Savannah River Site™

Environmental Report

2018

SRNS-RP-2019-00022

The cover photos are courtesy of Mike Baggett, a North Augusta, South Carolina photographer who graciously gave SRS permission to display his work.

Front Cover—A swallowtail at Audubon's Silver Bluff Center and Sanctuary, Silver Bluff, Jackson, South Carolina

Back Cover—A bee gathering pollen from a coneflower at Hopelands Gardens, Aiken, South Carolina

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or go to the SRS Environmental Report webpage at
http://www.srs.gov/general/pubs/ERsum/index.html
and under the SRS Environmental Report 2018, complete the electronic Customer Satisfaction Survey.

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Savannah River Site

Environmental Report 2018

Prepared by
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To Our Readers

Highlights

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

ASERs 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 ASERs in 1959.

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

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

The SRS Environmental Report for calendar year 2018 is an overview of environmental management activities conducted on and in the vicinity of SRS from January 1 through December 31, 2018. 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 Environmental Report 2018 webpage. Many of the reports mentioned in Chapter 3, *Compliance Summary*, are submitted to meet compliance requirements and are not available on the SRS Environmental Report 2018 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 this report is reported by 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 2018 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

SRNS develops this report as the management & operations contractor to the DOE at SRS. In addition to SRNS, the contributors to the annual report include Savannah River Remediation, LLC (SRR); Parsons Government Services, Inc.; U.S. Department of Energy, Savannah River Operations Office (DOE-SR); CB&I AREVA MOX Services, LLC; Centerra-SRS; Ameresco Federal Solutions; Savannah River Ecology Laboratory (SREL); and U.S. Department of Agriculture (USDA) Forest Service-Savannah River (USFS-SR). Links to their websites may be found on pages 1–3 through 1–5 of this report.

The SRS 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

ALARA	As Low As Reasonably Achievable
ARP	Actinide Removal Process
ANSI	American National Standards Institute
ASER	Annual Site Environmental Report
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
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMP	Chemicals, Metals, and Pesticides
CO	Carbon Monoxide
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
EISA	Energy Independence Security Act
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

HLW	High-Level Waste
HWMF	Hazardous Waste Management Facility

I

I&D	Industrial and Domestic
ICRP	International Commission on Radiological Protection
ILA	Industrial, Landscaping, and Agricultural
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
LLW	Low-Level 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
MDA	Minimum Detectable Activity

N

NADP	National Atmospheric Deposition Program
NA-MRF	North Augusta, South Carolina 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
NNIPS	Non-native Invasive Plant Species
NNSA	National Nuclear Security Administration
NOAV	Notice of Alleged Violation
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
PMI	Project Management Institute
Pu	Plutonium

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
SCEEP	South Carolina Environmental Excellence Program
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
SST	Solvent Storage Tanks
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
TEEM	Targeting Environmental Excellence at MOX
TLD	Thermoluminescent Dosimeter
TNX	678T Facilities
TRI	Toxic Release Inventory
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facilities
TSS	Total Suspended Solids

U

UTMA	Underground Radioactive Material Area
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) 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 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
- Descriptions 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 U.S. Atomic Energy Commission (the precursor to DOE) constructed SRS in the early 1950s to produce materials used to create nuclear weapons during the Cold War. Over the following 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. The Site performs these activities to support its mission, described in the next section.

1.2 MISSION

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 and transforming the Site for future use. The Site is recognized as a long-term national asset in the areas of environmental stewardship, innovative technology, national security, and energy independence.

1.3 ORGANIZATION

The DOE Environmental Management (DOE EM) program and the National Nuclear Security Administration (NNSA) oversee the Site mission. These two DOE Program Offices direct the Savannah River Operations Office (DOE-SR). To execute SRS's mission, two federal agencies, two state universities, and several contractors participate in various supporting roles. Figure 1-1 shows the relationship of these contractors to DOE.

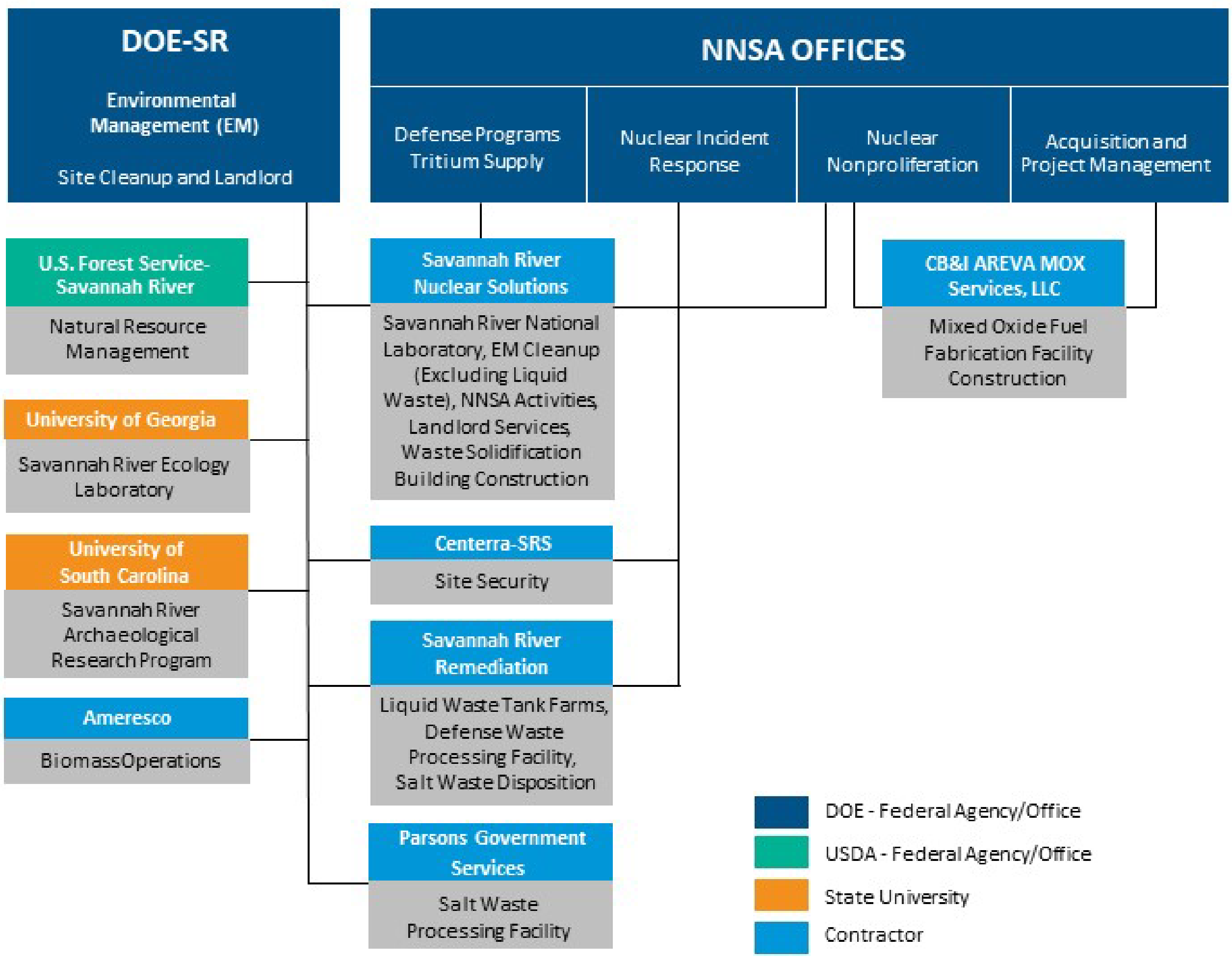


Figure 1-1 SRS Organization, 2018

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 oversees 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; Stoller Newport News Nuclear, Inc.; 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 support of SRS's mission 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, Inc.; Jacobs; and BWX Technologies, Inc. The critical subcontractors for the contract are Orano, Atkins, and AECOM N&E Technical Solutions. 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.

CB&I AREVA MOX Services, LLC was responsible for designing, constructing, starting up, and operating the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) in 2018. The MFFF when complete would have converted plutonium that could be used to make weapons to a form that could be used in a commercial nuclear power plant.

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 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.

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.

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 the 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.

