant's stations. SRS conducts most gamma exposure monitoring onsite and at the SRS perimeter.

SRS monitors offsite in population centers located near the Site boundary, with limited monitoring beyond this distance at the three 25-mile air surveillance stations.

5.3.4.1 Ambient Gamma Results Summary

Ambient gamma exposure rates at all TLD monitoring locations show some variation based on normal location and annual variations in the components of natural ambient gamma radiation exposure levels. In 2017, ambient gamma exposure rates onsite varied between 70.5 mR/yr at location NRC3 (onsite southwest) and 135 mR/yr at the GAP 4L location (onsite south) (SRNS 2018). Rates at population centers ranged from 99.5 mR/yr at the McBean location to 135 mR/yr at the Beech Island location. The annual exposure rate recorded at the NRC2 location (onsite, southwest) was 48.6 mR/yr and at the Windsor location was 71.8 mR/yr.

Consistent with the previous five-year trends, ambient gamma results indicate that no significant difference in average annual dose rates exists between monitoring networks. Ambient dose rates in population centers are slightly elevated compared to the other monitoring networks, as expected, because materials present in buildings and roadways contribute to the natural background radiation.

5.3.5 Soil Surveillance

SRS conducts soil surveillance to provide the following:

- Data for long-term trending of radioactivity deposited from atmospheric fallout (both wet and dry deposition)
- Information on the concentrations of radioactive materials in the environment

In 2017, SRS collected soil samples from 5 onsite locations, 10 Site perimeter locations, and 3 offsite locations (Environmental Maps, *Radiological Soil Sampling Locations*). Radionuclide concentrations in soil vary greatly among locations because of differences in the patterns, retention, and transport of rainfall in different types of soils. Therefore, a direct comparison of year-to-year data could be misleading. However, SRS evaluates the data for long-term trends.

Sampling technicians use hand augers, shovels, or other similar devices to collect soil to a depth of 6 inches. The technicians mix the soil samples to be analyzed to ensure they are homogeneous. SRS analyzes these samples for gamma-emitting radionuclides, strontium-89,90, and actinides including neptunium.

5.3.5.1 Soil Results Summary

Technician Preparing Grassy Vegetation Sample

In 2017, SRS detected radionuclides in soil samples from all 18 sampling locations. The uranium isotopes (U-234, U-235, and U-238) are detected in the soil samples each year. Uranium is naturally occurring in soil and expected to be present in the environment. The concentration range for naturally occurring uranium in soil is typically from about 1 to 5 pCi/g, with an average concentration of 2 pCi/g in soils in the United States. Uranium-238 had a maximum level onsite of 1.49 pCi/g observed near the Burial Ground (sampling location 643-26E-2) and a maximum level offsite at the control location (Highway 301) of 1.75 pCi/g (uranium-238). These levels are within the typical range for soils and are at or below the average concentration in U.S. soils. Concentrations of all detected uranium isotopes are consistent with naturally occurring uranium. Many factors affect the uranium concentration in soil over time. These include the potential of hydrogen (pH) of the soil, the type of soil, and deposits from the air transferred through rainfall. Organic matter and clay minerals provide exchange sites in soil, which can increase the uranium sorption. All measured uranium levels were below the concentration at the control location.

The concentrations of other radionuclides at these locations are consistent with historical results, with maximum cesium-137 concentrations of 0.359 pCi/g found at the D-Area location and 0.0486 pCi/g found at the control location (Highway 301). Appendix Table D-5 summarizes the results.

5.3.6 Grassy Vegetation Surveillance

SRS analyzes grassy vegetation samples at locations onsite and offsite (Environmental Maps, *Radiological Vegetation Sampling Locations*). This information complements the soil and sediment sample results that the Site uses to evaluate the accumulation of radionuclides in the environment and to validate SRS dose models. Vegetation can receive radioactive contamination either externally, when radioactive particles from the air settle on the plant, or internally, when the plant absorbs contaminants in soil and water through its roots. The Site prefers Bermuda grass for surveillance because of its importance as a pasture grass for dairy herds. SRS collects vegetation samples from the following:

- Locations where soil radionuclide concentrations are expected to be higher than normal background levels
- Locations receiving water that has the potential to be contaminated

- All air sampling locations

Vegetation sample analyses consist of tritium, gross alpha, gross beta, gamma-emitting radionuclides, strontium-89,90, technetium-99, and actinides (including neptunium).

5.3.6.1 Grassy Vegetation Results Summary

SRS detected various radionuclides in the grassy vegetation samples collected during 2017 at all locations (1 onsite, 10 at the perimeter, and 3 offsite). Appendix Table D-6 summarizes the results. Results for all radionuclides are within the trends of the previous 10 years.

5.3.7 Terrestrial Food Surveillance

SRS personnel collect terrestrial food products grown and consumed in the communities surrounding the Site, as well as fish and shellfish caught from the Savannah River. They analyze these samples for radionuclides. The results reveal whether radionuclides are present in the environment. Tritium releases from SRS and non-SRS sources are the primary contributors to tritium in food products.

Agricultural products, livestock, and game animals ingested by humans may contain radionuclides. Livestock and game animals may be exposed if the radionuclides are in the air. Radionuclides in the air can deposit on grass, which can then be eaten by the animals. If humans consume the meat of these exposed animals, they become exposed to radiation. Dairy cows are also livestock of concern to SRS because they produce milk that we consume, leading to a potential radiation exposure. SRS samples milk, meat, fruit, nuts, and green vegetables based on the potential to transport radionuclides to humans through the food chain.

Local gardens, farms, and dairies are the source of the terrestrial food products. SRS collects beef, watermelon, and greens annually. Site personnel also collect a variety of vegetables, grains, and nuts on a rotational schedule, resulting in two specific crops being collected each year. Once a quarter, the Site collects milk samples. Food product samples come from each of the four quadrants surrounding SRS and extending up to 10 miles from the Site boundary. Additionally, SRS collects a control sample to the southeast at a distance between 10 miles and 25 miles from the Site boundary.

5.3.7.1 Terrestrial Food Results Summary

In 2017, SRS sampled the milk and the following terrestrial foodstuffs: greens, watermelons, beef, peanuts, and soybeans. All food types were collected from all four quadrants and the control area. Laboratory analysis of the food samples included gamma-emitting radionuclides; tritium, strontium-89,90; technetium-99; gross alpha; gross beta; and actinides, including neptunium. Laboratory analysis of the dairy samples included gamma-emitting radionuclides, tritium, and strontium-90. The analytical results of the terrestrial foodstuffs and milk are consistent with 10-year trends. Results for most foodstuffs (81% for terrestrial foodstuffs and 98% for dairy) did not detect radionuclides.

Appendix Tables D-7 and D-8 summarize the foodstuffs and dairy results. The detectable results are near the laboratory sample quantitation limits.

5.4 WATER PATHWAY

The media presented in this section support the water pathway dose assessment discussed in Chapter 6, *Radiological Dose Assessment.* The Environmental Maps, *Stream Systems,* identifies SRS stream systems included in the pathway.

5.4.1 Liquid Effluents Monitoring Program

SRS routinely samples, analyzes for radionuclides, and monitors flow at each liquid effluent discharge point that releases, or has potential to release, radioactive materials. Figure 5-5 shows the effluent sampling points near SRS facilities.

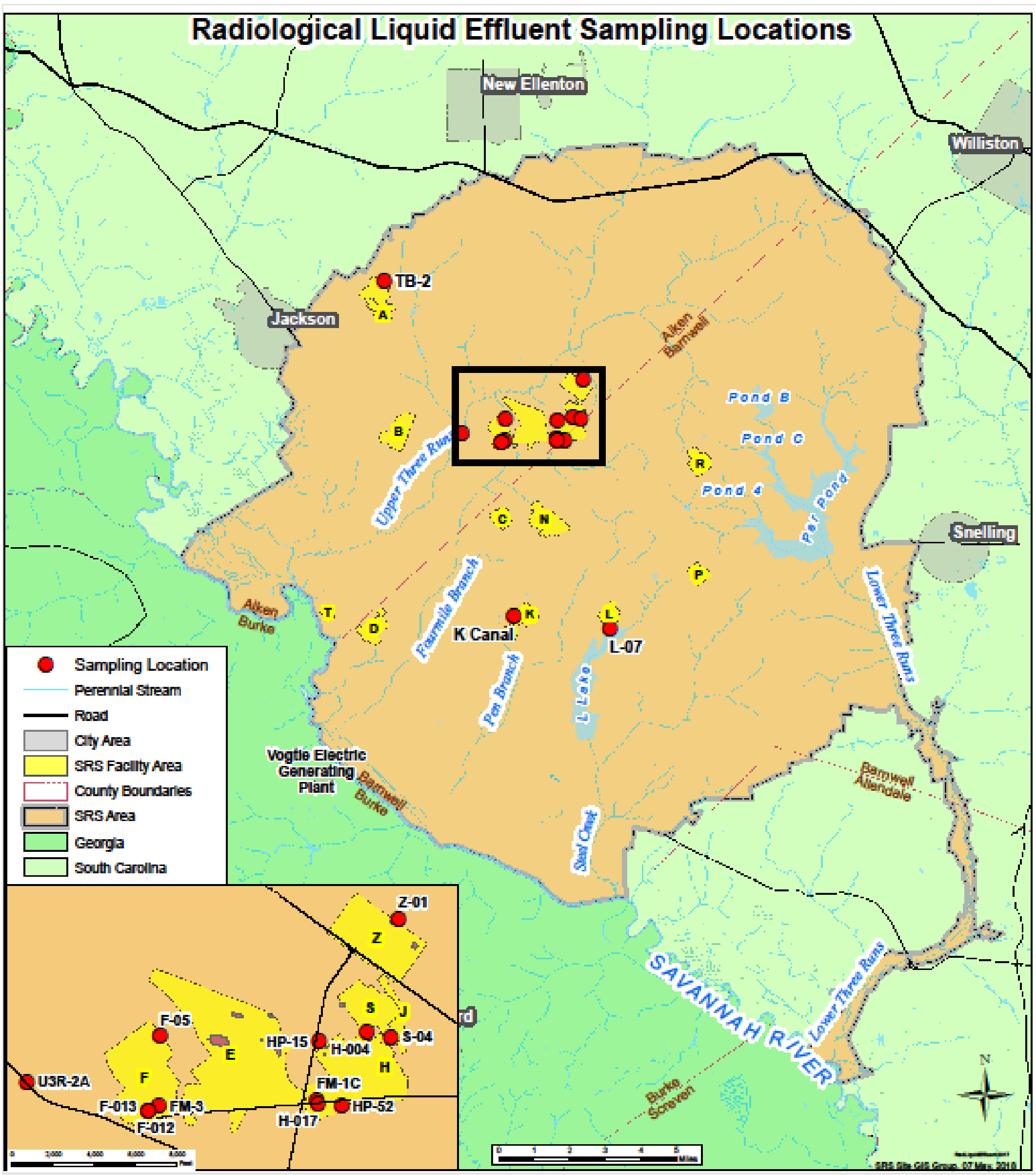


Figure 5-5 Radiological Liquid Effluent Sampling Locations

5.4.1.1 Liquid Effluent Results Summary

Appendix Table D-9 provides SRS liquid radionuclide releases for 2017 to include direct releases plus the shallow groundwater migration of radioactivity from SRS seepage basins and the Solid Waste Disposal Facility (SWDF). Table 5-4 provides a summary. The total amount of tritium released directly from process areas to SRS streams during 2017 was 64.9 Ci. This is a slight decrease from the 68.1 Ci released in 2016. Figure 5-6 presents the tritium released by potential source area and shows that the total direct release of tritium has had a general decreasing trend over the last 10 years.

The DCS sum of the fractions for all locations was less than 1.00. Appendix Table D-10 summarizes the 2017 liquid effluent sum of the fractions and radionuclides monitored for each outfall or facility. The raw data includes the specific radionuclide average concentrations and associated DOE DCS for each monitored facility and outfall (SRNS 2018).

Table 5-4 SRS Liquid Effluent Releases of Radioactive Material for CY 2017 (measured in curies)

Release Type	Totals (in Curies)
Tritium	4.94E+02
Fission and Activation Products ($T_{1/2} > 3$ hr)[a,b]	3.18E-02
Total Radioiodine[c]	2.18E-02
Total Radio-strontium[d]	7.63E-02
Total Uranium	7.21E-02
Plutonium[e]	2.70E-03
Other Actinides	5.83E-03
Other	7.27E-04

Notes:

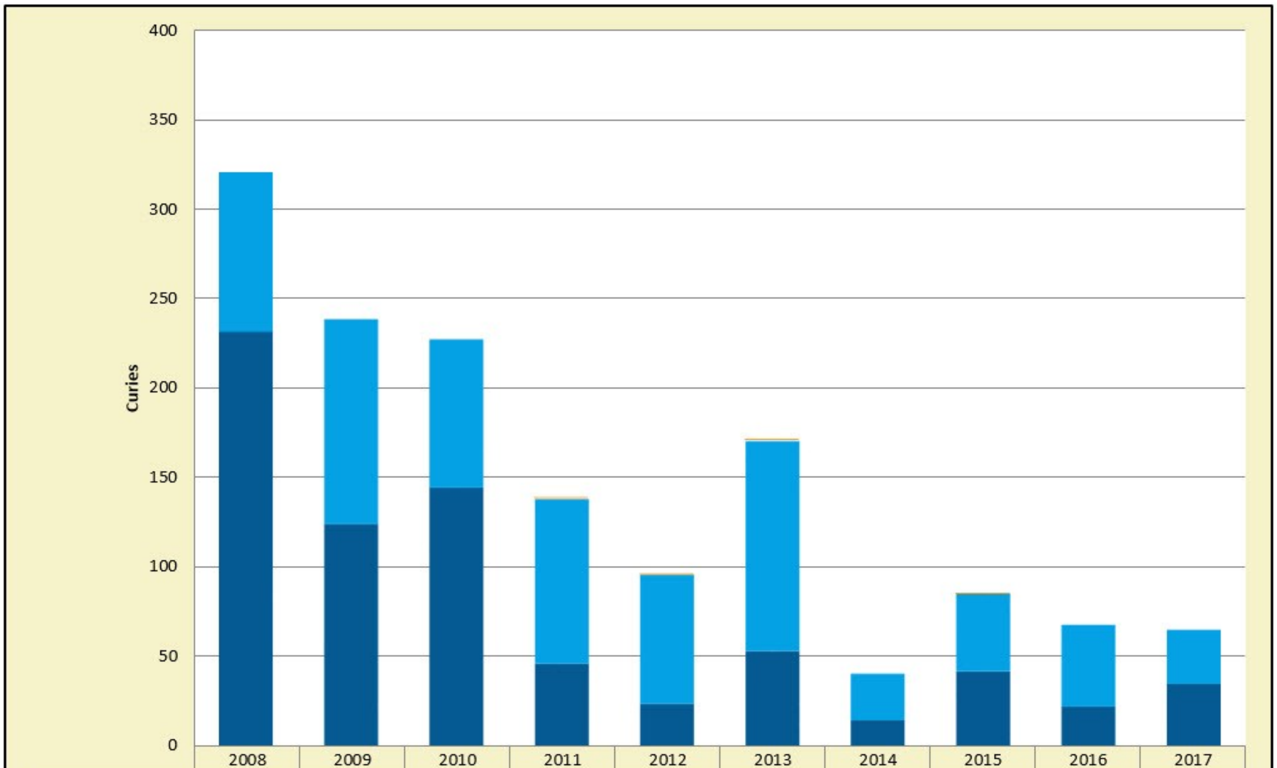
[a] International Commission on Radiological Protection (ICRP) 107 Half-life data, *Nuclear Decay Data for Dosimetric Calculations (2008)*

[b] International Atomic Energy Agency (IAEA) Common Fission and Activation Products

[c] Includes iodine-129

[d] Includes unidentified beta releases

[e] Includes unidentified alpha releases



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
SRNL	0	0	0	0.28	0.21	0.12	0	0	0	0.0
Reactor Areas	89	114	83	91.5	71.6	116.8	26.1	43.8	45.2	29.9
Separations Areas	231	124	144	46.5	24.1	53.3	14.5	41.8	22.9	35

Notes:

1. The SRNL contribution to direct releases is minimal; thus, it is not visible on this figure.
2. Tritium releases from the separations areas comprise the combination of releases from the separations, waste management, and tritium processing facilities.

Figure 5-6 10-Year History of Direct Releases of Tritium to SRS Streams

5.4.2 Stormwater Basin Surveillance

SRS samples the accumulated stormwater in the Site's stormwater basins (Figure 5-7) for gross alpha, gross beta, tritium, strontium, technetium, gamma-emitting radionuclides, and carbon. With no active processes discharging to SRS's stormwater basins, the accumulations in these basins are mainly stormwater runoff. SRS selects the specific radionuclides for monitoring based on the operational history of each basin. The E-Area basins receive stormwater from the SWDF, E-Area Vault, and stormwater from the controlled clean-soil pit on the east side of E Area. F-Area Pond 400 receives stormwater from F Area and the Mixed Oxide Fuel Fabrication Facility. Z-Area Stormwater Basin receives stormwater from Z Area (Saltstone processing and disposal facilities). Stormwater basins release to monitored outfalls during heavy rainfall.

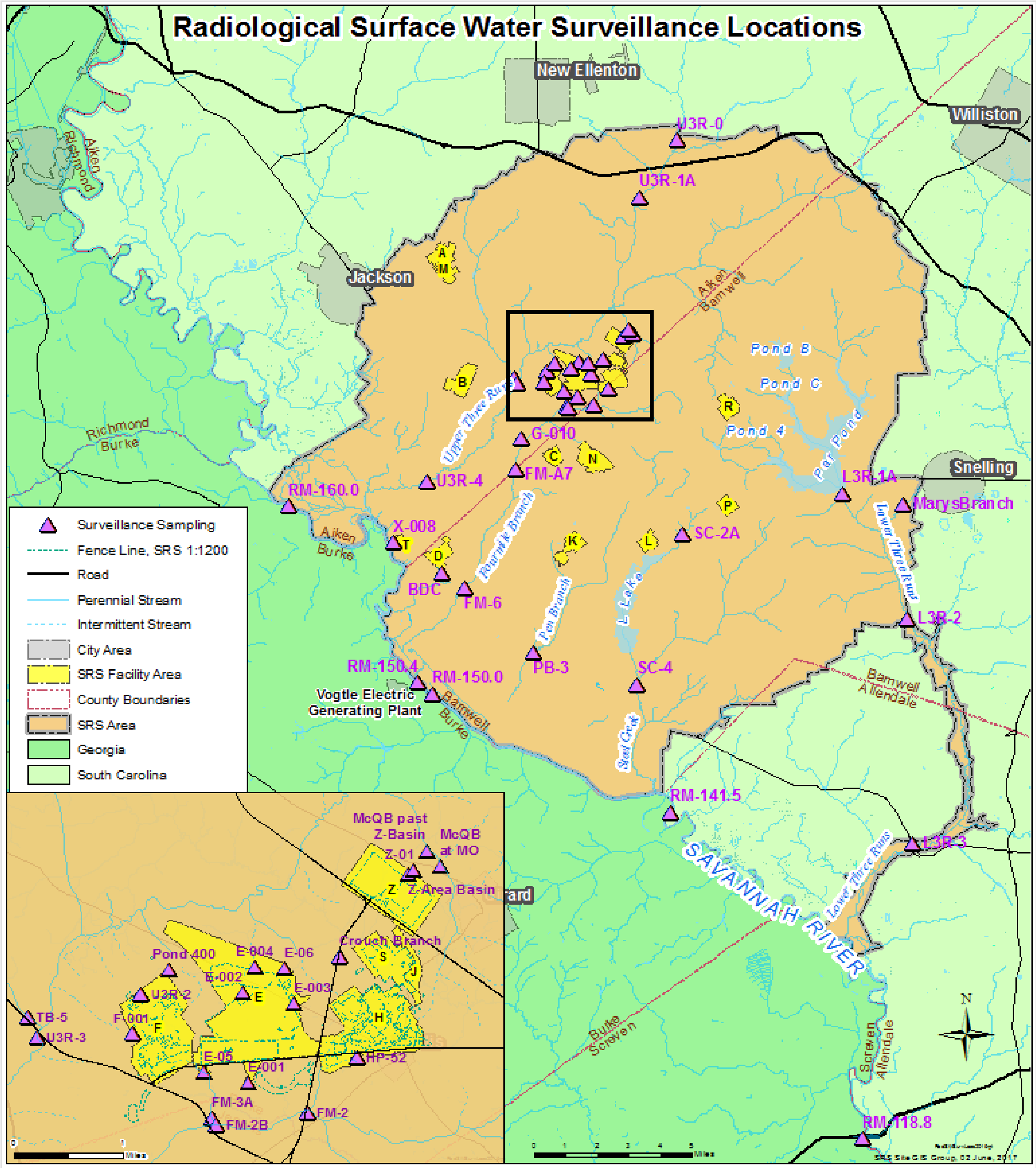


Figure 5-7 Radiological Surface Water Sampling Locations

5.4.2.1 Stormwater Basin Results Summary

In 2017, SRS sampled at five E-Area basins, as well as at the Z-Area Stormwater Basin and F-Area Pond 400. Table 5-5 summarizes gross alpha, beta, and tritium results for stormwater basins, which SRS sampled in the following locations: E-001, E-002, E-003, E-004, E-005, Pond 400, and Z Basin. The highest tritium concentration, 18,400 pCi/L, was observed at the E-002 Basin, which is consistent with the previous five years of results.

Table 5-5 Radionuclide Concentrations Summary for Stormwater Basins (pCi/L)

Basin Location	Average Gross Alpha	Average Gross Beta	Average Tritium	Maximum Tritium
E-001	0.289	2.55	2,990	4,510
E-002	0.245	3.22	9,480	18,400
E-003	0.462	2.91	6,580	10,600
E-004	0.351	1.89	6,300	10,800
E-005	0.808	3.09	5,580	7,920
Pond 400	0.790	5.04	199	478
Z-Basin	0.367	107	745	1,740

5.4.3 SRS Stream Sampling and Monitoring

SRS continuously samples SRS streams downstream of several process areas to detect and quantify levels of radioactivity that effluents and shallow groundwater migration transport to the Savannah River. The five primary streams that deposit into the Savannah River are Upper Three Runs, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs. SRS monitors and quantifies radioactivity migration from SRS seepage basins and the SWDF as part of its stream surveillance program. Seepage basins include the General Separations Area (F and H Area) Seepage Basins and the K-Area Seepage Basin, which have been closed. SRS closed the F-Area and H-Area Seepage Basins in 1991, and the K-Area Seepage Basin in 2002. Radioactivity previously deposited in the F-Area and H-Area Seepage Basins and SWDF in E Area continues to migrate through the groundwater and enter Fourmile Branch (also known as Four Mile Creek) and Upper Three Runs. Groundwater migration from the F-Area Seepage Basins enters Fourmile Branch where there are three monitoring locations (FM-3A, FM-2B, and FM-A7) along the stream. Groundwater migration from the H-Area Seepage Basins enters Fourmile Branch, where two monitoring stations (FM-2B and FM 3-A) are located, and from SWDF, where the FM 3-A monitoring station is located. Groundwater from K-Area Seepage Basin migrates into Pen Branch.

Figure 5-7 displays the radiological surface water sampling locations. The sampling frequency and types of analyses are dependent on the upstream discharges and groundwater migration history of radionuclides.

5.4.3.1 SRS Stream Results Summary

Table 5-6 presents the average 2017 concentrations of gross alpha, gross beta, and tritium in SRS streams. These stream locations represent the last monitoring location for the respective tributary before discharging into the Savannah River. SRS found detectable concentrations of tritium at least once at all stream locations except the control location (U3R-0), which had no detected tritium. The 10-year trend for the average tritium levels in the streams shows a decrease, which is due to a combination of decreases in Site releases and the natural decay of tritium. Figure 5-8 indicates that average tritium levels in Fourmile Branch are trending closer to the EPA standard of 20 pCi/mL, although onsite streams are not a direct source of drinking water. In the surveillance program, the EPA standard is used as a benchmark for

Table 5-6 Radionuclide Concentrations in SRS Streams by Location

Location	Average Alpha (pCi/L)	Average Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
Onsite Stream Locations				
Tims Branch (TB-5)	4.53	2.39	159	565
Lower Three Runs (L3R-3)	3.13	3.09	527	835
Steel Creek (SC-4)	1.17	1.59	1,620	1,980
Pen Branch (PB-3)	0.431	0.923	13,000	17,900
Fourmile Branch (FM-6)	3.39	6.51	27,300	34,600
Upper Three Runs (U3R-4)	6.11	3.52	495	1,010
Onsite Control Locations (for comparison)				
Upper Three Runs (U3R-0)	4.42	2.68	ND	ND

Note:
ND = nondetect

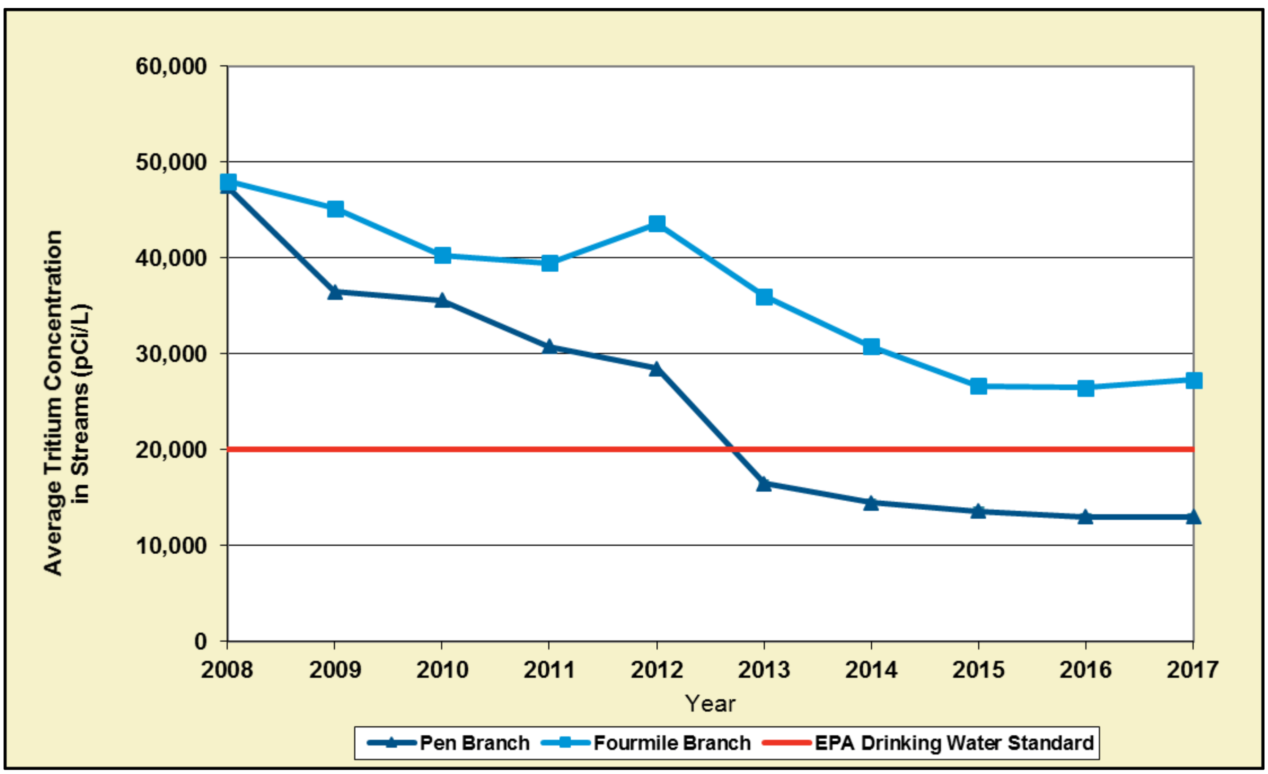


Figure 5-8 10-Year Trend of Tritium in Pen Branch and Fourmile Branch (pCi/L)

comparing stream surface water results. Tritium levels are higher in Fourmile Branch compared to the other streams due to shallow groundwater migration from the historical seepage basins and SWDF. SRS has taken active measures to reduce this migration. Section 7.3.3, *Remediating SRS Groundwater,* presents additional information on the groundwater remediation efforts to reduce tritium to Fourmile Branch.

Figure 5-9 presents a graphical representation of releases of tritium via migration to Site streams from 2008 through 2017. As seen in the figure, migration releases of tritium generally have declined over the past 10 years, with year-to-year variability caused mainly by the amount of annual rainfall. During 2017, the total quantity of tritium migrating from SRS seepage basins and SWDF into SRS streams was 429 Ci, compared to 600 Ci in 2016, which represents a greater than 28% decrease. The 10-year trend displays a decrease in tritium migration.

Of the 429 Ci of tritium migrating into SRS streams, 263 Ci (61%) was measured in Fourmile Branch. Migration releases of other radionuclides vary from year-to-year but have remained below 0.1 Ci the past 10 years. Sampling in Pen Branch measures the tritium migration from the K-Area Seepage Basin and the percolation field below the K-Area Retention Basin. It is estimated that 138 Ci migrated in 2017, which represents a greater than 29% decrease compared to 195 Ci in 2016. Stream transport accounts for tritium migration releases from C-Area, L-Area, and P-Area Disassembly Basins (see Section 5.4.5 *Tritium Transport in Streams and Savannah River Surveillance,* in this chapter).

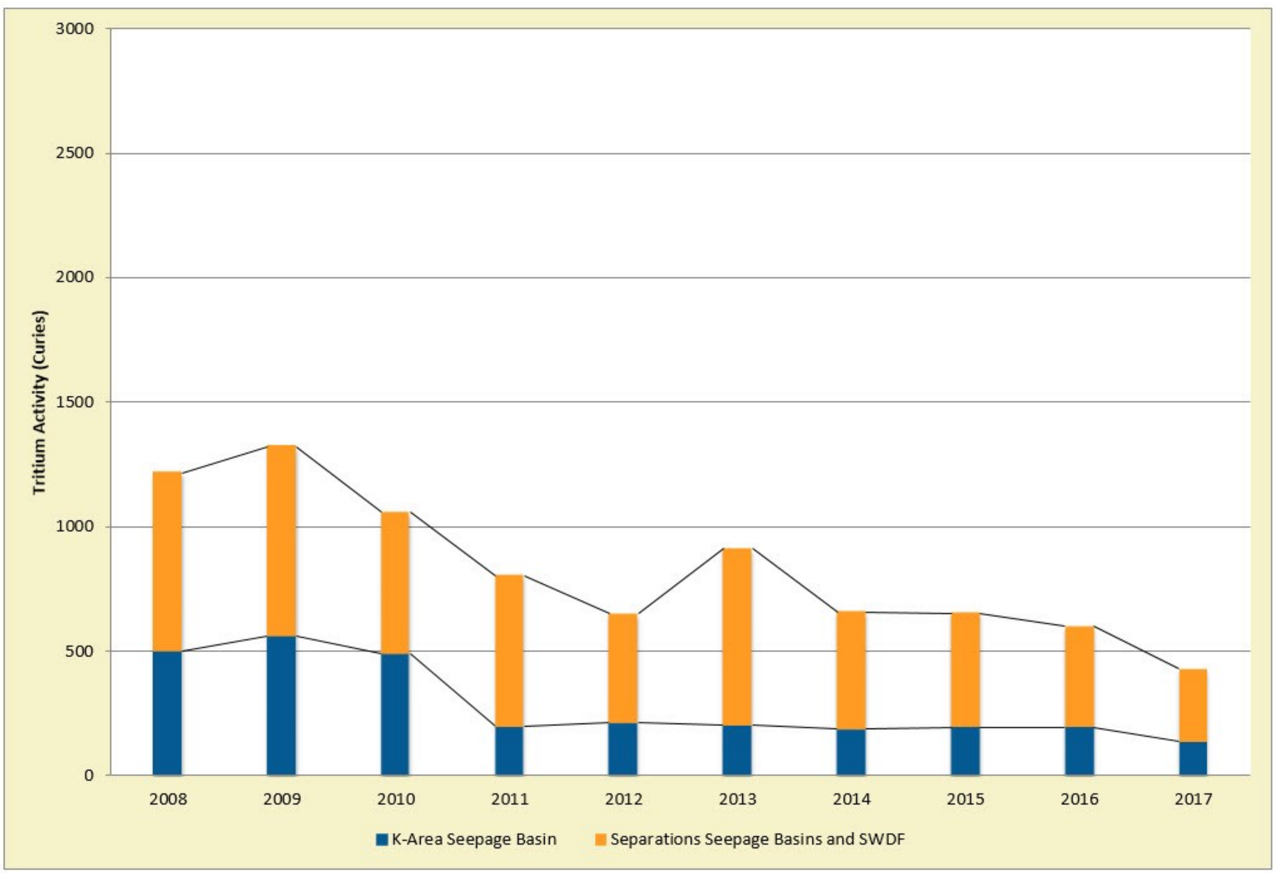


Figure 5-9 Tritium Migration from SRS Seepage Basins and SWDF to SRS Streams

SRS measures gross alpha concentrations in Site streams. If the results for any of the major stream locations, shown in Table 5-6, are greater than the EPA screening level, of 15 pCi/L gross alpha, then SRS measures for alpha-specific isotopes, such as the actinides. U3R-4 is the only major stream that measured greater than the EPA screening level, at 22.0 pCi/L. Actinide results for this sample showed detectable concentrations of U-234, U-235, and U-238, at background concentrations. For annual shallow groundwater migration reporting, alpha-specific isotopes are also measured annually for most stream locations. The alpha-specific isotopic (Pu-238, Pu-239, Am-241, Cm-244, Np-237, U-234, U-235, and U-238) results for 2017 showed no elevated levels and are consistent with historical measurements.

5.4.4 Savannah River Sampling and Monitoring

SRS conducts continuous sampling along the Savannah River at locations above and below SRS streams, including at a location where liquid discharges from Vogtle Electric Generating Plant (VEGP) enter the river.

Five locations (Figure 5-7) along the river continued to serve as environmental surveillance points in 2017. SRS collects samples at these river locations and analyzes them for gross alpha, gross beta, tritium, strontium, technetium, actinides, and gamma-emitting radionuclides.

5.4.4.1 Savannah River Results Summary

Table 5-7 lists the average 2017 concentrations of gross alpha, gross beta, and tritium and the maximum 2017 concentrations of tritium at river locations. The tritium concentration levels are well below the EPA drinking water standard of 20 pCi/mL.

Table 5-7 Radionuclide Concentrations in the Savannah River

Location	Average Gross Alpha (pCi/L)	Average Gross Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
RM-160 (CONTROL)	0.135	2.05	97.1	263
RM-150.4 (VEGP)	0.170	2.03	1,120	6,220
RM-150	0.159	1.96	339	514
RM-141.5	0.175	1.99	604	2,020
RM-118.8	0.175	1.91	566	1,930

Tritium is the predominant radionuclide detected above background levels in the Savannah River. The combined SRS, VEGP, and Barnwell Low-Level Disposal Facility (BLLDF) tritium estimates based on concentration results at Savannah River RM 141.5 and average flow rates at RM 118.8 were 2,893 Ci in 2017 compared to 1,698 Ci in 2016 at RM 118.8. This increase was due to increased releases from VEGP. Total releases from VEGP were 2,337 Ci in 2017 compared to 992 Ci in 2016, which represents an increase of greater than 135%. An unplanned outage occurred on February 3 on Vogtle Unit 1 at VEGP. Also, there were two planned refueling outages at VEGP, with Unit 1's refueling occurring in March, and Unit 2's refueling occurring in September. In addition to the weekly samples collected for tritium, gross alpha, gross beta, and gamma analyses, SRS collects samples annually for strontium-89,90, technetium-99, and actinides analyses to provide a more comprehensive suite of radionuclides. The *2017 Environmental*

Monitoring Program Data Report (SRNS 2018) provides the analytical results. Average radionuclide concentrations are consistent with the results from the previous 10 years.