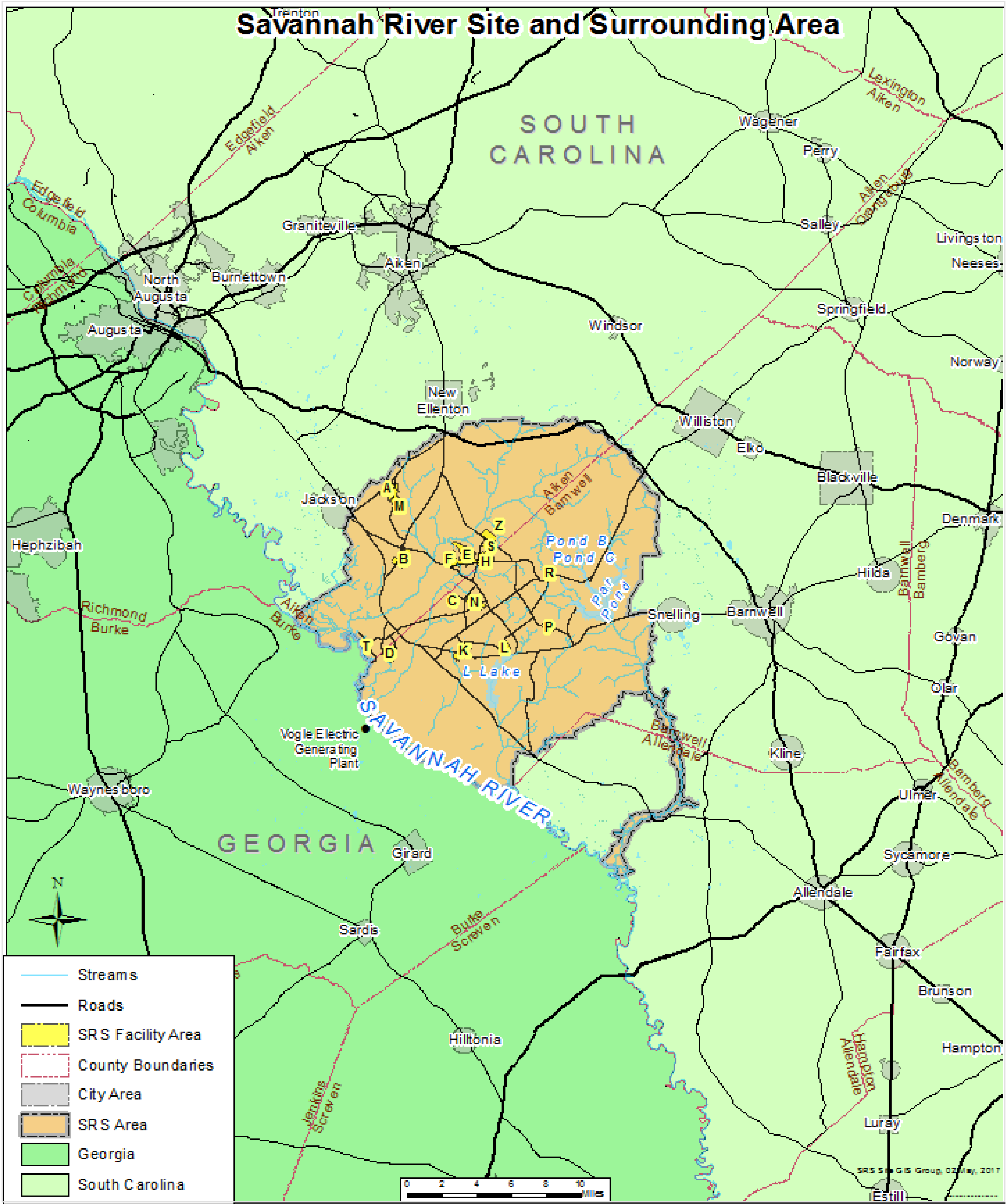


Figure 1-2 The Savannah River Site and Surrounding Area

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 onsite, 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.

A Juvenile Alligator, One of More Than 100 Species of Reptiles and Amphibians at SRS

1.5 DOE-EM PRIMARY SITE ACTIVITIES

The Environmental Management program oversees many Site activities. The following sections highlight key activities. You will find additional information on these activities on SRS's website.

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. SRS completed its production mission at F Canyon in 2002 and deactivated it 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 fuel. Blending down or down blending, as it is sometimes referred to, mixes the uranium with natural uranium to not only make it undesirable to use in nuclear weapons, but also to make it useable for commercial nuclear reactors.

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 to prepare it for disposal as transuranic waste at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico.

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.

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 2018, SRS completed onsite startup testing for 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 uses cylindrical tanks, known as Saltstone Disposal Units (SDUs), to dispose of the low-activity liquid waste. In 2018, SRS began constructing SDU 7, the second of seven mega-volume SDUs to be built at SRS. SDU 6, the first mega-volume SDU at SRS, received its first transfer of decontaminated salt solution in August 2018. In fiscal year (FY) 2018, the Saltstone facilities processed and disposed of 384,000 gallons of waste. DOE awarded the SDU 6 project the 2018 Project Management Excellence Award. In 2017, DOE EM named the project the DOE Project of the Year.

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 61.2 million curies of radioactivity—and pouring more than 4,100 canisters. Canister pouring resumed in June 2018 when melter 3 replaced melter 2. DWPF in FY 2018 produced 15 canisters of glass, weighing more than 61,000 pounds and immobilizing approximately 257,000 curies of radioactivity.

1.5.4.2 Solid Waste Management

SRS manages the following types of solid waste:

- 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
- Construction and demolition waste

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 has made more than 1,650 shipments. SRS made one TRU shipment in 2018. In 2018, the Site received approval of the Resource Conservation and Recovery Act Closure Certification Report for Interim Status TRU Pad 2.

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.

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. SRS's 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).

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

In 2018, SRS completed a 5-year project to restore 90 acres located near the former coal-fired power plant in D Area. SRS completed the project more than a year ahead of schedule and saved nearly $9 million. The restoration included consolidating more than 430,000 cubic yards of coal ash that had been deposited over decades and associated soils and constructing an engineered cover system. In 2018, the Project Management Institute (PMI) awarded the D-Area Ash Basins project the 2018 PMI Award for Project Excellence. This award recognizes global, large, and complex projects that have superior project management practices, superior organizational results, and positive impacts on society.

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. The Site checks these samples for radionuclides, metals, and other chemicals that could be in the environment because of SRS activities.

The potential radiation dose to the public from SRS operations is well below the DOE public dose limit. Chapter 6, *Radiological Dose Assessment*, contains more information on the public dose limit.

1.6 NNSA PRIMARY SITE ACTIVITIES

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. You will find more information on SRS's website.

Tritium Facility

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.

1.6.2 Nuclear Nonproliferation

Since 1999 the NNSA Nuclear Nonproliferation Program had been working to design and build the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF), which would have converted surplus weapons-grade plutonium into fuel for commercial facilities to generate electricity. Due to project cost over-runs and schedule delays and identifying a less-expensive alternative to dispose of weapons-grade plutonium, NNSA decided to terminate the project in October 2018. It is expected that in April 2019, SRNS will take over managing the MFFF building and prepare it for a future use. The NNSA Materials Management and Minimization Program will now prepare the surplus weapons-grade plutonium for disposal at WIPP, the federal geologic repository, using the dilute and dispose approach. The Surplus Plutonium Disposition Project will expand the current SRS down-blending capability to do so with SRNS as the primary contractor.

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. Department of Agriculture (USDA) 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 Environmental Report 2018 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 SRS 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. These safeguards 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 made toward achieving those goals.

2018 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 58% (504 metric tons) of nonhazardous solid waste.
- **Greenhouse Gas Reduction**—SRS continued to reduce greenhouse gas emissions. The Site has reduced emissions by 78% since 2008.
- **Transportation and Fleet Management**—More than 98% of the current fleet of light-duty vehicles are hybrid, electric, or vehicles that use E85 (ethanol) fuel.
- **EMS Audit**—SRS had a successful external conformance audit and was declared to be in conformance with the International Organization for Standardization (ISO) 14001:2015 standard. As part of the triennial audit, SRS revised a short environmental policy.

2.1 SRS EMS IMPLEMENTATION

2.1.1 Introduction

DOE has chosen 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. In May 2018, President Trump signed Executive Order No. 13834, *Efficient Federal Operation*, revoking Executive Order No. 13693. This chapter will account for the Executive Order in future Annual Site Environmental Reports, once DOE Headquarters gives SRS guidance on implementing it at the Site. For this year, sustainability reporting will be per the previous Executive Order.

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.

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.

Chapter 2—Key Terms

Environmental impacts *are any positive or negative changes 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.*

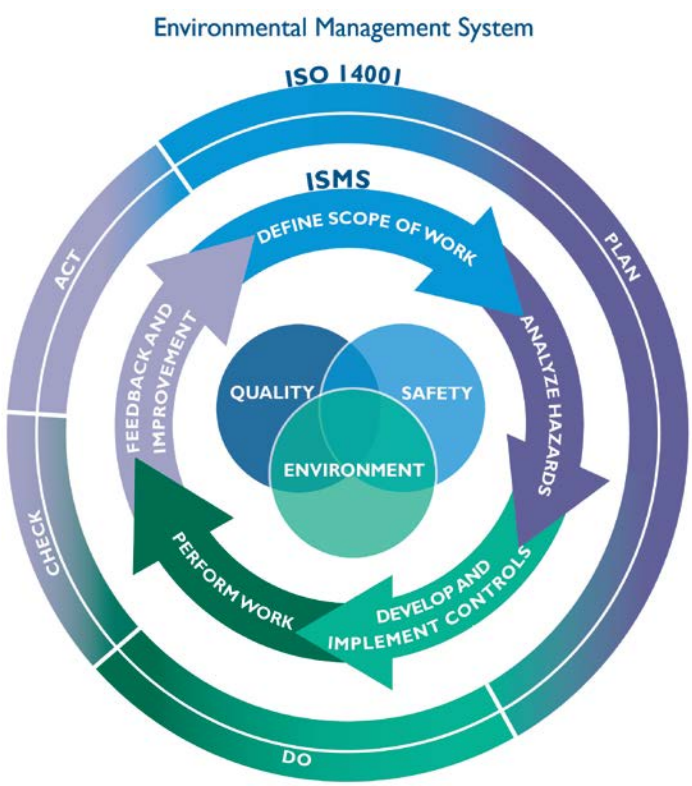


Figure 2-1 Integrated Safety Management System Continual Improvement Framework within the ISO 14001 Environmental Management System

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 Figure 2-1 shows, 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 every three years by a qualified party outside the control or scope of the EMS. Savannah River Nuclear Solutions, LLC (SRNS); Savannah River Remediation LLC (SRR); and CB&I AREVA MOX Services, LLC conform to ISO 14001, and Centerra-SRS is registered to the ISO 14001 standard.

SRS contractors had the following audits for ISO 14001 compliance:

- SRNS and SRR had an external conformance audit in March 2018
- Centerra had an external reregistration audit in January 2018
- MOX Services had an external conformance audit in April 2016

As a result of these successful audits, SRNS and SRR were declared to be in conformance with the ISO 14001 standard. Likewise, Centerra was declared to be in conformance with the ISO 14001 standard following a successful reregistration audit. Since MOX Services had a conformance audit within the specified schedule, it did not need to have one in 2018.

2.1.2 Goals and Objectives

The Site uses the SSP to implement the sustainability goals outlined in DOE's Strategic Sustainability Performance Plan. The goals, which DOE sets annually for all sites, 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

Sustainability Goals

Appendix A presents the sustainability goals as well as environmental compliance goals for 2018, identifies the related environmental objectives and 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 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 DOE Order 436.1, Executive Order No. 13423, and the DOE Strategic Sustainability Performance Plan require. 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 2018 EMS goals and objectives related to sustainability.

2.2.1 Greenhouse Gas Reduction

By reducing greenhouse gas (GHG) by 78%, SRS has surpassed the 50% goal to reduce Scope 1 and 2 GHG emissions 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 2018 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. As of 2018, SRS has met that goal by reducing emissions 87%. The Site has accomplished this by such efforts as using webinars and conference calls to reduce business travel and by promoting employee carpooling.