5.4.5 Tritium Transport in Streams and Savannah River Surveillance

Due to the mobility of tritium in water and the amount released over the course of more than 60 years of SRS operations, SRS monitors and compares the amount of tritium measured at various onsite stream sampling locations to that found at the Savannah River sampling locations. The comparison uses the following methods of calculation:

- Direct releases measured at the source—Total direct tritium releases, including releases from facility effluent discharges and measured shallow groundwater migration of tritium from SRS seepage basins and SWDF
- Stream transport, which measures the amount of tritium leaving the Site—Tritium transport in SRS streams, measured at the last sampling point before entry into the Savannah River
- River transport—Tritium transport in the Savannah River, measured downriver of SRS (near RM 141.5) after subtracting any measured contribution above SRS

The methods SRS uses for estimating releases are based on environmental data reporting guidance described in *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015). General agreement between the three calculation methods of annual tritium transport—measurements at the source plus any measured migration, stream transport, and river transport—validates both that SRS is sampling at the appropriate locations and the accuracy of analytical results.

5.4.5.1 Tritium Transport in Streams and Savannah River Results Summary

In 2017, tritium levels in streams showed a slight decrease, while river transport showed a large increase, specifically as described below:

- The direct releases of tritium decreased by 26% (from 668 Ci in 2016 to 494 Ci).
- The stream transport of tritium decreased by 33% (from 731 Ci in 2016 to 563 Ci).
- The river transport of tritium increased by greater than 70% (from 1,698 Ci in 2016 to 2,893 Ci). VEGP, BLLDF, and SRS contributed to these values. 45 Ci is attributed to the BLLDF. 2,337 Ci is attributed to VEGP.

SRS attributes the decreases in direct releases and stream transport observed from 2016 to a decrease in shallow groundwater migration and a decrease in direct releases to Upper Three Runs from the Effluent Treatment Facility. The increase for river transport from 2016 to 2017 is attributable to increases from VEGP, as discussed in Section 5.4.4, *Savannah River Sampling and Monitoring*.

SRS tritium transport data from 1960–2017 (Figure 5-10), shows the history of direct releases, stream transport, and river transports. The general trend over time is attributable to the following:

- Variations in tritium production and processing at SRS
- Implementing effluent controls beginning in the early 1960s
- SRS tritium inventory continuing to deplete and decay

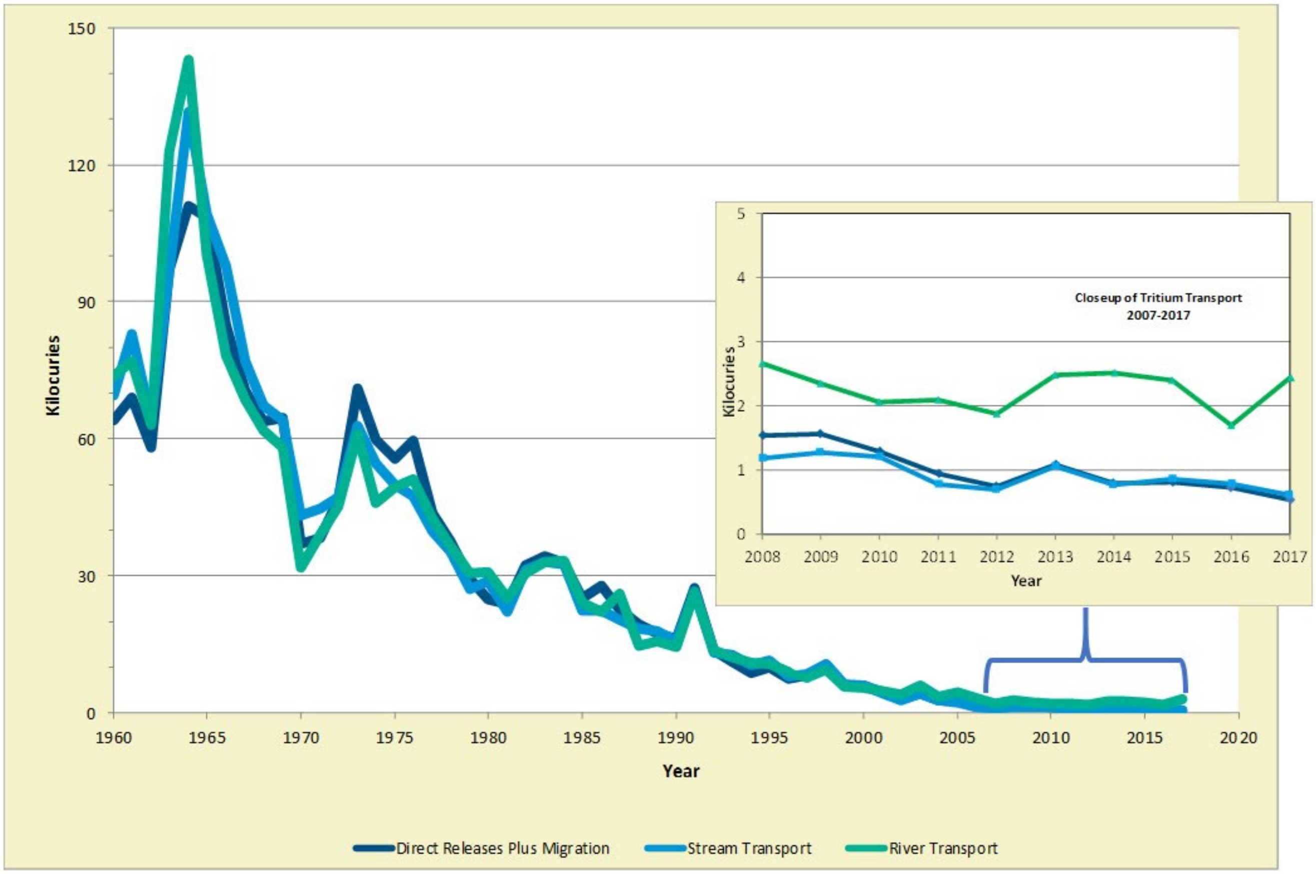


Figure 5-10 SRS Tritium Transport Summary

Within the past 10 years, SRS has detected a measurable amount of tritium migrating from a non-SRS source, the BLLDF, which Energy*Solutions*, LLC operates. The tritium continues to enter the SRS stream system at Mary's Branch, which deposits into Lower Three Runs. The facility is privately owned and adjacent to SRS. The tritium currently in groundwater will continue to decay and dilute as it moves from the source toward Lower Three Runs. In 2014, SRS started monitoring at Mary's Branch, which is near BLLDF, to account for the tritium BLLDF contributes. SRS estimated the amount of tritium from BLLDF during 2017 to be 45 Ci, which was not included in SRS direct release or stream transport totals.

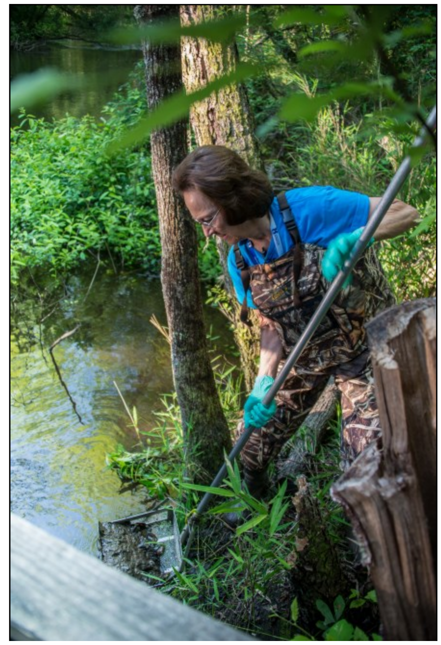
For compliance dose calculations, the value of SRS direct releases and of the stream transport measurements (which was 563 Ci from stream transport measurements in 2017) are used (see Chapter 6, *Radiological Dose Assessment*).

5.4.6 Settleable Solids Surveillance

Settleable solids are solids in water that are heavy enough to sink to the bottom of the collection container. SRS evaluates settleable solids in water to determine, in conjunction with routine sediment monitoring, whether a long-term buildup of radioactive materials occurs in stream systems. Accurately measuring radioactivity levels in settleable solids is impractical in water samples with low total suspended solids (TSS). SRS monitors for TSS as part of the routine National Pollutant Discharge Elimination System (NPDES) monitoring program from outfalls colocated at or near several radiological effluent points. In 1995, DOE interpreted the radioactivity levels in settleable solids requirement. The interpretation indicated that TSS levels below 40 parts per million were considered to comply with the DOE limits. If TSS results are at or above 40 parts per million for TSS at the NPDES outfall that are colocated at or near radiological effluent points, samples are analyzed for alpha-emitting and beta/gamma-emitting radionuclides or additional samples may be collected and analyzed. The DOE limits for the radioactivity levels in settleable solids are 5 pCi/g above background for alpha-emitting radionuclides and 50 pCi/g above background for beta/gamma-emitting radionuclides.

5.4.6.1 Settleable Solids Results Summary

In 2017, all NPDES TSS sample results that are colocated at or near radiological effluent points were well below 40 parts per million with no result higher than 8 parts per million. The NPDES TSS results indicate that SRS remains in compliance with DOE's requirement related to radioactivity levels in settleable solids.



Field Technician Collecting Sediment Sample from a Stream on SRS

5.4.7 Sediment Sampling

In 1996, SRS incorporated the settleable solids program into the radiological environmental surveillance program for sediments to provide a more reliable and cost-effective method to determine radioactivity buildup in sediments. SRS added eight sample sites to the sediment program to compensate for the loss of the settleable solids sampling program.

Sediment sample analysis measures the movement, deposition, and accumulation of long-lived radionuclides in streambeds and in the Savannah River bed. Year-to-year differences may be evident because sediment is continuously moved and deposited at different locations in the stream and riverbeds (or because of slight variations in sampling locations), but the data obtained can be used to observe long-term environmental trends. In 2016, SRS implemented a composite sediment sampling strategy based on recommendations from the University of Georgia Savannah River Ecology Laboratory report *Technical Assessment of DOE Savannah River Site-Sponsored Radionuclide Monitoring Efforts in the Central Savannah River Area* (SREL 2014).

In 2017, SRS collected sediment samples at 12 Savannah River locations, 8 basin or pond locations, and 23 onsite streams or swamp discharge locations (Environmental Maps, *Radiological Sediment Sampling Locations*).

5.4.7.1 Sediment Results Summary

Appendix Table D-11 shows the maximum of each radionuclide compared to the applicable SRS control location. The Z-Area Stormwater Basin, a posted Soil Contamination Area, had the maximum cesium-137 concentration of 2,000 pCi/g. Soil Contamination Areas at SRS are locations where the contamination levels exceed 150 pCi/g for beta and gamma radionuclides. The lowest levels of cesium-137 in river, stream, and basin sediments were below detection. Table 5-8 shows the maximum sediment concentrations.

Table 5-8 Maximum Cesium-137 Concentration in Sediments Collected in 2017

Location	Maximum Location	Maximum Concentration (pCi/g)
Savannah River Sediment	RM-150.2 below Four Mile Creek	1.05E+00
SRS Stream Sediment	R-Area (Downstream of R-1)	2.96E+01
SRS Basin Sediment	Z-Basin	2.00E+03

The levels in SRS streams show a decreasing trend, which is due to a combination of decreases in Site releases and the natural decay of radionuclides. Results indicate the radioactive materials from effluent release points are not building up in the sediment at the sampling locations.

5.4.8 Drinking Water Monitoring

SRS collects drinking water samples from 10 locations at SRS and at 2 water treatment facilities that use water from the Savannah River as a source of drinking water (Environmental Maps, *Domestic Water Systems*).

Onsite drinking water sampling consists of samples from the large treatment plant in A Area and samples at four wells and five small systems.

SRS monitors potable water at offsite treatment facilities to ensure that SRS operations do not adversely affect the water supply and to assure that drinking water does not exceed EPA drinking water standards for radionuclides. SRS collects samples offsite from the following two locations (Figure 5-11):

- Beaufort-Jasper Water and Sewer Authority's (BJWSA) Purrysburg Water Treatment Plant (WTP)
- North Augusta (South Carolina) WTP

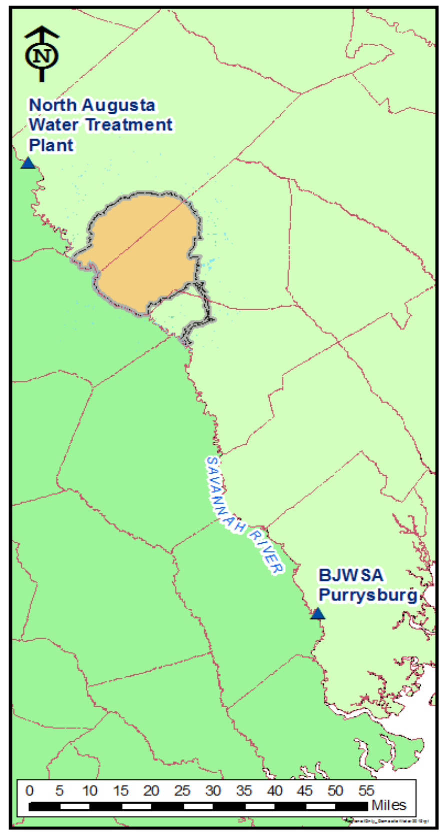


Figure 5-11 Offsite Drinking Water Sampling Locations

SRS collects treated water from these two WTPs, which supply water to the public. The North Augusta WTP samples determine concentrations in drinking water upstream of SRS. The BJWSA Purrysburg WTP is the furthest downriver sampling location. SRS compares these locations to evaluate potential impacts from upstream sources that include SRS.

5.4.8.1 Drinking Water Results Summary

In 2017, SRS performed gross alpha and gross beta screening on all onsite and offsite drinking water samples. No results exceeded the EPA's 15 pCi/L alpha concentration limit or 50 pCi/L beta concentration limit. In addition, no onsite or offsite drinking water samples exceeded the 20 pCi/mL EPA

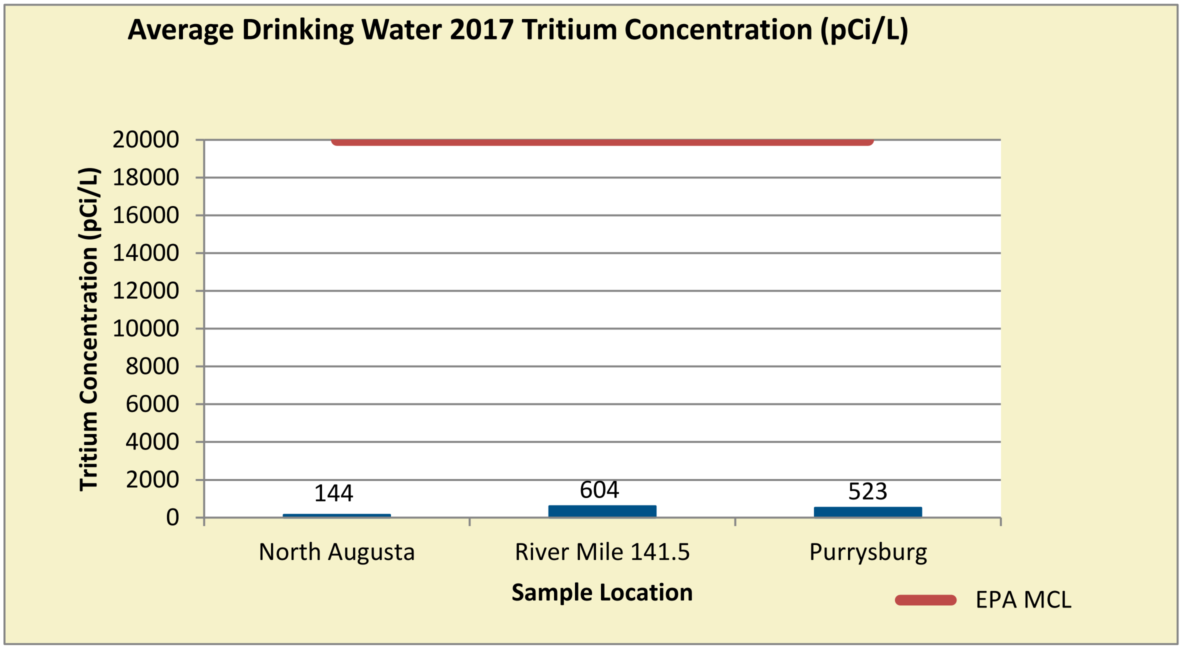


Figure 5-12 Tritium in Offsite Drinking Water and River Mile 141.5

standard for tritium or the 8 pCi/L strontium-89,90 maximum contaminant level.

Figure 5-12 presents the average drinking water tritium concentrations for the local water treatment plants upstream and downstream from SRS in comparison to the average of weekly river water samples collected at RM 141.5. The average tritium concentration at RM 141.5 is approximately 3% of the EPA standard for tritium and decreases further at the downstream sampling location.

Sample results did not detect tritium, cobalt-60, cesium-137, plutonium-238, and curium-244 in onsite drinking water test locations. Sample results indicated detectable levels of americium-241 in 2 onsite samples, plutonium-239 in 1 onsite sample, strontium-89,90 in 1 onsite sample, uranium-234 and uranium-238 in 10 onsite samples, and uranium-235 in 1 onsite sample. Appendix Table D-12 summarizes the results. Concentrations are near the sample quantitation limit for these six analytes. All analytical results are well below the EPA standard.

5.5 AQUATIC FOOD PRODUCTS

5.5.1 Fish Collection in the Savannah River

SRS collects aquatic food from the Savannah River. Freshwater fish come from six locations on the Savannah River from above SRS at Augusta, Georgia, to the Highway 301 bridge (Environmental Maps*, Fish Sampling Locations*). Onsite, SRS collects freshwater fish at the mouth of the streams that traverse the Site. Saltwater fish come from the Savannah River mouth near Savannah, Georgia. Additionally, shellfish come from the Savannah River mouth near Savannah, Georgia, or SRS purchases them from vendors in the Savannah area that harvest from local saltwater that is potentially influenced by waters of the Savannah River. Table 5-9 identifies the aquatic products collected in 2017.

Table 5-9 Aquatic Products Collected by SRS in 2017 for the Radiological Environmental Monitoring Program

Freshwater Fish	Saltwater Fish	Shellfish
Bass	Mullet	Crab
Catfish	Red Drum	Shrimp
Panfish	Sea Trout	

SRS analyzes both edible (meat and skin only) and nonedible (bone) samples of freshwater and saltwater fish. SRS analyzes only the edible portion of shellfish. Beginning in 2017, SRS discontinued tritium analysis in all edible samples. This improvement to the fish sampling program is discussed in section 8.4. Analyses of edible samples of all aquatic species collected include gross alpha, gross beta, gamma-emitting radionuclides (that is cesium-137 and cobalt-60), strontium-89,90, technetium-99, and iodine-129. Strontium-89,90 is the only analysis SRS conducts on the nonedible samples.

5.5.1.1 Fish in Savannah River Results Summary

In 2017, SRS collected freshwater fish from the six locations, saltwater fish and shrimp from the Savannah River mouth, and purchased crabs in the Savannah area from a vendor that harvests from saltwater potentially influenced by Savannah River water. SRS analyzed 54 freshwater fish composites, 9 saltwater fish composites, and 2 shellfish composites. The freshwater and saltwater composites consisted of three to eight fish each. The two shellfish composites consisted of one bushel of crab and one bushel of shrimp, respectively. The analytical results of the freshwater and saltwater fish, and shellfish collected are consistent with results for the previous 10 years. The majority of the results for the specific radionuclides associated with SRS operations were nondetectable (49% for freshwater fish, 98% for saltwater fish, and 72% for shellfish). Table 5-10 lists the maximum concentration for those radionuclides detected in the flesh of all fish types sampled. The table also identifies the fish type and the collection location associated with the maximum concentration for each radionuclide. Cobalt-60 and iodine-129 were not detected in any fish flesh samples. Appendix Tables D-13, D-14, and D-15 for freshwater fish, saltwater fish and shellfish, respectively, summarize results for all fish and shellfish.

Collecting Fish by Netting

The maximum gross alpha result for shellfish was detected at 1.03 pCi/g in crab. This value is greater than the gross alpha trigger level of 0.951 pCi/g, which SRS uses as the basis for additional analyses of alpha-emitting radionuclides. The sample was reanalyzed with a reported value below the gross alpha trigger level. The average of the values was close to the trigger level. Therefore, analysis of alpha-emitting radionuclides was performed for the crab samples. Uranium-234 (U-234), U-235, U-238, and Cm-244 were detected. The uranium is associated with decay of naturally occurring uranium. The Cm-244 result is between the instrument method detection limit and the sample quantitation limit, indicating the amount is very small.

Gross alpha results were below the minimum detectable concentration for all edible saltwater and freshwater fish composites. Gross beta activity was detectable in all freshwater and saltwater fish, as well as shellfish. The concentrations are consistent with results from the previous 10 years and are most likely attributed to the naturally occurring radionuclide potassium-40.

The data from the fish monitoring is included in the determination of the potential dose and risk to the public, as reported in Chapter 6, *Radiological Dose Assessment*.

Table 5-10 Location and Fish Type for the Maximum Detected Concentration of Specific Radionuclides Measured in Flesh Samples

Radionuclide	Maximum Concentration	Location	Fish Type
Cesium-137	0.593 pCi/g	Lower Three Runs Creek river mouth	Catfish
Strontium-89,90	0.00520 pCi/g	Lower Three Runs Creek river mouth	Panfish
Technetium-99	0.0889 pCi/g	Four Mile Creek river mouth	Catfish

5.6 WILDLIFE SURVEILLANCE

The wildlife surveillance program monitors wildlife harvested from SRS and subsequently released to the public. Monitoring assesses any impact of Site operations on the wildlife populations and ensures that the SRS Annual Administrative Game Animal Release Limit of 22 mrem/yr is not exceeded for any individual. Annual game animal hunts for deer, coyote, and feral hogs are open to members of the public. During 2017, SRS held one turkey hunt for Wounded Warriors and residents with mobility impairments in the spring and 11 game animal hunts in the fall. The Site holds the annual hunts to reduce animal-vehicle collisions and control Site deer, coyote, and feral hog populations.

SRS monitors all animals harvested during the annual hunts to ensure the total dose to any hunter is below the SRS 22 mrem/yr limit. SRS uses portable sodium iodide detectors to perform field analyses for cesium-137. SRS fully implemented the field monitoring equipment that was developed and field verified in 2016.

SRS uses the cesium-137 concentration detected in the edible flesh of the animal to calculate dose. The edible flesh is that portion of the animal that is consumed.

SRS Personnel Calibrate the Wildlife Monitoring System

A dose is assigned to each hunter for every animal harvested if the cesium-137 concentration is above the background concentration of 2.59 picocurie per gram (pCi/g). In addition to the field monitoring, SRS collects samples of muscle for laboratory analysis of cesium-137 concentrations in both deer and hogs based on the following: 1) a set frequency, 2) the field measured cesium-137 levels, or 3) exposure limit considerations. These laboratory-analyzed data provide a quality-control check on the field monitoring results. Cesium-137 is chemically similar to and behaves like potassium in the environment. Cesium-137 has a half-life of about 30 years and tends to persist in soil, where it can readily enter the food chain through plants. It is widely distributed throughout the world from nuclear weapons detonations from 1945 to 1980 and is present at low levels in all environmental media. Flesh sample laboratory analyses also include cobalt-60, strontium-89,90, gross alpha, and gross beta. Bone samples are collected on the same frequency as the flesh samples and are analyzed in the laboratory for strontium-89,90.

5.6.1 Wildlife Results Summary

During the hunts in 2017, SRS monitored a total of 267 deer, 96 feral hogs, 13 coyotes, and 26 turkeys. No dose was assigned to any hunter during 2 of the 11 game animals hunts, as well as the turkey hunt. This indicates that all animals harvested during those hunts were at or below the background cesium-137 concentration of 2.59 pCi/g (Aucott et al., 2017). All animals harvested during the 2017 hunts were below the administrative game animal release limit of 22 mrem. SRS released all animals to the hunters; however, hunters chose not to keep 12 coyotes and 2 hogs.

Appendix Table D-16 summarizes the muscle and bone sample results from a subset of the monitored deer and hogs. As seen in previous years, laboratory analysis detected cesium-137, a man-made gamma-emitting radionuclide, in muscle tissue. Laboratory analysis detected strontium-89,90, a beta-emitting radionuclide, in bone and in some muscle tissue.

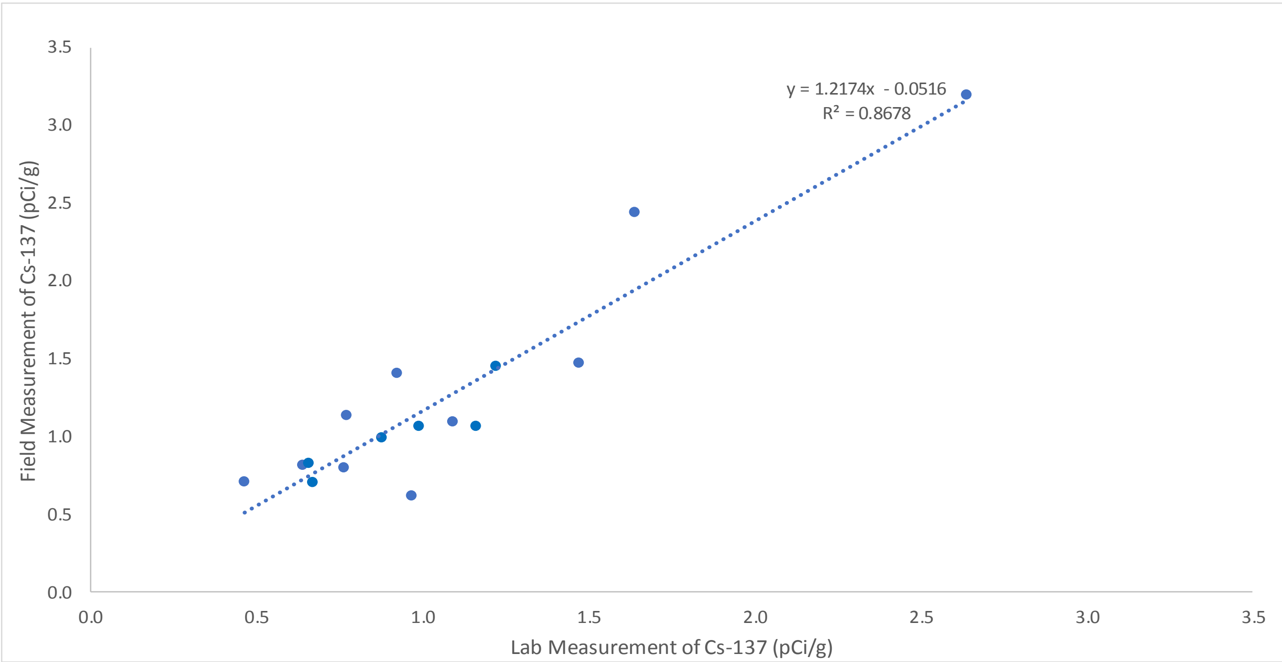
Generally, the cesium-137 concentration field detectors measure is similar to that of laboratory methods. Figure 5-13 compares the 2017 field versus laboratory measurement for each muscle sample collected. Table 5-11 summarizes all field and laboratory measurements. Average cesium-137 concentrations in deer have indicated an overall decreasing trend for the past 50 years, with relatively little change in the last 10 years. Figure 5-14 shows the historical trend analysis.

Because its chemistry is similar to that of calcium, strontium exists at higher concentration in bone than in muscle tissue. In 2017, all 40 deer bone and 11 hog bone samples had detectable levels of strontium-89,90. Strontium-89,90 was detected in deer bone with an average of 1.14 pCi/g and a maximum of 7.03 pCi/g. Strontium-89,90 was detected in hog bone with an average of 1.00 pCi/g and a maximum of 3.81 pCi/g.

For the deer muscle tissue samples, 4 out of the 40 muscle tissue samples had levels greater than the minimum detectable concentration for strontium-89,90 with a maximum concentration of 0.018 pCi/g. These average results are similar to those of previous years.

All cobalt-60 results were not detectable. Two of 40 gross alpha results had levels greater than the minimum detectable concentration, with a maximum concentration of 0.141 pCi/g. Gross beta activity, detected in all samples, is consistent with 2012 through 2016 results.

Chapter 6, *Radiological Dose Assessment,* presents the calculation of dose from consuming wildlife harvested on SRS.



Note: Data points represent those samples where the field measurement was above the detection limit.

Figure 5-13 Comparison of Cesium-137 Field Measurements to Laboratory Analyses for Deer Muscle Samples

Table 5-11 Cesium-137 Results for Laboratory and Field Measurements in Wildlife

	Number of Animals Field Monitored	Field Gross Average Cs-137 Conc. (pCi/g)	Field Maximum Cs-137 Conc. (pCi/g)	Number of Samples Collected for Laboratory Analysis	Number of Detected Results	Lab Average Cs-137 Conc. (pCi/g)	Lab Maximum Cs-137 Conc. (pCi/g)
Deer	267	0.95	5.48	40	40	0.698	2.64
Hog	96	2.00	6.28	11	11	1.76	4.92
Coyote	13	2.73	5.96	-----	-----	-----	-----
Turkey	26	0.62	0.752	-----	-----	-----	-----

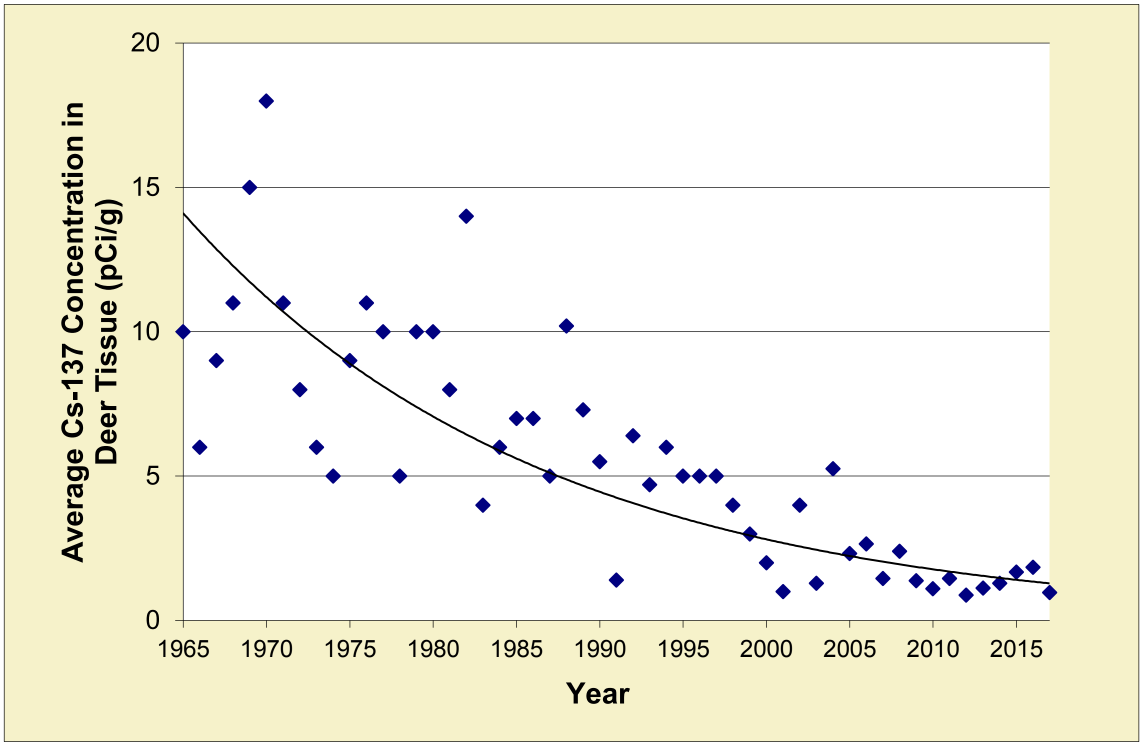


Figure 5-14 Historical Trend of Average Cesium-137 Concentration in Deer Tissue (1965–2017)

5.7 FIVE-YEAR COMPREHENSIVE SAMPLING

SRS conducts annual soil, vegetation, and ambient gamma surveillance both on and off site. Offsite annual sampling includes limited sampling of soil and vegetation at Creek Plantation. Creek Plantation is privately owned offsite land located downstream of all SRS stream mouths. In addition to the annual sampling at Creek Plantation, SRS performs a detailed comprehensive sampling of soil, vegetation, and ambient gamma surveillance every five years, including 2017. In the event of a change in environmental conditions such as flooding, additional sampling beyond the annual soil and vegetation samples may be performed. This area is sampled because in the 1960s, SRS operations contaminated an area of the Savannah River Swamp on Creek Plantation, specifically the area between Steel Creek Landing and Little Hell Landing. During high river levels, water from Steel Creek flowed along the lowlands that contained the swamp, depositing radioactive materials. Studies estimated that approximately 25 curies (Ci) of cesium-137, 1 Ci of cobalt-60, and trace amounts of strontium-89,90 were deposited in the swamp. Ongoing monitoring since 1974 documents a decreasing trend in concentrations of cesium-137, the primary radionuclide detected in Creek Plantation soil and vegetation.

The 5-Year Comprehensive Survey sampling is performed at multiple locations along 10 trails located between Steel Creek Landing to below Little Hell Landing, with each trail beginning on the Savannah River edge and progressing inland. The annual samples are collected from the locations with the historically highest cesium-137 concentration and the highest concentration from the previous five-year comprehensive study, which is typically on Trail 1. High water levels in the river may result in moving and redepositing radioactive materials. To support sampling areas of contamination, SRS employs gamma over-flight data to verify that the sampling locations will support representative sampling of contamination and identify any additional sampling trails to support a comprehensive evaluation. Gamma overflight measurements are obtained using gamma spectroscopy instrumentation from a helicopter flying over the Creek Plantation at slow speeds. The gamma spectroscopy instrumentation obtains an average of spectral counts for a footprint over time. These measurements provide the levels of gamma-emitting radionuclides such as cesium-137. The soil and vegetation samples obtained from locations verified by the gamma-overflight data are analyzed for cobalt-60, cesium-137, and strontium-89,90.

In addition to the comprehensive survey soil and vegetation sampling, external gamma exposure is measured using thermoluminescent dosimeters (TLDs). TLDs are placed into the field at designated locations for three months. The crystals in the dosimeters absorb the gamma exposure over time and are analyzed for the gamma exposure rates in air.

5.7.1 Five-Year Comprehensive Survey Results Summary

In addition to the 10 trails that are normally sampled during the comprehensive sampling, the previous gamma overflight results indicated a potential area of contamination between Trails 6 and 7. SRS added an additional sampling trail, for a total of 11 trails. This additional location is called “Trail-6 Special” and can be seen on Figure 5-15.

Savannah River Swamp at Creek Plantation

The 2017 survey confirmed previous observations that cesium-137 is the primary man-made radionuclide detected in Creek Plantation. No cobalt-60 was detected in any of the soil samples. Cesium-137 was detected in nearly all soil samples. Historically, the highest soil concentrations occur on Trail 1; however, some sample locations on Trail 1 were not collected in 2017 but were collected after the flooding during 2016 and are included in this dataset. With the 2017 comprehensive survey, the highest soil concentrations were found at Trail 6 (Table 5-12), and concentrations decreased with depth. The highest overall soil concentration was collected on Trail 1 after the 2016 flooding event (Table 5-12, Figure 5-15).

Soil and vegetation samples are collected annually at select locations on Trail 1 to trend concentrations at the area that historically has the highest concentrations. Additionally, the high location at Trail 6 will be sampled annually to monitor concentrations at that location.

The 2017 comprehensive survey detected cesium-137 in 36 (about 70%) of the 50 vegetation samples, with no cobalt-60 detected in any samples. Historically, the highest Cs-137 concentrations in vegetation occur on Trails 5 and 6. During the 2017 survey, the highest vegetation Cs-137 concentrations were consistent with historical results, with Trail 6 having the single highest concentration (Table 5-12).

Several floods have occurred since the comprehensive survey of 2012. These floods likely deposited sediment or washed contamination down from higher concentration areas causing elevated concentrations of Cs-137 of soil and vegetation at Trail 6. SRS will continue to monitor this area and conduct follow up sampling on the high concentration areas in 2018.

SRS placed TLDs at 50 monitoring sites in the swamp to determine ambient gamma exposure rates, and retrieved all but two of them, which were uncollectable. The gamma exposure rates were consistent with the ranges observed historically. The highest exposure rates were measured on Trail 1, consistent with cesium-137 results in soil and gamma footprints from aerial survey measurements. More information on exposure and dose results from the Creek Plantation datasets can be found in Chapter 6, "Radiological Dose Assessments."

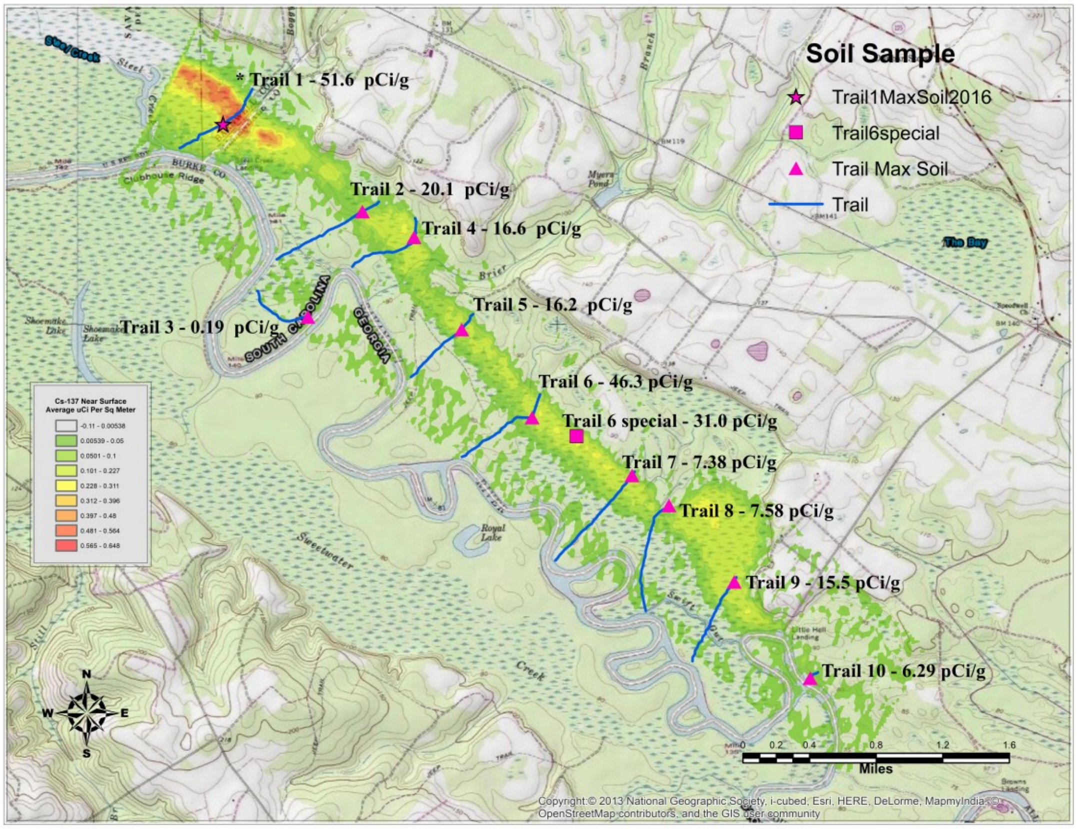


Figure 5-15 Gamma Overflight Survey of Creek Plantation with Maximum Cesium-137 Soil Concentrations from 2016 Annual Sampling and 2017 Comprehensive Survey

Table 5-12 Results of 2017 Creek Plantation Comprehensive Survey

Trail	Cs-137 Activity in Soil (pCi/g)		Cs-137 Activity in Vegetation (pCi/g)		TLD Results (mR/day)	
	Min	Max	Min	Max	Min	Max
Trail 1 (2016 Sampling)[a]	2.50E+00	5.16E+01	N/A[b]	N/A[b]	N/A[b]	N/A[b]
1	3.02E-01	2.49E+01	5.21E-02	2.77E+00	2.73E-01	5.63E-01
2	2.88E-01	2.01E+01	4.18E-02	1.08E+00	3.19E-01[c]	4.35E-01[c]
3	4.19E-02	2.16E-01	8.93E-04	3.09E-01	3.23E-01	3.38E-01
4	7.48E-02	1.66E+01	4.54E-02	1.54E+00	3.44E-01	3.96E-01
5	7.87E-02	1.62E+01	5.66E-02	1.03E+01	3.24E-01	4.44E-01
6	9.65E-02	4.63E+01	1.78E-02	1.45E+01	3.08E-01	3.27E-01
6 Special[d]	1.08E+01	3.10E+01	4.05E+00	4.05E+00	4.35E-01	4.35E-01
7	2.66E-02	7.38E+00	2.64E-02	6.58E-01	3.02E-01	3.90E-01
8	8.27E-03	7.58E+00	7.60E-02	4.95E-01	3.16E-01	3.75E-01
9	2.24E-01	1.55E+01	5.19E-02	3.03E+00	2.93E-01	3.87E-01
10	3.07E-02	6.29E+00	3.42E-02	4.92E-01	2.89E-01	3.36E-01

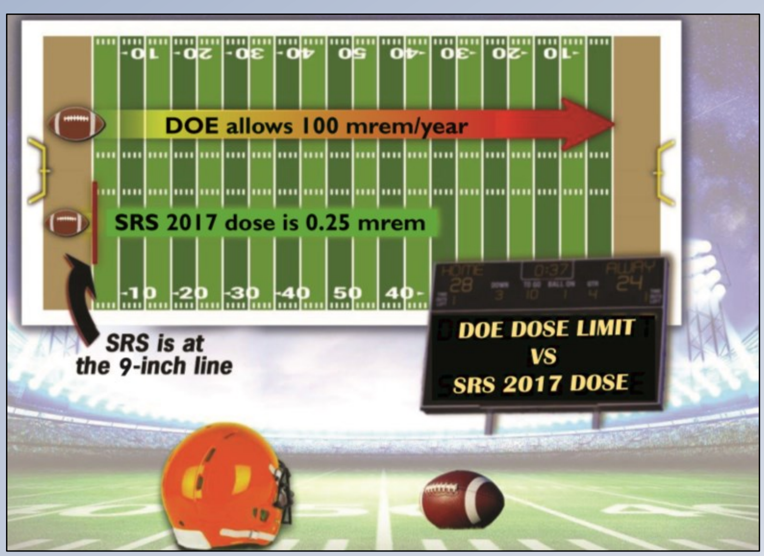
Notes:
[a] The Trail 1 (2016 sampling) consisted of collecting only soil samples
[b] NA = not available
[c] Two TLDs were unrecoverable. Minimum and maximum results may not be accurate
[d] Trail 6 Special consists of one sampling location

Chapter 6 Radiological Dose Assessment

Department of Energy (DOE) Order 458.1, *Radiation Protection of the Public and the Environment*, establishes dose limits for the public and onsite plants and animals. These dose limits are established to protect the public and environment from the potential effects of radiation released during DOE radiological operations. To ensure that radiation exposure does not exceed the DOE public dose limit of 100 mrem/year (yr), the Savannah River Site (SRS) calculates the potential dose to the public from radioactive releases in air and water through all reasonable exposure pathways (direct, ingesting, absorbing, inhaling). SRS also considers and quantifies exposure pathways that are nontypical and not included in the standard dose calculations to the representative person. These apply to conservative and unlikely scenarios, such as a member of the public eating fish caught only from the mouths of SRS streams, or to special scenarios, such as hunters who participate in onsite hunts. In addition, DOE Order 458.1 establishes authorized surface contamination limits, which allow SRS to release personal and real property unconditionally. SRS performs radiological surveys on all equipment considered for release and follows applicable procedures.

2017 Highlights

Dose to the Offsite Representative Person—The dose to the offsite representative person was 0.22 mrem from SRS liquid releases and 0.027 mrem from SRS air releases. To comply with the DOE all-pathway dose limit of 100 mrem/yr, SRS conservatively adds these two doses for a total representative person dose of 0.25 mrem, which is 0.25% of the 100 mrem/yr DOE dose limit.



Comparison of DOE's 100 mrem/yr Dose Limit to SRS's 2017 All-Pathway Dose of 0.25 mrem

2017 Highlights (continued)

Sportsman Doses

- **Onsite Hunter**—SRS conducts annual hunts to control onsite deer and wild hog populations. SRS determines the estimated potential dose from eating harvested deer or hog meat for every onsite hunter. The maximum potential dose was 12.2 mrem, or 12.2% of the 100 mrem/yr DOE dose limit.
- **Creek Mouth Fisherman**—SRS estimated the maximum potential dose from fish consumption from catfish collected at the mouth of Lower Three Runs at 0.36 mrem. This dose is 0.36% of the 100 mrem/yr DOE dose limit. SRS bases this hypothetical dose on the low probability that, during 2017, a fisherman consumed 53 pounds (lbs) of catfish caught exclusively from the mouth of Lower Three Runs.

Release of Material Containing Residual Radioactivity—SRS did not release any real property (land or buildings) in 2017. SRS unconditionally released 14,498 items of personal property (such as tools) from radiological areas. Most of these items did not leave SRS but were reused elsewhere on the Site. However, 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 evaluates plant and animal doses for water and land systems. For 2017, all SRS water, sediment, and soil locations passed their Level 1 (using maximum measured concentrations) or Level 2 (using average measured concentrations) screenings and did not require further assessments.

6.1 INTRODUCTION

Routine SRS operations release controlled amounts of radioactive materials to the environment through air and water. These releases could expose people offsite to radiation. To confirm that this exposure is below public dose limits, SRS calculates annual dose estimates using environmental monitoring and surveillance data, combined with relevant Site-specific data (such as weather conditions, population characteristics, and river flow). SRS also confirms that the potential doses to plants and animals (biota) living onsite remain below the DOE biota dose limits. This chapter explains radiation doses, describes how SRS calculates doses, and presents the estimated doses from SRS activities for 2017.

Radiological Impact of 2017 Operations at the Savannah River Site (Jannik, Bell, and Dixon 2018) details SRS dose calculation methods and results.

To calculate the potential doses to the public, SRS used the data from the monitoring programs described in Chapter 5, *Radiological Environmental Monitoring Program*.

6.2 WHAT IS RADIATION DOSE?

Radiation dose to a person is the amount of energy absorbed by the human body from a radiation source located either inside or outside of the body. SRS typically reports dose in millirem (mrem), which is one-thousandth of a rem. A rem is a standard unit used to measure the amount of radiation deposited in human tissue.

Humans, plants, and animals potentially receive radiation doses from natural and man-made sources. The average annual background dose for all people living in the United States is 625 mrem (NCRP 2009). This includes an average background dose of 311 mrem from naturally occurring radionuclides found in our bodies, in the earth, and from cosmic radiation, such as from the sun. Man-made sources and their doses include medical procedures (300 mrem), consumer products (13 mrem), and industrial and occupational exposures from facilities such as SRS (less than 1 mrem).

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. Exposure to radiation primarily occurs through the following pathways, which Figure 6-1 illustrates:

- Inhaling air
- Ingesting water and food
- Absorbing through skin
- Direct (external) exposure to radionuclides in soil, air, and water

Chapter 6—Key Terms

Exposure pathway *is the way that releases of radionuclides into the water and air could impact a person.*

Reference person *is a hypothetical person with average physical and physiological characteristics—including factors such as age and gender—used internationally to standardize radiation dose calculations.*

Representative person *is a hypothetical individual receiving a dose that is representative of highly exposed individuals in the population. The calculations incorporate age, gender, food and water consumption, and breathing rate. At SRS, the representative person equates to the 95th percentile of applicable national human-use radiation exposure data.*

6.3 CALCULATING DOSE

To comply with DOE Order 458.1, dose can be calculated to the maximally exposed individual (MEI) or to a representative person. Since 2012, SRS has used the representative person concept to determine if the Site is complying with the DOE public dose limit. SRS calculates the representative person dose using site-specific reference person parameters. The SRS representative person falls at the 95th percentile of national and regional data. The applicable national and regional data used are from the U.S. Environmental Protection Agency's (EPAs) *Exposure Factors Handbook*, 2011 Edition (EPA 2011).

The reference person is weighted based on gender and age. The International Commission on Radiation Protection Publication 89, (ICRP 2002) groups these ages as: Infant (0 years), 1 year, 5 years, 10 years, 15 years, and Adult (17 years and older). The reference person accounts for the fact that younger people are, in general, more sensitive to radioactivity than older people. SRS also developed human usage parameters at the 50th percentile for calculating dose to a "typical" person when determining population doses.

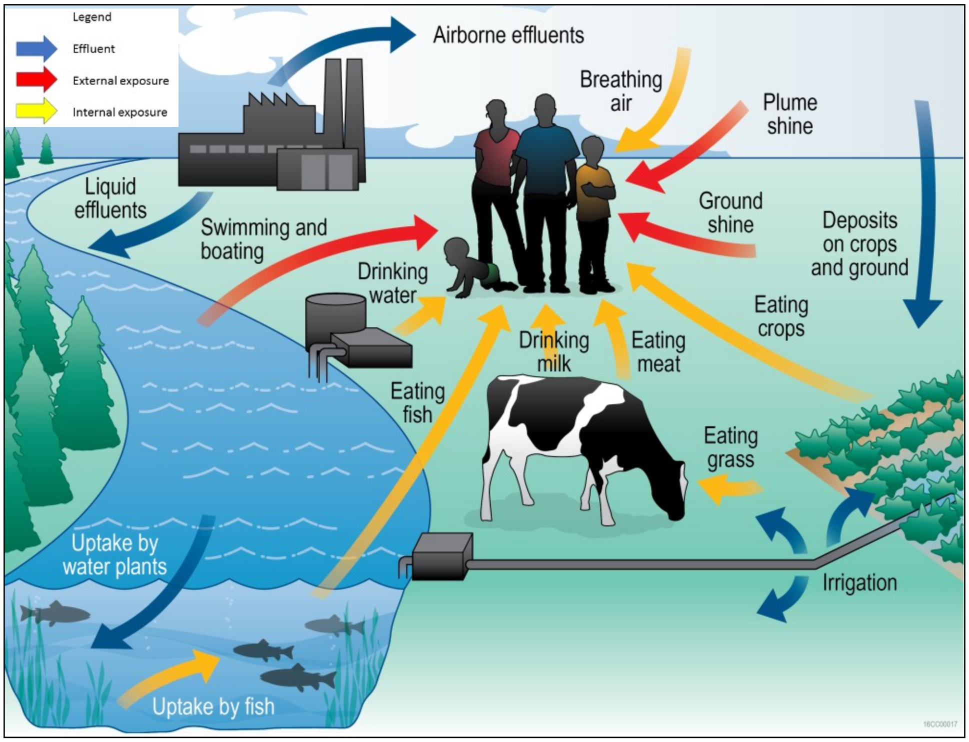


Figure 6-1 Exposure Pathways to Humans from Air and Liquid Effluents

The SRS report *Site-Specific Reference Person Parameters and Derived Concentration Standards for SRS* (Stone and Jannik 2013) documents SRS-specific reference and typical person usage parameters. The SRS report *Land and Water Use Characteristics and Human Health Input Parameters for Use in Environmental Dosimetry and Risk Assessments at the Savannah River Site* (Jannik and Stagich 2017) documents all other applicable land- and water-use parameters in the dose calculations. These parameters include local characteristics of food production, river recreational activities, and other human usage parameters required in SRS models to calculate radiation dose exposure.

In 2017, SRS made two conservative changes in the locations of the representative person:

1) For the liquid pathway, the representative person was moved from river mile (RM) 118.8 (near US Hwy 301 bridge) to RM 141.5, which is slightly downriver from the Steel Creek mouth. The historical location at RM 118.8 is downriver of all SRS streams, but SRS radiological releases into Lower Three Runs have been small for many years, and moving the representative person to near Steel Creek gives a better indication of the potential dose from fish.

2) For the air pathway, in addition to the offsite representative person living near the Site boundary, SRS also calculated potential dose for an adult worker at the Three Rivers Landfill located near B Area. Three Rivers Landfill is located on SRS, but it is accessed directly from public South Carolina Hwy 125 outside of the Site's security perimeter in Aiken County. The workers at Three Rivers Landfill are not Site employees and are now considered members of the public to comply with DOE Order 458.1 and with National

Emissions Standards for Hazardous Pollutants Compliance (NESHAP) regulations (EPA 2002). Figure 6-2 shows these new locations.

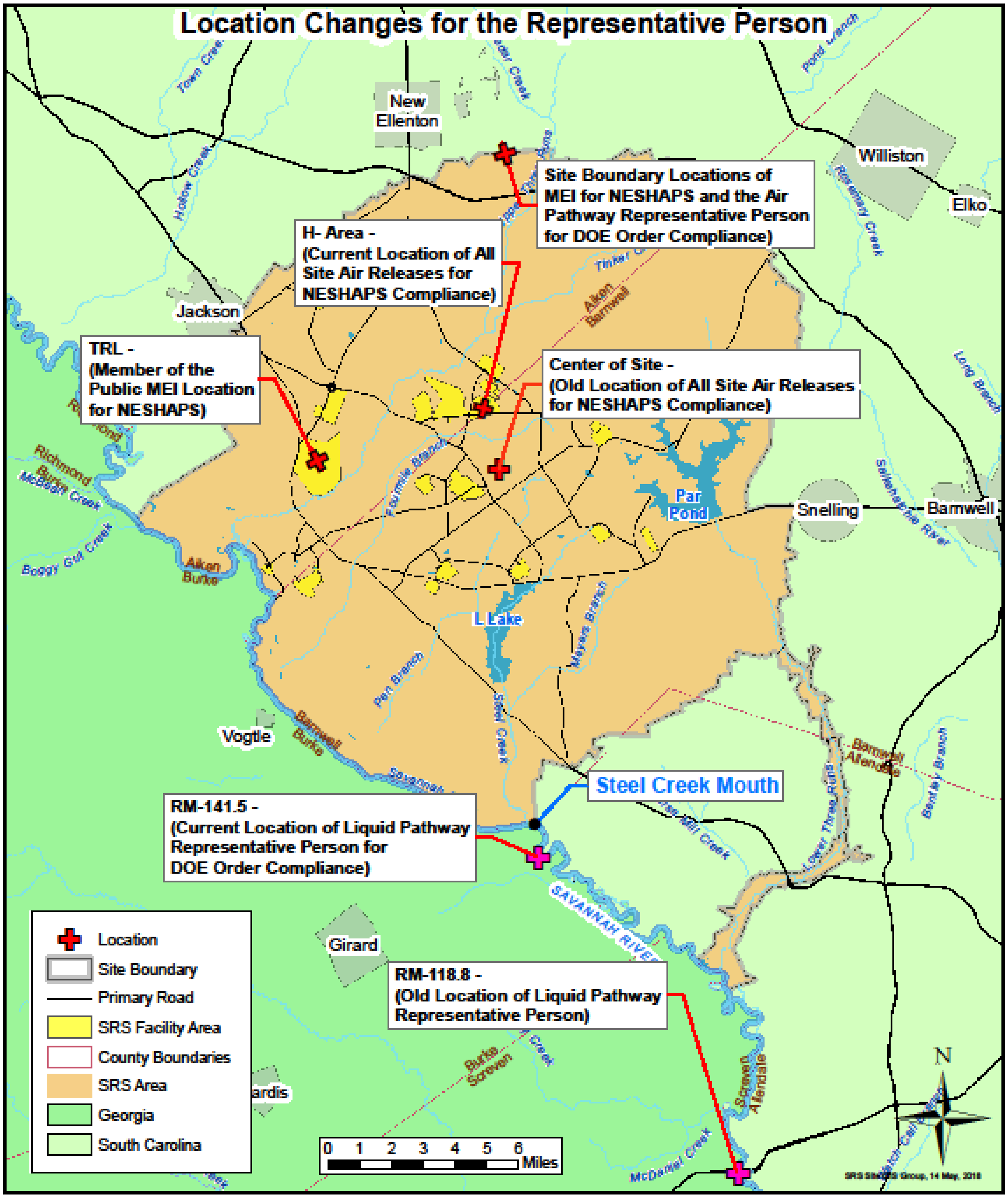


Figure 6-2 Locations of Representative Persons (for DOE Compliance) and MEIs (for NESHAP Compliance) for the Air and Liquid Pathways

To determine if the Site is complying with DOE public dose requirements, SRS calculates the potential offsite doses from Site effluent releases of radioactive materials (air and liquid) for the following scenarios:

- Representative person living near the SRS boundary
- Adult person working at the Three Rivers Landfill located on SRS (near B Area)
- Population living within a 50-mile (80-kilometer [km]) radius of SRS

For all routine environmental dose calculations, SRS uses environmental transport and dose models based on codes the Nuclear Regulatory Commission (NRC) developed (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. The SRS report *Environmental Dose Assessment Manual* (Jannik 2017) describes the specific models SRS uses.

At SRS, the dose to a representative person is based on the following:

1) SRS-specific reference person usage parameters at the 95th percentile of appropriate national or regional data (Stone and Jannik 2013).
2) Reference person (gender- and age-averaged) ingestion and inhalation dose coefficients from the *DOE Derived Concentration Technical Standard*, DOE-STD-1196-2011 (DOE 2011).
3) External dose coefficients from the DC_PAK3 toolbox, (accessed at https://www.epa.gov/radiation/tools-calculating-radiation-dose-and-risk). Currently, there are no age-specific external dose factors available.

6.3.1 Weather Database

Complete and accurate weather (meteorological) data are important to determine offsite contamination levels. SRS calculated potential offsite doses from radioactive releases to the air with quality-assured weather data from 2007 to 2011 (Viner 2013).

Figure 6-3 presents the H-Area wind rose plot for 2007-2011 and shows the direction and frequency the wind blows. As shown, the wind blows the most towards the East-Northeast sector (about 9% of the time), but there is no strongly prevalent wind direction.

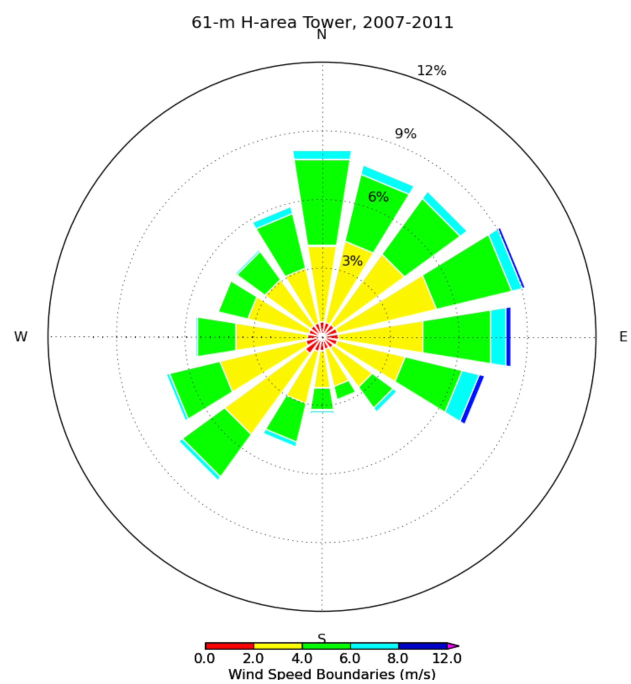


Figure 6-3 2007–2011 Wind Rose Plot for H Area (Showing Direction and Frequency Toward Which the Wind Blows)

6.3.2 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 people. This translates to about 104 people per square mile outside the SRS boundary, with the largest concentration in the Augusta metropolitan area.

Table 6-1 presents the number of people currently served by the three drinking water supply plants that are downriver of SRS.

The total population dose from routine SRS liquid releases is the sum of the following five contributing categories:

1) Consumers of water from Beaufort-Jasper Water and Sewer Authority (BJWSA)
2) Consumers of water from City of Savannah Industrial and Domestic (I&D)
3) Consumers of fish and invertebrates of Savannah River origin
4) Participants of recreational activities on the Savannah River
5) Gardeners and farmers irrigating foodstuffs with river water near RM 141.5

Table 6-1 Regional Water Supply Service

Water Supply Plant	Nearest City	Population Served
City of Savannah Industrial and Domestic Water Supply Plant (City of Savannah I&D)	Port Wentworth, Georgia	35,000 people
Beaufort-Jasper Water and Sewer Authority's (BJWSA) Chelsea Water Treatment Plant	Beaufort, South Carolina	83,700 people
BJWSA Purrysburg Water Treatment Plant	Beaufort, South Carolina	64,800 people

6.3.3 River Flow Rate Data

The annual rate of flow in the Savannah River, which varies greatly from year to year, is an important criterion for determining down-river concentrations of the contaminants SRS releases. The U.S. Geological Survey (USGS) measures Savannah River flow rates down river of SRS at its RM 118.8 gauging station, located near the U.S. Hwy 301 Bridge.

Figure 6-4 provides the river flow rates measured by USGS at this location from 1954 to 2017. It also shows that the average river flow rate for these years is about 10,000 cubic feet per second (cfs). However, in the last 10 years, there has been a downward trend in these data, with an average measured flow rate of just 7,530 cfs.

For 2017, SRS used a calculated "effective" Savannah River flow rate of 5,460 cfs in the dose calculations. The 2017 effective flow rate is about 15% less than the 2016 effective flow rate of 6,426 cfs. This effective flow rate (based on actual measured tritium concentrations in the river) is more conservative than the 2017 USGS measured flow rate of 5,698 cfs (based on daily flow rates). By using a conservative method, the calculated effective flow rate assumes radioactive material is less diluted and, therefore, increases the estimated potential dose.

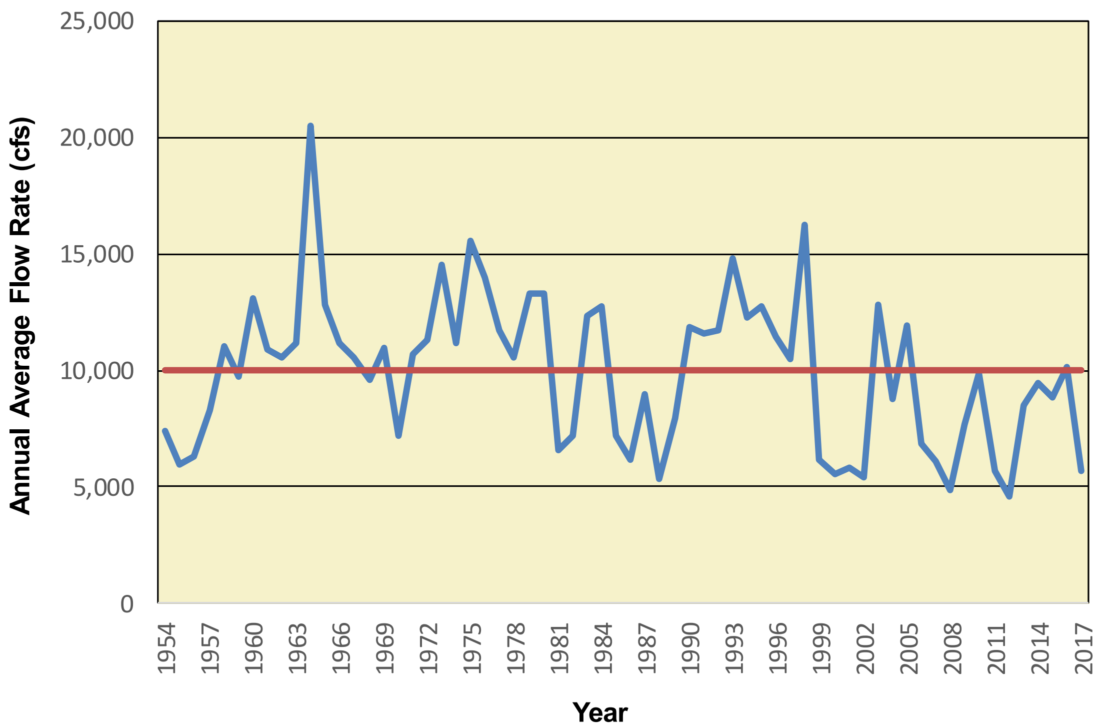


Figure 6-4 Savannah River Annual Average Flow Rates Measured by USGS at River Mile 118.8

6.4 OFFSITE REPRESENTATIVE PERSON DOSE CALCULATION RESULTS

To determine the Site is complying with DOE public dose requirements, SRS calculates the potential offsite doses from Site effluent releases of radioactive materials in air and liquid pathways for a representative person living near the SRS boundary. SRS calculates the pathways individually and then adds the two results to obtain the representative person dose.

6.4.1 Liquid Pathway

6.4.1.1 <u>Liquid Release Source Terms</u>

Table 6-2 shows, by radionuclide, the amount of radioactivity in liquid form that SRS released in 2017. SRS uses these release amounts in the dose calculations. Discussions of the sources of these data are in Chapter 5, *Radiological Environmental Monitoring Program.*

Tritium accounts for more than 99% of the total amount of radioactivity released from the Site to the Savannah River. In 2017, SRS released a total of 563 curies of tritium to the river, a 23% decrease from the 2016 amount of 731 curies. For compliance dose calculations, SRS used the stream transport measurement (563 curies), which was higher than the direct release total (494 curies). Refer to Chapter 5, *Radiological Environmental Monitoring Program*, Section 5.4.5 for details concerning these measurements.

Table 6-2 2017 Liquid Release Source Term 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]	**5.63E+02**	**6.04E+02**	**5.23E+02**	2.00E+04
C-14	**1.09E-02**	**2.23E-03**	**1.93E-03**	2.00E+03
Sr-90	**2.13E-02**	**4.37E-03**	**3.78E-03**	8.00E+00
Tc-99	**1.51E-02**	**3.09E-03**	**2.68E-03**	9.00E+02
I-129	**2.18E-02**	**4.47E-03**	**3.87E-03**	1.00E+00
Cs-137	**5.78E-03**	**2.95E-02**	**2.56E-02**	2.00E+02
Ra-226	**7.27E-04**	**1.49E-04**	**1.29E-04**	5.00E+01
U-234	**3.48E-02**	**7.13E-03**	**6.17E-03**	1.03E+01
U-235	**1.23E-03**	**2.52E-04**	**2.18E-04**	4.67E-01
U-238	**3.61E-02**	**7.40E-03**	**6.41E-03**	1.00E+01
Np-237	**5.57E-05**	**1.14E-05**	**9.88E-06**	1.50E+01
Pu-238	**2.33E-04**	**4.77E-05**	**4.13E-05**	1.50E+01
Pu-239	**2.00E-05**	**4.10E-06**	**3.55E-06**	1.50E+01
Am-241	**5.62E-03**	**1.15E-03**	**9.97E-04**	1.50E+01
Cm-244	**1.49E-04**	**3.05E-05**	**2.64E-05**	1.50E+01
Alpha	**2.45E-03**	**5.02E-04**	**4.35E-04**	1.50E+01
Beta	**5.50E-02**	**1.13E-02**	**9.76E-03**	8.00E+00

Notes:
[a] Near Savannah River Mile 141.5, downriver of SRS near the Steel Creek mouth
[b] Beaufort-Jasper Water and Sewer Authority, drinking water at the Purrysburg Water Treatment Plant
[c] MCLs for uranium based on radioisotope specific activity X 30 µg/L X isotopic abundance
[d] Actual measurements of the Savannah River water at the various locations are the basis for the tritium concentrations and source term. They include contributions from VEGP and the Barnwell Low-Level Disposal Facility. SRS uses the effective or measured river flow rate to calculate all other radionuclide concentrations.

During 2017, in addition to the 563 curies SRS released, the Georgia Power Company's Vogtle Electric Generating Plant (VEGP) released 2,337 curies of tritium to the Savannah River, and 45 curies migrated from the Barnwell Low-Level Disposal Facility (BLLDF) for an overall total of 2,945 curies of tritium (SRS plus VEGP plus BLLDF). This is slightly more than the total of 2,893 curies measured in the Savannah River, as Chapter 5 reports.

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

SRS measures concentrations of tritium in the river water and cesium-137 in fish at several locations along the Savannah River. SRS uses these direct measurements to make dose determinations. The amounts of all other radionuclides SRS released are so small that their concentration in the Savannah River usually cannot be detected using conventional analytical techniques. SRS calculates the concentrations in the river based on the annual release amounts and river flow rates and then compares them to the Safe Drinking Water Act, 40 CFR 141 (EPA 2000) maximum contaminant level (MCL) for each radionuclide.

Radionuclide Concentrations in River Water and Treated Drinking Water—Table 6-2 shows the measured concentrations of tritium in the Savannah River near RM 141.5 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, the VEGP, and BLLDF. In 2017, the 12-month average tritium concentration measured in Savannah River water near RM 141.5 was 604 picocuries per liter (pCi/L). This concentration is well below EPA's MCL for tritium of 20 pCi/ml. Table 6-2 also provides the calculated concentrations for the other released radionuclides and a comparison of these concentrations to EPA's MCLs. As shown, all radionuclide concentrations are well below the MCLs.

Radionuclide Concentrations in Fish—Consuming fish is an important dose pathway for the representative person. 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 estimated at 3,000, meaning that the cesium concentration 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).

SRS samples fish from the Savannah River using electrofishing methods. Radionuclide concentrations in fish harvested from the Steel Creek mouth are used in the representative person dose calculations.

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 bases the fish pathway dose from cesium-137 directly on analyzing the fish collected from the location of the hypothetical representative person, which is near the mouth of Steel Creek, at RM 141.5. In 2017, SRS used the Steel Creek fish concentrations to determine the Site's overall cesium-137 release value of 0.144 Ci, which was three times more than the 2016 value of 0.0479 Ci. This relatively large increase is attributed to SRS moving the location of the representative person from RM 118.8 to near Steel Creek (RM 141.5), which has legacy contamination in its sediment (see Chapter 5).

6.4.1.3 Dose to the Representative Person

The 2017 potential dose to the representative person from all liquid pathways (including irrigation) was estimated at 0.22 mrem (0.0022 mSv), which is 47% more than the comparable dose in 2016. Again, this increase is attributed to SRS moving the location of the representative person from RM 118.8 to near Steel

Table 6-3 Potential Dose to the Representative Person from SRS Liquid Releases in 2017

	Committed Dose (mrem)	Applicable Limit (mrem)	Percent of Limit (%)
Near Site Boundary (All Liquid Pathways)			
All Liquid Pathways Except Irrigation	0.13		
Irrigation Pathways	0.089		
Total Liquid Pathways	0.22	100[a]	0.22%

Note:

[a]DOE dose limit: 100 mrem/yr (DOE Order 458.1)

Creek (RM 141.5), which increased the dose from fish consumption. Table 6-3 shows that the total liquid pathway dose is 0.22% of the DOE public dose limit of 100 mrem/yr (1 mSv/yr).

About 41% of the 2017 total dose to the representative person is from consuming meat, milk, and vegetables that have been raised using Savannah River water from RM 141.5. The fish consumption pathway accounted for 51%, and the drinking water pathway accounted for 7%. As Figure 6-5 shows, cesium-137 (54%) and technetium (11%) contributed the most to the liquid pathway dose.

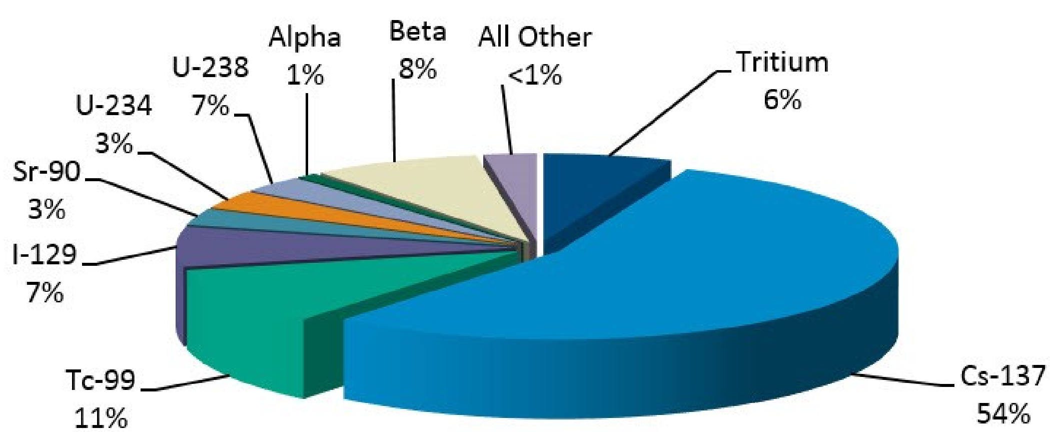


Figure 6-5 Radionuclide Contributions to the 2017 SRS Total Liquid Pathway Dose of 0.22 mrem (0.0022 mSv)

6.4.1.4 Drinking Water Pathway Dose

People living downriver of SRS may receive some dose by drinking water that contains radioactive releases from the Site. Tritium in downriver drinking water represented the highest percentage of the dose (about 82%) received by customers of the three downriver water treatment plants.