2.2.2 Sustainable Buildings

Using FY 2015 as a baseline, by FY 2025 DOE must reduce by 25% the amount of energy per square foot (energy intensity) used in an identified class of buildings. DOE expects sites to aggressively strive toward the 25% reduction goal when it is cost-effective and prudent to do so. The annual goal is to reduce intensity by 2.5%. As of FY 2018, SRS has reduced its energy intensity by 19% from the FY 2015 baseline.

In FY 2018, SRS conducted many activities that reduced energy intensity. Operating the Biomass Cogeneration Facility had the most impact. The following are some additional notable accomplishments supporting this program:

- Conducted an energy study to identify the buildings that require energy and water audits under Section 432 of the Energy Independence and Security Act of 2007 (EISA)
- Removed 22 unoccupied and aging trailers, reducing energy consumption and reducing footprint
- Continued installing energy-efficient lighting, such as light-emitting diodes (LEDs), as existing fluorescent lighting failed in facilities
- Replaced 22 heating and cooling units with new higher Seasonal Energy Efficiency Ratio (SEER) units
- Replaced roofs on five buildings with cool roof technology, which uses light-colored tiles or shingles to reflect sunlight and heat, decreasing the need for air conditioning

EISA and Executive Order 13693 have been the drivers for many years in the ongoing effort to improve energy efficiency at the Site. Installing energy-efficient lighting, heating and cooling units with a higher SEER (a 2008 efficiency standard defined by the Air Conditioning, Heating, and Refrigeration Institute), and cool roofs are the types of recommended actions EISA audits identified. SRNS conducted the 2018 energy study to ensure the appropriate facilities meet the energy-reduction goals under EISA. Energy efficiencies have come from a wide variety of strategies including the following:

- Upgrading utility systems
- Minimizing boiler use for winter heating
- Operating the Biomass Cogeneration Facility and the biomass steam plants in A Area, K Area, and L Area
- Deactivating and decommissioning many facilities, including entire areas (TNX), multiple buildings, land, and associated waste disposal areas
- Consolidating employee-occupied building space into fewer buildings
- Using more energy-efficient equipment in facilities (such as lighting timers, lighting sensors, and programmable thermostats)
- Upgrading various small-scale light fixtures to LEDs

SRNS also manages energy efficiency at a facility level through 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 22 peak events during FY 2018: 8 during cool months and 14 during warm months.

2.2.3 Renewable Energy

Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*, Clean Energy goal requires at least 25% of an agency's total electric and thermal energy come from renewable and alternative energy sources by FY 2025. Additionally, DOE's Renewable Electric Energy goal requires that renewable electric energy account for at least 30% of a total agency electric consumption by FY 2025. SRS has exceeded the clean energy generation goal by generating power from biomass. SRS no longer uses coal to generate energy. SRS meets the Renewable Electric Energy goal with 30% of overall facility electricity use coming from renewable energy in the form of biomass. Using clean and renewable energy at the Site is a high-level priority. The Biomass Cogeneration Facility is in its seventh 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 2018 target goal to reduce this ratio by 22%.

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 baseline (FY 2007), SRS has reduced potable water consumption intensity through FY 2018 by 17% and has not met the DOE FY 2018 target goal of 22%. The FY 2007 baseline does not account for potable water conservation efforts such as the new primary domestic water system installed prior to 2007. 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.

SRS has been using 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 less-efficient faucets and flush valves with more-efficient low-flow units. In FY 2018, SRS continued that process.

DOE as an agency is also required to realize a 30% water consumption reduction of industrial, landscaping, and agricultural (ILA) water by FY 2025 relative to the FY 2010 baseline. SRS has an FY 2018 interim target goal of 16% reduction. SRS's ILA water usage has decreased 43.9% as of FY 2018 as compared to the FY 2010 baseline. Long-term reductions in ILA water have been achieved due to the biomass facility operating, which consumes significantly less water than the prior coal-fired power plant.

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 2018 performance in meeting key fleet management goals.

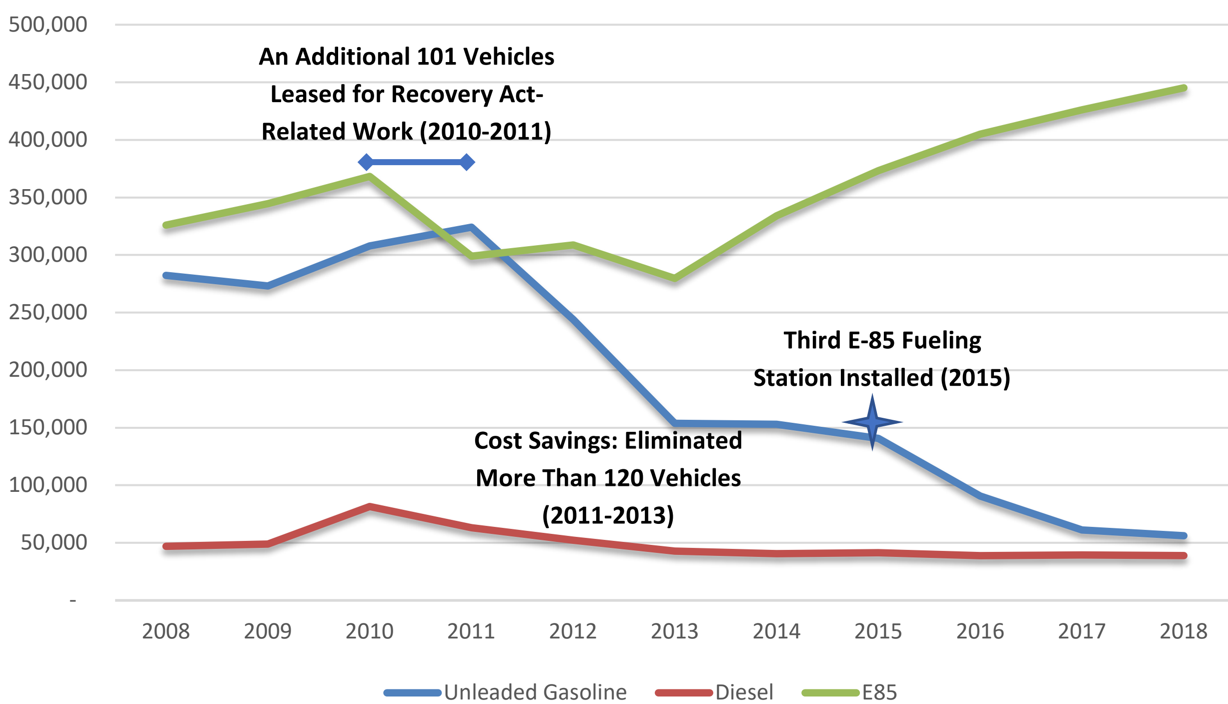


Figure 2-2 GSA Fuel Consumption by Type, FY 2008 to FY 2018

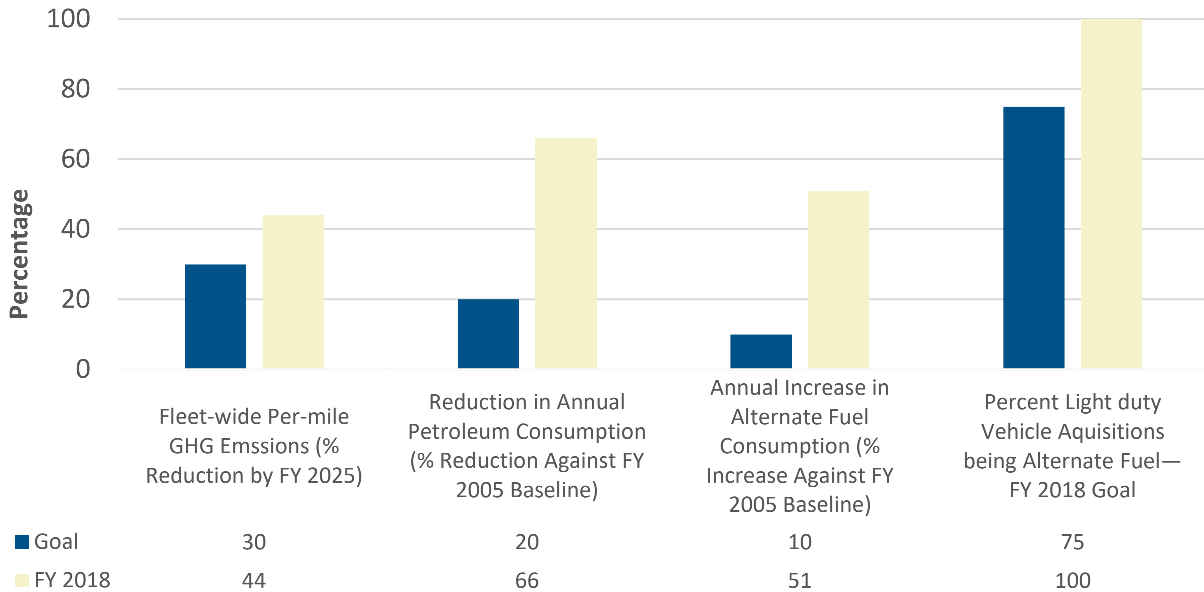


Figure 2-3 SRS Performance in Meeting Fleet Management and Transportation Goals

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 2018, the Site consumed approximately 56,000 gallons of unleaded gasoline, 39,000 gallons of diesel fuel, and 445,000 gallons of E85 alternative fuel. SRS has reduced its fleet-wide per mile greenhouse gas emissions goal by 44%, exceeding the Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*, goal of a 30% reduction by FY 2025. In FY 2018, 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 66% reduction in petroleum and a 51% 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 2018, SRS leased 94 new light-duty vehicles, all of which used E-85 alternative fuel, and increased the number of vehicles in the light duty fleet that are either E-85, hybrid, or electric to 546 (98.6%), out of an approximately 552-vehicle fleet. This acquisition of 100% alternative fuel vehicles in FY 2018 exceeded the goal of 75% of the vehicles using alternative fuel. Of the passenger vehicles that are unleaded vehicles, 74% 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. 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.

For FY 2018, SRS procurement reviewed 96,353 purchase order line descriptions to determine if the product meets the U.S. Department of Agriculture's (USDA's) definition of BioPreferred®. However, the product information available was not adequate to effectively determine bio-based content as described in the USDA biobased-preferred catalog.