In 2017, SRS-only releases were responsible for a maximum potential drinking water dose of 0.013 mrem (0.00013 mSv). This dose is about 8% more than the 2016 dose of 0.012 mrem. SRS attributes this slight increase to the 15% decrease in the Savannah River flow rate during 2017, which caused less dilution to occur. There is not a separate drinking water dose limit, but the EPA MCLs, as defined in 40 CFR 141 (EPA 2000), are based on a potential dose of about 4 mrem/yr for beta and gamma emitters.

6.4.1.5 Collective (Population) Dose

SRS calculates the collective drinking water consumption dose for the separate population groups that are customers of the BJWSA and City of Savannah I&D water treatment plants. Calculations of collective doses from agricultural irrigation assume that major food types (vegetables, milk, and meat) grow on 1,000-acre parcels of land in the SRS area, with the population within 50 miles of SRS consuming all the food produced on these 1,000-acre parcels.

In 2017, the collective dose from all liquid pathways was 3.4 person-rem (0.034 person-Sv). This dose is slightly less than the 2016 dose of 3.5 person-rem. SRS calculates the collective dose in person-rem as the average dose per typical person, multiplied by the number of people exposed. DOE Order 458.1 requires that SRS calculate and report a collective dose, but there is not a separate collective dose limit for comparison.

6.4.2 Air Pathway

6.4.2.1 Air Release Source Terms

Chapter 5, *Radiological Environmental Monitoring Program*, documents the 2017 radioactive air release quantities used as the source term in SRS dose calculations. Tritium accounts for a majority of the dose from SRS air releases. As discussed in Chapter 5, SRS tritium releases decreased about 30% from 2016 to 2017, which decreased the 2017 SRS air pathway doses.

6.4.2.2 Air Concentrations

SRS uses calculated radionuclide concentrations instead of measured concentrations for dose determinations because conventional analytical methods do not detect most of the radionuclides SRS released in the air samples collected at the Site perimeter and offsite locations. However, SRS can routinely measure tritium concentrations at locations along the Site perimeter and compare these results with the calculated concentrations to confirm the dose models. In 2017, this comparison showed that the dose models used at SRS were about 2 to 4 times more conservative than the actual measured tritium concentrations.

6.4.2.3 Dose to the Representative Person

The 2017 estimated dose from air releases to the representative person was 0.027 mrem (0.00027 mSv), 0.27% of the EPA air pathway limit of 10 mrem per year. DOE Order 458.1 requires that all DOE sites comply with EPA's NESHAP regulations. Table 6-4 compares the representative person dose with the EPA dose limit. The 2017 dose was about 29% less than the 2016 dose of 0.038 mrem (0.00038 mSv). SRS attributes this decrease to the 30% decrease in tritium releases during 2017 (See Chapter 5, *Radiological Environmental Monitoring Program*). The air pathway representative person is located at the SRS boundary in the north compass point direction, near New Ellenton, South Carolina (see Figure 6-2).

Table 6-4 Potential Doses to the Representative Person and to the MEI from SRS Air Releases in 2017 and Comparison to the Applicable Dose Limit

	MAXDOSE-SR (Using DOE Dose Coefficients)	CAP88-PC (EPA NESHAP)
Calculated dose (mrem)	0.027	0.029
Applicable Limit (mrem)	10[a]	10[b]
Percent of Limit (%)	0.27	0.29

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

As Figure 6-6 shows, tritium releases were 88% of the dose to the representative person. Iodine-129 was about 5%, unidentified alpha was 2%, and plutonium-239 was 1%. No other individual radionuclide was more than 1% of the representative person dose.

The major ways a representative person received radiation dose from air releases were inhalation (41%), consuming vegetables (35%), and consuming cow milk (23%).

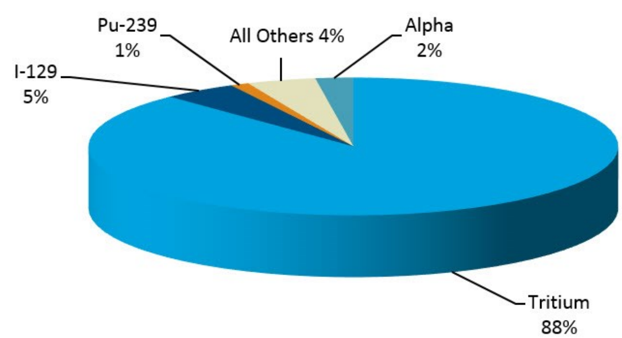


Figure 6-6 Radionuclide Contributions to the 2017 SRS Air Pathway Dose of 0.027 mrem (0.00027 mSv)

In 2017, SRS began to calculate the potential dose for an adult worker at the Three Rivers Landfill near B Area. As shown in Figure 6-2, Three Rivers Landfill is located on SRS, but it is accessed directly from public Hwy 125 outside of the Site's security perimeter. The workers at Three Rivers Landfill are not Site employees and are now considered members of the public to comply with DOE Order 458.1.

For this assessment, SRS assumed that an adult person worked at Three Rivers Landfill for 2000 hours during the year (8 hours/day, 5 days/week, 50 weeks/year). SRS also assumed that this worker was only exposed from the inhalation and external-exposure pathways. No locally grown food consumption was considered at this industrial location.

For 2017, SRS calculated a potential dose to a Three Rivers Landfill worker of 0.0064 mrem (0.000064 mSv). This dose is less than the representative person dose of 0.027 mrem that was reported for DOE Order 458.1 compliance.

6.4.2.4 Collective (Population) Dose

SRS calculates the air-pathway collective dose for all 781,060 members of the population living within 50 miles of the center of the Site. In 2017, SRS estimated the airborne-pathway collective dose to be 0.97 person-rem (0.0097 person-Sv). DOE Order 458.1 requires that SRS calculate and report a collective dose, but there is not a separate collective dose limit for comparison.

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

To demonstrate the Site is complying with NESHAP regulations (EPA 2002), SRS calculated maximally exposed individual (MEI) and collective doses using the following:

1) The CAP88 PC version 4.0.1.17 computer code, which EPA requires
2) The 2017 airborne-release source term
3) Site-specific input parameters

EPA requires using the MEI concept and not the reference person concept, and it specifies most of the input parameters in the CAP88 PC program. The EPA requires specific approval for any changes to these parameters.

For 2017, SRS calculated doses to two potential MEIs to demonstrate it complied with EPA's 10 mrem/yr (0.1 mSv/yr) public dose limit for air emissions from DOE sites. One potential MEI was at the usual offsite location, near the site boundary in the north compass point direction (see Figure 6-2). The second potential MEI was a worker at the Three Rivers Landfill. This location also is shown in Figure 6-2 and is described in the "Dose to the Representative Person" section of this chapter. EPA requires that all exposure pathways (including food consumption) be considered for the potential MEI, even for an industrial worker.

For 2017, SRS requested and received approval from EPA to change the location of all site releases from the Center of Site to H Area (see Figure 6-2). This change was requested because a large majority of SRS's radiological air releases occur from the Tritium Facilities in H-Area (Minter et al. 2018).

SRS estimated the MEI dose at the site boundary to be 0.025 mrem (0.00025 mSv). SRS estimated the MEI dose for the Three Rivers Landfill worker to be 0.029 mrem (0.00029 mSv). For 2017, SRS reported the higher Three Rivers Landfill worker dose of 0.029 mrem for NESHAP compliance. This dose is 0.29% of the 10-mrem/yr EPA limit, as Table 6-4 shows.

Tritium oxide releases accounted for 88% of the MEI dose, elemental tritium accounted for 7.5%, and cesium-137 accounted for 1.3%. Even though SRS tritium air releases were 30% less in 2017, the NESHAP compliance dose (MEI dose) was about 20% more than the 2016 dose of 0.024 mrem (0.00024 mSv). SRS attributes most of this increase to moving the compliance dose MEI location to Three Rivers Landfill, which, as shown in Figure 6-2, is much closer to the current H-Area release location than the 2016 site-boundary MEI was to the Center of Site release location.

6.4.3 All-Pathway Doses

6.4.3.1 All-Pathway Representative Person Dose

As stated in DOE Order 458.1, the all-pathway dose limit to a member of the public is 100 mrem/yr. SRS ensures a conservative estimate by combining the representative person airborne all-pathway and liquid all-pathway dose estimates, even though the two estimated doses are for hypothetical individuals living in different geographic locations (see Figure 6-2).

For 2017, the potential representative person all-pathway dose was 0.25 mrem (0.0025 mSv), calculated as 0.22 mrem from liquid pathways plus 0.027 mrem from air pathways. As Table 6-5a shows, the all-pathway representative person dose is 0.25% of the 100 mrem/yr (1 mSv/yr) DOE dose limit. The all-pathway total dose is about 30% more than the 2016 total dose of 0.19 mrem (0.0019 mSv). This increase is attributed to SRS moving the location of the liquid pathway representative person from RM 118.8 to RM 141.5 near Steel Creek, which increased the potential dose from fish consumption.

Figure 6-7 shows a 10-year history of SRS's all-pathway (airborne pathways plus liquid pathways) doses to the representative person.

6.4.3.2 All-Pathway Collective (Population) Dose

DOE Order 458.1 requires that SRS calculate and report a collective dose, but there is not a separate collective dose limit for comparison. For 2017, the total potential collective all-pathway dose was 4.4 person-rem (0.044 person-Sv), calculated as 3.4 person-rem from liquid pathways plus 0.97 person-rem from air pathways. To compare, the annual collective dose from natural sources of radiation that the population within the 50-mile radius surrounding SRS receives is about 243,000 person-rem. As Table 6-5b shows, the SRS all-pathway collective dose of 4.4 person-rem is less than 0.01% of the annual collective background dose.

Table 6-5a Potential Dose to the Representative Person from all Standard Pathways in 2017

Pathways	Committed Dose (mrem)	Applicable Limit (mrem)	Percent of Limit (%)
Near Site Boundary (All Pathways)			
Total Liquid Pathways	0.22	100[a]	0.22%
Total Air Pathways	0.027	10[a,b]	0.27%
Total All Pathways	0.25	100[a]	0.25%

Notes:

[a] DOE: DOE Order 458.1

[b] EPA: (NESHAP) 40 CFR 61, Subpart H

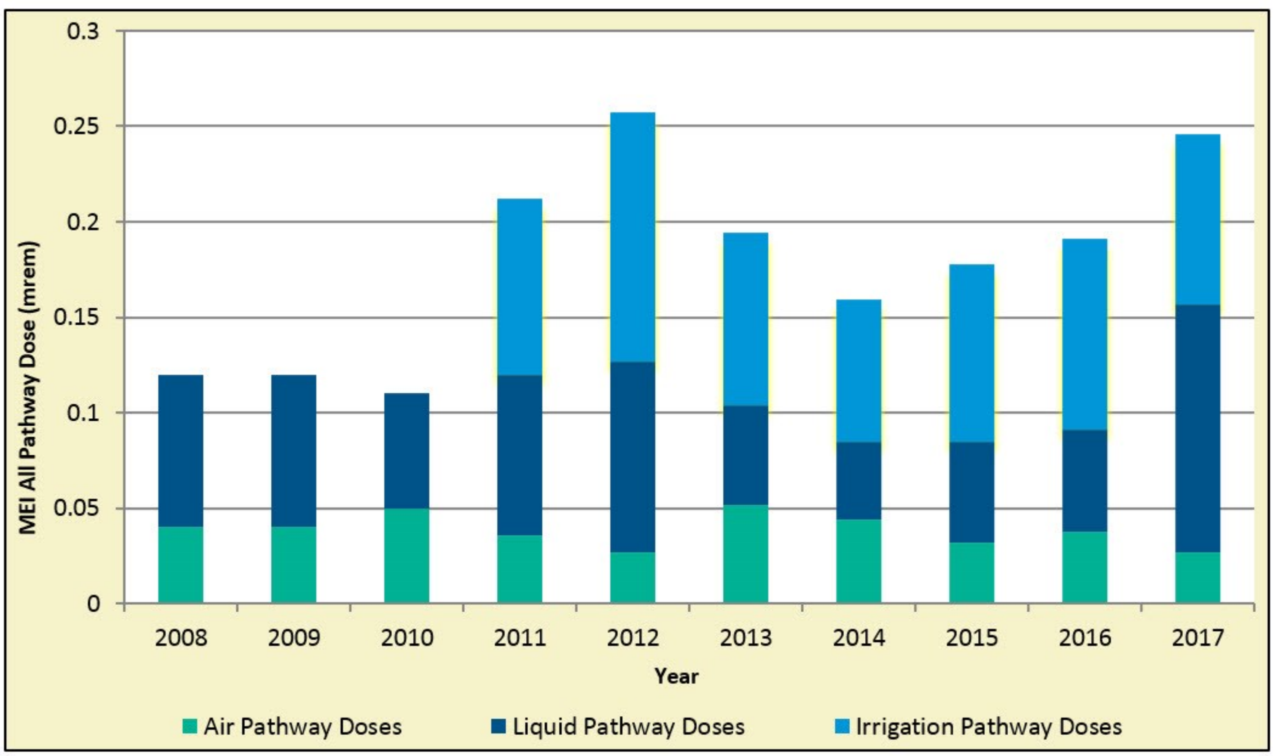
Table 6-5b Potential Collective Dose to the 50-Mile Population Surrounding SRS, Including the People Served by the Downriver Drinking Water Plants

(Based on Dose to a Typical Person from all Standard Pathways in 2017)

Pathways	Collective Dose (person-rem)	Natural Background Dose (person-rem)	Percent of Natural Background (%)
50-mile Population Dose (All Pathways)			
Total Liquid Pathways	3.4	Not Applicable	Not Applicable
Total Air Pathways	0.97	Not Applicable	Not Applicable
Total All Pathways	4.4	243,000[a]	< 0.01%

Note:

[a] Calculated as 781,060 people (surrounding SRS population) times 311 mrem (0.311 rem) per person per year, which is the average annual natural background dose for people living in the United States (NCRP 2009).



Notes:

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. In 2012, SRS began using the representative person dose instead of the Maximally Exposed Individual dose.

Figure 6-7 10-Year History of SRS Maximum Potential All-Pathway Doses

6.5 SPORTSMAN DOSE CALCULATION RESULTS

DOE Order 458.1 specifies radiation dose limits for individual members of the public. The dose limit of 100 mrem/yr includes the dose a person receives from routine DOE operations through all exposure pathways. Additionally, SRS considers and quantifies nontypical 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 hunters who volunteer to participate in an onsite hunt.

SRS also considered the following exposure pathways for a hypothetical offsite hunter and offsite fisherman on Creek Plantation, a neighboring, privately owned portion of the Savannah River Swamp:

- Ingesting deer meat or fish harvested on Creek Plantation
- Receiving external exposure to contaminated soil
- Incidentally ingesting contaminated soil
- Incidentally inhaling resuspended contaminated soil

6.5.1 Onsite Hunter Dose

Deer and Hog Consumption Pathway—SRS holds annual hunts for the public to control the Site's deer and wild hog populations and to reduce animal-vehicle accidents. The estimated dose from consuming harvested deer or hog meat is determined for every onsite hunter. Table 6-6 presents the maximum potential dose an onsite hunter received in 2017 as 12.2 mrem (0.122mSv), or 12.2% of DOE's 100 mrem/yr dose limit. This dose is for an actual hunter who harvested two deer and one hog during the hunts. For the hunter-dose calculation, SRS conservatively assumes that this hunter individually consumed the entire edible portion, about 80 kilogram (kg) (178 lbs).

Turkey Consumption Pathway—SRS hosts a special turkey hunt in April for hunters with mobility impairments. Hunters harvested 26 turkeys in 2017. SRS measured all the turkeys for radiation. Because none of them measured above the background value, SRS did not assign a dose to these hunters.

6.5.2 Hypothetical Offsite Hunter Dose

Deer and Hog Consumption Pathway—The deer and hog consumption pathways considered were for hypothetical offsite individuals whose entire intake of meat (81 kg [179 lbs]) during the year was either deer or hog meat. SRS assumes that these individuals harvest deer or hogs that had lived on SRS during the year but then moved offsite prior to hunting season.

Based on these unlikely assumptions and on the measured average concentration of cesium-137 in all deer (0.95 pCi/g) and hogs (2.0 pCi/g) harvested from SRS during 2017, the potential maximum doses from this pathway were estimated to be 1.83 mrem (0.018 mSv) for the offsite deer hunter and 6.11 mrem (0.061 mSv) for the offsite hog hunter.

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 (See Section 5.7 of Chapter 5). The potential dose assumed that this person hunted for 120 hours during the year (8 hours a day for 15 days) at the location of maximum radionuclide contamination. SRS estimated this offsite-hunter soil exposure dose to be 1.86 mrem.

As Table 6-6 shows, the offsite hog consumption pathway dose (6.11 mrem) and the Savannah River Swamp hunter soil exposure pathway dose (1.86 mrem) were conservatively added together to obtain a total maximum offsite hunter dose of about 7.97 mrem (0.0797 mSv). This potential dose is about 8.0% of the DOE 100 mrem/yr dose limit.

Table 6-6 2017 Sportsman Doses Compared to the DOE Dose Limit

	Committed Dose (mrem)	Applicable Standard (mrem)[a]	Percent of Standard (%)
Sportsman Dose			
Onsite Hunter	12.2	100	12.2
Creek-Mouth Fisherman[b]	0.36	100	0.36
Savannah River Swamp Hunter			
Offsite Hog Consumption	6.11		
Offsite Deer Consumption	1.83		
Soil Exposure[c]	1.86		
Maximum Offsite Hunter Dose (Hog + Soil Exposure)	7.9	100	7.97
Savannah River Swamp Fisherman			
Steel Creek Fish Consumption	0.13		
Soil Exposure[d]	2.08	100	2.21
Total Offsite Fisherman Dose (Fish + Soil Exposure)	2.21		

Notes:
[a] DOE dose liomit; 100 mrem/yr (DOE Order 458.1)
[b] In 2017, the maximum dose to a hypothetical fisherman resulted from consuming catfish from the mouth of Lower Three Runs
[c] Includes the dose from combining external exposure and incidentally ingesting and inhaling the worst-case Savannah River swamp soil
[d] Includes the dose from combining external exposure and incidentally ingesting and inhaling Savannah River swamp soil near the mouth of Steel Creek.

6.5.3 Hypothetical Offsite Fisherman Dose

Creek-Mouth Fish Consumption Pathway—For 2017, 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 to be 0.36 mrem (0.0022 mSv) from catfish it collected at the mouth of Lower Three Runs. SRS bases this hypothetical dose on the low probability scenario that during 2017, a fisherman consumed 24 kg (53 lb) of bass caught exclusively from the mouth of Fourmile Branch. About 98% of this potential dose was from cesium-137.

Savannah River Swamp Fisherman Soil Exposure Pathway—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 using the RESidual RADioactivity (RESRAD) code (Yu et al., 2001). 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 at this location, SRS estimated the potential dose to a fisherman 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 2.08 mrem (0.0208 mSv).

As Table 6-6 shows, the maximum Steel Creek fish consumption dose (0.13 mrem) and the Savannah River Swamp fisherman soil exposure dose (2.08 mrem) were added to conservatively obtain a total offsite fisherman dose of 2.21 mrem (0.0221 mSv). This potential dose is 2.21% of the DOE 100 mrem/yr dose limit.

6.5.4 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 EPA, the Georgia Department of Natural Resources, and South Carolina Department of Health and Environmental Control (SCDHEC). This plan includes assessing radiological risk from consuming Savannah River fish and requires that SRS summarize the results in the annual *SRS Environmental Report*. SRS estimated the potential risks using the cancer morbidity risk coefficients from Federal Guidance Report No. 13 (EPA, 1999). For 2017, SRS estimated the maximum potential lifetime risk of developing fatal and nonfatal cancer from consuming SRS creek-mouth fish to be 2.7E-07. That is, if 10 million people each received a dose of 0.36 mrem, there is a potential for 2.7 extra cancer incidents.

6.6 RELEASE OF MATERIAL CONTAINING RESIDUAL RADIOACTIVITY

DOE Order 458.1 establishes authorized surface contamination limits for unconditional release of personal and real property. 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 the unconditional release of real property on an individual basis that requires specific approval from DOE. SRS did not release any real property in 2017, so the following discussion is associated with release of personal property from SRS. DOE Order 458.1 specifies that the Site must prepare and submit an annual summary of cleared property to the DOE-SR Manager.

6.6.1 Property Release Methodology

SRS uses procedures to govern unconditionally releasing equipment. SRS can release the item after it has a radiological survey if it meets specific documented limits. For items meeting unconditional release criteria, SRS generates a form and attaches it electronically to the applicable radiological survey via the Visual Survey Data System (VSDS). In some areas, SRS documents equipment and material release directly on the radiological survey form. SRS subsequently compiled these VSDS and survey forms and coordinated a site-wide review to determine the amount of material and equipment SRS released from its facilities in 2017. These measures ensure that radiological material releases from SRS are consistent with DOE Order 458.1 requirements.

SRS unconditionally released 14,498 items of personal property from radiological areas in 2017. Most of these items did not leave the Site and were reused elsewhere on the Site. However, all items required no additional radiological controls post-survey as they met DOE Order 458.1 release criteria (DOE Order 458.1 allows the use of DOE Order 5400.5-derived supplemental limits for unconditionally releasing equipment and materials.)

In 2003, DOE approved a SRS request to use supplemental limits to release material from the Site with no further DOE controls. These supplemental release limits, provided in Table 31 of *Radiological Impact of 2017 Operations at the Savannah River Site* (Jannik, Bell, and Dixon 2018), are dose-based and 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 volume criteria allow SRS the option to dispose of potentially volume-contaminated material in Three Rivers Landfill, an onsite sanitary waste facility. In 2017, SRS did not release any material from the Site using the supplemental release limits volume concentration criteria.

6.7 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 of radiation and radioactive material releases. To demonstrate it is complying 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 the following:

- 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)
- Terrestrial animals: 0.1 rad/day (0.001 gray/day)

6.7.1 DOE Biota Concentration Guides

SRS evaluates plant and animal doses for water and land systems using the RESRAD Biota model (version 1.5) (SRS EDAM 2012), which directly implements the DOE (2002) guidance. The RESRAD Biota model uses a graded approach consisting of three increasingly more detailed steps of analysis:

- Level 1 Screening—uses maximum measured concentrations and conservative default model input parameters

- Level 2 Screening—uses average concentrations or site-specific input parameters, as appropriate
- Level 3 Analysis—uses site-specific biota parameters or measured concentrations in the actual biota living at the assessed location

For water systems (animals and plants who live in the water or along riverbanks), the RESRAD Biota model performs a combined water-plus-sediment evaluation. SRS performed initial (Level 1) screenings in 2017 using maximum radionuclide concentration data from SRS's 14 onsite stream and sediment sampling locations. A sum of the fractions less than 1.0 indicates the sampling site has passed its initial pathway screening, which means that the sampling site did not exceed its biota dose rate limits, and SRS does not have to assess the location further. All SRS aquatic system location passed the initial screening and did not require further assessment.

To evaluate land-based systems, 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 2017, all land-based locations passed their initial pathway screenings.

Chapter 7 Groundwater Management Program

The purpose of the Savannah River Site's (SRS's) groundwater management program is to protect, monitor, remediate, and use groundwater. This program does the following:

- **Ensures future groundwater contamination does not occur**
- **Monitors groundwater to identify areas of contamination**
- **Remediates groundwater contamination as needed**
- **Conserves groundwater**

2017 Highlights

Drinking Water Standards—The data show no exceedances of drinking water standards (measured by maximum contaminant limit [MCLs] or regional screening levels [RSLs]) in SRS boundary wells near A/M Area.

Groundwater Contaminant Removal—SRS removed 14,061 pounds (lbs) of volatile organic compounds (VOCs) from groundwater and the vadose zone and prevented 91 curies of tritium from reaching SRS streams.

Offsite Groundwater Monitoring (Georgia)—For more than 15 years, detections of tritium in Georgia groundwater monitoring wells have been well below the MCL for tritium (20 pCi/mL). This data supports the conclusions drawn from a U.S. Geological Survey (USGS) that indicate there is no mechanism by which groundwater could flow under the Savannah River and contaminate Georgia wells (Cherry 2006).

7.1 INTRODUCTION

Some of SRS's past operations have released chemicals and radionuclides into the soil and contaminated the groundwater around hazardous waste management facilities and waste disposal sites. Because of these past releases, SRS operates extensive groundwater monitoring and groundwater remediation programs.

The SRS groundwater monitoring program requires regular well sampling to monitor for groundwater contaminants. Wells are monitored to meet sampling requirements in the Federal Facility Agreement (FFA) for the Savannah River Site (FFA 1993) and in Resource Conservation and Recovery Act (RCRA) permits, and to ensure South Carolina Department of Health and Environmental Control (SCDHEC) and U.S. Environmental Protection Agency (EPA) drinking water quality standards are being met. SRS uses SCDHEC-certified laboratories to analyze groundwater samples.

The monitoring data show that the contaminated groundwater is in the central area of SRS and does not extend beyond the SRS boundary. Groundwater contamination at SRS is primarily limited to the Upper

Chapter 7—Key Terms

Aquifer *is an underground water supply found in porous rock, sand, gravel, etc.*

Attenuation *is a reduction of groundwater contaminants over time due to naturally occurring physical, chemical, and biological processes.*

Confining Unit *is the opposite of an aquifer. It is a layer of rock or sand that limits groundwater movement in and out of an aquifer.*

Contaminants of Concern *are contaminants found at the unit that have undergone detailed analysis and have been found to present a potential threat to human health and the environment.*

Groundwater *is water found underground in cracks and spaces in soil, sand, and rocks.*

Maximum Contaminant Level (MCL) *is the highest level of a contaminant allowed in drinking water.*

Plume *is a volume of contaminated water originating at a waste source (for example, a hazardous waste disposal site). It extends downward and outward from the waste source.*

Recharge *occurs when water from the surface travels down into the subsurface, replenishing the groundwater.*

Regional Screening Level (RSL) *is the risk-based concentration derived from standardized equations combining exposure assumptions with toxicity data.*

Remediation *cleans up sites contaminated with waste due to historical activities.*

Surface water *is water found above ground (for example, streams, lakes, wetlands, reservoirs, and oceans).*

Vadose Zone *is the subsurface layer below the land surface and above the water table. The vadose zone has a low water compared to saturated zone, so therefore it is also referred to as being unsaturated.*

Waste Unit *is an area that is, or may be, posing a threat to human health or the environment. They range in size from a few square feet to tens of acres and include basins, pits, piles, burial grounds, landfills, tank farms, disposal facilities, process facilities, and contaminated groundwater.*

Three Runs/Steed Pond Aquifers and the Gordon/Lost Lake Aquifers (Figure 7-1). SRS submits summaries of groundwater data to regulatory agencies, and, if necessary, remediates or removes the contamination. A list of documents that SRS submits to the regulatory agencies reporting groundwater monitoring data is in Appendix E.

SRS uses several technologies to remediate groundwater that exceeds the MCLs or the RSLs. Remediation includes closing waste units to reduce the potential for contaminants to reach groundwater, actively treating contaminated water, and employing passive and natural (attenuation) remedies.

Groundwater remediation at SRS focuses on VOCs and tritium. VOCs in groundwater, mainly trichloroethylene (TCE) and tetrachloroethylene (PCE), originate from industrial work at SRS where they were used as degreasing agents. Tritium in groundwater is a byproduct of nuclear materials production at SRS. Corrective measures at SRS include monitored natural attenuation and phytoremediation (using trees and plants to remove or break down contaminants). These practices are removing VOCs from the groundwater and effectively reducing tritium releases into SRS streams and the Savannah River.

7.2 GROUNDWATER AT SRS

The groundwater flow system at SRS consists of the following four major aquifers separated by confining units:

- Upper Three Runs/Steed Pond
- Gordon/Lost Lake
- Crouch Branch
- McQueen Branch

Groundwater flow in recharge areas generally migrates downward and laterally. It eventually flows into the Savannah River and its tributaries or migrates into the deeper regional flow system. Figure 7-1 presents a three-dimensional block diagram of these units at SRS and the generalized groundwater flow patterns within those units. The movement of water from the ground's surface into the aquifers can carry contamination along with it, resulting in underground plumes of contaminated water (Figure 7-2).

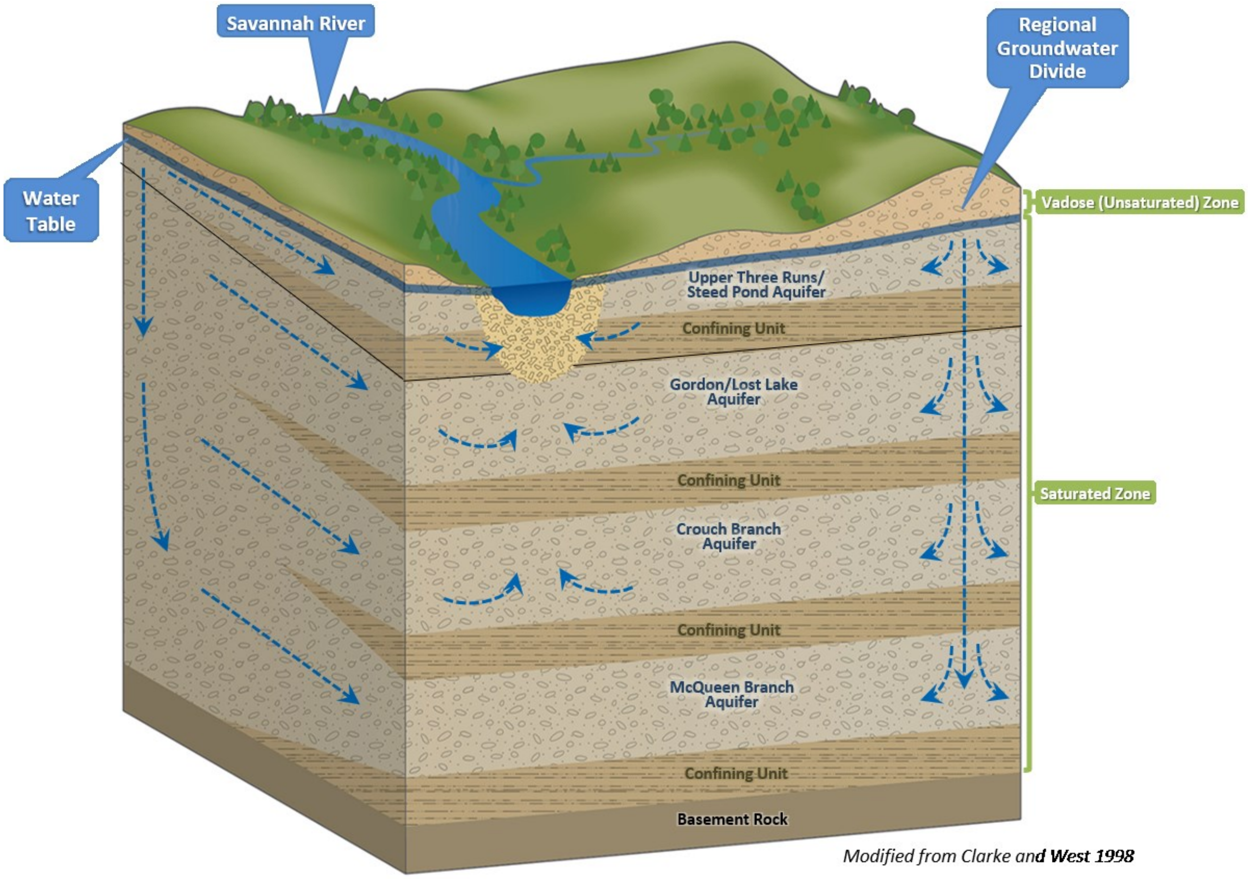


Figure 7-1 Groundwater at SRS

7.3 GROUNDWATER PROTECTION PROGRAM AT SRS

SRS has designed and implemented a groundwater protection program to prevent new releases to groundwater, and to remediate contaminated groundwater to meet federal and state laws and regulations, U.S. Department of Energy (DOE) Orders, and SRS policies and procedures. It contains the following elements:

- Protecting SRS groundwater
- Monitoring SRS groundwater
- Remediating SRS groundwater
- Conserving SRS groundwater

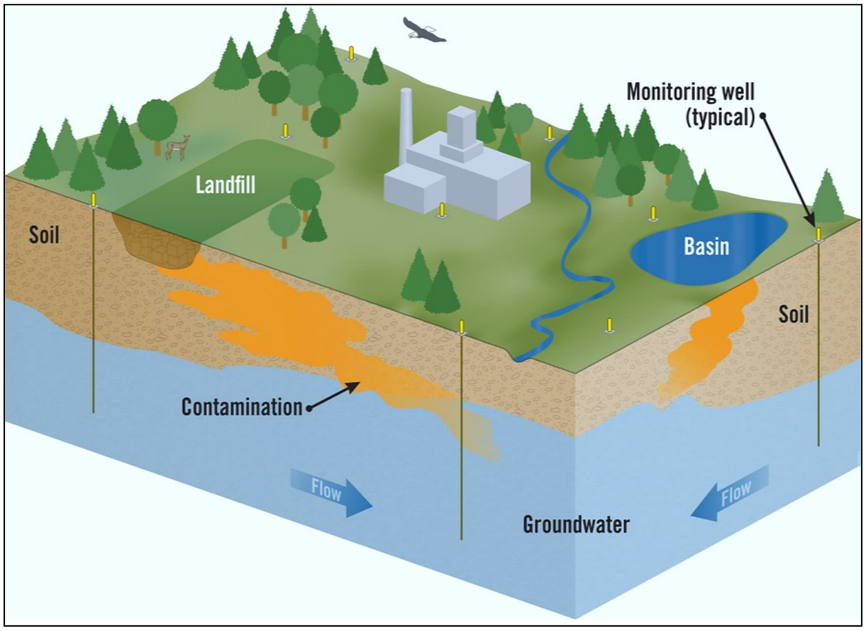


Figure 7-2 How Contamination Gets to Soil and Groundwater

7.3.1 Protecting SRS Groundwater

SRS groundwater management focuses on preventing and monitoring groundwater contamination, protecting the public and environment from contamination, and preserving groundwater quality for future use. Groundwater protection is performed through the following:

- Preventing or controlling groundwater contamination sources from construction sites, hazardous waste management facilities, and waste units
- Monitoring groundwater and surface water to detect contaminants
- Reducing contaminants via a groundwater cleanup program

7.3.2 Monitoring SRS Groundwater

The purpose of monitoring groundwater is to observe and evaluate changes in the groundwater quality over time and to establish, as accurately as possible, the baseline quality of the groundwater occurring naturally in the aquifers. The SRS groundwater monitoring program includes two primary components: groundwater contaminant source monitoring and groundwater surveillance monitoring. SRS evaluates groundwater-monitoring data frequently to identify whether new groundwater contamination exists or if it needs to modify current monitoring programs.

SRS uses groundwater-monitoring data to determine the effects of Site operations on groundwater quality. The program supports the following critical activities:

- Complying with environmental regulations and DOE directives
- Evaluating the status of groundwater plumes
- Evaluating new activities planned near or within the groundwater plume footprint
- Enhancing groundwater remediation through basic and applied research projects

Monitoring the groundwater around SRS facilities, waste disposal sites, and associated streams is the best way to detect and track contaminant migration. Through careful monitoring and analysis, SRS implements appropriate remedial or corrective actions. Figure 7-3 shows the groundwater plumes associated with SRS.