USDA CERTIFIED BIOBASED PRODUCT

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.

Reduce Reuse Recycle

The goal for FY 2018 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 2018, SRS recycled about 58% of this stream, 504 metric tons of the 872 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 2018, SRS successfully implemented concrete and asphalt recovery, recycling more than 21,360 metric tons of rubble from scraping and paving a major road onsite. The Site otherwise would have

Table 2-1 SRNS Recycling and Sustainability in FY 2018 by Amount

Items Recycled Onsite in FY 2018	Amount Recycled
Silver Fixative	75 gallons
Batteries (nickel-cadmium, lithium-ion, mercury)	10,071 pounds
Lead Salvage	0 pounds
Light Bulbs/Mercury-containing Equipment	10,282 pounds
Batteries (lead acid)	99,540 pounds
Furniture	203,720 pounds
Scrap Metal	675,540 pounds
Used Tires	8,000 pounds

Note:
SRS also recycles brass casings that the Site security contractor generates during security activities.

treated the rubble as waste and sent it to the on-site construction and demolition landfill. SRS will use some of this recovered material for beneficial reuse both onsite to improve secondary roads and offsite in nearby Orangeburg, South Carolina, where the Savannah River Site Community Reuse Organization (SRSCRO) will direct more than 13,000 metric tons.

2.2.8 Energy Saving Perfomance Contracting

SRS has used Energy Saving Performance Contracting (ESPC) to engage Ameresco Federal Solutions in 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 2018:

- 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 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 2018, SRS continued exemplary performance and met sustainable electronics purchasing and disposal goals. SRS purchased 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 are set up to automatically print on both sides of paper. 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 2018, SRS recycled 50,290 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 South Carolina Environmental Excellence Program (SCEEP)

In 2018, CB&I AREVA MOX Services maintained its membership in SCEEP. Membership is active for three years. The South Carolina Department of Health and Environmental Control (SCDHEC) has recognized MOX Services for its membership in the 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.

2.3.2 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 the Site's footprint on the environment. Employees practice simple acts, such as turning off lights when leaving a room or workspace, which promote environmental stewardship.

MOX Services TEEM (Targeting Environmental Excellence at MOX) is an elite group of MOX employees selected by their peers whose members volunteer their time to identify ways to reduce MOX's environmental footprint. TEEM championed two sustainability campaigns in 2018:

- Last Out Lights Out—MOX reduced its electricity consumption by 3% over the past 4 years. This campaign curbed 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.

2.3.3 Earth Day

SRS hosted an Earth Day celebration onsite for its employees on April 19 with approximately 600 employees attending. The theme was "Earth Day 2018…naturally" and focused on natural solutions to everyday issues and situations. The exposition-format event included exhibits on animals and nature, pesticides, the importance of pollinators, environmental monitoring techniques, solar power use, and sustainable environmental remediation. There was broad participation from organizations internal to SRS (for example, CB&I AREVA MOX Services, Savannah River Remediation, Savannah River Ecology Laboratory, U.S. Department of Agriculture [USDA] Forest Service-Savannah River) and external to SRS (for example, South Carolina Department of Health and Environmental Control, the Aiken Beekeepers, Lexington Beekeepers, and the Clemson Cooperative Extension).

DOE's Jolene Seitz, Maatsi Ndingwan, and Avery Hammett at the SRNL Booth on 3-D Printing

Clemson Cooperative Extension Sharing Information on Pesticides

2.3.4 Reuse or Recycling of Equipment and Materials

SRS is partnering with 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 2018, SRS shipped $8.1 million in usable assets for reuse and recovery. Based on SRSCRO's 2018 annual report, the program facilitated by this partnership generated $278,243 in gross revenue during the fiscal year.

2.3.5 Sustainable Environmental Compliance and Environmental Remediation

SRS continues to excel in various sustainable remediation activities. Of the 36 remediation systems currently operating, 18 are completely passive, requiring no energy to implement, and 12 are low energy systems. These low-energy systems use sustainable technologies (such as solar-powered MicroBlowers and barometric-pressure-driven Baroballs) to pump volatile organic contaminants from the subsurface, thus reducing contamination. SRS is also using the Hydrasleeve sampling methodology for more than 230 wells, which eliminates managing purge water as waste.

Drones Save on Fuel Usage

SRS implemented innovative methods to address environmental compliance, improve worker safety, and increase productivity. These included

- Deploying oyster shells upstream of industrial stormwater outfalls to treat industrial stormwater for zinc and copper
- Testing video-enabled drones for surveying decommissioned reactor building roofs (versus helicopters and a photographer)
- Deploying remotely operated wireless stormwater sampling equipment to comply with the conditions of the Industrial Stormwater General Permit (the sample must be collected within the first 30 minutes of initial discharge from a measurable storm event)

Utilizing remotely operated devices (drones and wireless equipment) decreases use of vehicles, thereby saving fuel usage supporting fleet management goals.

SRS Uses Oyster Shells to Treat Stormwater

A MicroBlower Pumps Volatile Organic Contaminants from the Subsurface

2.3.6 Challenges and Barriers to Implementation

In 2018, SRS continued to make progress conserving and managing resources to meet the sustainability goals in the Site Sustainability plan. However, aging infrastructure continually poses challenges with initiating sustainable projects. Achieving new goals is becoming significantly difficult with the high cost of implementing sustainability upgrades at SRS's many aging facilities (for example, administrative, shops, laboratories, warehouses). As discussed in Section 2.2.4, SRS significantly decreased potable water use in 1996 when it installed a more-efficient primary domestic water system. SRS is below 2018 interim targets for reducing potable water intensity (17% versus a goal of 22%) when comparing water conservation measures to the baseline year (FY 2007). SRS reduces potable water use with the ongoing installation of water-efficient toilet systems when repairs are needed. However, site-wide retrofitting with low-flow flush valves and faucets is not cost effective. Likewise, sustainability efforts related to energy management will require additional guidance as SRS works to complete EISA audits for site infrastructure with limited resources and competing priorities.

In 2018, SRS identified program challenges with the implementation of the 2015 ISO 14001 EMS standard. The 2018 EMS Triennial Audit identified an opportunity for improving leadership engagement in the EMS program. An internal assessment conducted later in the year reiterated the need to improve leadership engagement including communicating the importance of EMS to all personnel and integrating EMS policy into daily work practices and into a tangible metric for accountability. While SRS successfully implemented the latest version (2015) of the ISO 14001 standard, implementing the sustainability initiatives, using this standard has been challenging.

SRS continues to consider green or sustainable technologies or initiatives to facilitate the Site's environmental compliance. Under the Industrial stormwater program, SRS is pursuing the use of oyster shells to mitigate copper levels in industrial stormwater. Upon deployment, this treatment is very effective for zinc; however, the oyster shells are not as effective for copper. To ensure effective treatment for copper, SRS continues to evaluate different factors to optimize this treatment approach.

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. The Site's goal is to comply with regulatory requirements and eliminate or minimize any environmental impacts. SRS continues its commitment to protect human health and the environment.

2018 Highlights

Permitting

SRS managed more than 560 operating and construction permits. SRS received one Notice of Alleged Violation (NOAV), and Ameresco received one Notice of Violation (NOV). More information on the NOAV and NOV can be found below and in Sections 3.3.2.3, 3.3.6.1, and 3.8.

Remediation (Environmental Restoration and Cleanup)

To date, SRS has completed the cleanup of 408 of the 515 waste units containing or having contained solid or hazardous waste. An additional 10 waste units are currently being remediated.

Tank Closure (Radioactive Liquid Waste Processing and Dispositioning)

- SRS installed the Tank Closure Cesium Removal (TCCR) system and performed a readiness assessment to prepare for a January 2019 start date.
- The Defense Waste Processing Facility (DWPF) filled 15 canisters with approximately 61,000 pounds of glass waste mixture, immobilizing 257,000 curies of high-level radioactive waste.
- The Saltstone facilities processed 384,000 gallons of low-activity waste.

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.
- SRS sent one transuranic waste (TRU) shipment to the Waste Isolation Pilot Plant (WIPP) for deep geologic disposal in 2018.

Resource Conservation and Recovery Act (RCRA)

- SRS received TRU Pad 2 Closure Certification Approval from the South Carolina Department of Health and Environmental Control (SCDHEC) in December.
- SRS received approval for the revised Solvent Storage Tanks (SSTs) S33-S36 Closure Plan in November.

2018 Highlights (continued)

- SCDHEC and the U.S. Environmental Protection Agency (EPA) conducted a compliance evaluation inspection at selected RCRA facilities in May 2018. SCDHEC noted two labeling deficiencies in E Area during the inspection, which SRS corrected before the inspection close-out. It found no other deficiencies.
- During the SCDHEC annual Underground Storage Tank (UST) inspection on October 23, 18 of 19 USTs were in compliance. However, SCDHEC gave SRS an NOAV for UST 715-H on Permit 10838 because the spill bucket integrity was not maintained, identifying a suspected release. SRS addressed the corrective actions as directed by SCDHEC and received notification from SCDHEC that “No Further Action” is required.

Air Quality and Protection

- On August 21, SCDHEC inspected SRS to determine if the Site was complying with state and federal air quality regulations, and with one of the air quality permits issued to the facility. SCDHEC found no violations of TV-0080-0041 permit requirements or applicable regulations during the evaluation.
- Ameresco received an NOV associated with Air Quality Permit TV-0080-0144 for failing to meet carbon monoxide (CO) emission limits. All matters concerning SCDHEC have been resolved with no further enforcement actions.

Water Quality and Protection

All 39 SRS Industrial storm water outfalls in the General Permit 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 6, *Radiological Dose Assessment,* explains the public dose.)

Environmental Protection and Resource Management

- SRS conducted 669 National Environmental Policy Act (NEPA) reviews to identify potential environmental impacts from proposed federal activities. SRS identified 621 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 Community Right-to-Know Act, the Superfund Amendments and Reauthorization Act (SARA) Title III, the Endangered Species Act, the Federal Insecticide, Fungicide, and Rodenticide Act, the National Historic Preservation Act, and the Migratory Bird Treaty Act.

2018 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

EPA and 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. 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 SCDHEC, 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. Additional information regarding the FFA commitments discussed in this section can be found on the SRS and SRR web pages.

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 2018, 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 2018* explains the status of FFA activities at SRS for FY 2018.

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.

SRS prepared the following reports to satisfy the CERCLA requirements:

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

- *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Geosynthetic or Stabilization/Solidification Cover Systems:* SCDHEC and EPA approved in January and February 2018, respectively. SRS issued to the public on March 27, 2018.
- *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Operating Equipment:* SCDHEC and EPA approved in August 2018 and September 2018, respectively. SRS issued to the public on December 5, 2018.
- *Sixth Five-Year Remedy Review Report for Savannah River Site Operable Units with Native Soil Covers and/or Land Use Controls:* DOE submitted to SCDHEC and EPA in December 2018.

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

SRS closed the 488-1D basin and 489-D coal pile runoff basin in November 2018. Construction on these two basins began in July 2016. Previously, SRS completed both the 488-2D basin and the 488-4D landfill closures in November 2016 (Figure 3-1).

For decades, pipes carried a hazardous watery ash-laden solution from the powerhouse to the basins. Now, consolidating the ash into two large mounds (approximately 1.56 million cubic yards) underneath a protective cap and grassy cover is eliminating the risk to human health, ecology, and groundwater in the area.

The *Removal Action Report for the 488-2D Ash Basin and the 488-4D Ash Landfill* (Revision 1) was approved by the regulators in March 2018. SRS drafted the *Removal Action Report for the 488-1D Ash Basin and 489-D Coal Pile Runoff Basin (Revision 0)* and submitted it to EPA and SCDHEC in March 2019.

Before October 2013

After October 2018

Figure 3-1 D-Area Ash Project Completion

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 Site stores the waste in underground waste tanks grouped into two tank farms (F-Tank Farm and H-Tank Farm). While in the tanks, a sludge settles on the bottom of the tank, and a liquid salt waste rises to the top. The waste removed from the tanks feeds the sludge and salt waste processing programs, as Figure 3-2 depicts.

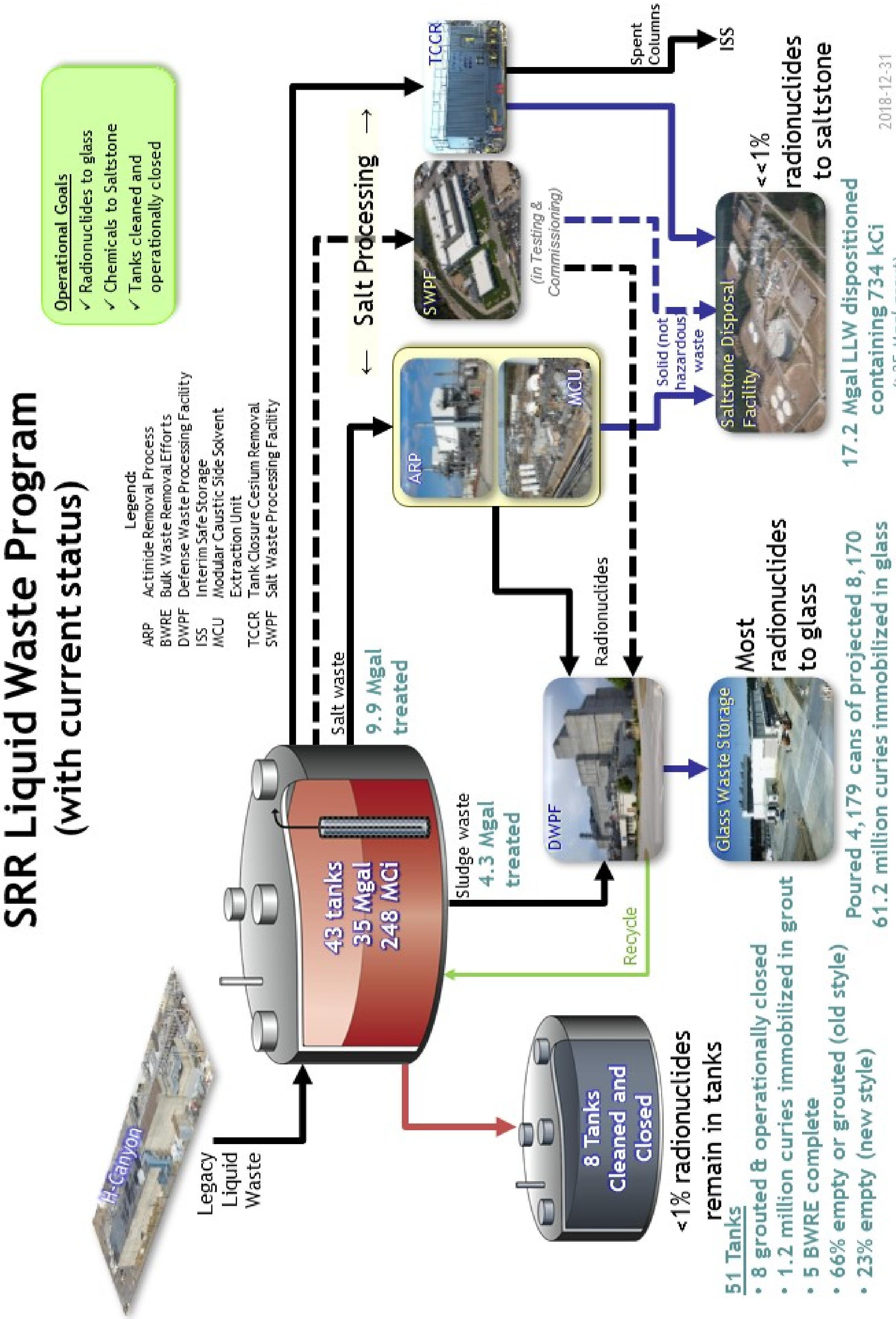


Figure 3-2 Pathway for Processing and Dispositioning Radioactive Liquid Waste at SRS

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 to consult 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 coordinates with SCDHEC to monitor the steps DOE takes to dispose of the waste to assess if it is complying with the performance objectives of 10 Code of Federal Regulations (CFR) Part 61, Subpart C. Additionally, the EPA may participate in the NRC monitoring. *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 2018, 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, performance assessment [PA] maintenance plan) as the NRC requested. The NRC conducted one on-site observation visit for F- and H-Tank Farms during 2018 and did not identify any issues. 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). Preparing for BWRE is typically a multiyear engineering and modification process to install specialized equipment that meets strict nuclear safety standards.

In November 2018, DOE restarted BWRE in Tank 10 by adding water to dissolve the salt. This activity was completed more than two months ahead of the FFA deadline to restart BWRE activities in the tank. Salt dissolution in Tank 10 will continue in 2019. There were no other FFA tank closure commitments required for FY 2018 as the Tank 10 BWRE commitment was extended into 2019, and other commitments were suspended pending follow-up negotiations that are planned to be held in 2019.

3.2.2.2 Salt Processing

SRS is using several processes to dispose of 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 2018, the MCU processed about 149,000 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, a low-activity salt solution, is sent to the Saltstone facilities.

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, and installation and readiness assessments were completed in 2018. The TCCR is projected to start operating in January 2019.

Ion Exchange Column Installed at TCCR

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 waste, which is disposed of 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 Determination for Salt Waste Disposal at the Savannah River Site.* NDAA Section 3116(b) requires that the 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.

During 2018, DOE supported the NRC's monitoring SDF under Section 3116 of the NDAA by providing routine documentation (for example, groundwater monitoring reports, PA maintenance plan) as the NRC requested. The NRC made one NRC on-site observation visit for salt waste disposal during 2018.

Saltstone Disposal Unit (SDU) 7 Being Constructed Next to SDU 6

In FY 2018, Saltstone facilities processed and disposed of 384,000 gallons of waste. In 2018, SRS continued to use cylindrical Saltstone Disposal Units (SDUs) for disposal. SRS began operating the mega-vault SDU-6, a 32.8 million-gallon concrete rubber-lined tank, in August 2018. SRS began preparing the site for the second mega-vault, SDU-7, in January 2018 and is anticipating completing it in mid-2020.

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 is less than 10% of the waste volume stored in the tanks and contains about half of the radioactivity, as Figure 3-2 shows. 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. The melter heats the waste/frit mixture to nearly 2,100 degrees Fahrenheit, until molten. The resulting 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.

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 61.2 million curies of radioactivity and pouring more than 4,100 canisters. Canister pouring began in June 2018 when replacement Melter 3 was put into service. This resulted in DWPF producing 15 canisters with more than 61,000 pounds of glass, immobilizing approximately 257,000 curies of radioactivity during FY 2018.

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 National Pollutant Discharge Elimination System (NPDES)-permitted outfall. ETP processed more than 3.9 million gallons of treated wastewater in FY 2018. 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 2018.

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. DOE Order 435.1 governs all radioactive waste management (low-level waste [LLW], high-level waste [HLW], and transuranic [TRU] waste) to protect the public, workers, and the environment. LLW is the only one of these waste types disposed of at SRS, at the E-Area Low-Level Waste Facility and the Saltstone Disposal Facility. LLW is radioactive waste not classified as HLW or TRU waste and that does not contain any RCRA hazardous waste.

As DOE Manual 435.1-1, *Radioactive Waste Management Manual* requires, 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 LLW 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 conducted activities within the bounds of the 2010 analysis. The FY 2017 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.

Packaging Waste for Shipment to WIPP

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, New Mexico 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 waste regulations. SRS sent one TRU shipment to WIPP for disposal in 2018.

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 as identified in Section 3.3.10.

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.

SRS began closing the Solvent Storage Tanks (SSTs), as described in the approved closure plan, in 2018, by inspecting the tanks' contents. SRS used a guided camera system specifically designed to remotely inspect inside the tanks. Camera inspections determined that the tanks contained no waste. Soil and concrete sampling around the perimeter of the SSTs followed the inspection. The next step was to stabilize the tanks with an inert fill material such as concrete or grout. SST closure, including removing the above-ground equipment and piping, will continue into 2019. When the area has been capped, it will remain an underground radioactive material area (URMA). Even though the tanks have been verified as empty, there is a history of radiological material being stored in them. Consequently, the URMA designation will provide adequate land-use controls until a final closure action is accomplished for the entire area surrounding the SST location.