Per discussions with EPA and SCDHEC, SRS adds emerging contaminants to analyte lists when historical or process knowledge indicates that a contaminant could now be of concern. Emerging contaminants are chemicals that have been detected in drinking water supplies, but their risk to human health and the environment is not fully understood. 1,4-Dioxane is one of the emerging contaminants that SRS monitors regularly in conjunction with VOC plumes.

7.3.2.1 Groundwater Surveillance Monitoring

Surveillance monitoring at SRS focuses on collecting and analyzing data to characterize the groundwater flow and the presence or absence of contaminants. Characterization at SRS includes the following activities:

- Collecting soil and groundwater samples to determine the extent of contamination
- Obtaining geologic soil cores or seismic profiles to better determine underground structural features, as warranted
- Installing wells to periodically collect water-level measurements and groundwater samples
- Developing maps to help define groundwater flow
- Performing calculations based on water elevation data to estimate groundwater velocities
- Analyzing regional groundwater to provide a comprehensive understanding of SRS groundwater movement, and specifically contaminant movement, near facilities, individual waste units, and at the Site boundary
- Characterizing regional surface water flow to assess contaminant risk to perennial streams, which are the receptors of groundwater flow.

Sampling a Monitoring Well (above) and Equipment (right)

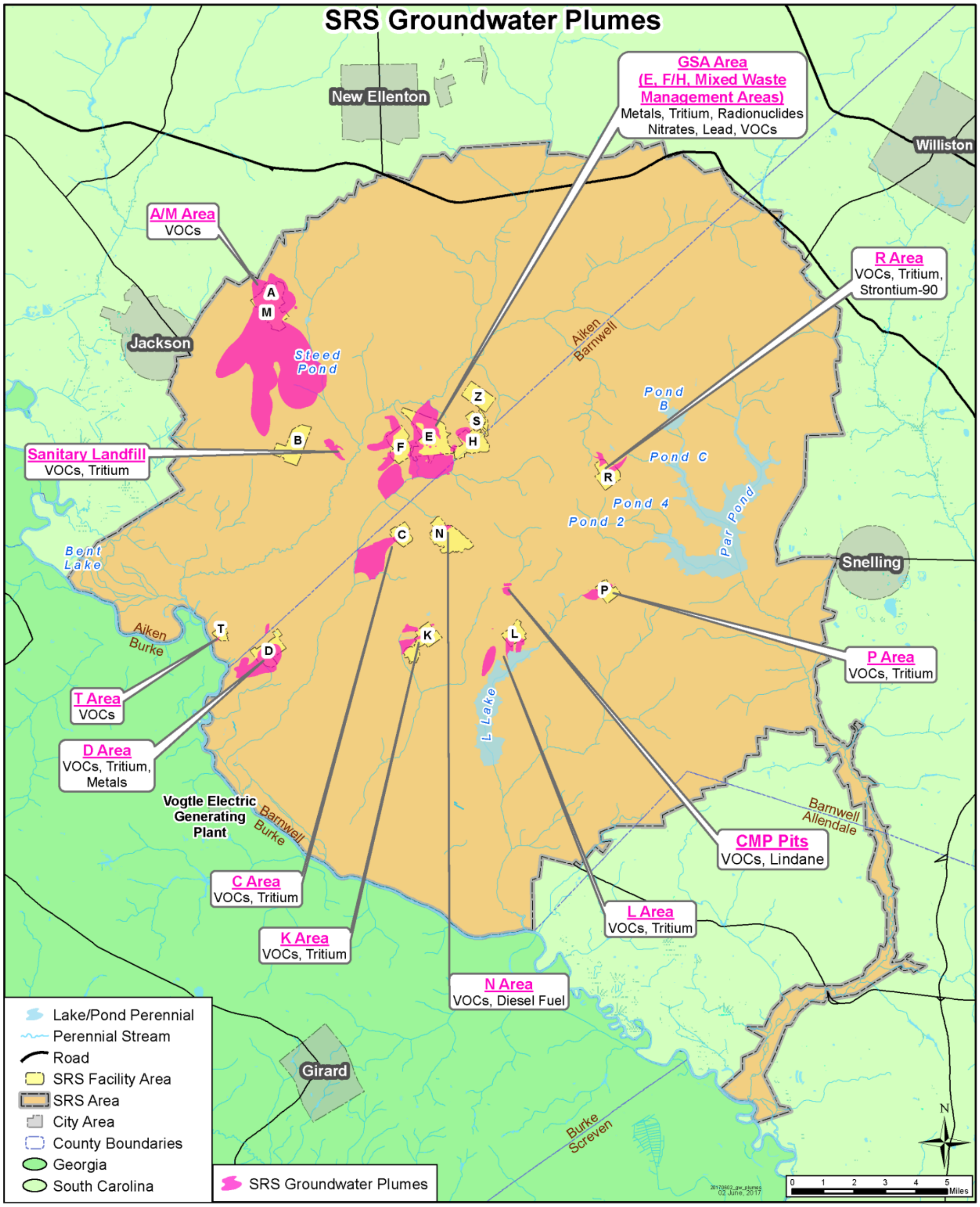


Figure 7-3 Groundwater Plumes at SRS

7.3.2.2 2017 Groundwater Data Summary

SRS uses more than 150 wells to monitor a significant plume beneath A/M Area. Some of these monitoring wells lie within a half-mile of the northwestern boundary of SRS. The direction of groundwater flow in the area parallels the Site boundary; however, groundwater flow direction can fluctuate. Because of this, SRS concentrates on the groundwater results from the wells along the Site boundary, as well as those between A/M Area and the nearest population center, Jackson, South Carolina (Figure 7-4). The data show no exceedances of drinking water standards (MCLs or RSLs) in SRS boundary wells near A/M Area. No detectable contamination exists in a majority of these SRS boundary wells.

Although most SRS-contaminated groundwater plumes do not approach the Site boundary, the potential to affect Site streams exists when contaminated groundwater flows into nearby streams. SRS monitors and evaluates groundwater contamination that flows into Site streams and remediates it as appropriate. In conjunction with stream monitoring, as discussed in Chapter 5, *Radiological Environmental Monitoring Program*, Section 5.4.3, *SRS Stream Sampling and Monitoring*, SRS conducts extensive monitoring near SRS waste units and operating facilities, regardless of their proximity to the boundary. *Savannah River Site Groundwater Management Strategy and Implementation Plan* (SRNS 2017) contains details concerning groundwater monitoring and conditions at individual sites.

Table 7-1 identifies the typical contaminants of concern (COCs) found in SRS groundwater and their significance. These COCs are a result of SRS operations that released chemicals and radionuclides into the soil and groundwater near hazardous waste management facilities and waste disposal sites. Table 7-2 presents a general summary of the most common contaminants found in groundwater at SRS facility areas, based on 2017 monitoring data, and compares the maximum concentrations to the appropriate drinking water standards. Table 7-2 shows the major COCs in the groundwater beneath SRS, including common degreasers (TCE and PCE) and radionuclides (tritium, gross alpha, and nonvolatile beta emitters).

Since the early 1990s, SRS has directed considerable effort to assessing the likelihood of flow beneath the Savannah River from South Carolina to Georgia. A groundwater model developed by the U.S. Geological Survey (USGS) indicates there is no mechanism by which groundwater could flow under the Savannah River and contaminate Georgia wells (Cherry 2006). SRS continues to monitor for tritium in groundwater wells in Georgia (Figure 7-5) by collecting samples annually during the second half of the year. Detections of tritium in groundwater in these Georgia off-site wells have been below 1.5 pCi/mL since 1999 (Figure 7-6). The MCL, or drinking water standard, for tritium is 20 pCi/mL. The 2017 results had no detectable concentrations of tritium.

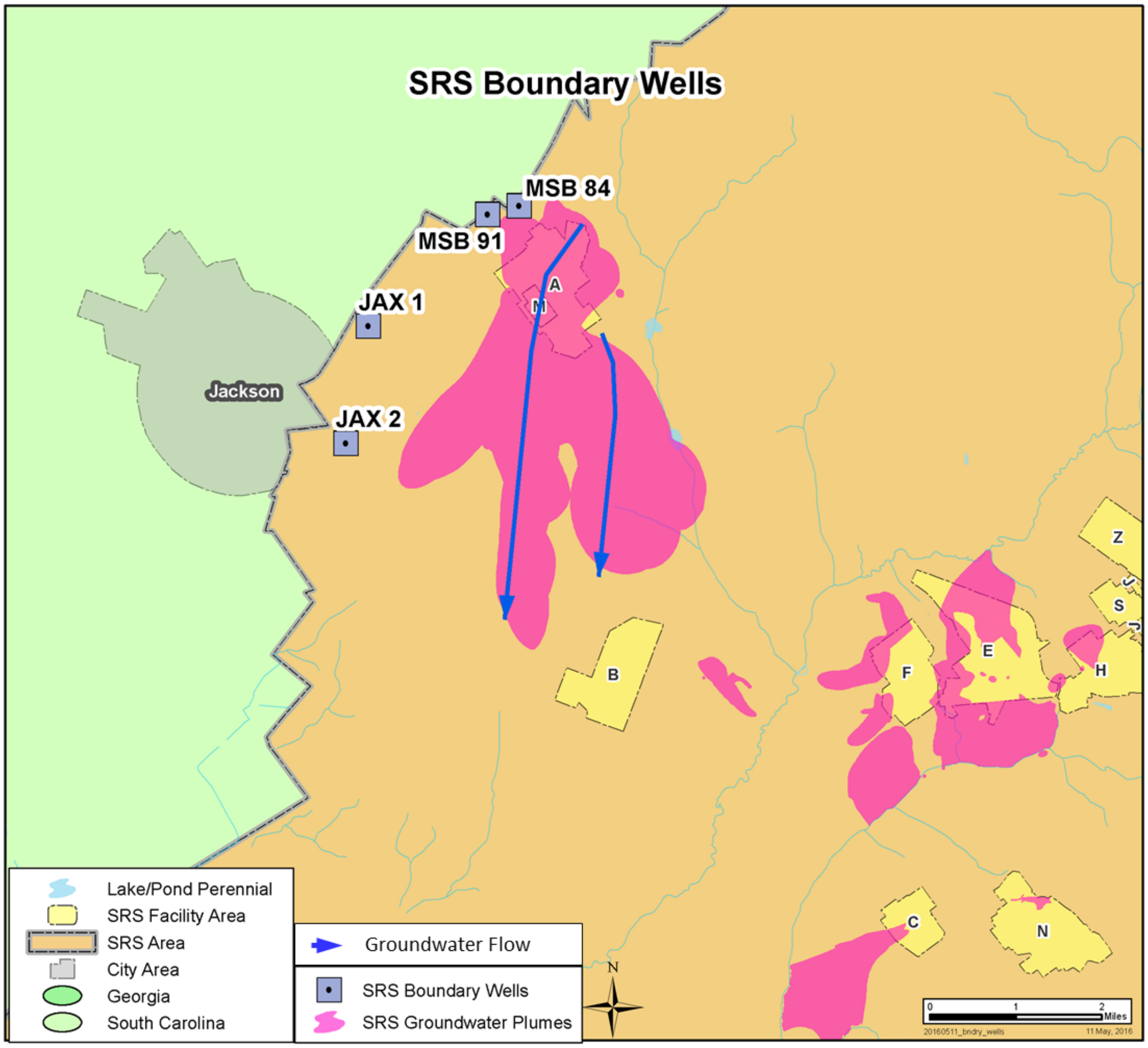


Figure 7-4 Location of Site Boundary Wells at SRS—Between A/M Area and Jackson, South Carolina

Table 7-1 Typical Contaminants of Concern at SRS

Contaminants	Sources	Limits, Exposure Pathways, and Health Effects
Gross Alpha	Alpha radiation emits positively charged particles from the radioactive decay of certain elements including uranium, thorium, and radium. Alpha radiation in drinking water can be in the form of dissolved minerals or a gas (radon).	MCL is 15 pCi/L. An alpha particle cannot penetrate a piece of paper or human skin. It causes increased risk of cancer through ingestion or inhalation.
Nonvolatile Beta	Beta decay commonly occurs among neutron-rich fission byproducts produced in nuclear reactors.	MCL is 4 mrem/yr. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
Tritium	Radioactive isotope of hydrogen with a half-life of 12.3 years. It emits a very weak beta particle and behaves like water.	MCL is 20 pCi/mL. It primarily enters the body when people swallow tritiated water. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
Trichloroethene/ Tetrachloroethene	VOCs used primarily to remove grease from fabricated metal parts.	MCL is 5 µg/L. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
Vinyl Chloride	VOC formed as a degradation product of TCE/PCE.	MCL is 2 µg/L. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
1,4-Dioxane	Synthetic industrial chemical used as a stabilizer for VOCs to reduce degradation.	RSL for tap water is 0.46 µg/L. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.

Table 7-2 Summary of the Maximum Contaminant Concentrations for Major Areas within SRS

Location	Major Contaminant	Units	2017 Max Concentration	Well	MCL/ RSL	Likely Stream Endpoints
A/M Area	Tetrachloroethylene	µg/L	80,000	MSB002BR	5	Tims Branch/Upper Three Runs in Swamp in West
	Trichloroethylene	µg/L	32,000	MSB004BR	5	
	1,4-Dioxane	µg/L	250	ARP 1A	6.1[a]	
C Area	Tetrachloroethylene	µg/L	9.55	CRP 5C	5	Fourmile Branch and Castor Creek
	Trichloroethylene	µg/L	2,260	CRP 20CU	5	
	Tritium	pCi/mL	3,890	CAGW-06	20	
CMP Pits (G Area)	Tetrachloroethylene	µg/L	795	CMP 35D	5	Pen Branch
	Trichloroethylene	µg/L	495	CMP 35D	5	
	Lindane	µg/L	5.78	CMP 35D	0.2	
D Area	Beryllium	µg/L	189	DCB 23C	4	Savannah River Swamp
	Tetrachloroethylene	µg/L	9.47	DCB 45C	5	
	Trichloroethylene	µg/L	140	DCB 62	5	
	Vinyl Chloride	µg/L	18	DOB 15	2	
	Tritium	pCi/mL	329	DCB 26AR	20	
E-Area MWMF	Trichloroethylene	µg/L	500	BSW 4D2	5	Upper Three Runs/Crouch Branch in North; Fourmile Branch in South
	1,4-Dioxane	µg/L	690	BSW 6C3	6.1[a]	
	Tritium	pCi/mL	20,600	BSW 4D2	20	
	Gross Alpha	pCi/L	17.9	HSB 85C	15	
	Nonvolatile Beta	pCi/L	45.8	HSP 097A	50[b]	

Location	Major Contaminant	Units	2017 Max Concentration	Well	MCL/ RSL	Likely Stream Endpoints
F Area	Trichloroethylene	µg/L	29.4	FGW003C	5	Fourmile Branch
	Tritium	pCi/mL	70.5	FGW012C	20	
	Gross Alpha	pCi/L	1,160	FGW 5C	15	
	Nonvolatile Beta	pCi/L	844	FGW 5C	50[b]	
F-Area HWMF	Trichloroethylene	µg/L	17	FSB 78C	5	Fourmile Branch
	Tritium	pCi/mL	1,460	FSB 78C	20	
	Gross Alpha	pCi/L	479	FSB 94C	15	
	Nonvolatile Beta	pCi/L	921	FSB 78C	50[b]	
F-Area Tank Farm	Tritium	pCi/mL	105	FTF030D	20	Fourmile Branch/Upper Three Runs
	Nonvolatile Beta	pCi/L	598	FTF 28	50[b]	
	Manganese	µg/L	179	FTF030D	430	
H Area	Trichloroethylene	µg/L	4.92	HGW 2D	5	Upper Three Runs/Crouch Branch in North; Fourmile Branch in South
	Gross Alpha	pCi/L	56.5	HAA 15A	15	
	Nonvolatile Beta	pCi/L	99.1	HAA 15A	50[b]	
	Tritium	pCi/mL	28.9	HGW 2D	20	
H-Area HWMF	Trichloroethylene	µg/L	134	HSB120C	5	Fourmile Branch
	Tritium	pCi/mL	1,460	HSB129C	20	
	Gross Alpha	pCi/L	56.5	HSB102D	15	
	Nonvolatile Beta	pCi/L	99.1	HSB103D	50[b]	
H-Area Tank Farm	Tritium	pCi/mL	56.7	HAA 12C	20	Fourmile Branch/Upper Three Runs
	Nonvolatile Beta	pCi/L	28.9	HAA 4D	50[b]	
	Manganese	µg/L	370	HAA 10D	430	
K Area	Tetrachloroethylene	µg/L	6.47	KDB 1	5	Indian Grave Branch
	Trichloroethylene	µg/L	2.8	KRP 9	5	
	Tritium	pCi/mL	3,430	KRB 19D	20	
L Area	Tetrachloroethylene	µg/L	48.4	LSW 25DL	5	L Lake
	Trichloroethylene	µg/L	3.68	LSW030DL	5	
	Tritium	pCi/mL	593	LSW 25DL	20	
P Area	Trichloroethylene	µg/L	2.55	PRP 6	5	Steel Creek
	Tritium	pCi/mL	682	PDB 2	20	
R Area	Trichloroethylene	µg/L	15	RAG008B	5	Mill Creek in Northwest; Tributaries of PAR Pond
	Tritium	pCi/mL	1,930	RDB 3D	20	
	Strontium-90[c]	pCi/L	264	RSE 10	8	
Sanitary Landfill	1,4-Dioxane	µg/L	180	LFW 62C	6.1[a]	Upper Three Runs
	Trichloroethylene	µg/L	7.4	LFW 32C	5	
	Vinyl Chloride	µg/L	18	LFW 10A	2	
TNX	Trichloroethylene	µg/L	24	TRW 2	5	Savannah River Swamp
Z Area	Technetium-99	pCi/L	126	ZBG020D	50[b]	Upper Three Runs
	Nonvolatile Beta	pCi/L	51.9	ZBG020D	50[b]	

Notes: MWMF is the Mixed Waste Management Facility; HWMF is the Hazardous Waste Management Facility; TNX is the 678-T facilities; CMP is the Chemicals, Metals, and Pesticides Pits.

[a] The 1,4-Dioxane standard is a RCRA-permitted Groundwater Protection Standard.

[b] The MCL for nonvolatile beta activity (pCi/L or pCi/mL) equivalent to 4 mrem/yr varies according to which specific beta emitters are present in the sample. At SRS this value equates to 50 pCi/L.

[c] At R Area, strontium-90 is sampled every two years. It was last sampled in 2017.

µg = micrograms

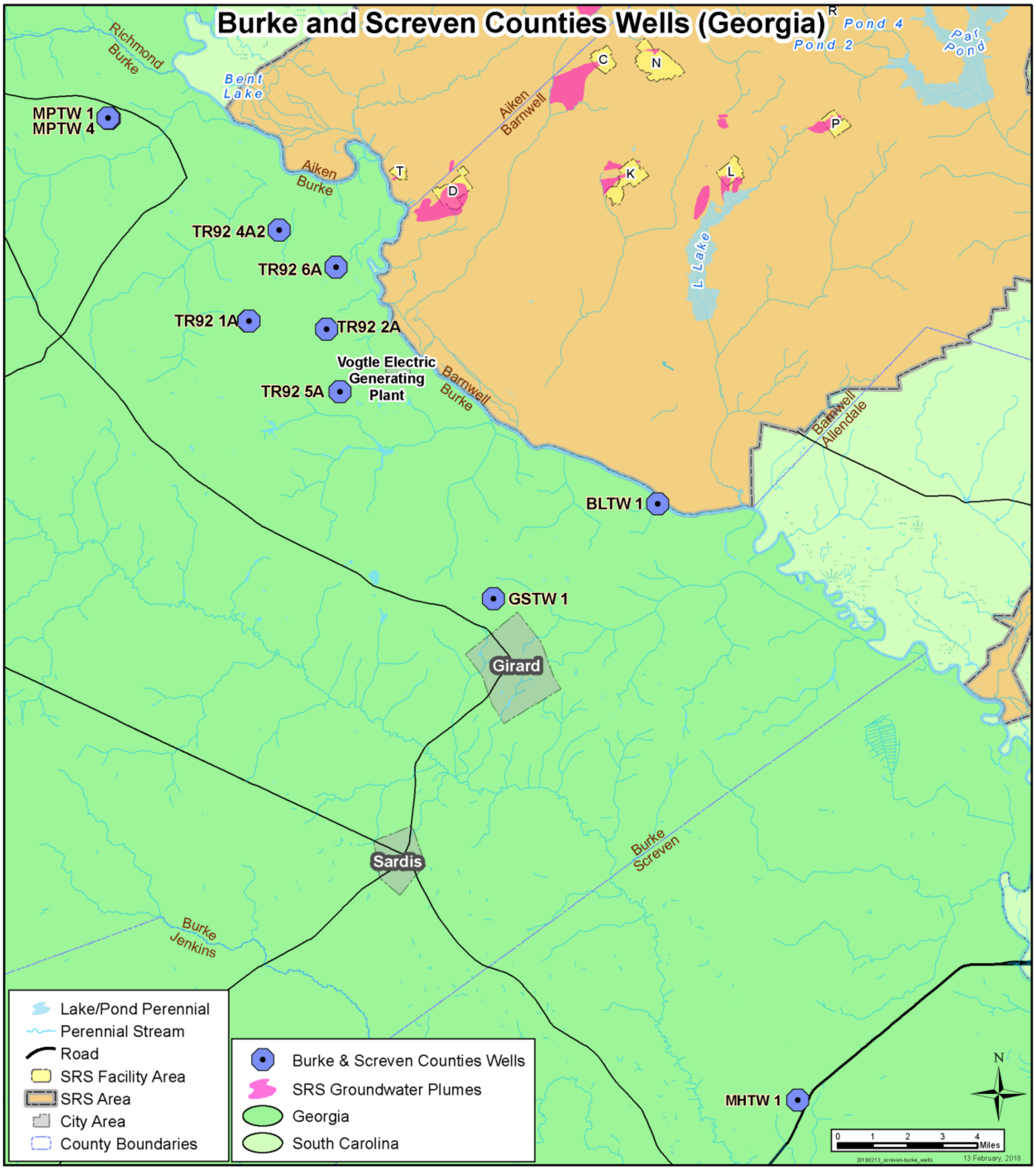


Figure 7-5 Location of Monitoring Wells Sampled for Tritium in Burke and Screven Counties, Georgia

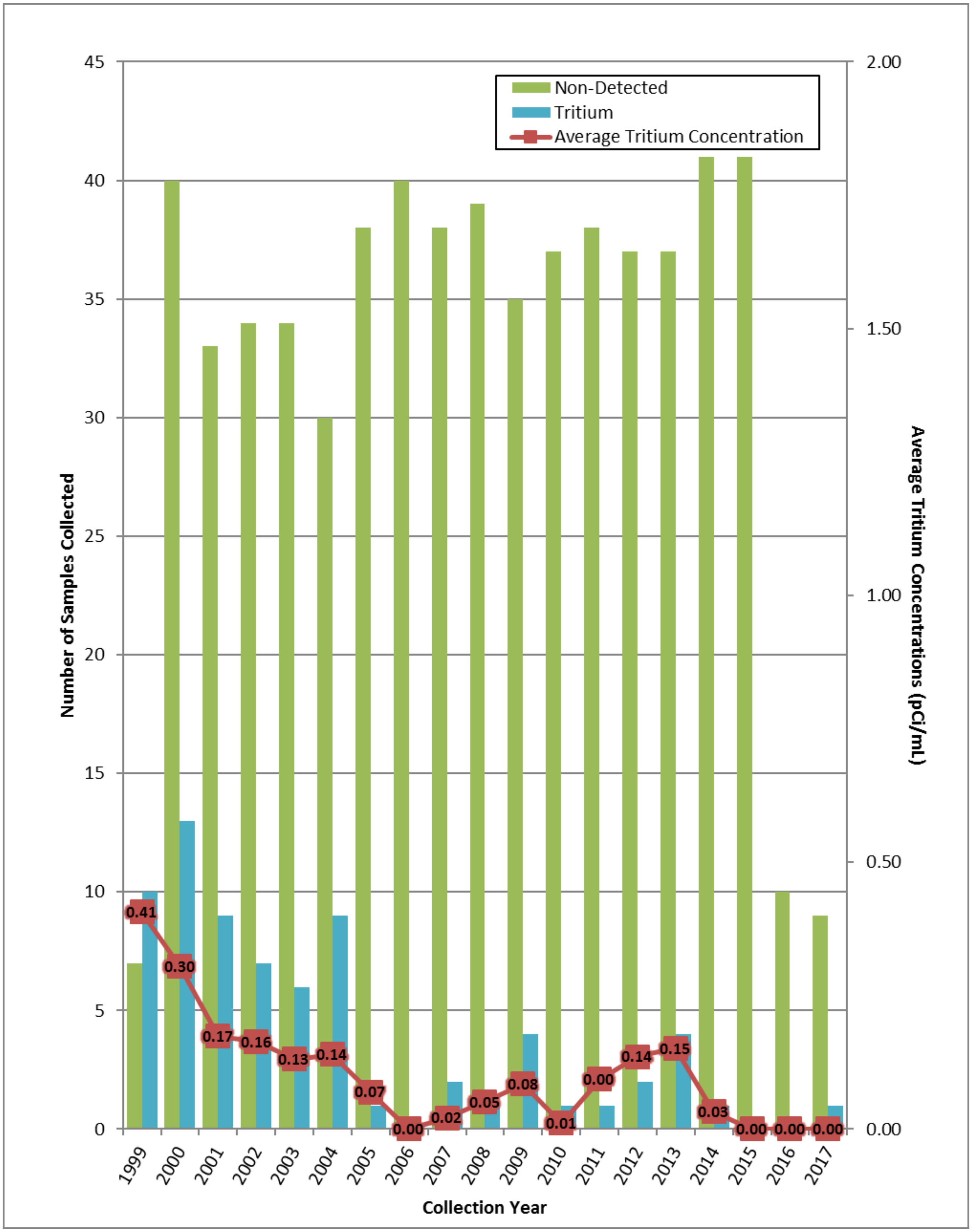


Figure 7-6 Tritium Concentration in Wells Sampled in Burke and Screven Counties, Georgia

7.3.3 Remediating SRS Groundwater

SRS's environmental remediation program has been in place for more than 20 years. The Federal Facility Agreement (FFA) for the Savannah River Site (FFA 1993) specifies that RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulate remediating and monitoring contaminated groundwater. Remediation focuses on removing mass, reducing contaminant levels, and reducing the exposure of humans and the environment to contaminants that exceed either the MCLs or RSLs. Table 7-2 identifies the MCLs and RSLs for the primary contaminants of concern in SRS groundwater.

For each remediation project, SRS determines the degree of and extent to which the groundwater is contaminated. After completing this evaluation, SRS and the regulatory agencies decide upon a strategy for remediating the groundwater.

SRS often applies remedial actions to the groundwater contamination source. For instance, SRS widely uses soil vapor extraction, a technology that extracts contaminated soil vapor from the vadose (unsaturated) zone to remove VOCs. This technology minimizes the VOCs that will reach the water table.

SRS implements several groundwater remedial technologies. These technologies manage the rate the contaminants move and reduce the risk of contaminant exposure to human health and ecological receptors. Thirty-seven remediation systems are currently operating. In 2017, SRS removed 14,061 lbs of VOCs from the groundwater and the vadose zone, and prevented 91 curies of tritium from reaching SRS streams (SRNS 2017). SRS has worked for more than 20 years to reduce the tritium flux to Fourmile Branch. Since 2000, SRS has reduced the tritium flux to Fourmile Branch by almost 70% using groundwater remedial technologies (subsurface barriers and water capture with irrigation). The Mixed Waste Management Facility (MWMF) Phytoremediation Project has the largest reductions.

A/M Area is SRS's largest groundwater plume, as shown in Figure 7-3. The earliest identified contamination in the A/M Area plume is associated with the M-Area and Metallurgical Laboratory Hazardous Waste Management Facility (Met Lab HWMF), located in the general proximity of the "M" shown in Figure 7-4. Remediation at these two facilities began in 1988 when groundwater was pumped from wells to an above-ground treatment system, followed by soil vapor extraction, then by thermal treatment as shown in Figure 7-7. As of 2017, these technologies have removed 1.54 million pounds of solvent, consisting of TCE and PCE.

Another technology SRS is implementing to address VOC contamination is humate amendment injection. Humate is a mixture of high molecular weight organic molecules that have an affinity for many metals and radionuclides. Humate amendment injection consists of adding dissolved humate to the source of contamination to weaken the effect of the VOCs. This technology treats the source by increasing the sorption of TCE to aquifer sediment and increasing the attenuation of TCE. A study investigating using humate amendments to enhance the attenuation of the VOCs was conducted for the Southern Sector of the A/M Area plume. Humate injection started in July when one batch, or approximately 10,000 gallons of humate-amended groundwater, was injected into well SSR001. However, injection rates were lower than expected. Consequently, in October, SRS suspended all operations to modify the system to increase the injection rates of the humate. The system is expected to restart in 2018.

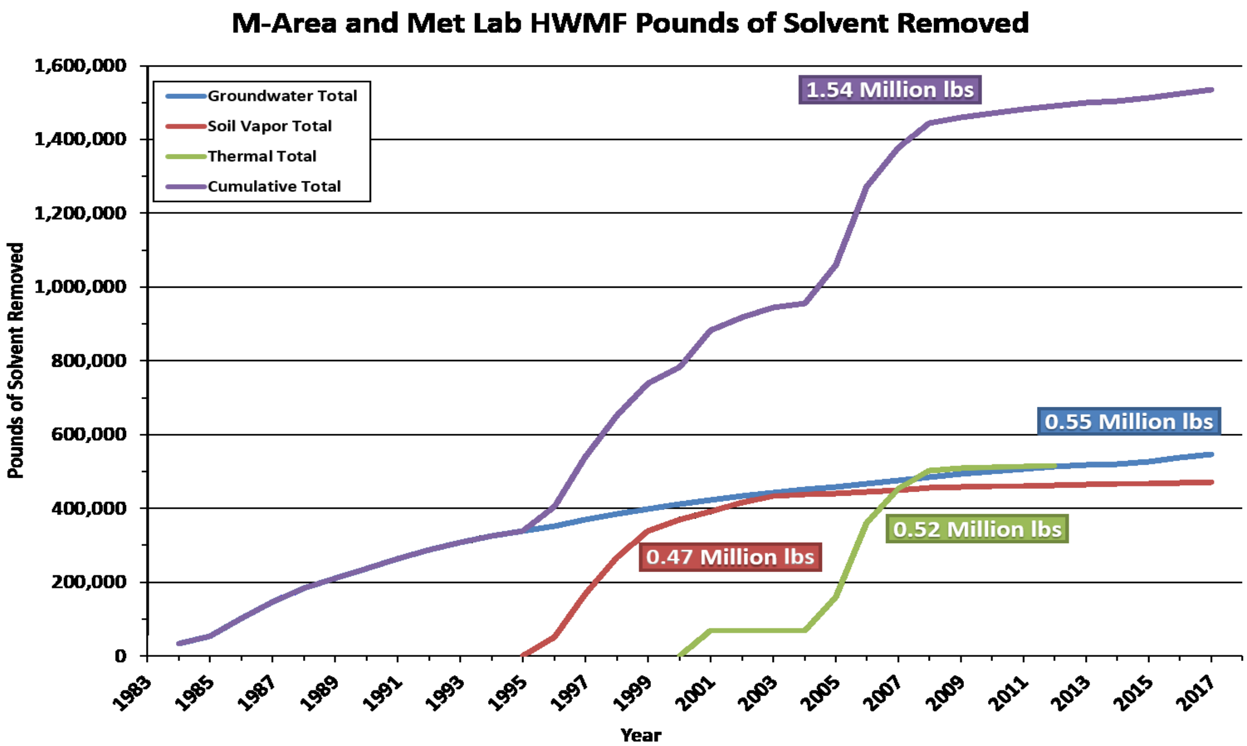


Figure 7-7 Solvent Removed from A/M Area Groundwater Plume

Overall, the size, shape, and volume of most SRS groundwater plumes are shrinking because most of the contaminant sources have remediation systems in place. The *Soil and Groundwater Closure Projects Technology Descriptions* (WSRC 2007) explains SRS remediation systems.

7.3.4 Conserving SRS Groundwater

As in the past, SRS continues to report its drinking and process water use to SCDHEC. In 2017, SRS used 2.76 million gallons of water per day. Information on SRS water conservation is in Chapter 2, *Environmental Management System*.

SRS manages its own drinking and process water supply from groundwater beneath the Site. Approximately 40 production wells in widely scattered locations across the Site supply SRS domestic and process water systems. Eight of these wells are domestic water systems that supply drinking water. The other 32 wells provide water for all SRS facility operations. The *SRS Environmental Report for 2017* webpage contains a map of SRS domestic water systems under the *Environmental Maps* heading.

The A-Area domestic water system now supplies treated water to most Site areas. The system is made up of a treatment plant, distribution piping, elevated storage tanks, and a well network. The wells range in capacity from 200 to 1,500 gallons per minute. Remote facilities, such as field laboratories, barricades, and pump houses, use small drinking water systems and bottled water. SRS domestic water systems meet state and federal drinking water quality standards. SCDHEC samples the systems quarterly for chemical analyses. Monitoring the A-Area water system for bacteria occurs monthly. SCDHEC performs sanitary surveys every two years on the A-Area system and inspects the smaller systems every three years. All 2017 water samples complied with SCDHEC and EPA water quality standards. Information on compliance activities associated with the SRS drinking water system is in Chapter 3, *Compliance Summary*, Section 3.3.7.2, *Safe Drinking Water Act (SDWA).*

A, F, H, and S Areas have process water systems to meet SRS demands for boiler feedwater, equipment cooling water, facility washdown water, and makeup water. The makeup water is used for cooling towers, fire storage tanks, chilled-water-piping loops, and Site test facilities. Process water wells ranging in capacity from 100 to 1,500 gallons per minute supply water to these systems. In K Area, L Area, and Z Area, the domestic water system supplies the process water system. At some locations, the process water wells pump to ground-level storage tanks, where SRS implements corrosion control measures. At other locations, the wells directly pressurize the process water distribution piping system without supplemental treatment.

Chapter 8 Quality Assurance

The Savannah River Site (SRS) Quality Assurance (QA)/Quality Control (QC) program objectives ensure SRS products and services meet or exceed customers' requirements and expectations. SRS QA/QC objectives associated with the Environmental Monitoring Program ensure the environmental data accurately represents SRS discharges and the conditions of the surrounding environment. The Environmental Monitoring Program has multiple QA requirements for collecting samples, analyzing and reporting, data management, and records management. It is important to confirm the accuracy of sample results so SRS can confidently assess the impacts Site activities may have on human health and the environment.

2017 Highlights

Analytical Laboratory Quality Assurance—SRS uses South Carolina Department of Health and Environmental Control (SCDHEC)-certified laboratories to analyze environmental monitoring samples that are reported to SCDHEC.

The DOE Consolidated Audit Program (DOECAP) audited three SRS subcontracted laboratories and five treatment, storage, and disposal facilities (TSDFs). The audits determined that each facility provided services that were of sufficient quality to warrant DOE continuing to use them.

Quality Control Activities—QC samples identified no defects affecting the analytical results of the surveillance and monitoring programs. Onsite and subcontracted laboratories reported acceptable proficiency and maintained SCDHEC certification for all analyses.

8.1 INTRODUCTION

SRS implements and conducts its QA program to comply with the following regulations: 1) U.S. Department of Energy (DOE) Order 414.1D, *Quality Assurance*, 2) American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA) standards NQA-1-2008 with the NQA-1a-2009 Addenda, *QA Requirements for Nuclear Facility Applications*, and 3) 10 CFR 830, *Nuclear Safety Management*. In addition, specific programs may have other QA requirements from outside organizations. For example, under the tank closure program and area closure projects, the U.S. Environmental Protection Agency (EPA) and the State of South Carolina require DOE to develop and follow a project-specific sampling and analysis plan and a QA program plan. DOE has QA programs to verify the integrity of analyses from onsite and subcontracted offsite environmental laboratories, and to ensure it is complying with the quality-control program requirements.