SCDHEC approved SRS's RCRA Closure Certification Report for Interim Status TRU Pad 2 on December 18.

In November, a revision to the sitewide SRS RCRA Permit went into effect, approving changes to several volumes of the Site's permit. The updates, which affect several different facilities' or units' permit modules, included the following:

- Added a condition allowing a TRU shipment to be staged outside of a regulated pad (within certain parameters),
- Approved revision to the closure plan for solvent storage tanks,
- Added clarification to the remedy for Gunsite 012 Operable Unit, and
- Added the remedy for the wetland area at Dunbarton Bay.

Soil Sampling at the Solvent Storage Tanks

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, and the Z-Area Saltstone Industrial Solid Waste Landfill (see section 3.2.2.3). All the solid waste landfills were active and operated in compliance with their permits in 2018. SCDHEC terminated the 488-4D Industrial Solid Waste Landfill in February 2018. The 488-4D facility was capped in 2016, and closure was completed under the FFA (see section 3.2.1). To ensure the effectiveness of the remedy and to continue to monitor it, groundwater monitoring wells were permitted and installed at the 488-4D facility as part of the closure.

3.3.2.3 Underground Storage Tank Permits

Subtitle I of RCRA regulates 19 USTs containing usable petroleum products. These tanks require an annual compliance certificate from SCDHEC. A SCDHEC inspection and audit on October 23 found that 18 of 19 were in compliance.

SCDHEC issued SRS a Notice of Alleged Violation (NOAV) for UST 715-H on Permit 10838 that listed violations for not maintaining spill bucket integrity and a suspected release the inspector found. In response to the NOAV, SRS addressed the corrective actions as directed by SCDHEC including repairing the spill bucket on November 9, conducting a hydrostatic test to confirm spill bucket integrity on November 12, and conducting soil sampling on October 29 and December 17. Upon completion of the corrective actions, SRS received notification from SCDHEC that "No Further Action" is required.

3.3.3 Federal Facility Compliance Act (FFCA)

The 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, SRS now prepares and submits the 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 was finalized and approved by SCDHEC in October 2018.

SRS and SCDHEC held STP Cleanup Credit validation meetings in January, May, August, and November. A total of 761 Cleanup Credits were earned and validated during FY 2018.

3.3.4 Toxic Substances Control Act (TSCA)

SRS complies with 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 made three shipments of PCB waste to off-site hazardous waste facilities in 2018. 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. SRS made one shipment to WIPP containing PCB waste in 2018.

SRS completed the 2018 annual PCB document log on May 23, 2019 and submitted the 2018 annual report of onsite PCB disposal activities to EPA on June 25, 2019, 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 has a vendor contracted to pick up infectious waste every four weeks. In 2018, SRS sent 13 shipments with the vendor. Once offsite, the waste is treated and disposed of in accordance with the SCDHEC regulations. In 2018, 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 facilities currently have 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)
- Mixed Oxide Fuel Fabrication Facility (MFFF) (TV-0080-0139-CA-R1)
- Building 235-F D&D Construction Permit (TV-0080-0041-C1)
- Ameresco Federal Solutions, Inc. (“Ameresco”) Biomass Facilities Permit (TV-0080-0144)

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 Air Quality 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 Air Quality Permit (TV-0080-0041) 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 2018, the Site continued to operate under the expired Part 70 Air Quality Permit.

SCDHEC issued a Notice of Violation (NOV) to Ameresco (TV-0080-0144) for failing to meet carbon monoxide (CO) emission limits. Ameresco, a direct contractor to DOE, operates biomass-fueled steam cogeneration plants onsite. During a stack test for CO on one of the Ameresco Biomass Boilers (BCB-3), there were some difficulties in the performance to meet the required CO emission limit. The results of the initial stack test were noncompliant, and a re-test was scheduled. Ameresco performed an internal inspection of the combustor and identified that poor air distribution through the floor grates was causing the elevated CO emissions. Repairs to replace nearly half of the floor grates were completed, and the boiler was re-tested. BCB-3 passed the re-test for CO emissions with significantly improved performance. Corrective actions have been implemented, and routine inspections occur to prevent further noncompliance issues. All matters concerning SCDHEC have been resolved with no further enforcement actions.

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 2018.

3.3.6.3 Ozone-Depleting Substance (ODS)

Section 608 of the CAA prohibits the knowing release of refrigerant during the maintenance, service, repair, or disposal of air-conditioning and refrigeration equipment. Refrigerants include ODSs and substitute refrigerants such as hydrofluorocarbons. Releases of chemical gases widely used as refrigerants, insulating foams, solvents, and fire extinguishers cause ozone depletion or contribute to greenhouse gas emissions. SRS complies with 40 CFR 82 to ensure no refrigerants are knowingly or willfully released into the atmosphere. SRS did not experience any noncompliances associated with 40 CFR 82 during 2018.

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 emissions have dropped below the threshold that requires an annual air emissions inventory; therefore, SRS reports on a three-year cycle for permit TV-0080-0041.

SRS was not required to submit an air emissions inventory for 2018. The most recent information on the EPA National Emission Inventories is available on the website. SRS will submit the next required inventory for 2020 before March 31, 2021.

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.

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 2018* on June 24, 2019 to EPA, SCDHEC, and DOE Headquarters.

During 2018, 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 2018, 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 210 asbestos notifications and conducted 42 permitted renovations and demolitions involving asbestos in 2018. 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 disposing 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 Savannah River Remediation LLC (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 2018

Asbestos Type	Nonradiological, Friable	Nonradiological, Nonfriable	Radiologically Contaminated Asbestos
Linear Feet Disposed	170	921	85
Square Feet Disposed	93	15,561	6
Cubic Feet Disposed	72	1,287	0
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

3.3.7.1 <u>Clean Water Act (CWA)</u>

Except for Ameresco, which has its own CWA National Pollutant Discharge Elimination System (NPDES) permit, SRS operated pursuant to the following CWA permits in 2018:

- 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 Practices 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 Countermeasures plan to minimize the potential for discharges of oil, including petroleum, fuel oil, sludge, and oily wastewater.

Outfall H-02 Access Location

SRS has two NPDES permits for industrial activities that discharge to surface water: one covering D Area (Permit No. SC0047431) and the other for the remainder of the Site (Permit No. SC0000175). Throughout the year, SRS monitors 28 NPDES-permitted industrial wastewater outfalls across the Site on a frequency the permits specify. 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 permits. 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 September 2018, SCDHEC conducted the annual compliance evaluation inspection (CEI) and issued a satisfactory rating, the highest grade possible.
- The 2018 update to the SRS SWPPP contains information on the 39 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 2018.
- 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 2018, SCDHEC issued a construction permit for the tank closure cesium removal system and improvements related to an NPDES Outfall in F Area. SCDHEC also approved placing the additional recovery well for the M-1 Air Stripper remediation system permitted in 2017 into operation.

The results from sampling of both industrial and storm water outfalls are summarized 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 669 Environmental Evaluation Checklists (EECs) and 71 Site Use applications for potential wetland impacts in 2018. During this time, SRS had eight open permits under the NWPs program, as follows:

- Submitted a request to the U.S. Army Corps of Engineers for authorization under NWP 38, Cleanup of Hazardous and Toxic Waste, for the Mixed Waste Management Facility phytoremediation pond that was constructed on an intermittent tributary to Four Mile Branch,
- Installed a stormwater sampling device in an ephemeral tributary to Crouch Branch under NWP 5, Scientific Measurement Devices,
- Installed a piezometer in wetlands adjacent to Castor Creek under NWP 5,
- Installed a stormwater sampling device in an ephemeral tributary to McQueen Branch under NWP 5,
- Stabilized the bank on Crouch Branch under NWP 13, Bank Stabilization,
- Installed a wooden platform and aluminum dock ladder at a sampling station on Steel Creek under NWP 5,
- Installed a monitoring well in wetlands adjacent to Castor Creek under NWP 5, and
- Installed a monitoring well in Savannah River floodplain wetlands at the TNX Outfall Delta under NWP 5.

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 2018 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.

SRS samples domestic water systems for lead and copper on a three-year, rotating cycle. Based on this cycle, SRS will sample 30 locations across the Site 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 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 669 NEPA reviews of proposed activities in 2018 (Table 3-2). Categorical exclusion (CX) determinations accounted for more than 90% of completed reviews. Additional information on SRS NEPA activities may be found on the SRS NEPA web page.

The following major NEPA reviews were either completed or in progress in 2018:

- *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 supplement analysis (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. DOE issued an amended record of decision for the proposed activity on February 27, 2018.
- *Supplement Analysis for the Removal of One Metric Ton of Plutonium from the State of South Carolina to Nevada, Texas, and New Mexico (DOE/EIS-0236-S4-SA-01).* https://www.energy.gov/nepa/listings/supplement-analyses-sa/. On August 6, 2018, the National Nuclear Security Administration (NNSA) signed its *Supplement Analysis for Removal of One Metric Ton of Plutonium from the State of South Carolina to Nevada, Texas, and New Mexico* (SA for Removal of 1 MT of Pu from SC). Removal of 1 metric ton (MT) of plutonium (Pu), mandated by a U.S. District Court pursuant to a December 20, 2017 Order, must be completed within 2 years (or by January 1, 2020, at the latest). NNSA proposes to repackage 1 MT of Pu at SRS and transport the repackaged Pu to and from the Pantex Plant or Nevada National Security Site or both for staging until it is transported to Los Alamos National Laboratory for pit production use. The proposed action is perceived as having minimal impacts and risks to other Environmental Management actions at SRS. Based on the results of this SA, DOE has determined the proposed action does not constitute a substantial change from actions previously analyzed in existing DOE/NNSA NEPA documents, and there are no significant new circumstances or information relevant to environmental concerns. Therefore, DOE/NNSA determined in August 2018 that no further NEPA documentation is required.

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 and is not counted in the Table 3-2 total.