Chapter 8—Key Terms

Quality assurance *is an integrated system of management activities involving planning, implementing, documenting, assessing, reporting, and improving quality to ensure quality in the processes by which products are developed. The goal of QA is to improve processes so that defects do not arise when the product is produced. It is proactive.*

Quality control *is a set of activities to ensure quality in products by identifying defects in the actual products. The goal of QC is to identify and correct defects in the finished product before it is made available to the customer. QC is a reactive process.*

In summary, quality assurance makes sure you are doing the right things, the right way; quality control makes sure the results of what you have done are what you expected.

The SRS Environmental Monitoring Program uses and disseminates high-quality data to further environmental stewardship and support other Site missions. The environmental monitoring QA/QC program is designed to improve the methods and techniques used to both collect and analyze the environmental data and to prevent errors in generating the data. The QA/QC program includes continuous assessments, precision checks, and accuracy checks, as Figure 8-1 shows. The results of activities in one area provide input to assessments or checks conducted in the other two areas in an ongoing process. The result is high-quality data. By combining continuous assessment of field, laboratory, and data management performance with checks for accuracy and precision, SRS ensures that all monitoring and surveillance data accurately represent conditions at SRS. The glossary contains definitions for each term Figure 8-1 presents.

Some elements of the QA/QC program are inherent within environmental monitoring standard procedures and practices. SRS personnel evaluate these elements as part of the continuous assessment process. The DOECAP focuses on assessing specific QA/QC program elements. Figure 8-1 shows the QA/QC elements discussed in this chapter in bold text.

8.2 BACKGROUND

DOE Order 414.1D, *Quality Assurance*, requires an integrated system of management activities to ensure that the results of the Environmental Monitoring Program meet the requirements of federal and state regulations and DOE Order 458.1, *Radiation Protection of the Public and the Environment*. SRS uses field and laboratory procedures to guide activities such as collecting samples, analyzing samples, evaluating data, and reporting results. SRS uses an integrated testing system to ensure the integrity of analyses SRS and offsite laboratories perform. This testing includes internal laboratory QA and QC tests and testing associated with state and national testing programs, such as the Mixed Analyte Performance Evaluation Program (MAPEP). In addition, SRS uses QA and QC procedures to verify and control environmental monitoring activities. Together, these quality measures ensure the resulting data provide a representative evaluation of SRS operational impacts on the health and safety of the public, workers, and the environment.

8.3 QUALITY ASSURANCE PROGRAM SUMMARY

The SRS environmental monitoring QA/QC program focuses on minimizing errors through ongoing assessment and control of the program components. The QA and QC activities are interdependent.

For example, QC identifies an ongoing problem with the quality of the product and alerts QA personnel that there is a problem in the process. QA determines the root cause and extent of the problem and changes the process to eliminate the problem, prevent reoccurrences, and improve product quality.

QA focuses on the processes implemented to produce the data presented in this report. In 2017, QA efforts associated with the Environmental Monitoring Program that led to program improvements were as follows:

- Implemented monitoring program changes
- Performed DOECAP audits of laboratories SRS used and audits of commercial treatment, storage, and disposal facilities (TSDFs) SRS waste generators used

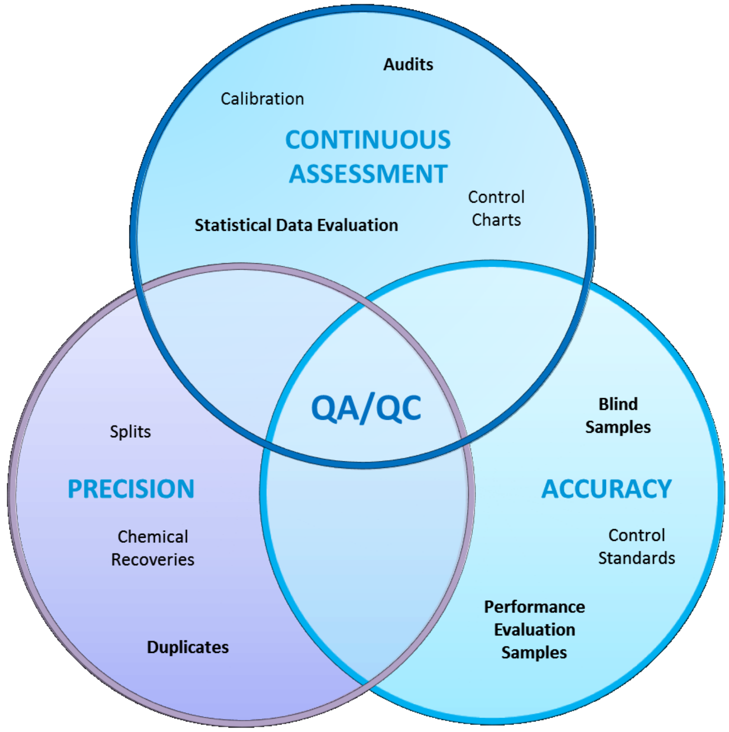


Figure 8-1 Interrelationship between QA/QC Activities

QC activities are the tests and checks that ensure SRS is complying with defined standards. In 2017, the QC activities associated with the environmental monitoring program included the following:

- Participated in MAPEP by laboratories that perform analytical measurements on SRS samples
- Participated in proficiency testing for laboratories performing National Pollutant Discharge Elimination System (NPDES) and drinking water analyses
- Collected and analyzed QC samples (duplicates and blind samples) associated with field sampling

8.4 ENVIRONMENTAL MONITORING PROGRAM QA ACTIVITIES

SRS continuously assesses the Environmental Monitoring Program to identify and implement continuous improvement and minimize the potential for errors. During 2017, SRS implemented the following improvements:

- Air Effluent – Completed implementing compositing of individual airborne effluent samples through the Air Effluent Program. This effort was initiated and reported in the *2016 Annual Site Environmental Report*. Initiated compositing of air filter samples in the Air Surveillance program to decrease the minimum detected concentration.
- Wildlife Monitoring – Completed implementing the new field monitoring system. The development efforts were summarized in the *2016 Annual Site Environmental Report*.
- Liquid Surveillance Program – Added three long-lived radionuclides to monitoring of Fourmile Branch. Radium-226, neptunium-237, and niobium-94 were added to the annual sampling and

carbon-14 was added to the monthly sampling. These additions were based on a recommendation in the *Critical Radionuclide and Pathway Analysis for the Savannah River Site, 2016 Update* (Jannik and Hartman, 2016).

- Fish Surveillance – Discontinued analyzing fish flesh for tritium. This improvement is based on the recommendation in the *Critical Radionuclide and Pathway Analysis for the Savannah River Site, 2016 Update* (Jannik and Hartman, 2016). Key points in the recommendation are that tritium does not bioaccumulate in fish and the dose from tritium in fish has been, and will continue to be, less than 1% of the estimated total fisherman dose.
- Reporting Improvements – Redesigned the *Annual Site Environmental Report Summary* to improve transfer of information and improve readability for the lay reader.

Other quality improvements included the following:

- Representative Person Location – Relocated the Representative Person location from Savannah River Mile (RM) 118.8 to RM 141.5. This change allows SRS to continue to comply with DOE Order 458.1 dose calculation requirements (SRNS-TR-2017-00338 and SRNL-L3200-2017-00128).
- National Pollutant Discharge Elimination System (NPDES) Stormwater Program – Increased efficiency and safety of collection stormwater samples by upgrading sample and data collection equipment. Upgraded ISCO samplers and modems were implemented for the entire NPDES Stormwater Program. The upgrades to the system improve wireless communication between the field equipment and office technical personnel.
- Stream Surveillance – Evaluated the representativeness of sample locations for both the radiological and nonradiological programs. The recommendations include discontinuing sampling at one location as there are no upstream radiological sources, reclassifying one location thus changing the sampling protocol, and relocating one location to improve sample collection efficiency and for increased worker safety when accessing that location.
- Radiological Settleable Solids Program – Evaluated current NPDES and radiological liquid effluent locations against DOE Order 458.1 requirements for monitoring settleable solids. The recommendation is to add total suspended solids analysis at 11 locations.

8.4.1 Department of Energy Consolidated Audit Program (DOECAP)

The DOECAP is a comprehensive audit program of contract and subcontracted laboratories that provide analytical services to DOE Operations and Field Offices. The DOECAP performs consolidated audits to reduce the number of audits DOE field sites conduct independently and to standardize audit methodologies, processes, and procedures. DOECAP audits commercial environmental analytical laboratories and commercial TSDFs that DOE facilities use.

8.4.1.1 DOECAP Laboratory Audits

> **Priority Definitions**
>
> *A Priority I finding documents a deficiency that is of sufficient magnitude to potentially render the audited facility unacceptable to provide the affected service to DOE.*
>
> *A Priority II finding documents a deficiency that is not of sufficient magnitude to render the audited facility unacceptable to provide services to DOE. Each affected laboratory submits corrective action responses to DOECAP that auditors review and approve prior to the next year's audit.*

DOECAP audits annually each subcontracted laboratory SRS uses to ensure the laboratories demonstrate technical capability and proficiency and comply with DOE QA requirements. The audit evaluates how well the laboratories document incoming samples, calibrate instruments, adhere to analytical procedures, verify data, issue data reports, manage records, perform nonconformance and corrective actions, perform preventative maintenance, and dispose of samples. Within these topics, auditors evaluate the use of control charts, control standards, chemical recoveries, performance evaluation samples, and laboratory procedures.

In 2017, DOECAP audited three SRS subcontracted laboratories that analyze the environmental samples documented in this annual report. The audits determined there was nothing of sufficient magnitude that would make the audited facilities unacceptable to provide service to DOE or SRS. Table 8-1 summarizes the number of Priority I and II findings and the status of their resolution. In 2017, there were no Priority I and 16 Priority II findings. None of the findings affected either SRS samples or analyses SRS requested in 2017. To close the open item, the audit team verified that the laboratory implemented corrective actions that were satisfactory. Any corrective actions that did not satisfy the requirement will remain open until the 2018 audit.

8.4.1.2 DOECAP TSDF Audits

DOECAP performs annual audits of the commercial TSDFs SRS uses to treat and dispose of mixed and hazardous waste. These reviews ensure that TSDFs are meeting contract requirements and are complying with applicable local, state, and federal regulations. DOECAP uses functional area checklists to conduct the following audits: QA, analytical data quality, environmental compliance, radiological controls, waste operations, safety and industrial hygiene, and transportation.

In 2017, DOECAP audited five TSDFs that SRS waste generators used. A review of the final reports from each audit indicated there were no significant findings that would cause SRS waste generators to discontinue using the TSDFs.

Table 8-1 summarizes the 13 Priority II findings. The total number of Priority II findings was down from last year, relatively minor and primarily programmatic in nature. One of the 30 Priority II findings from the previous year remains open while the vendors implement corrective actions. Auditors will address all open findings during the 2018 audits.

Table 8-1 2017 DOECAP Audits for SRS Subcontracts

Program Audit Types	Number of Audits Conducted in 2017	2017 Priority I Findings	2017 Priority II Findings	Closed 2016 Priority I Findings	Closed 2016 Priority II Findings	Open 2016 Priority I Findings	Open 2016 Priority II Findings
Laboratory	3	0	16	0	15	0	2
TSDF	5	0	13	0	21	0	1

8.5 ENVIRONMENTAL MONITORING PROGRAM QC ACTIVITIES

An important part of the SRS Environmental Monitoring Program QC activities is to ensure collecting and analyzing samples are performed to the highest standard and are free of errors. The Site collects quality control samples and analyzes them to identify any collection and analysis errors. All laboratories analyzing samples for the SRS Environmental Monitoring Program must participate in QC programs that either SCDHEC or DOE direct.

8.5.1 QC Sampling

SRS personnel collect and transport several types of QC samples, including blinds, field duplicates, trip blanks, and field blanks throughout the year to determine the source of any measurement error.

SRS personnel routinely analyze blind samples (a sample with a composition known to the submitter, but not to the analyst) of field measurements of potential of hydrogen (pH) to assess the quality and reliability of field data measurements. For 2017, all 24 blind sample results were within the acceptable limit of less than a 0.4 pH unit difference between the original and blind samples. Analysis of blind samples tests the analyst’s proficiency in performing the specified analysis.

During intralaboratory checks performed for the National Pollutant Discharge Elimination System (NPDES) industrial wastewater program, SRS personnel collect blind and duplicate field samples for at least 10% of each outfall’s required frequency. For example, if an outfall has a monthly sampling requirement, then SRS collects two blinds and two duplicates during the year. SRS onsite and subcontracted laboratories also analyze duplicate samples for the water quality (nonradiological) program. Each month, SRS collects duplicate samples at one river and one stream location to verify analytical results.

The relative percent difference (RPD) between each sample and its blind or duplicate (comparing only when both values are at least five times above the detection limit) should be 20% or less. Table 8-2 summarizes the results of blind and duplicate sample analyses associated with the NPDES industrial wastewater program and the water quality program. This table addresses analyses both SRS and offsite subcontracted laboratories conduct. The duplicate samples test the samplers’ proficiency in collecting the samples. Ninety-seven percent (97%) of the blind samples, 98% of the NPDES duplicate samples, and 97%

Table 8-2 Summary of Laboratory Blind and Duplicate Sample Analyses

Program and Sample Type	Number of Samples Analyzed	Number of Samples within Acceptable Limits (RPD between results < 20%)	Number of Samples Outside Acceptable Limits (RPD between results ≥ 20%)
NPDES Blind	101	98	3
NPDES Duplicate	118	116	2
Water Quality River/Stream Duplicate	648	627	21

of the water quality duplicate samples met the acceptable difference limit. The three NPDES blind samples with a difference greater than 20% represent three analytes. The two NPDES duplicate samples with a difference greater than 20% represent two analytes. The twenty-one water quality duplicate samples with a difference greater than 20% represent nine analytes. Reasons for results differing for both NPDES and water quality include analytical uncertainties associated with the measurements, such as the precision of the analytical instruments and detection limits of the analytical instruments.

Though results indicate there were some differences between the quality control samples and their corresponding compliance samples, they did not impact conclusions made with the data. The results indicate that in 2017 there were no consistent problems with either sample collection or laboratory analysis techniques.

Table 8-3 summarizes the results of field and trip blank analyses associated with the NPDES program. Field blanks determine whether the field sampling and sample processing environments have contaminated the sample. A trip blank documents contamination associated with shipping and field-handling procedures. The analytical results indicate neither sampling nor shipping contributed to contaminants being found in the actual samples as discussed in Chapter 4, *Nonradiological Environmental Monitoring Program.*

Table 8-3 Summary of Trip and Field Blank Sample Analyses

Program and Sample Type	Number of Samples Analyzed	Number of Samples with Results Below Detection Limits
NPDES Trip Blank	58	58
NPDES Field Blank	12	12

8.5.2 Laboratory Proficiency Testing

8.5.2.1 Nonradiological Methods Proficiency Testing

SRS laboratories performing NPDES and drinking water analyses maintained state certification for all analyses after achieving acceptable results in SCDHEC-required proficiency testing. Proficiency testing is also known as comparative testing and evaluates a laboratory's performance against pre-established criteria by testing the same samples at other laboratories and comparing the results. South Carolina state regulation 61-81, *State Environmental Laboratory Certification Program,* requires the testing. All laboratories used proficiency-tested providers that SCDHEC approved.

During 2017, onsite and subcontracted laboratories participated in water pollution and water supply performance evaluation studies, and each reported proficiency greater than 99% for the parameters tested for NPDES and drinking water laboratories. Therefore, both onsite and subcontracted laboratories maintained SCDHEC certification for all analyses at SRS.

The laboratories develop corrective actions for the failed analyses that they document and submit to SCDHEC, along with passing proficiency testing results for those analyses. The objective of the corrective actions is to prevent a reoccurrence of failed analyses. These corrective actions may include modifying sample preparation or analysis procedures. The underlying reasons for the unacceptable measurements did not affect the analyses provided to SRS in support of the NPDES and drinking water monitoring programs.

8.5.2.2 Radiological Methods Proficiency Testing

All laboratories with licenses to handle and analyze radioactive materials must participate in the Mixed Analyte Performance Evaluation Program (MAPEP) to support DOE's Environmental Management activities. MAPEP is a laboratory comparison program that tracks performance accuracy and tests the quality of environmental data reported to DOE. One SRS laboratory continues to participate in MAPEP, analyzing MAPEP performance evaluation samples including water, soil, air filter, and vegetation matrices for stable inorganic, organic, and radioactive elements representative of those at DOE sites.

MAPEP offered two separate studies in 2017. The MAPEP studies include soil, vegetation, water, and air filter test samples as well as an unknown sample. The unknown samples for 2017 were: 1) a syrup sample in MAPEP 36, and 2) an unknown food sample in MAPEP 37. The SRS Environmental Laboratory participated in the two studies, receiving 98.4% acceptable results in MAPEP 36 and 98.4% in MAPEP 37. All unacceptable measurements were related to measurements very close to method detection limits, and would not typically affect routine environmental analyses. Steps were taken to address this for future MAPEP Sessions. MAPEP results for SRS subcontracted laboratories were also satisfactory, with an average percent passing parameters of 99% for water matrix and 97% for soil matrix. The laboratories developed corrective actions for the failed analyses to prevent a reoccurrence. These corrective actions included modifying procedures for preparing and analyzing samples. The underlying reasons for the unacceptable measurements did not affect the analyses provided to SRS in support of the Environmental Monitoring Program.

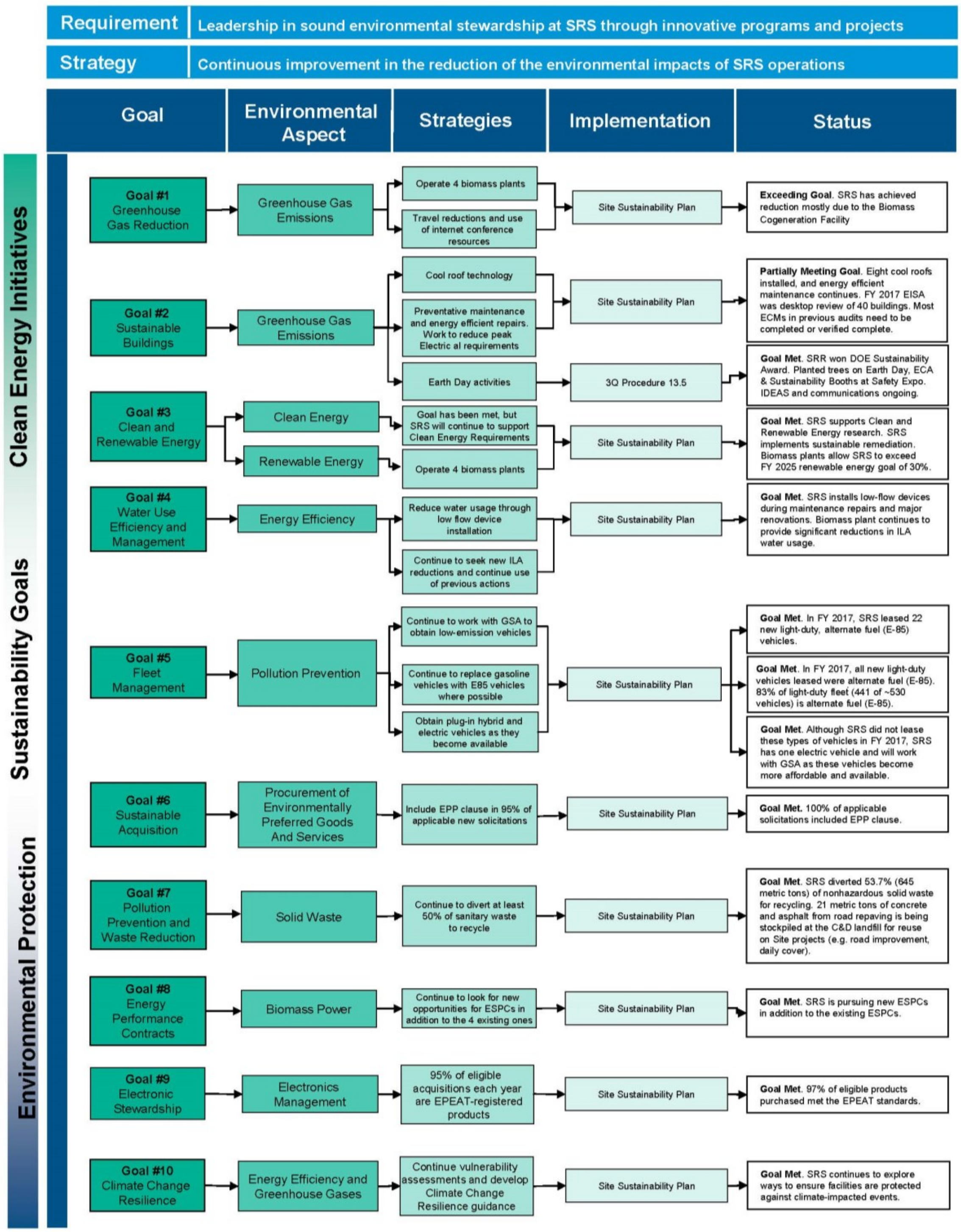
8.6 RECORDS MANAGEMENT

Environmental Monitoring Program documentation is an important part of the SRS environmental program. The Annual Site Environmental Report is the public record of the SRS Environmental Monitoring Program's performance. SRS compiles it every year following guidelines in DOE Order 231.1B, *Environment, Safety, and Health Reporting*.

In addition to the Annual Site Environmental Report, SRS generates various records and reports to document SRS nonradiological and radiological environmental programs, groundwater management, and how the Site complies with applicable regulations. In addition, records and reports notify the proper officials of unusual or unforeseen occurrences and maintain an accurate and continuous record of the effects of SRS operations on the environment. This documentation also communicates results of the Environmental Monitoring Program and groundwater management and compliance programs to government agencies and the public. SRS maintains the documents and records generated as part of the SRS Environmental Monitoring Program in accordance with SRS records management procedures.

Appendix A Environmental Management System

FY 2017 EMS Goals and Objectives



Appendix B Environmental Surveillance Media and Sampling Frequencies

Appendix Table B-1 SRS Nonradiological Media and Sampling Frequencies

Media		Sampling Frequency		
		Monthly	Quarterly	Annually
Surface Water[a]	Water quality downstream of NPDES outfalls (stream and river)	✓	✓	
Sediment	Surveillance for existence and possible buildup of the inorganic contaminants			✓
Fish	Bioaccumulation of nonradiological contaminants in fish			✓
Drinking Water	Safe Drinking Water Act compliance	✓	✓	✓

Note:
[a] All water quality parameters for surface water are sampled monthly except pesticides. Pesticides are sampled quarterly.

Appendix Table B-2 SRS Radiological Media and Sampling Frequencies

Media		Sampling Frequency				
		Weekly	Bi-Weekly	Monthly	Quarterly	Annually
Air	Airborne particulate matter		✓			
	Gaseous state of radioiodine		✓			
	Tritiated water vapor		✓			
	Tritium in rainwater			✓		
Soil	Radionuclide deposition into soils					✓
Food Products	Radionuclides uptake in the food chain					✓
Vegetation	Radionuclide uptake in plants					✓
TLDs	Ambient gamma radiation monitoring				✓	
Water	Onsite drinking water				✓	✓
	Offsite drinking water			✓		
	Onsite surface water (Streams and basins)	✓		✓		✓
	Savannah River	✓				✓
Sediment	Radionuclides in streambeds, the Savannah River bed, and SRS basins bed					✓
Fish and Shellfish	Radionuclides in freshwater fish, saltwater fish and shellfish					✓
Wildlife	Radionuclides in onsite deer, feral hogs, turkey, and coyotes during SRS-sponsored hunts					✓

Appendix C Nonradiological Environmental Monitoring Program Supplemental Information

Appendix Table C-1 River and Stream Water Quality Summary Results

15 river and stream locations were sampled monthly for a total of 180 samples.

Analyte	SC Freshwater Quality Std. (µg/L)	Unit	Number of Results Outside Std.	Individual Result				Average [1]					Comments
				Highest River Location		Highest Stream Location		All Locations	Highest River Location		Highest Stream Location		
DO [2]	min. 4.0	mg/L	7	RM-118.8	6.2	FMC-2	1.5	8.3	RM-118.8	8.2	FMC-2	5.0	
pH [2]	6.0-8.5	SU	4	RM-160.0	5.3	FMC-2	5.7	7.1	See comment				All locations within range of standard
Temperature	< 5° F above nat. cond. & not > 90° F (32.2° C)	° F	0	RM-118.8	28	SC-4	28.5	17.8	RM-118.8	19.4	SC-4	19.4	
Aluminum	87 [3]	µg/L	126	RM-129.1	736	PB-3	799	182	RM-118.8	290	U3R-4	274	152 detected
Beryllium	none	µg/L	N/A	RM-141.5	1.23	FMC-2	4.62	0.18	RM-118.8	0.25	FMC-2	0.79	26 detected
Cadmium	0.1	µg/L	See comment	RM-118.8	4.3	FMC-2	14.9	0.8	RM-118.8	1.0	FMC-2	2.8	16 detected, but detection limit (DL) of 0.5 µg/L higher than standard
Chromium	11	µg/L	0	RM-118.8	3	FMC-2	8	2	RM-118.8	2	FMC-2	3	6 detected
Copper	2.9	µg/L	15	RM-160.0	7.2	FMC-2	14.7	2.3	RM-160	3.0	FMC-2	4.1	27 detected
Hardness (total)	none	mg/L	N/A	RM-129.1	40	L3R-2	46	15	RM-129.1	24	L3R-2	32	134 detected
Iron	1000 [3]	µg/L	42	RM-118.8	1,510	FMC-2	12,400	1,088	RM-129.1	727	FMC-2	3,744	180 detected
Lead	0.54	µg/L	See comment	All 5	<10	All 10	<10	<10	All 5	<10	All 10	<10	0 detected, but DL of 10 µg/L higher than standard
Manganese	none	µg/L	N/A	RM-118.8	185	FM-2B	1,160	77	RM-118.8	92	FMC-2	204	179 detected
Mercury	0.91	µg/L	0	All 5	<0.02	FMC-2	0.043	0.02	All 5	<0.02	FMC-2	0.023	4 detected
Nickel	16	µg/L	1	RM-150.4	24	FMC-2	15	3	RM-150.4	5	FMC-2	4	12 detected
Nitrate-Nitrogen	1 [4]	mg/L	1	RM-141.5	1.1	FM-6	0.9	0.2	RM-141.5	0.3	FM-6	0.7	178 detected
Nitrite-Nitrogen	1 [4]	mg/L	0	RM-160.0	0.02	U3R-0	0.01	0.005	RM-150.4	0.01	FM-6, FMC-2 & U3R-4	0.004	130 detected
Thallium	none	µg/L	N/A	All 5	<15	FM-2B & PB-3	15.3	15	All 5	<15	FM-2B & PB-3	15.03	2 detected
TOC	none	mg/L	N/A	RM-129.1	10	FMC-2	15	5	RM-129.1	5	FMC-2	8	180 detected
Phosphorus	0.06	mg/L	144	RM-118.8	0.38	FM-2B	0.33	0.1	RM-118.8	0.14	FM-6	0.13	179 detected. U3R-1A ave. passed; all other locations ave. >0.06
TSS	none	mg/L	N/A	RM-129.1	34	PB-3	67	9	RM-118.8	12	FMC-2	14	180 detected
Zinc	37	µg/L	1	RM-160	23	FMC-2	39	9	RM-160	10	FMC-2	18	173 detected

[1] When results fell below the detection limit, the detection limit value was used to determine average

[2] Lowest values reported

[3] EPA National Recommended Water Quality Criteria - Aquatic Life

[4] per DHEC Environmental Surveillance and Oversight Program 2015 Data Report (CR-004111 3/17)

Appendix Table C-2 Summary of Detected Metal Results for Sediments Collected from the Savannah River, SRS Streams, and Stormwater Basins

Bolded concentration results were reported as detected. Concentrations not bolded indicate the result was less than the sample quantitation limit. The control location for the river sediment samples is River Mile 160 (RM-160.0_SED).

River Sediment Results			
Analyte	**Control Conc. (mg/kg)**	**Location of Maximum Result**	**Maximum Conc. (mg/kg)**
Aluminum	**5.50E+03**	RM-150.4_SED	**2.10E+04**
Arsenic	**4.40E+00**	RM-160_SED	**4.40E+00**
Barium	**5.50E+01**	RM-118.7_SED and RM-150.4 (Vogtle Discharge)	**1.20E+02**
Chromium	**7.90E+00**	RM-150.4_SED	**2.30E+01**
Copper	**3.50E+00**	RM-150.4_SED	**1.30E+01**
Iron	**8.70E+03**	RM-150.4_SED	**1.60E+04**
Lead	**4.80E+00**	RM-118.7_SED	**9.30E+00**
Magnesium	**6.80E+02**	RM-150.4_SED	**2.40E+03**
Manganese	**5.80E+02**	RM-118.7_SED	**1.10E+03**
Nickel	**3.50E+00**	RM-150.4 (Vogtle Discharge)	**1.00E+01**
Selenium	1.20E+00	RM-129_L3RM-SED	**1.50E+00**
Uranium	3.10E+01	RM-118.7_SED	**5.10E+01**
Zinc	**1.80E+01**	RM-118.7_SED	**4.70E+01**

Note: Cadmium, cyanide, mercury, and silver were non-detects.

The control location for the stream and stormwater basin sediment samples is Upper Three Runs U3R-0 (U3R-0_SED).

Stream and Stormwater Basin Sediment Results			
Analyte	**Control Conc. (mg/kg)**	**Location of Maximum Result**	**Maximum Conc. (mg/kg)**
Aluminum	**8.00E+03**	E-05_SED	**4.50E+04**
Arsenic	2.80E+00	E-004_SED	**7.80E+00**
Barium	**8.70E+01**	MCQBR_MON_OWENS	**1.20E+02**
Cadmium	9.40E-01	BDC_SED	**3.40E-01**
Chromium	**1.30E+01**	E-05_SED	**5.60E+01**
Copper	**8.00E+00**	BDC_SED and MCQBR_MON_OWENS	**1.50E+01**
Cyanide	2.50E+00	SC-4_SED	**1.84E-01**
Iron	**4.70E+03**	E-05_SED	**2.60E+04**
Lead	**1.90E+01**	U3R-0_SED	**1.90E+01**
Magnesium	9.40E+02	SC-RM	**1.50E+03**
Manganese	**1.80E+01**	BDC_RM_SED	**9.80E+02**
Mercury	3.60E-01	L3R-1A_SED	**2.70E-01**
Nickel	7.50E+00	BDC_SED	**1.7E+01**
Selenium	3.80E+00	E-004_SED	**2.50E+00**
Zinc	**1.70E+01**	MCQBR_MON_OWENS	**6.60E+01**

Note: Silver was non-detects.

Appendix Table C-3 Summary of Detected Metal Results for Freshwater Fish Tissue Collected from the Savannah River

Analyte	Number of Detected Values (above the MDC)	Number of Estimated Values (above the MDC, below the SQL)	Maximum Concentration (ug/g)	SQL (ug/g)	MDC (ug/g)	Fish Type with Maximum Concentration	Location of Maximum Concentration
Mercury	124	46	2.10	0.2	0.02	Bass	Upper Three Runs Creek Mouth
Arsenic	11	11	1.72	8.35	0.835	Bass	Augusta Lock and Dam
Cadmium	6	6	0.46	0.706	0.071	Bass	Fourmile Creek Mouth
Chromium	38	38	0.311	0.741	0.074	Catfish	Hwy 301 Bridge
Copper	90	90	0.789	1.48	0.148	Catfish	Hwy 301 Bridge
Manganese	85	84	1.03	0.707	0.071	Panfish	Augusta Lock and Dam
Nickel	4	4	0.247	1.68	0.168	Catfish	Augusta Lock and Dam
Zinc	119	1	12.7	1.48	0.148	Catfish	Hwy 301 Bridge

Note: 119 freshwater tissue samples were collected and analyzed for metals. 124 freshwater tissues samples were collected and analyzed for mercury.

Appendix Table C-4 Summary of Detected Metal Results for Saltwater Fish Tissue Collected from the Savannah River between River Miles 0–8, Near Savannah, GA

Analyte	Number of Detected Values (above the MDC)	Number of Estimated Values (above the MDC, below the SQL)	Maximum Concentration (ug/g)	SQL (ug/g)	MDC (ug/g)	Fish Type with Maximum Concentration
Mercury	15	14	0.216	0.20	0.02	Sea Trout/Flounder
Arsenic	4	4	1.03	9.00	0.90	Red Drum
Chromium	6	6	0.445	0.88	0.083	Mullet
Copper	17	17	0.927	1.02	0.102	Mullet
Manganese	18	16	1.09	0.82	0.082	Mullet
Zinc	21	0	9.96	1.82	0.182	Mullet

Notes:
21 saltwater tissue samples were collected and analyzed for metals and mercury.

Appendix Table C-5 Precipitation Results of SRS National Trends Network Station for Calendar Year 2016

Analyte	Precipitation Weighted Concentration	Deposition
Calcium (Ca^{2+})	0.054 mg/L	0.71 kg/ha
Magnesium (Mg^{2+})	0.021 mg/L	0.278 kg/ha
Potassium (K^{+})	0.015 mg/L	0.198 kg/ha
Sodium (Na^{+})	0.147 mg/L	1.944 kg/ha
Ammonium (NH_4^{+})	0.148 mg/L	1.96 kg/ha
Nitrate (NO_3^{-})	0.509 mg/L	6.73 kg/ha
Chloride (Cl^{-})	0.249 mg/L	3.29 kg/ha
Sulfate (SO_4^{2-})	0.372 mg/L	4.92 kg/ha

Note: ha = hectare—a metric unit of area defined as 10,000 square meters.

Appendix D Radiological Environmental Monitoring Program Supplemental Information

Negative values are reported in tables in this appendix. Background counts are subtracted from the sample counts. Negative values occur when the background count is greater than the sample count. Background counts reflect naturally occurring radionuclides and cosmic radiation that is detected by laboratory instrumentation.

Appendix Table D-1 Summary of Radioactive Atmospheric Releases by Source

All values under the “Calculated” column through “Totals” column are reported in curies.[a]

In the Calculated column, blanks indicate the radionuclide is not present. In the facility (Reactors, Separations, SRNL) columns, a blank indicates the radionuclide was not analyzed. A 0.00E+00 in the facility columns indicates the result was not significant.