Table 3-2 Summary of 2018 NEPA Reviews

Type of NEPA Review		Number
CX Determinations[a]		621
"All No" Environmental Evaluation Checklist (EEC) Determinations[a]		33
Previous NEPA Review [a]		10
Environmental Impact Statement (EIS)		2
Supplement Analysis (SA)		2
Interim Action		0
Revised Finding of No Significant Impact		0
Environmental Assessment (EA)		1
	Total	**669**

[a] Proposed action that requires 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 2018 hazardous chemical storage information to state and local authorities on February 14, 2019. The report included 60 reportable chemical categories, the same as 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 2018 TRI report on June 19, 2019 for each of the following regulated chemicals: ammonia, chromium compounds, lead compounds, mercury compounds, naphthalene, nitrate compounds, nitric acid, and sodium nitrite. 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 according 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. SRS generates and maintains application records for general use and restricted use pesticides 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 the only DOE site to conduct experimental translocations of gopher tortoises, where they are captured, transported, and released to another location. Conservation organizations use protocols developed during these SRS translocation studies to establish viable populations elsewhere in the species' range.

South Carolina's State Wildlife Action Plan of 2015 recognizes 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 swallow-tailed kite, as well as numerous other animals and plants considered species of conservation concern. The United States Forestry Service-Savannah River (USFS-SR) considers these species sensitive and takes that into consideration when developing forest management plans. While the bald eagle is no longer on the federally listed endangered or threatened species list, the Bald and Golden Eagle Protection Act protects nesting bald eagles and wintering golden eagles. Bald eagles nest on SRS and are considered year-round residents; golden eagles use SRS as a wintering habitat. The 2018 mid-winter bald eagle survey reported seven bald eagles on SRS; nine golden eagles were recorded.

The USFS-SR actively manages more than 65,000 acres in the red-cockaded woodpecker habitat management areas by using prescribed fire or by mechanical or chemical treatments to control vegetation. These methods create and improve habitat by restoring the natural fire regime, improving native plant diversity in the understory, and enhancing the native longleaf pine and wiregrass communities. Additionally, the USFS-SR inserts artificial cavities into living pine trees to supplement the available cavities for roosting and nesting. From 1985 through FY 2018, active red-cockaded woodpecker clusters increased from 3 to 133 due to successful habitat restoration. As of 2018, the USFS-SR managed 133 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%. In addition to managing for endangered wildlife species, the USFS-SR actively manages for six endangered plant populations: four smooth coneflower and two pondberry.

During FY 2018, while implementing the *United States Department of Energy Natural Resources Management Plan for SRS,* USFS-SR developed one SRS watershed management plan for standard USFS-SR project plans, resulting in one biological evaluation for timber, research, and wildlife-related management. The biological evaluation determined that forest implementation plans are not likely to adversely affect federally listed endangered or threatened species due to beneficial, insignificant, or discountable effects.

U. S. Forest Service Biologist Installing an Artificial Nest Box Insert for Red-cockaded Woodpeckers

3.3.8.5 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 2018 count found 103 species. A one-day bald eagle survey is conducted every year in January. The 2018 eagle survey found seven eagles.

In 2018, 13 active bird nests were discovered on large mobile equipment or in areas SRS personnel actively used. Bird species consisted of Northern Mockingbird (*Mimus polyglottos*), nine nests; Eastern Bluebird (*Sialia sialis*), one nest; Carolina Wren (*Thryothorus ludovicianus*), one nest; Barn Swallow (*Hirundo rustica*), one nest; and House Finch (*Haemorhous mexicanus*), one nest.

SRS determined five nests (three Northern Mockingbird, one Carolina Wren, one Eastern Bluebird) to be abandoned and removed them. and SRS determined seven nests (five Northern Mockingbird, one House Finch, one Barn Swallow) to be active and barricaded them to allow the birds to complete the nesting cycle.

USFS-SR coordinated with the U.S. Fish and Wildlife Service to remove one active Northern Mockingbird nest due to radiological concerns.

Also in 2018, USFS-SR staff found an osprey (*Pandion haliaetus*) nest on a platform they built in 2014. This marked the fourth year that ospreys nested on the platform after their nest had been moved from a power pole at the L-Lake Dam.

3.3.8.6 Invasive Species Management

The purpose of Executive Order 13751, *Safeguarding the Nation from the Impacts of Invasive Species,* is to prevent the introduction and spread of invasive species, and to support efforts to eradicate and control established invasive species. The Site is surveying invasive plant and animal species and taking steps to control their populations.

Many of the former home and community sites that area residents left nearly 70 years ago to allow for the government to construct the Savannah River Site have since become primary sources of non-native invasive plant species (NNIPS). Escaping cultivation and containment for decades, aggressive plant species such as Chinese privet, (*Ligustrum sinenis*), wisteria (*Wisteria sinensis*), chinaberry (*Melia azedarach*), and kudzu (*Pueraria montana*) now threaten native species onsite. Invasive species such as these are a major threat to National Forests in the 21st century. These NNIPS contribute to long-term ecosystem degradation due to the loss of diversity and their directly competing with native species. They also provide unwanted ladder fuels that can increase fire intensity during prescribed burning or wildfire.

Prior to 2012, there had been no sitewide effort to document NNIPS as part of the watershed prescription process. However, recently conducted plant surveys include recording observations and locations for NNIPS; this information is now being captured geospatially for inclusion into compartment stand maps and geographic information system layers for management planning. Historical records and image interpretations from photos and maps, compartment folders, and stand exam data helped to identify developed openings, old home sites, and community places (churches, schools, cemeteries) that may contain robust sources of introduced NNIPS communities.

The USFS-SR annually contracts botanical surveys of 5,000 to 7,000 acres, which include 44 species of plants considered to be non-native and invasive. USFS-SR chemically treats an average of 50 acres each year to control across target areas that either contain former homesites and community areas or that are in proximity to red-cockaded woodpecker colony sites. When a forest stand is cut and regenerated, the USFS treats any NNIPS populations discovered as part of the site preparation for replanting.

Wild pigs are considered an invasive species in the United States and abroad. As of 2016, the U.S. Department of Agriculture estimated that in the United States alone, these animals cost $1.5 billion each year in damages and control costs. On SRS, wild pigs present safety hazards due to vehicle collisions and disease transmission and ecological impacts by negatively affecting water quality, disturbing soil, and constantly threatening rare and endangered plant populations. The USFS-SR has two dedicated wildlife technicians who oversee two wildlife contractors who trap and remove wild pigs on SRS. In 2018, USFS-SR removed more than 2,000 pigs primarily through baiting and trapping. Additionally, USFS-SR and the Southern Research Station, part of the U.S. Forest Service Research and Development organization, are collaborating with the Savannah River Ecology Laboratory to research ways to control the wild pig population.

3.3.8.7 National Historic Preservation Act (NHPA)

The NHPA requires all federal agencies to consider the impacts to historic properties in all their undertakings. SRS ensures it complies with the NHPA through several processes. For example, 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) guides DOE in managing its cultural resources to ensure it fulfills its compliance commitments. SRARP also serves as a primary facility to investigate archaeological research problems associated with cultural development within the Savannah River valley. DOE uses the results to help 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 2018, SRARP investigated 388 acres of land on SRS for cultural resource management, including conducting 23 field surveys and testing. It recorded 17 newly discovered sites and revisited 11 previously recorded sites.

The 2018 SRARP annual report is available on SRARP's website.

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 releases in 2018.

3.3.10 Permits

SRS had 560 construction and operating permits in 2018 that specified operating levels to each permitted source. Table 3-3 identifies the number of permits by the permit type.

Table 3-3 SRS Permits

Type of Permit	Number of Permits
Air	6 [a]
U.S. Army Corps of Engineers (USACE—Nationwide Permits)	9
Asbestos Demolition Licenses/Abatement Licenses/Temporary Storage of Asbestos Waste Notices	252
Asbestos Abatement Group License	1
Asbestos Temporary Storage of Waste License	1
Domestic Water	96
Industrial Wastewater Treatment	66
NPDES Permits	11
Construction Storm Water Grading Permit	7
RCRA Hazardous Waste	1
RCRA Solid Waste	3
RCRA Underground Storage Tank	7
Sanitary Wastewater	89
SCDHEC 401	0
SCDHEC Navigable Waters	0
Underground Injection Control	11
Total	**560**

[a] This count includes the CAA permit (TV-0080-0144) for Ameresco.

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, of this report*
- 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 Site to prepare this Annual SRS 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 71 ORPS-reportable events at SRS in FY 2018, none was within ORPS Group 5 (Environmental), and two were 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] 2018. SRS received one NOAV or Noncompliance Notification in CY 2018, 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 no regulatory self-disclosures in 2018.

3.6 ENVIRONMENTAL AUDITS

SCDHEC, EPA, NRC, 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 2018 audits and inspections.

During 2018, the SRS Independent Evaluation Board conducted two assessments of environmental programs: 1) the Asbestos Management Program in January and February and 2) the Environmental Protection Program in August. Each assessment identified several findings and opportunities for improvement.

Table 3-4 Summary of 2018 External Agency Audits/Inspections of the SRS Environmental Program and Results

Audit/Inspection	Action	Results
632-G C&D Landfill and 288-F Ash Landfill Inspections	South Carolina Department of Health and Environmental Control (SCDHEC) conducted four quarterly inspections of the 632-G and 288-F landfills.	No issues were identified.
Federal Energy Regulatory Commission (FERC) Inspection	Savannah River Nuclear Solutions (SRNS) completed Potential Failure Mode Analyses for Par Pond Dam and Steel Creek Dam. FERC also performed its annual inspections in October but has not issued the reports.	A list of Potential Failure Modes has been generated and an action plan is being developed. There were no immediate failure modes threatening the dams.
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 March 26 and 27. SCDHEC also completed a records review of groundwater-related files.	The inspection identified no deficiencies or permit violations.
Industrial Wastewater Construction Permit Inspections	• SCDHEC inspected the Tank Closure Cesium Removal (TCCR) system on December 12 and provided the Approval to Place into Operation on December 13. • SCDHEC inspected the RWM018 recovery well, associated with the M-1 Air Stripper, on March 16 to support placing it into operation. • SCDHEC toured the Waste Solidification Building (WSB) on September 25 as part of the biennial WSB meeting. • The Integrated Independent Evaluations Board conducted an environmental review of Defense Waste Processing Facility (DWPF) during the fall.	No issues were identified.