Radionuclide	Half-Life[b]	Calculated[c]	Reactors	Separations[d]	SRNL	Total
Gases and Vapors						
H-3 (oxide)	12.3 y	2.58E+03	9.36E+02	1.03E+04		**1.38E+04**
H-3 (elemental)	12.3 y			1.38E+03		**1.38E+03**
H-3 Total	12.3 y	2.58E+03	9.36E+02	1.17E+04		**1.52E+04**
C-14	5700 y	6.51E-08		3.00E-02		**3.00E-02**
Hg-203	46.6 d	5.07E-10				**5.07E-10**
Kr-85	10.8 y			5.45E+03		**5.45E+03**
I-129	1.57E+07 y	1.99E-04		2.86E-03	1.33E-06	**3.06E-03**
I-131	8.02 d	5.64E-10				**5.64E-10**
Particles						
Ag-110m	250 d	1.48E-11				**1.48E-11**
Am-241	432 y	1.12E-05	0.00E+00	2.15E-05		**3.28E-05**
Am-243	7370 y	3.76E-09				**3.76E-09**
Ba-133	10.5 y	1.40E-06				**1.40E-06**
Cd-109	461 d	1.20E-08				**1.20E-08**
Ce-139	138 d	5.15E-10				**5.15E-10**
Ce-141	32.5 d	4.94E-11				**4.94E-11**
Ce-144	285 d	2.00E-08				**2.00E-08**
Cm-243	29.1 y	1.56E-09				**1.56E-09**
Cm-244	18.1 y	2.85E-07	0.00E+00	3.17E-07		**6.02E-07**
Co-57	272 d	4.81E-10				**4.81E-10**
Co-58	70.9 d			0.00E+00		**0.00E+00**
Co-60	5.27 y	5.37E-07	0.00E+00	0.00E+00	0.00E+00	**5.37E-07**
Cr-51	27.7 d			0.00E+00		**0.00E+00**
Cs-134	2.06 y	4.31E-07				**4.31E-07**
Cs-137	30.2 y	1.05E-03	1.57E-07	7.95E-05	0.00E+00	**1.13E-03**
Eu-152	13.5 y	1.43E-09				**1.43E-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	6.54E-09				**6.54E-09**
Mn-54	312 d	4.82E-10				**4.82E-10**
Nb-94	2.03E+04 y	2.42E-07				**2.42E-07**

Radionuclide	Half-Life[b]		Calculated[c]	Reactors	Separations[d]	SRNL	Total
Nb-95	35.0	d	3.63E-07				**3.63E-07**
Ni-59	1.01E+05	y	5.76E-11				**5.76E-11**
Particles							
Ni-63	100	y	4.73E-09				**4.73E-09**
Np-237	2.14E+06	y	1.54E-06	0.00E+00	5.66E-07		**2.11E-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	4.21E-10				**4.21E-10**
Pu-238	87.7	y	3.14E-05	0.00E+00	7.26E-06		**3.86E-05**
Pu-239	2.41E+04	y	2.90E-05	5.32E-10	2.29E-04		**2.58E-04**
Pu-240	6560	y	7.68E-06				**7.68E-06**
Pu-241	14.4	y	2.07E-04				**2.07E-04**
Pu-242	3.75E+05	y	2.88E-06				**2.88E-06**
Ra-226	1600	y	5.03E-07				**5.03E-07**
Ra-228	5.75	y	4.92E-07				**4.92E-07**
Rh-106	29.8	s	1.19E-08				**1.19E-08**
Ru-103	39.3	d	5.11E-10	8.72E-09			**9.23E-09**
Ru-106	374	d	3.04E-06		0.00E+00		**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			0.00E+00		**0.00E+00**
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	6.43E-10				**6.43E-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	5.80E-10				**5.80E-10**
Sr-89	50.5	d	6.66E-10				**6.66E-10**
Sr-90	28.8	y	3.04E-05	0.00E+00	5.48E-05		**8.53E-05**
Tc-99	2.11E+05	y	2.08E-05				**2.08E-05**
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	1.36E-08	1.27E-09			**1.49E-08**
Th-229	7340	y	1.38E-09				**1.38E-09**
Th-230	7.54E+04	y	1.12E-10	3.57E-09			**3.68E-09**
Th-231	25.5	h	2.12E-04				**2.12E-04**
Th-232	1.41E+10	y	6.09E-12	1.91E-09			**1.92E-09**

Radionuclide	Half-Life[b]		Calculated[c]	Reactors	Separations[d]	SRNL	Total
Tl-208	3.05	m	1.41E-06				**1.41E-06**
U-232	68.9	y	5.25E-09				**5.25E-09**
U-233	1.59E+05	y	3.90E-09				**3.90E-09**
U-234	2.46E+05	y	4.02E-07	2.04E-09	1.19E-04		**1.19E-04**
Particles							
U-235	7.04E+08	y	1.33E-08	0.00E+00	1.01E-05		**1.01E-05**
U-236	2.34E+07	y	3.39E-08				**3.39E-08**
U-238	4.47E+09	y	2.30E-07	2.13E-09	1.66E-04		**1.66E-04**
Y-88	107	d	4.67E-10				**4.67E-10**
Y-90(e)	64.1	h	3.04E-05	0.00E+00	5.48E-05		**8.53E-05**
Y-91	58.5	d	7.98E-10				**7.98E-10**
Zn-65	244	d	9.42E-10				**9.42E-10**
Zr-95	64.0	d	1.22E-07				**1.22E-07**
Unidentified alpha	N/A		2.95E-05	1.36E-07	5.14E-04	0.00E+00	**5.44E-04**
Unidentified beta	N/A		2.88E-04	6.57E-05	8.05E-04	3.36E-06	**1.16E-03**
TOTAL	N/A		2.58E+03	9.36E+02	1.72E+04	4.69E-06	**2.07E+04**

Notes:
[a] One curie equals 3.7E+10 becquerels
[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.

Appendix Table D-2 Summary of Air Effluent DOE DCS Sum of Fractions

Facility (Sampling Location)	Radionuclides Included in the DCS Sum of Fractions	DCS Sum of Fractions
A Area (791-A Sandfilter Discharge)	I-129	1.78E-04
C Area (C-Area Main Stack [148'])	H-3 (oxide)	1.75E+00
F Area (235-F Sandfilter Discharge)	U-234, U-235, U-238, Pu-239, Am-241	7.41E-04
F Area (291-F Stack Isokinetic)	Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244	5.80E+00
F Area (772-4F Stack)	Sr-89/90, U-234, U-235, U-238, Pu-239, Am-241	1.68E-03
H Area (291-H Stack Isokinetic)	H-3 (oxide), C-14, Kr-85, Sr-89/90, I-129, Cs-137, U-234, U-238, Pu-238, Pu-239, Am-241	5.10E-01
K Area (K-Area Main Stack [148'])	H-3 (oxide)	1.75E+00
K Area (KIS Facility)	Ru-103, Th-228, Th-230, Th-232, U-234, U-238, Pu-239	3.47E-03
L Area (L-Area Disassembly)	H-3 (oxide)	1.78E+00
L Area (L-Area Main Stack [148'])	H-3 (oxide)	1.74E+00
Tritium (232-H (200ft))	H-3 (elemental), H-3 (oxide)	2.12E+01
Tritium (233-H)	H-3 (elemental), H-3 (oxide)	9.11E-01
Tritium (234-H)	H-3 (elemental), H-3 (oxide)	1.43E+01
Tritium (238-H)	H-3 (oxide)	8.22E+00
Tritium (264-H)	H-3 (elemental), H-3 (oxide)	3.81E+00

Note: DOE-STD-1196-2011, Derived Concentration Technical Standard

Appendix Table D-3 Summary of Tritium in Environmental Air

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large.

The results at the following locations were all not detected: Site Perimeter (Hwy 21/167 and Jackson); 25-Mile Radius (Control Location–Hwy 301 @ State Line)

Location	Number of Samples	Mean Conc. (std. dev.) (pCi/m^3)	Minimum Conc. (std. dev.) (pCi/m^3)	Maximum Conc. (std. dev.) (pCi/m^3)
Onsite				
Burial Ground North	26	1.57E+02 (1.62E+00)	**4.65E+01 (8.48E+00)**	**3.89E+02 (1.23E+01)**
Site Perimeter				
Allendale Gate[a]	26	1.14E+00 (6.98E-01)	-6.68E+00 (3.61E+00)	1.45E+01 (2.04E+00)
Barnwell Gate	26	1.67E+00 (8.39E-01)	-5.68E+00 (5.40E+00)	**1.27E+01 (3.45E+00)**
D Area	26	4.65E+00 (8.69E-01)	-7.27E+00 (5.16E+00)	**3.35E+01 (6.22E+00)**
Darkhorse @ Williston Gate[a]	26	3.94E+00 (8.34E-01)	-5.08E+00 (4.98E+00)	1.40E+01 (6.53E+00)
East Talatha	26	3.47E+00 (8.50E-01)	-7.11E+00 (4.90E+00)	**1.35E+01 (5.03E+00)**
Green Pond[a]	26	3.07E+00 (8.44E-01)	-2.69E+00 (2.74E+00)	1.01E+01 (4.78E+00)
Patterson Mill Road[a]	26	1.85E+00 (8.38E-01)	-5.24E+00 (6.13E+00)	1.09E+01 (4.67E+00)
Talatha Gate	26	3.12E+00 (8.15E-01)	-4.14E+00 (4.73E+00)	**1.42E+01 (4.77E+00)**
25-Mile Radius				
Aiken Airport	26	1.50E+00 (8.89E-01)	-7.19E+00 (5.46E+00)	**1.45E+01 (5.16E+00)**
Augusta Lock and Dam 614[a]	26	1.03E+00 (8.34E-01)	-7.35E+00 (5.25E+00)	8.35E+00 (4.59E+00)

Note:
[a]There was one detected result. However, it was not the maximum measured value.

Appendix Table D-4 Summary of Tritium in Rainwater

Samples were collected approximately every 4 weeks at each of 14 locations. Thirteen samples were collected from each location during 2017. Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. The results at the following locations were all not detected: Site Perimeter (Allendale Gate, Barnwell Gate, Darkhorse @ Williston Gate, East Talatha, Green Pond, Jackson, and Patterson Mill Road) and 25-Mile Radius (Aiken Airport, Augusta Lock and Dam 614 and Highway 301 @ State Line). The Highway 301 @ State Line location is the control location.

Location	# of Detected Results	Mean Conc. (std. dev.) (pCi/L)	Minimum Conc. (std. dev.) (pCi/L)	Maximum Conc. (std. dev.) (pCi/L)
Onsite				
Burial Ground North	11	1.47E+03 (4.88E+01)	7.49E+01 (1.43E+02)	**3.86E+03 (2.19E+02)**
Site Perimeter				
D Area	2	8.36E+01 (3.90E+01)	-2.81E+02 (1.43E+02)	**6.22E+02 (1.66E+02)**
Highway 21/167	1	4..08E+01 (3.81E+01)	-2.06E+02 (1.36E+02)	**4.11E+02 (1.32E+02)**
Talatha Gate	1	1.00E+02 (3.88E+01)	-1.09E+02 (1.40E+02)	**4.08E+02 (1.35E+02)**

Appendix D-5 Summary of Radionuclides in Soil

Samples are collected annually from 18 locations. Bolded values are detected results. Values not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large.

The following locations are sampled: F Area (2000 feet West), H Area (2000 ft East), Z Area (#3), Burial Ground Locations (643-26E-2 and Burial Ground North), Plant Perimeter Locations (Allendale Gate, Barnwell Gate, D Area, Darkhorse @ Williston Gate, East Talatha, Green Pond, Highway 21/167, Jackson, Patterson Mill Road, and Talatha Gate) and 25-Mile Radius Locations (Aiken Airport, August Lock and Dam 614, and Highway 301 @ State Line). The Highway 301 @ State Line is the control location.

All Co-60, Np-237, and Sr-89/90 results were not detected; thus, they were not reported in this table.

Radionuclide	# of Detected Results	Control - HWY 301 Conc. (pCi/g)	Location of Minimum Conc.	Minimum Conc. (pCi/g)	Location of Maximum Conc.	Maximum Conc. (pCi/g)
Cs-137	**16 of 18**	4.86E-02	Burial Ground (643-26E-2)	-2.92E-02	D-Area	**3.59E-01**
U-234	**18 of 18**	**1.87E+00**	Allendale Gate	**3.95E-01**	Highway 21/167	**2.32E+00**
U-235	**17 of 18**	**7.78E-02**	Aiken Airport	**1.57E-02**	Burial Ground North	**8.16E-02**
U-238	**18 of 18**	**1.75E+00**	Allendale Gate	**3.62E-01**	Highway 301 @ State Line	**1.75E+00**
Pu-238	**7 of 18**	8.38E-02	Augusta Lock & Dam	-1.99E-04	Burial Ground (643-26E-2)	**1.01E+00**
Pu-239	**16 of 18**	**4.24E+00**	Talatha Gate	3.41E-04	Highway 301 @ State Line	**4.24E+00**
Am-241	**16 of 18**	**2.12E-03**	Highway 21/167)	1.55E-04	Green Pond	**1.75E-02**
Cm-244	**6 of 18**	6.24E-04	H-Area Wind Tower (2000 feet east), D-Area, and Aiken Airport	-1.54E-05	Talatha Gate	**2.24E+00**
Gross Beta	**17 of 18**	**7.27E+00**	Jackson	2.32E+00	Burial Ground (643-26E-2)	**9.89E+00**
Gross Alpha	**18 of 18**	**8.00E+00**	Patterson Mill Road	**2.36E+00**	Burial Ground (643-26E-2)	**1.49E+01**

Appendix Table D-6 Summary of Radionuclides in Grassy Vegetation

Samples are collected annually from 14 locations. Bolded values are detected results. Values not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All results for Co-60, U-235, Np-237, Pu-238, Pu-239, Am-241, and Cm-244 were not detected; thus, not reported in this table.

The following locations are sampled: Control (Highway 301 at the SC/GA State line), Onsite location (Burial Ground North), Site Perimeter locations (Allendale Gate, Barnwell Gate, D Area, Darkhorse @ Williston Gate, East Talatha, Green Pond, Highway 21/167, Jackson, Patterson Mill Road, Talatha Gate), and 25-Mile Radius Locations (Aiken Airport and the Augusta Lock and Dam 614). Samples are collected annually.

Radionuclide	# of Detected Results	Control (Highway 301) Conc. (pCi/g)	Location of Minimum Conc.	Minimum Conc. (pCi/g)	Location of Maximum Conc.	Maximum Conc. (pCi/g)
H-3	2 of 14	**1.38E+00**	East Talatha	-3.35E-02	Highway 301 @ State Line	**1.38E+00**
Cs-137	7 of 14	2.51E-02	Burial Ground North	1.21E-03	Barnwell Gate	**3.03E-01**
Sr-89/90	14 of 14	**8.54E-02**	Allendale Gate	**8.24E-02**	East Talatha	**4.62E-01**
U-234	14 of 14	**1.00E-02**	Barnwell Gate	**1.09E-03**	Burial Ground North	**1.25E-02**
U-238	14 of 14	**1.16E-02**	Highway 21/167	5.57E-04	Burial Ground North	**1.28E-02**
Tc-99	11 of 14	**2.89E-01**	Highway 21/167	1.30E-01	Green Pond	**3.84E-01**
Gross Beta	14 of 14	**1.25E+01**	Allendale Gate	**4.38E+00**	Aiken Airport	**2.10E+01**
Gross Alpha	1 of 14	4.35E-01	Green Pond	-1.85E-01	Allendale Gate	**1.31E+00**

Appendix Table D-7 Summary of Radionuclides in Foodstuffs

Samples of five foodstuffs are collected annually from five regions surrounding SRS. Beef, greens, and fruit are collected each year. There are six foodstuffs that are collected on a rotating three-year cycle. Soybeans and peanuts were the rotational crop samples collected in 2017.

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large.

Food Type	Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Sample Conc. (pCi/g)	Minimum Sample Conc. (pCi/g)	Maximum Sample Conc. (pCi/g)
Beef	H-3	5	1	3.78E-02	5.12E-03	**6.25E-02**
	Tc-99	5	1	4.52E-02	2.98E-02	**6.76E-02**
	U-234	5	1	3.40E-05	9.03E-06	**6.19E-05**
	U-238	5	3	3.28E-05	2.78E-06	**5.64E-05**
	Gross Beta	5	5	2.25E+00	**1.61E+00**	**2.68E+00**
Cs-137, Co-60, Np-237, Pu-238, Pu-239, Am-241, Cm-244, Sr-89,90, U-235, and gross alpha were not detected in beef						
Greens	Cs-137	5	2	2.06E-02	-7.25E-04	**7.06E-02**
	Sr-89,90	5	4	1.63E-01	2.35E-02	**3.84E-01**
	U-234	5	5	9.46E-03	**2.80E-03**	**2.10E-02**
	U-235	5	2	4.05E-04	-1.12E-05	**1.33E-03**
	U-238	5	5	8.94E-03	**1.85E-03**	**2.35E-02**
	Tc-99	5	5	3.68E-01	**2.47E-01**	**5.02E-01**
	Gross Beta	5	5	2.09E+01	**1.75E+01**	**2.85E+01**
H-3, Co-60, Np-237, Pu-238, Pu-239, Am-241, Cm-244 and gross alpha were not detected in greens						
Fruit (watermelon)	U-234	5	1	6.82E-05	3.94E-05	**1.47E-04**
	Gross Beta	5	5	6.75E-01	**5.50E-01**	**1.03E+00**
H-3, Cs-137, Co-60, Np-237, Pu-238, Pu-239, Am-241, Cm-244, Sr-89,90, U-235, U-238, Tc-99 and gross alpha were not detected in fruit						
Soybeans	Cs-137	5	1	4.99E-03	7.70E-04	**9.66E-03**
	U-234	5	3	2.60E-03	8.60E-04	**8.24E-03**
	U-238	5	4	2.58E-03	**1.02E-03**	**6.30E-03**
	Gross Beta	5	5	1.74E+01	**1.49E+01**	**2.13E+01**
H-3, Co-60, Pu-238, Pu-239, Am-241, Cm-244, Np-237, Sr-89,90, U-235, Tc-99 and gross alpha were not detected in soybeans.						

Food Type	Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Sample Conc. (pCi/g)	Minimum Sample Conc. (pCi/g)	Maximum Sample Conc. (pCi/g)
Peanuts	Cs-137	5	2	5.70E-03	3.09E-04	**9.90E-03**
	U-234	5	4	1.86E-03	1.31E-03	**2.84E-03**
	U-238	5	2	1.55E-03	6.55E-04	**3.65E-03**
	Pu-239	5	1	2.84E-04	3.88E-05	**7.25E-04**
	Gross Beta	5	5	5.78E+00	**5.23E+00**	**7.07E+00**
H-3, Co-60, U-235, Am-241, Cm-244, Np-237, Pu-238, Sr-89,90, Tc-99, and gross alpha were not detected in peanuts.						

Appendix Table D-8 Summary of Radionuclides in Dairy

SRS collects cow's milk samples from dairies located in communities surrounding the Site. The number listed in parentheses after the state in which the dairies are located, indicates the number of dairies that provide samples to SRS from that state.

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All Co-60 and Cs-137 results were not detected, thus, not reported in this table.

Location	Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Sample Conc. (pCi/L)	Minimum Sample Conc. (pCi/L)	Maximum Sample Conc. (pCi/L)
SC-Dairies (4)	Sr-90	16	1	3.84E-01	-5.05E-01	**1.41E+00**
GA-Dairies (4)	Sr-90	16	0			
SC-Dairies (4)	H-3	16	1	2.23E+01	-1.15E+02	**2.20E+02**
GA-Dairies (4)	H-3	16	0			

Appendix Table D-9 Radiation in Liquid Release Sources

All values under the three Areas columns and the "Totals" column are reported in curies.

Tritium is the main contributing radionuclide in Liquid Sources releases. Although the remaining radionuclides are contributors, their contributions in liquid source releases are minimal.

In the facility (Reactor, Separations, SRNL) columns, a blank indicates the radionuclide was not analyzed. A 0.00E+00 in the facility columns indicates the result was not significant.

All Co-60 results were not detected; thus, they were not reported in this table.

Radionuclide	Half-Life		Reactors (Ci)	Separations[a] (Ci)	SRNL (Ci)	Totals (Ci)
H-3[b]	12.3	y	1.68E+02	3.26E+02	0.00E+00	4.94E+02
C-14	5700	y		1.09E-02	0.00E+00	1.09E-02
Sr-90	28.8	y	0.00E+00	2.13E-02		2.13E-02
Tc-99	2.11E+05	y		1.51E-02	0.00E+00	1.51E-02
I-129	1.57E+07	y		2.18E-02	0.00E+00	2.18E-02
Cs-137[c]	30.2	y	0.00E+00	5.78E-03	0.00E+00	5.78E-03
U-234	2.46E+05	y		3.47E-02	2.96E-05	3.48E-02
U-235	7.04E+08	y		1.23E-03	1.36E-06	1.23E-03
U-238	4.47E-09	y		3.61E-02	2.15E-05	3.61E-02
Np-237	2.14E+06	y		5.57E-05		5.57E-05
Pu-238	87.7	y		2.32E-04	6.25E-07	2.33E-04
Pu-239	2.41E+04	y		2.00E-05	0.00E+00	2.00E-05
Am-241	432	y		5.62E-03		5.62E-03
Cm-244	18.1	y		1.49E-04		1.49E-04
Ra-226	1600	y		7.27E-04		7.27E-04
Nb-94	2.03E+04	y		0.00E+00		0.00E+00
Alpha[d]	N/A		1.71E-03	5.03E-04	2.33E-04	2.45E-03
Beta-Gamma[e]	N/A		5.17E-02	2.72E-03	5.63E-04	5.50E-02
					Sum	**4.94E+02**

Notes:

[a] Includes separations, waste management, and tritium processing facilities.

[b] The tritium release total, which includes direct + migration releases, is used in the dose calculations for SRS impacts.

[c] 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.

[d,e] For dose calculations, unidentified alpha and beta/gamma releases are assumed to be Pu-239 and Sr-90, respectively.

Appendix Table D-10 Summary of Liquid Effluent DOE DCS Sum of Fractions by Facility

Facility (sampling location)	Radionuclides Included in the Sum of Fractions	DCS Sum of Fractions
A Area (TB-2 Outfall at Road 1A)	U-234, U-235, U-238, Pu-238	2.50E-04
F Area (F-013 200-F Cooling Basin)	H-3, U-234, U-238, Pu-239, Am-241, Cm-244, Tc-99	1.22E-03
F Area (F-05)	H-3, C-14, Sr-89/90, U-234, U-238, Pu-238, Pu-239, Am-241, Cm-244, Tc-99	3.51E-03
F Area (FM-3 F-Area Effluent)	H-3, Sr-89/90, I-129, U-234, U-235, U-238, Pu-238, Pu-239, Am-241, Tc-99	1.68E-03
F-Tank Farm (F-012 281-8F Retention Basin)	H-3, Sr-89/90, Cs-137, U-234, U-238, Pu-238, Tc-99	3.93E-03
H Area (FM-1C H-Area Effluent)	H-3, Sr-89/90, Cs-137, U-234, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244	6.92E-03
H Area (H-004)	H-3, U-234, U-235, U-238, Pu-238	8.35E-03
H-ETP (U3R-2A ETP Outfall at Road C)	H-3, C-14, U-234, U-235, U-238, Pu-239	9.12E-01
H-Tank Farm (H-017 281-8H Retention Basin)	H-3, Sr-89/90, Cs-137, U-234, U-238, Pu-238, Pu-239, Am-241, Tc-99	1.47E-02
H-Tank Farm (HP-52 H-Area Tank Farm)	H-3, U-234, U-238, Pu-238, Am-241	6.56E-04
K Area (K Canal)	H-3, Sr-89/90	1.96E-04
L Area (L-07)	H-3	1.14E-04
S Area (S-004)	H-3, Sr-89/90, U-234, U-238, Pu-238	4.02E-03
Tritium (HP-15 Tritium Facility Outfall)	H-3	3.43E-03

Appendix Table D-11 Summary of Radionuclides in Sediments

This table summarizes the analytes detected for the sediment samples collected annually at 43 locations categorized as river, stream or stormwater basin. SRS collected sediment samples at 12 Savannah River, 8 basin, and 23 stream locations. Each table includes the respective control location concentration, whether detected or not, as well as the maximum value of each analyte for the river, stream, and stormwater basin samples. Bolded concentration results were reported as detected. Concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All results for Co-60 were not detectable. Np-237 was not detected in any river or stormwater basin samples. Radionuclides not detected in any waterbody type (river, stream, or stormwater basin) are not reported in the table.

The sampling locations are as follows: Controls (River Mile [RM] 160.5 and Upper Three Runs Creek (U3R)-1A Treadway Bridge RD 8-1), Savannah River Locations (RM 118.7, 129, 134.0, 141.0, 150.2, 150.4, 151, 152.1, and 157.2, 160.0, and 170.5), SRS Storm Basin locations (E-001, E-002, E-003, E-004, E-005, E-006, POND 400, and Z Basin), and SRS Stream locations (Beaver Dam Creek, FM-2 at Road 4, FM-3A Below F-Area Effluent, Four Mile-6, Four Mile A-7A (Beaver Pond), Four Mile Creek Swamp Discharge, Four Mile Creek at Road A-7, L3R-1A at Road B, L3R-2 Sediment, McQueens Branch (MCQBR) at Monroe Road, MCQBR downstream of Z-Basin, Pen Branch at Road A, Pen Branch Swamp Discharge, Steel Creek-River Mouth, SC-2A 1 mile above Road B, SC-4 Steel Creek at Road A, TB-5 Near Road C, Tinker Creek 1, U3R-3 Sediment, U3R-4 Sediment, U3R-USFS-RD2-1, and R-Area Sediment.

The streams and stormwater basins have the same control location, U3R-1A Treadway Bridge RD 8-1.

River Sediment Results			
Radionuclide	**Control Conc. (pCi/g)**	**Location of Maximum Result**	**Maximum Conc. (pCi/g)**
Cs-137	5.05E-03	RM-150.2 Below Four Mile Creek	**1.05E+00**
Sr-89/90	-3.38E-03	RM-151 R-3A Above Vogtle	**1.28E-01**
U-234	**1.23E+00**	RM-150.4 Sediment	**1.78E+00**
U-235	**5.62E-02**	RM-150.2 Below Four Mile Creek	**1.05E-01**
Np-237	**0.00E+00**	RM 150.4 Sediment	8.24E-04
U-238	**1.23E+00**	RM-150.2 Below Four Mile Creek	**1.87E+00**
Pu-238	-1.55E-04	RM-150.2 Below Four Mile Creek	**2.69E-03**
Pu-239	**1.65E-03**	RM-157.2 Upper 3 Runs Mouth	**6.65E-03**
Am-241	**2.97E-02**	RM-160.5 Demier Landing	**2.97E-02**
Cm-244	**7.73E-03**	RM-150.2 Below Four Mile Creek	**8.11E-03**
Gross B	**1.78E+01**	RM-151 R-3A Above Vogtle	**2.95E+01**
Gross A	**1.13E+01**	RM-150.2 Below Four Mile Creek	**5.03E+01**

Stream Sediment Results			
Radionuclide	**Control Conc. (pCi/g)**	**Location of Maximum Result**	**Maximum Conc. (pCi/g)**
Cs-137	9.92E-02	R-Area (Downstream of R-1)	**2.96E+01**
Sr-89/90	-2.48E-02	SC-4 Steel Creek at Road A	2.61E+01
U-234	**1.99E+00**	Tinker Creek 1	**3.73E+00**
U-235	**8.41E-02**	Tinker Creek 1	**1.56E-01**
Np-237	2.35E-04	FM-2 at Road 4	**7.89E-03**
U-238	**2.06E+00**	Tinker Creek 1	**3.27E+00**
Pu-238	1.11E-03	FM-2 at Road 4	**5.14E-01**
Pu-239	**8.11E-03**	Four Mile A-7A (Beaver Pond)	**7.65E-02**
Am-241	**7.78E-03**	Four Mile A-7A (Beaver Pond)	**1.01E-01**
Cm-244	5.43E-03	Four Mile A-7A (Beaver Pond)	**7.38E-02**
Gross B	**3.16E+01**	R-Area (Downstream of R-1)	**3.49E+01**
Gross A*	**4.35E+01**	U3R-1A Treadway Bridge RD 8-1	**4.35E+01**

Stormwater Basin Sediment Results			
Radionuclide	**Control Conc. (pCi/g)**	**Location of Maximum Result**	**Maximum Conc. (pCi/g)**
Cs-137	9.92E-02	Z Basin	**2.00E+03**
Sr-89/90	-2.48E-02	Z-Basin	6.21E-01
U-234*	**1.99E+00**	EAV Basin North (E-004)	**1.83E+00**
U-235	**8.41E-02**	Z-Basin	**1.13E-01**
Np-237	2.35E-04	Z-Basin	1.89E-03
U-238*	**2.06E+00**	EAV Basin North (E-004)	**1.85E+00**
Pu-238	1.11E-03	SWDF Basin South (E-001)	**3.00E-01**
Pu-239	**8.11E-03**	POND 400	**2.46E-01**
Am-241	**7.78E-03**	Z-Basin	**6.84E-02**
Cm-244	5.43E-03	Z-Basin	1.92E-02
Gross B	**3.16E+01**	Z-Basin	**1.93E+03**
Gross A*	**4.35E+01**	POND 400	**2.12E+01**

NOTE: *control location, a Site stream (U3R-1A Treadway Bridge RD 8-1), is the maximum result.

Appendix Table D-12 Summary of Radionuclides in Drinking Water

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large.

Samples at the Treatment Plants are collected monthly. These samples are analyzed for tritium, Co-60, Cs-137, gross alpha and gross beta. For the Treatment Plants samples, all results for Co-60, Cs-137, and gross alpha were below detection limits; and thus, not presented in the table below. One onsite location is collected quarterly. All other onsite locations are collected annually. For the quarterly onsite samples, all results for tritium, Co-60, and Cs-137 were below detection limits; and thus, not presented in the table below. For the onsite annual samples, all results for tritium, Co-60, Cs-137, Pu-238, and Cm-244 were below detection limits; and thus, not presented in the table below.

Treatment Plants—Finished Water Summary

	Nuclides		Tritium		
Locations	Number of Samples	Number of Detects	Mean Conc. (pCi/L)	Minimum Conc. (pCi/L)	Maximum Conc. (pCi/L)
BJWSA Purrysburg WTP	12	12	5.23E+02	**2.38E+02**	**8.65E+02**
N. Augusta Public Water Works	12	8	1.44E+02	4.57E+01	**2.39E+02**

	Nuclides		Gross Beta		
Locations	Number of Samples	Number of Detects	Mean Conc. (pCi/L)	Minimum Conc. (pCi/L)	Maximum Conc. (pCi/L)
BJWSA Purrysburg WTP	12	12	1.53E+00	**8.43E-01**	**2.04E+00**
N. Augusta Public Water Works	12	12	1.72E+00	**1.45E+00**	**2.09E+00**

Onsite Location Summary—Quarterly Samples

	Nuclides		Gross Beta		
Location	Number of Samples	Number of Detects	Mean Conc. (pCi/L)	Minimum Conc. (pCi/L)	Maximum Conc. (pCi/L)
782-3A quarterly	4	4	1.01E+00	**9.57E-01**	**1.05E+00**

	Nuclides		Gross Alpha		
Location	Number of Samples	Number of Detects	Mean Conc. (pCi/L)	Minimum Conc. (pCi/L)	Maximum Conc. (pCi/L)
782-3A quarterly	4	4	8.28E-01	**5.11E-01**	**1.18E+00**

Onsite Location Summary—Annual Samples

	Nuclides	Sr-90	U-234	U-235	U-238
Location	Number of Samples	Conc. (pCi/L)	Conc. (pCi/L)	Conc. (pCi/L)	Conc. (pCi/L)
617-G*	1	5.41E-03	**4.49E-02**	1.19E-02	**5.59E-02**
681-3G Dom. Water Faucet	1	-2.16E-01	**3.65E-02**	0.00E+00	**8.14E-02**
704-16G	1	**6.35E-01**	**6.35E-02**	0.00E+00	**6.86E-02**
709-1G	1	-1.48E-02	**9.84E-02**	0.00E+00	**6.89E-02**
737-G	1	-1.45E-02	**5.59E-02**	**2.95E-02**	2.07E-02
782-3A (annual)	1	1.83E-01	**1.16E-01**	1.92E-02	**1.17E-01**
905-112G Well	1	1.25E-01	**1.15E-01**	1.32E-02	**1.02E-01**
905-113G Well	1	2.47E-02	**5.00E-02**	1.91E-02	**6.89E-02**
905-125B	1	2.55E-02	**1.75E-01**	1.83E-02	**2.01E-01**
905-67B	1	-3.81E-02	**5.27E-02**	6.08E-03	**1.13E-01**

NOTE: This location is from the same water source as 617-8G. The sample tap located at a new building that was constructed and replaced Bldg. 617-8G.

Onsite Location Summary—Annual Samples (continued)

	Nuclides	Am-241	Pu-239	Gross Beta	Gross Alpha
Location	**Number of Samples**	**Conc. (pCi/L)**	**Conc. (pCi/L)**	**Conc. (pCi/L)**	**Conc. (pCi/L)**
617-8G*	1	2.34E-02	5.19E-03	**6.84E-01**	6.08E-02
681-3G Dom. Water Faucet	1	2.00E-02	6.73E-03	**4.38E+00**	**5.59E+00**
704-16G	1	1.31E-02	1.09E-02	**1.76E+00**	**1.49E+00**
709-1G	1	**2.54E-02**	-1.99E-05	**8.97E-01**	5.38E-01
737-G	1	2.59E-02	1.69E-03	**1.36E+00**	**3.70E-01**
782-3A (annual)	1	1.96E-02	-3.14E-03	Quarterly, See above	Quarterly, see above
905-112G Well	1	1.89E-02	**2.86E-02**	**1.19E+00**	**1.81E+00**
905-113G Well	1	1.44E-02	-1.99E-05	**1.52E+00**	**2.08E+00**
905-125B	1	**4.00E-02**	-1.99E-05	**1.52E+00**	**2.48E+00**
905-67B	1	5.57E-03	-1.99E-05	**9.22E-01**	**1.35E+00**

NOTE: This location is from the same water source as 617-8G. The tap is located at a new building that was constructed and replaced Bldg. 617-8G.

Appendix Table D-13 Summary of Radionuclides in Freshwater Fish

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. Beginning in 2017, tritium (H-3) is no longer analyzed in fish. All Co-60, I-129, and gross alpha results were nonsignificant and thus, not reported in this table.

The analyte mean is set to zero if all composite values per fish species at a single location are less than the MDL or the uncertainty is large. Three composite samples were analyzed for each fish type from each location.

Cs-137 (Edible)									
	Bass			Catfish			Panfish		
Location	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)
Augusta L&D	1.99E-02	1.14E-02	**3.03E-02**	1.25E-02	4.41E-03	**1.92E-02**	3.83E-02	**2.17E-02**	**6.78E-02**
Upper Three Runs Creek River Mouth	5.43E-02	**3.65E-02**	**7.81E-02**	7.75E-02	**2.24E-02**	**1.16E-01**	5.71E-02	9.46E-03	**1.18E-01**
Four Mile Creek River Mouth	6.68E-02	**3.86E-02**	**1.06E-01**	2.45E-02	9.49E-03	**3.92E-02**	2.38E-02	1.91E-02	**2.66E-02**
Steel Creek River Mouth	1.06E-01	**5.11E-02**	**1.88E-01**	9.93E-02	**8.49E-02**	**1.17E-01**	6.04E-02	1.91E-02	**1.32E-01**
Lower Three Runs Creek River Mouth	7.20E-02	**3.62E-02**	**1.02E-01**	2.98E-01	**1.34E-01**	**5.92E-01**	1.86E-02	1.25E-02	**2.42E-02**
Hwy 301 Bridge Area	4.04E-02	**2.54E-02**	**6.51E-02**	2.46E-02	**2.16E-02**	**2.70E-02**	7.67E-03	1.05E-03	**1.49E-02**

Sr-89/90 (Edible)									
	Bass			Catfish			Panfish		
Location	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)
Augusta L&D	0.00E+00	1.88E-03	3.78E-03	3.50E-03	2.49E-03	**4.00E-03**	0.00E+00	2.69E-03	5.14E-03
Upper Three Runs Creek River Mouth	0.00E+00	2.56E-05	2.38E-03	0.00E+00	9.30E-04	2.92E-03	0.00E+00	5.03E-03	5.70E-03
Four Mile Creek River Mouth	0.00E+00	5.81E-04	2.02E-03	3.13E-03	2.09E-03	**4.43E-03**	0.00E+00	3.14E-04	4.24E-03
Steel Creek River Mouth	0.00E+00	7.78E-04	1.51E-03	0.00E+00	9.57E-04	2.01E-03	0.00E+00	1.34E-03	5.68E-03
Lower Three Runs Creek River Mouth	1.03E-03	5.92E-04	**1.38E-03**	1.97E-03	1.45E-03	**2.56E-03**	4.39E-03	**3.76E-03**	**5.19E-03**
Hwy 301 Bridge Area	0.00E+00	9.43E-04	2.19E-03	2.02E-03	5.19E-04	**3.76E-03**	0.00E+00	-2.53E-04	4.32E-03

Sr-89/90 (Nonedible)									
	Bass			Catfish			Panfish		
Location	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)
Augusta L&D	6.97E-01	**6.05E-01**	**8.24E-01**	9.10E-01	**7.84E-01**	**1.04E+00**	8.68E-01	**6.65E-01**	**1.12E+00**
Upper Three Runs Creek River Mouth	5.91E-01	**5.41E-01**	**6.73E-01**	6.12E-01	**4.86E-01**	**7.70E-01**	8.86E-01	**6.49E-01**	**1.31E+00**
Four Mile Creek River Mouth	1.04E+00	**7.68E-01**	**1.38E+00**	7.58E-01	**7.24E-01**	**7.89E-01**	9.88E-01	**7.03E-01**	**1.24E+00**
Steel Creek River Mouth	7.15E-01	**6.32E-01**	**8.76E-01**	8.32E-01	**7.00E-01**	**9.08E-01**	8.25E-01	**7.86E-01**	**8.73E-01**
Lower Three Runs Creek River Mouth	4.98E-01	**3.24E-01**	**6.03E-01**	7.87E-01	**7.30E-01**	**8.46E-01**	7.89E-01	**5.41E-01**	**9.41E-01**
Hwy 301 Bridge Area	6.28E-01	**5.41E-01**	**7.41E-01**	6.20E-01	**4.92E-01**	**7.19E-01**	5.99E-01	**4.32E-01**	**7.41E-01**

Tc-99 (Edible)									
	Bass			Catfish			Panfish		
Location	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)
Augusta L&D	0.00E+00	1.12E-02	5.16E-02	0.00E+00	2.84E-02	4.95E-02	0.00E+00	1.12E-02	3.49E-02
Upper Three Runs Creek River Mouth	0.00E+00	3.41E-02	6.43E-02	7.59E-02	5.62E-02	**8.65E-02**	0.00E+00	4.41E-02	4.97E-02
Four Mile Creek River Mouth	6.45E-02	5.73E-02	**7.65E-02**	7.45E-02	4.65E-02	**8.89E-02**	4.81E-02	1.66E-02	**7.81E-02**
Steel Creek River Mouth	0.00E+00	2.15E-02	6.22E-02	0.00E+00	2.57E-02	5.49E-02	0.00E+00	3.22E-02	6.51E-02
Lower Three Runs Creek River Mouth	0.00E+00	-1.45E-02	1.87E-02	0.00E+00	2.92E-03	1.20E-02	0.00E+00	-6.24E-03	3.00E-02
Hwy 301 Bridge Area	0.00E+00	-5.86E-03	3.70E-02	0.00E+00	7.68E-03	3.30E-02	0.00E+00	5.84E-03	5.95E-02

Gross Beta (Edible)									
	Bass			Catfish			Panfish		
Location	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)	Mean (pCi/g)	Min. (pCi/g)	Max. (pCi/g)
Augusta L&D	2.65E+00	**2.26E+00**	**2.97E+00**	2.60E+00	**2.53E+00**	**2.70E+00**	2.24E+00	**1.93E+00**	**2.42E+00**
Upper Three Runs Creek River Mouth	2.69E+00	**2.47E+00**	**2.92E+00**	2.25E+00	**2.21E+00**	**2.35E+00**	2.21E+00	**1.79E+00**	**2.61E+00**
Four Mile Creek River Mouth	2.60E+00	**2.39E+00**	**2.89E+00**	2.26E+00	**2.03E+00**	**2.61E+00**	1.70E+00	**1.57E+00**	**1.86E+00**
Steel Creek River Mouth	2.62E+00	**2.25E+00**	**2.95E+00**	2.60E+00	**2.29E+00**	**2.78E+00**	2.65E+00	**2.52E+00**	**2.81E+00**
Lower Three Runs Creek River Mouth	2.35E+00	**2.14E+00**	**2.73E+00**	2.82E+00	**2.58E+00**	**2.97E+00**	2.30E+00	**2.21E+00**	**2.41E+00**
Hwy 301 Bridge Area	2.16E+00	**2.01E+00**	**2.35E+00**	2.09E+00	**1.86E+00**	**2.37E+00**	1.64E+00	**1.33E+00**	**1.84E+00**

Appendix Table D-14 Summary of Radionuclides in Saltwater Fish

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. Beginning in 2017, tritium (H-3) is no longer analyzed in fish. Results of all samples for Co-60, Cs-137, I-129, Tc-99, Sr-89/90 (in flesh), and gross alpha were below method detection limits.

All saltwater fish are collected at the location designated as River Miles 0–8 (mouth of Savannah River).

Analyte	Marine Mullet				Red Drum			
	Number of Samples	Mean (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Number of Samples	Mean (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)
Sr-89/90 Nonedible	3	2.16E-01	1.68E-01	**3.03E-01**	3	0.00E+00	6.76E-02	1.14E-01
Gross Beta	3	2.33E+00	**2.06E+00**	**2.70E+00**	3	2.86E+00	**2.53E+00**	**3.05E+00**

Analyte	Sea Trout			
	Number of Samples	Mean (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)
Sr-89/90 Nonedible	3	0.00E+00	4.38E-02	2.86E-01
Gross Beta	3	2.28E+00	**2.21E+00**	**2.38E+00**

Appendix Table D-15 Summary of Radionuclides in Shellfish

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All Co-60, Cs-137, I-129, and Tc-99 results were not detected; thus, not reported in this table.

All shellfish are collected at the location designated as River Miles 0-8 (at the mouth of Savannah River).

The species of shellfish collected in 2017 were shrimp and crab.

Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Concentration (pCi/g)	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)
Sr-89/90	2	1	5.83E-03	2.25E-03	**9.40E-03**
Gross B	2	2	1.44E+00	**8.26E-01**	**2.05E+00**
Gross A	2	2	6.18E-01	**2.86E-01**	**1.03E+00***

NOTE: * The gross alpha maximum value is greater than the trigger value of 0.951 pCi/g that SRS uses as the basis for performing analysis of alpha-emitting radionuclides.

Because the crab sampled exceeded the Gross alpha trigger value the alpha-emitting radionuclides were analyzed. The Np-237, Pu-238, Pu-239, and Am-241 results were not detected.

Alpha Emitting Nuclide	Concentration (pCi/g)
U-234	2.48E-03
U-235	1.31E-04
U-238	2.06E-03
Cm-244	1.06E-04

Appendix Table D-16 Summary of Radionuclides in Wildlife

Bolded concentration results were reported as detected. Concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All Co-60 results were below detection limits, and thus are not reported in this table.

Sample Type	Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Sample Conc. (pCi/g)	Minimum Sample Conc. (pCi/g)	Maximum Sample Conc. (pCi/g)
Deer Flesh	Cs-137	40	40	6.98E-01	**1.65E-01**	**2.64E+00**
Hog Flesh	Cs-137	11	11	1.76E+00	**2.76E-01**	**4.92E+00**
Deer Flesh	Sr-89/90	40	4	2.55E-03	-1.68E-03	**1.84E-02**
Hog Flesh	Sr-89/90	11	0	1.08E-03	-1.10E-03	3.81E-03
Deer Bone	Sr-89/90	40	40	3.32E+00	**1.14E+00**	**7.03E+00**
Hog Bone	Sr-89/90	11	11	2.15E+00	**1.00E+00**	**3.81E+00**

Appendix E Groundwater Management Program Supplemental Information

Appendix Table E-1 Summary of Documents that Report Groundwater Monitoring Data

Document Title	Submittal Frequency
Data Report for the C-Area Groundwater (CAGW) Operable Unit	Annual
K-Area Burning/Rubble Pit (131-K) and Rubble Pile (631-20G) (KBRP), L-Area Burning/Rubble Pit (131-L), Gas Cylinder Disposal Facility (131-2L) and L-Area Rubble Pile (131-3L) (LBRP), and P-Area Burning/Rubble Pit (131-P) (PBRP) Operable Units Combined Groundwater Monitoring Report Sampling Summary	Annual
Annual Comprehensive TNX Area Groundwater Monitoring and Remedial Action Effectiveness Interim Report	Annual
R-Area Groundwater Effectiveness Monitoring Report in Support of R-Area Operable Unit	Annual
2016 Effectiveness Monitoring Report (EMR) for Monitored Natural Attenuation (MNA) at the L-Area Southern Groundwater (LASG) Operable Unit	Biennial
Five-Year Remedy Review Report for Savannah River Site Operable Units	Phased - Annual
D-Area Groundwater Operable Unit	Annual
Groundwater Mixing Zone Report for the D-Area Oil Seepage Basin	Annual
Groundwater Mixing Zone Sampling Summary Report for the R-Reactor Seepage Basin, 108-4R Overflow Basin Operable Unit	Biannual
488-4D Class Two Landfill Midyear Groundwater Monitoring Report	Biannual
632-G C&D Class Two Landfill Groundwater Monitoring Report	Biannual
N-Area Heating Oil (NHO) Plume Groundwater Monitoring Report	Annual
Z-Area Saltstone Disposal Facility Groundwater Monitoring Report	Biannual
288-F Class Two Landfill Annual Groundwater Monitoring Report	Biannual
Interim Sanitary Landfill (Class Three) Annual Groundwater Monitoring Report	Biannual
Annual M-Area and Metallurgical Laboratory Hazardous Waste Management Facilities Groundwater Monitoring and Corrective Action Report	Annual
Annual Corrective Action Report for the F-Area Hazardous Waste Management Facility, the H-Area Hazardous Waste Management Facility, and the Mixed Waste Management Facility	Annual
Performance Evaluation Report for the M-Area Inactive Process Sewer Lines (MIPSL) (081-M) Operable Unit	Annual
Performance Evaluation Report for the A-Area Burning/Rubble Pit (731-A, 731-1A) and Rubble Pit (731-2A) and the Miscellaneous Chemical Basin/Metals Burning Pit (731-4A, 731-5A) Operable Unit	Annual
Effectiveness Monitoring Report (EMR) for the Monitored Natural Attenuation (MNA) at the Chemicals, Metals, and Pesticides (CMP) Pits Operable Unit	Annual

Document Title	Submittal Frequency
Biennial Effectiveness Monitoring Report (EMR) for Monitored Natural Attenuation (MNA) at the C-Area Burning/Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit	Biennial
Scoping Summary for the General Separations Area Eastern Groundwater Operable Unit	Annual
Scoping Summary for the General Separations Area Western Groundwater Operable Unit	Annual
Performance Evaluation Report for the A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit	Annual
SRS Annual Environmental Report	Not applicable[a]

Note:

[a] The SRS Annual Environmental Report is not submitted to the regulatory agencies as a regulatory requirement. The report is a publicly available document. The Annual Environmental Report summarizes information on offsite wells and onsite wells that are not included in regulatory submittals.

Appendix F Glossary

A

accuracy—Closeness of the result of a measurement to the true value of the quantity.

actinide—Group of radioactive metallic elements of atomic number 89 through 103. Laboratory analysis of actinides by alpha spectrometry generally refers to the elements plutonium, americium, uranium, and curium but may also include neptunium and thorium.

activity—See radioactivity.

alpha particle—Positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons)

ambient—Existing in the surrounding area. Completely enveloping.

ambient air—Surrounding atmosphere as it exists around people, plants, and structures.

analyte—Constituent or parameter that is being analyzed.

analytical detection limit—Lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

aquifer—Saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

Area Completion Project—U.S. Department of Energy program that directs the assessment and cleanup of inactive waste units and groundwater (remediation) contaminated as a result of nuclear-related activities.

Atomic Energy Agency—Federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian application. It was abolished by the Energy Reorganization Act of 1974 and succeeded by the Energy Research and Development Administration. Functions of the Energy Research and Development Administration eventually were taken over by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission.

audit—A systematic evaluation to determine the conformance to quantitative specifications of some operational function or activity.

B

Background control location—A sampling point that is not impacted by SRS operations.

background radiation—Naturally occurring radiation, fallout, and cosmic radiation. Generally, the lowest level of radiation obtainable within the scope of an analytical measurement, i.e., a blank sample.

Benchmark — A standard or point of reference against which things may be compared or assessed.

Best Available Technology (BAT) —The preferred technology for treating a particular process liquid waste. BAT is not a specific level of treatment but the conclusion of a selection process that includes several treatment alternatives. The selection process looks at factors related to technology, economics, public policy, and other parameters.

best management practices—Sound engineering practices that are not required by regulation or by law.

beta particle—Negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

Biobased products—Products derived from plants and other renewable agricultural, marine, and forestry materials that provide an alternative to conventional petroleum-derived products.

Biopreferred® —A program the U.S. Department of Agriculture (USDA) manages to increase the purchase and use of biobased products. The program's purpose is to spur economic development, create new jobs and provide new markets for farm commodities. For more information, please see the USDA website.

biota—Plant and animal life.

blind sample—A subsample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample, but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.

C

calibration—Process of applying correction factors to equate a measurement to a known standard. Generally, a documented measurement control program of charts, graphs, and data that demonstrate that an instrument is properly calibrated.

canyon—Two facilities located at SRS where nuclear materials are chemically recovered and purified. They are called "canyons" because of their similarity to how a canyon looks, open space with high wall-like mountains on either side of a valley.

Carolina bay—Type of shallow depression commonly found on the coastal Carolina plains. Carolina bays are typically circular or oval. Some are wet or marshy, while others are dry.

categorical exclusion—Categories of actions that do not individually or cumulatively have a significant effect on the human environment and for which, therefore, neither an environmental assessment nor an environmental impact statement is required.

Central Savannah River Area—Eighteen-county area in Georgia and South Carolina surrounding Augusta, Georgia. The Savannah River Site is included in the Central Savannah River Area. Counties are Richmond, Columbia, McDuffie, Burke, Emanuel, Glascock, Jenkins, Jefferson, Lincoln, Screven, Taliaferro, Warren, and Wilkes in Georgia and Aiken, Edgefield, Allendale, Barnwell, and McCormick in South Carolina.

chlorocarbons—Compounds of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, tetrachloroethylene, etc. They are among the most significant and widespread environmental contaminants. Classified as hazardous wastes, chlorocarbons may have a tendency to cause detrimental effects, such as birth defects.

cleanup—Actions taken to deal with release or potential release of hazardous substances. This may mean complete removal of the substance; it also may mean stabilizing, containing, or otherwise treating the substance so that it does not affect human health or the environment.

closure—Control of a hazardous waste management facility under Resource Conservation and Recovery Act requirements.

compliance—Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

composite—A blend of more than one portion to be used as a sample for analysis.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)—This Act addresses the cleanup of hazardous substances and establishes a National Priority List of sites targeted for assessment and, if necessary, restoration (commonly known as “Superfund”).

concentration—Amount of a substance contained in a unit volume or mass of a sample.

conductivity—Measure of water’s capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

contamination—State of being made impure or unsuitable by contact or mixture with something unclean, bad, etc.

contaminant pathway—The way contaminants move and settle in the environment after release from operating facilities to the air and water.

continuous assessment—Evaluation of a program or employee carried out on a fixed interval (e.g. weekly, monthly, annually)

control chart—A graph of some measurement plotted over time or sequence of sampling, together with control limit(s) and, usually, a central line and warning limit(s). Control charts provide a graphical representation of accuracy and precision, a long-term mechanism for self-evaluation of analytical data, and an assessment of analytical capability of the laboratory analyst.

control standard—A standard prepared independently of and run with the calibration. It is used to verify the accuracy of the calibration.

cool roof—A thick white rubber-type roof that lowers the temperature of standard roofs from about 150 degrees Fahrenheit to 100 degrees or less.

criteria pollutant—Six common air pollutants found all over the United States. They are particle pollution (often referred to as particulate matter), ground-level ozone, carbon monoxide, sulfur dioxide, nitrogen oxides, and lead. The Environmental Protection Agency is required by the Clean Air Act to set National Ambient Air Quality Standards for these six pollutants.

curie—Unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

- **kilocurie (kCi)**—10^{3} Ci, one thousand curies; 3.7×10^{13} disintegrations per second.
- **millicurie (mCi)**—10^{-3} Ci, one-thousandth of a curie; 3.7×10^{7} disintegrations per second.
- **microcurie (µCi)**—10^{-6} Ci, one-millionth of a curie; 3.7×10^{4} disintegrations per second.
- **picocurie (pCi)**—10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

D

DCS sum of fractions—The sum of the ratios of the average concentration of each radionuclide to its corresponding DCS value. (See below for definition of DCS-derived concentration standard.)

decay (radioactive)—Spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

deactivation—The process of placing a facility in a stable and known condition, including the removal of hazardous and radioactive materials to ensure adequate protection of the worker, public health and safety, and the environment, thereby limiting the long-term cost of surveillance and maintenance.

decommissioning—Process that takes place after deactivation and includes surveillance and maintenance, decontamination, and dismantlement.

decontamination—The removal or reduction of residual radioactive and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

derived concentration standard (DCS)—Concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv). The guides for radionuclides in air and water are given in U.S. Department of Energy Derived Concentration Technical Standard (DOE-STD-1196-2011) (DOE 2011).

detection limit—See analytical detection limit, lower limit of detection, minimum detectable concentration.

detector—Material or device (instrument) that is sensitive to radiation and can produce a signal suitable for measurement or analysis.

disposal—Permanent or temporary transfer of U.S. Department of Energy control and custody of real property to a third party, which thereby acquires rights to control, use, or relinquish the property.

disposition—Those activities that follow completion of program mission including, but not limited to, surveillance and maintenance, deactivation, and decommissioning.

dissolved oxygen—Desirable indicator of satisfactory water quality in terms of low residuals of biologically available organic materials. Dissolved oxygen prevents the chemical reduction and subsequent leaching of iron and manganese from sediments.

DOECAP—A comprehensive audit program for contract laboratories with the intent of conducting consolidated audits to eliminate redundant audits previously conducted independently by DOE field element sites and to achieve standardization in audit methodology, processes, and procedures.

dose—Energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

- **absorbed dose**—Quantity of radiation energy absorbed by an organ, divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 Gy).
- **equivalent dose**—Product of the absorbed dose (rad) in tissue and a radiation weighting factor. Equivalent dose is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).
- **effective dose**—Sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate tissue weighting factor.
- **committed effective dose**—Is the effective dose integrated over time, usually 50-years. Committed effective dose is expressed in units of rem (or sievert).
- **collective dose**—Sum of the effective dose of all individuals in an exposed population within a 50-mile (80-km) radius, and expressed in units of person-rem (or person-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or U.S. Department of Energy program activities.

dosimeter—Portable detection device for measuring the total accumulated exposure to ionizing radiation.

drinking water standards—Federal primary drinking water standards, both proposed and final, as set forth by the Environmental Protection Agency.

duplicate result—Result derived by taking a portion of a primary sample and performing the identical analysis on that portion as is performed on the primary sample.

E

effluent—A release of treated or untreated water or air from a pipe or a stack to the environment. Liquid effluent flows into a body of water such as a stream or lake. Airborne effluent (also called emission) discharges into the atmosphere.

effluent monitoring—Collection and analysis of samples or measurements of liquid and gaseous effluents for purpose of characterizing and quantifying the release of contaminants, assessing radiation exposures to members of the public, and demonstrating compliance with applicable standards.

emission—A release of a gas.

ENERGY STAR®—A U.S. Environmental Protection Agency program that helps businesses and individuals save money and protect the climate through energy efficiency. For more information, please visit the ENERGY STAR website.

environmental compliance—Actions taken in accordance with government laws, regulations, orders, etc., that apply to Site operations' effects on onsite and offsite natural resources and on human health; used interchangeably in this document with regulatory compliance.

environmental monitoring—Program at Savannah River Site that includes effluent monitoring and environmental surveillance with the dual purpose of 1) showing compliance with federal, state, and local regulations, as well as with U.S. Department of Energy orders, and 2) monitoring any effects of Site operations on onsite and offsite natural resources and on human health.

environmental occurrence—Any sudden or sustained deviation from a regulated or planned performance at a DOE operation that has environmental protection and compliance significance.

environmental surveillance—Collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from U.S. Department of Energy sites and their environs and the measurement of external radiation for purpose of demonstrating compliance with applicable standards, assessing radiation exposures to members of the public, and assessing effects, if any, on the local environment.

EPEAT—A product database that registers products based on the devices' ability to meet various criteria developed and agreed upon by diverse stakeholders to address the full lifecycle of an electronic product. This system ensures all products listed in the EPEAT database truly represent environmental leadership. For more information, please visit the EPEAT website.

exception (formerly “exceedance”)—Term used by the Environmental Protection Agency and the South Carolina Department of Health and Environmental Control that denotes a report value is more than the guide limit. This term is found on the discharge monitoring report forms that are submitted to the Environmental Protection Agency or the South Carolina Department of Health and Environmental Control.

exclusion or exclusion device—Material or equipment used for wildlife control. These devices may be used to deter animal use of an area, to provide a method of collecting animals, or to provide a means of exit for an animal.

exposure (radiation)—Incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is the exposure to ionizing radiation that takes place during a person’s working hours. Population exposure is the exposure to the total number of persons who inhabit an area.

exposure pathway—The way that a person could be impacted from releases of radionuclides into the water and air.

F

fallout—The settling to the ground of airborne particles ejected into the atmosphere from the earth by explosions, eruptions, forest fires, etc. or from human production activities such as found at nuclear facilities.

Federal Facility Agreement (FFA)—Agreement negotiated among the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control, specifying how the Savannah River Site will address contamination or potential contamination to meet regulatory requirements at Site waste units identified for evaluation and, if necessary, cleanup.

feral hog—Hog that has reverted to the wild state from domestication.

field duplicate—An independent sample collected as closely as possible to the same point in space and time as the original sample. The duplicate and original are two separate samples taken from the same source, stored in separate containers, and analyzed independently.

fiscal year—An established period of time when an organization's annual financial records start and end. In the federal government, this period is from October 1 to September 30.

fugitive greenhouse gas emissions—The inadvertent release of greenhouse gases to the atmosphere from various facilities or activities. Some common sources include leaks or releases from valves, pumps, compressors, flanges from refrigeration, and air conditioning systems.

G

global fallout—Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

grab sample—Sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

gross alpha and beta releases—The total alpha-emitting and beta-emitting activity determined at each effluent location.

ground shine—Exposure to gamma radiation produced by radioactive materials on the ground surface is called ground shine and it contributes to external dose.

groundwater—Water found underground in cracks and spaces in soil, sand, and rocks.

H

half-life (radiological)—Time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

hazardous waste—Any waste that is a toxic, corrosive, reactive, or ignitable material that could affect human health or the environment.

I

International Organization for Standardization (ISO)—Creates documents that provide requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that materials, products, processes, and services are compatible with their purpose. For more information, please visit the ISO website.

Intralaboratory checks—Compare performance within a laboratory by analyzing duplicate and blind samples throughout the year.

isotope—Each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; in particular, a radioactive form of an element.

L

legacy—Anything handed down from the past; inheritance, as of nuclear waste.

low-level waste—Waste that includes protective clothing, tools, and equipment that have become contaminated with small amounts of radioactive material.

lower limit of detection—Smallest concentration/amount of an analyte that can be reliably detected in a sample at a 95% confidence level.

M

manmade radiation—Radiation from sources such as consumer products, medical procedures, and nuclear industry.

MAPEP—A laboratory comparison program that tracks performance accuracy and tests the quality of environmental data reported to DOE.

maximally exposed individual—Hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

maximum contaminant level—The maximum allowable concentration of a drinking water contaminant as legislated through the Safe Drinking Water Act.

mercury—Silver-white, liquid metal solidifying at -38.9°C to form a tin-white, ductile, malleable mass. It is widely distributed in the environment and biologically is a nonessential or non-beneficial element. Human poisoning due to this highly toxic element has been clinically recognized.

migration—Transfer or movement of a material through the soil or groundwater.

minimum detectable concentration (radionuclides)—Smallest amount or concentration of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

minimum detectable concentration (chemicals)—Smallest amount or concentration of a chemical that can be distinguished in a sample by a given measurement system at a given confidence level.

mixed waste—Waste that has both hazardous and radioactive components.

monitoring—Process whereby the quantity and quality of factors that can affect the environment and or human health are measured periodically to regulate and control potential impacts.

N

nonroutine radioactive release—Unplanned or nonscheduled release of radioactivity to the environment.

nuclide—Atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

O

organic—Of, relating to, or derived from living organisms (plant or animal).

outfall—Place where treated or untreated water flows out of a pipe to mix with water from a water body, such as a stream or lake.

P

parameter—Analytical constituent; chemical compound(s) or property for which an analytical request may be submitted.

passive device—A device that does not require a source of energy for its operation.

PCB bulk product waste—Waste derived from products manufactured to contain PCBs in a non-liquid state at 50 ppm or greater. Typical examples are caulk, pain, and sealants.

performance evaluation (PE) sample—A sample, the composition of which is unknown to the analyst, that is provided to test whether the analyst/laboratory can produce analytical results within specified performance limits.

person-rem—Collective dose to a population group. For example, a dose of one rem to 10 individuals results in a collective dose of 10 person-rem.

pH—Measure of the hydrogen ion concentration in an aqueous solution (acidic solutions, pH <7; basic solutions, pH>7; and neutral solutions, pH 7).

piezometer—Instrument used to measure the potentiometric surface of the groundwater. Also, a well designed for this purpose.

plume—Volume of contaminated water originating at a waste source (e.g., a hazardous waste disposal site). It extends downward and outward from the waste source.

plume shine—Exposure to gamma radiation from airborne radioactive materials is called plume shine (sometimes called cloud shine or sky shine) and it contributes to external dose.

point source—Any defined source of emission to air or water such as a stack, air vent, pipe, channel, or passage to a water body.

population dose—See collective dose equivalent under dose.

potable water—Water that is safe to drink.

practical quantitation—The lowest level a laboratory can quantify with 99% confidence.

precision—A estimate of the degree to which a set of observations or measurements of the property, usually obtained under similar conditions agree. It is a data quality indicator.

priority I finding—Documents a deficiency that is of sufficient magnitude to potentially render the audited facility unacceptable to provide the affected service to DOE.

priority II finding—Documents a deficiency that is not of sufficient magnitude to render the audited facility unacceptable to provide services to DOE.

process sewer—Pipe or drain, generally located underground, used to carry off either process water or waste matter, or both.

proficiency testing—An evaluation of a laboratory's performance against pre-established criteria by means of inter-laboratory comparison. It is also known as comparative testing.

purge—To remove water prior to sampling, generally by pumping or bailing.

Q

quality assurance (QA)—An integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure quality in the processes by which products are developed.

quality control (QC)—A set of activities for ensuring quality in products by identifying defects in the actual products.

R

rad—Unit of absorbed dose deposited in a volume of material.

radioactivity—Spontaneous emission of radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

radioisotopes—Radioactive isotopes.

radionuclide—Unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

reference person—A hypothetical age and gender averaged individual that is a combination of human (male and female) physical and physiological characteristics arrived at by international consensus for the purpose of standardizing radiation dose calculations.

RCRA/CERCLA Units—Units subject to the remedial action process established in the Federal Facilities Agreement.

Regional Screening Level (RSL)—The risk-based concentration derived from standardized equations combining exposure assumptions with toxicity data.

regulatory compliance—Actions taken in accordance with government laws, regulations, orders, etc., that apply to Savannah River Site operations' effects on onsite and offsite natural resources and on human health; used interchangeably in this document with environmental compliance.

release—Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem—Unit of dose equivalent (absorbed dose in rads times the radiation quality factor). Dose equivalent frequently is reported in units of millirem (mrem), which is one thousandth of a rem.

remediation—Assessment and cleanup of sites contaminated with waste due to historical activities.

representative person—A hypothetical individual receiving a dose that is representative of the more highly exposed individuals in the population.

Resource Conservation and Recovery Act (RCRA)—Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes. This act also requires corrective action for releases of hazardous waste at inactive waste units.

retention basin—Unlined basin used for emergency, temporary storage of potentially contaminated cooling water from chemical separations activities.

routine radioactive release—Planned or scheduled release of radioactivity to the environment.

S

seepage basin—Excavation that receives wastewater. Insoluble materials settle out on the floor of the basin and soluble materials seep with the water through the soil column, where they are removed partially by ion exchange with the soil. Construction may include dikes to prevent overflow or surface runoff.

SEER—Seasonal Energy Efficiency Ratio—This is a measure of equipment energy efficiency over the cooling season. It represents the total cooling of a central air conditioner or heat pump during the normal cooling season as compared to the total electric energy input consumed during the same period.

sensitivity—Capability of methodology or instruments to discriminate between samples with differing concentrations or containing varying amounts of an analyte.

sievert—The International System of Units (SI) derived unit of dose equivalent. It attempts to reflect the biological effects of radiation as opposed to the physical aspects, which are characterized by the absorbed dose, measured in gray. One sievert is equal to 100 rem.

significant analytical result—Indicates that the result is statistically significant or is at or above the detection limit of the applicable radioanalytical method, or both.

Silvex— A herbicide and a plant growth regulator. It has been banned for use as a herbicide in the United States since 1985.

site stream—Any natural stream on the Savannah River Site. Surface drainage of the Site is via these streams to the Savannah River.

source—Point or object from which radiation or contamination emanates.

source term—Quantity of radioactivity (released in a set period of time) that is traceable to the starting point of an effluent stream or migration pathway.

spent nuclear fuel—Used fuel elements from reactors.

splits or split sample—Two or more representative portions taken from a single sample and analyzed by different analysts or laboratories. Split samples are used to replicate the measurement of the parameters of interest.

SRS Community Reuse Organization (SRSCRO)—A nonprofit organization charged with developing and implementing strategy to diversify the economy in the five South Carolina and Georgia counties surrounding the Site. For more information, please see the SRSCRO website.

stable—Not radioactive or not easily decomposed or otherwise modified chemically.

stack—Vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

standard deviation—Indication of the dispersion of a set of results around their average.

statistical data evaluation—A collection of methods used to process large amounts of data and report overall trends.

stormwater runoff—Surface streams that appear after precipitation.

Superfund—See Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

surface water—Water that has not penetrated below the surface of the ground.

T

tank farm—Interconnected underground tanks used for storage of high-level radioactive liquid wastes.

temperature—Thermal state of a body, considered with its ability to communicate heat to other bodies.

terrestrial—Living on or growing from the land.

thermoluminescent dosimeter (TLD)—A passive device that measures the exposure from ionizing radiation.

total dissolved solids—Dissolved solids and total dissolved solids are terms generally associated with freshwater systems; they consist of inorganic salts, small amounts of organic matter, and dissolved materials.

total phosphorus—May occasionally stimulate excessive or nuisance growths of algae and other aquatic plants when concentrations exceed 25 mg/L at the time of the spring turnover on a volume- weighted basis in lakes or reservoirs.

total suspended particulates—Refers to the concentration of particulates in suspension in the air, regardless of the nature, source, or size of the particulates.

translocation—The deliberate movement of organisms from one site for release in another. It must be intended to yield a measurable conservation benefit at the levels of a population, species or ecosystem, and not only provide benefit to translocated individuals.

transport pathway—Pathway by which a released contaminant is transported physically from its point of discharge to a point of potential exposure to humans. Typical transport pathways include the atmosphere, surface water, and groundwater.

transuranic waste—Solid radioactive waste containing primarily alpha-emitting elements heavier than uranium.

trend—General drift, tendency, or pattern of a set of data plotted over time.

tritium—Elemental form of the radioactive isotope of hydrogen and occurs as a gas.

tritium oxide—Water in which the tritium isotope has replaced a hydrogen atom. Stack releases of tritium oxide typically occur as water vapor.

turbidity—Measure of the concentration of sediment or suspended particles in solution.

U

unidentified alpha and beta releases—The unspecified alpha and beta releases that are conservatively determined at each effluent location by subtracting the sum of the individually measured alpha-emitting (e.g., plutonium-239 and uranium-235) and beta- emitting (e.g., cesium-137 and strontium-90) radionuclides from the measured gross alpha and beta values, respectively. Unidentified alpha and beta releases also include naturally occurring radionuclides, such as uranium, thorium, radon progeny, and potassium-40.

utility water—Once-through non-contact cooling water, recirculated non-contact cooling water, boiler blowdown, steam condensate, air conditioning condensate, and other uncontaminated heating, ventilation and air conditioning or compressor condensates.

V

volatile organic compounds—Broad range of organic compounds, commonly halogenated, that vaporize at ambient, or relatively low, temperatures (e.g., acetone, benzene, chloroform, methyl alcohol).

W

waste management—The U.S. Department of Energy uses this term to refer to the safe, effective management of various kinds of nonhazardous, hazardous, and radioactive waste generated at DOE facilities.

waste unit—A particular area that is or may be posing a threat to human health or the environment. Waste units range in size from a few square feet to tens of acres and include basins, pits, piles, burial grounds, landfills, tank farms, disposal facilities, process facilities, and groundwater contamination.

waste stream—Waste material generated from a single process or from an activity that is similar in material, physical form, isotopic makeup and hazardous constituents.

WaterSense®—A U.S. Environmental Protection Agency partnership that offers ways to increase water efficiency through products and services. For more information, please visit the U.S. EPA website.

water table—Planar, underground surface beneath which earth materials, such as soil or rock, are saturated with water.

Waters of the State—Surface or underground water within the jurisdiction of the state, as defined in the South Carolina Pollution Control Act.

weighting factor—Value used to calculate dose equivalents. It is tissue specific and represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be attributed to that particular tissue. The weighting factors used in this report are recommended by the International Commission on Radiological Protection (Publication 26).

wetland—Lowland area, such as a marsh, swamp, bog, Carolina bay, floodplain bottom, where land is covered by shallow water at least part of the year and is characterized by somewhat mucky soil.

Appendix G References

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Appendix H Units of Measure

Symbol	Name	Symbol	Name
Temperature		***Concentration***	
°C	degrees Celsius	ppb	parts per billion
°F	degrees Fahrenheit	ppm	parts per million
Time		***Rate***	
d	day	cfs	cubic feet per second
h	hour	gpm	gallons per minute
y	year	***Conductivity***	
Length		µmho	micromho
cm	centimeter	***Radioactivity***	
ft	foot	Ci	curie
in	inch	cpm	counts per minute
km	kilometer	mCi	millicurie
m	meter	µCi	microcurie
mm	millimeter	pCi	picocurie
µm	micrometer	Bq	becquerel
Mass		***Radiation Dose***	
g	gram	mrad	millirad
kg	kilogram	mrem	millirem
mg	milligram	Sv	sievert
µg	microgram	mSv	millisievert
Area		µSv	microsievert
mi^2	square mile	R	roentgen
ft^2	square foot	mR	milliroentgen
Volume		µR	microroentgen
gal	gallon	Gy	gray
L	liter		
mL	milliliter		

Fractions and Multiples of Units				
Multiple	**Decimal Equivalent**	**Prefix**	**Symbol**	**Report Format**
10^6	1,000,000	mega-	M	E+06
10^3	1,000	kilo-	k	E+03
10^2	100	hecto-	h	E+02
10	10	deka-	da	E+01
10^{-1}	0.1	deci-	d	E-01
10^{-2}	0.01	centi-	c	E-02
10^{-3}	0.001	milli-	m	E-03
10^{-6}	0.000001	micro-	µ	E-06
10^{-9}	0.000000001	nano-	n	E-09
10^{-12}	0.000000000001	pico-	p	E-12
10^{-15}	0.000000000000001	femto-	f	E-15
10^{-18}	0.000000000000000001	atto-	a	E-18

Conversion Table (Units of Radiation Measure)		
Current System	***Systeme International***	**Conversion**
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Conversion Table					
Multiply	**By**	**To Obtain**	**Multiply**	**By**	**To Obtain**
in	2.54	cm	cm	0.394	in
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liq qt-US	0.945	L	L	1.057	liq qt-US
ft^2	0.093	m^2	m^2	10.764	ft^2
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.31	ft^3
d/m	0.450	pCi	pCi	2.22	d/m
pCi	10^{-6}	µCi	µCi	10^6	pCi
pCi/L (water)	10^{-9}	µCi/mL (water)	µCi/mL (water)	10^9	pCi/L (water)
pCi/m^3 (air)	10^{-12}	µCi/mL (air)	µCi/mL (air)	10^{12}	pCi/m^3 (air)

Savannah River Nuclear Solutions, LLC
Aiken, SC

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