Table 3-4 Summary of 2018 External Agency Audits/Inspections of the SRS Environmental Program and Results (continued)

Audit/Inspection	Action	Results
Environmental Laboratory Certification On-site Evaluations	SCDHEC performed recertification inspections on the Domestic Water Lab, Environmental Analysis Lab, and the Environmental Bioassay Lab on March 8.	All inspected laboratories were recertified for three years.
SCDHEC Sanitary Survey of SRS Drinking Water Systems	SCDHEC inspects the wells, tanks, and treatment systems supporting the A-Area drinking water system biannually.	SCDHEC did not conduct a Sanitary Survey of SRS Drinking Water System in 2018. The next expected year for the survey is 2019.
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	SCDHEC conducted an inspection on August 21, 2018 for conditions in permit TV-0080-0041.	SCDHEC observed no violations of permit requirements or applicable regulations during the evaluation.
Resource Conservation and Recovery Act (RCRA) Compliance Evaluation Inspection (CEI)	U.S. Environmental Protection Agency (EPA) and 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 May 22-24 CEI.	SCDHEC and EPA noted incomplete labels on five containers stored on TRU Pad 26. SRS corrected these deficiencies before the end of the inspection.
Underground Storage Tank (UST) CEI	SCDHEC inspected 19 USTs.	UST 715-H on Permit 10838 was found to have two violations on October 23. SCDHEC issued a Notice of Alleged Violation (NOAV) for not maintaining spill bucket integrity and a suspected release.
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.
N-Area Heating Oil Plume Field Visit	SCDHEC performed a field visit on October 17 to become familiar with the Site and observe groundwater sampling required for reporting on this project.	No issues were identified.
National Pollutant Discharge Elimination System (NPDES) Compliance Evaluation Inspection (3560)	SCDHEC performed monthly inspections of the SDF. This included reviewing facility procedures and performing walk downs of the SDF.	No issues were noted.

3.7 KEY FEDERAL LAWS COMPLIANCE SUMMARY

The Code of Federal Regulations implements Federal laws and state regulations that a federal agency has delegated to the state. You can find additional information online at epa.gov. Table 3-5 summarizes SRS's 2018 compliance status with applicable key federal environmental laws.

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

Regulatory Program Description	2018 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 2017 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 (TV-0080-0041) that expired on March 31, 2008 and was administratively extended; the Ameresco permit (TV-0080-0144); and other applicable CAA regulatory requirements. Ameresco received a Notice of Violation (NOV) for failing to meet carbon monoxide emission limits. The violation was resolved with South Carolina Department of Health and Environmental Control (SCDHEC) following corrective actions.
The Clean Water Act regulates liquid discharges at outfalls (for example, drains or pipes) that carry effluent to streams (National Pollutant Discharge Elimination System [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 100% compliance rate for NPDES Industrial Wastewater.
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 Federal Facility Agreement (FFA).
The Emergency Planning and Community Right-to-Know Act (EPCRA), also referred to as Superfund Amendments and Reauthorization Act (SARA), Title III, requires SRS to report hazardous substances and their releases to U.S. Environmental Protection Agency, state emergency response commissions, and local planning units.	SRS complied with all reporting and emergency planning requirements.
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.

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

Regulatory Program Description	2018 Status
The Federal Facility Agreement (FFA) for the Savannah River Site between the EPA, DOE, and SCDHEC integrates CERCLA and Resource Conservation and Recovery Act (RCRA) requirements to achieve a comprehensive remediation strategy and sets annual work priorities and establishes milestones to clean up and close the 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 conducted one on-site monitoring observation visit to F- and H-Tank Farms and Saltstone in 2018.
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.
RCRA governs hazardous and nonhazardous solid waste management 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 waste, nonhazardous solid waste, and USTs in compliance with RCRA. One UST received a Notice of Alleged Violation (NOAV) in 2018. Corrective actions were taken, and SRS received notification from SCDHEC that "No Further Action" is required.

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

Regulatory Program Description	2018 Status
The Safe Drinking Water Act (SDWA) protects drinking water and public drinking water resources.	All drinking water samples taken in 2018 met drinking water quality standards.
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 2018 annual PCB report was submitted on June 25, 2019.

3.8 ENVIRONMENTAL COMPLIANCE SUMMARY

SRS was not involved in any environmental lawsuits during 2018. SRS received no NOVs and one NOAV in 2018, which is discussed in Section 3.3.2.3. Ameresco received one NOV, which is discussed in Section 3.3.6.1. Table 3-6 summarizes the NOVs/NOAVs SRS received from 2014–2018.

Table 3-6 NOV/NOAV Summaries, 2014–2018

Program Area	Notice of Violation (NOV)/Notice of Alleged Violation (NOAV)				
	2014	**2015**	**2016**	**2017**	**2018**
Clean Air Act (CAA)	0	1	0	3	1[a]
Clean Water Act (CWA)	0	0	1	2	0
Resource Conservation and Recovery Act (RCRA)	0	0	0	0	1[b]
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	0	0	0	0	0
Others	0	0	0	0	0
Total	**0**	**1**	**1**	**5**	**2**

[a] This NOV was issued to Ameresco, a direct contractor to DOE.

[b] NOAV

Chapter 4: **Nonradiological Environmental Monitoring Program**

The purpose of the Savannah River Site (SRS) nonradiological environmental monitoring program is twofold in that it confirms 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 it is complying 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.

2018 Highlights

Effluent Releases

- Nonradiological effluent releases for all categories met permit limits and applicable standards.
- All SRS industrial wastewater outfalls, under the National Pollutant Discharge Elimination System (NPDES) permit, achieved a 100% 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 were consistent with historical levels.

4.1 INTRODUCTION

Environmental monitoring programs at SRS examine both radiological and nonradiological constituents that Site 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 consists of two focus areas: 1) effluent monitoring, and 2) environmental surveillance. The objective of the effluent monitoring program is to demonstrate the Site is complying with permits, 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.

Chapter 4—Key Terms

Effluent *is a release to the environment of treated or untreated water or air from a pipe or a stack. 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.*

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. Section 8.4, *Environmental Monitoring Program QA Activities,* and Section 8.5, *Environmental Monitoring Program QC Activities,* summarize the quality assurance and quality control practices that support the sampling and analysis reported in this chapter. Appendix Table B-1 of this document summarizes the nonradiological surveillance sampling media and frequencies.

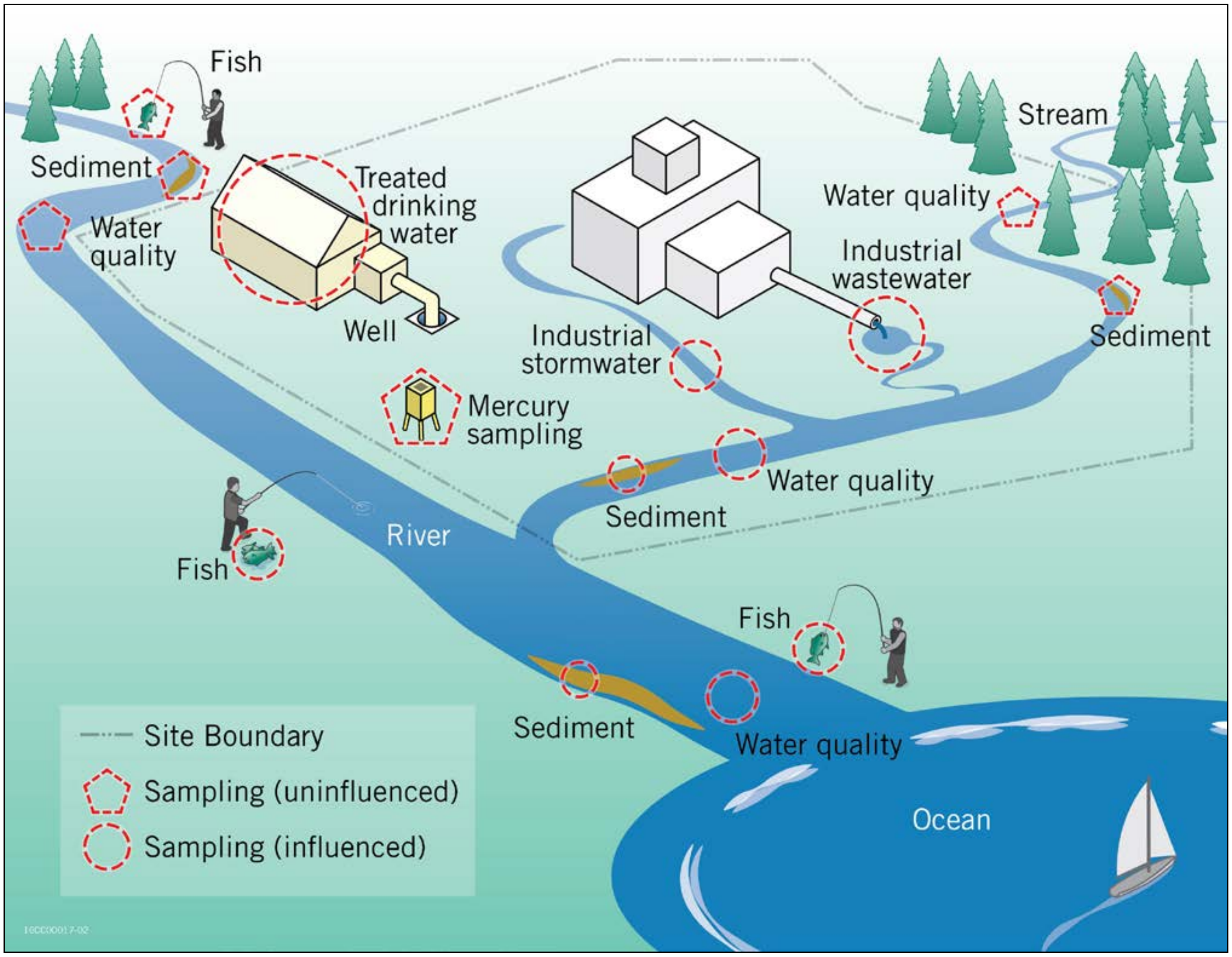


Figure 4-1 Types and Typical Locations of Nonradiological Sampling

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 that demonstrate compliance.

SRS uses nonradioactive volatile chemicals (for example, 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 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.

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, collection methods, analytes, monitoring frequency, permit limits for each analyte, 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.

In 2018, SRS monitored 28 industrial wastewater outfalls for physical and chemical properties, including flow, dissolved oxygen, potential 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.

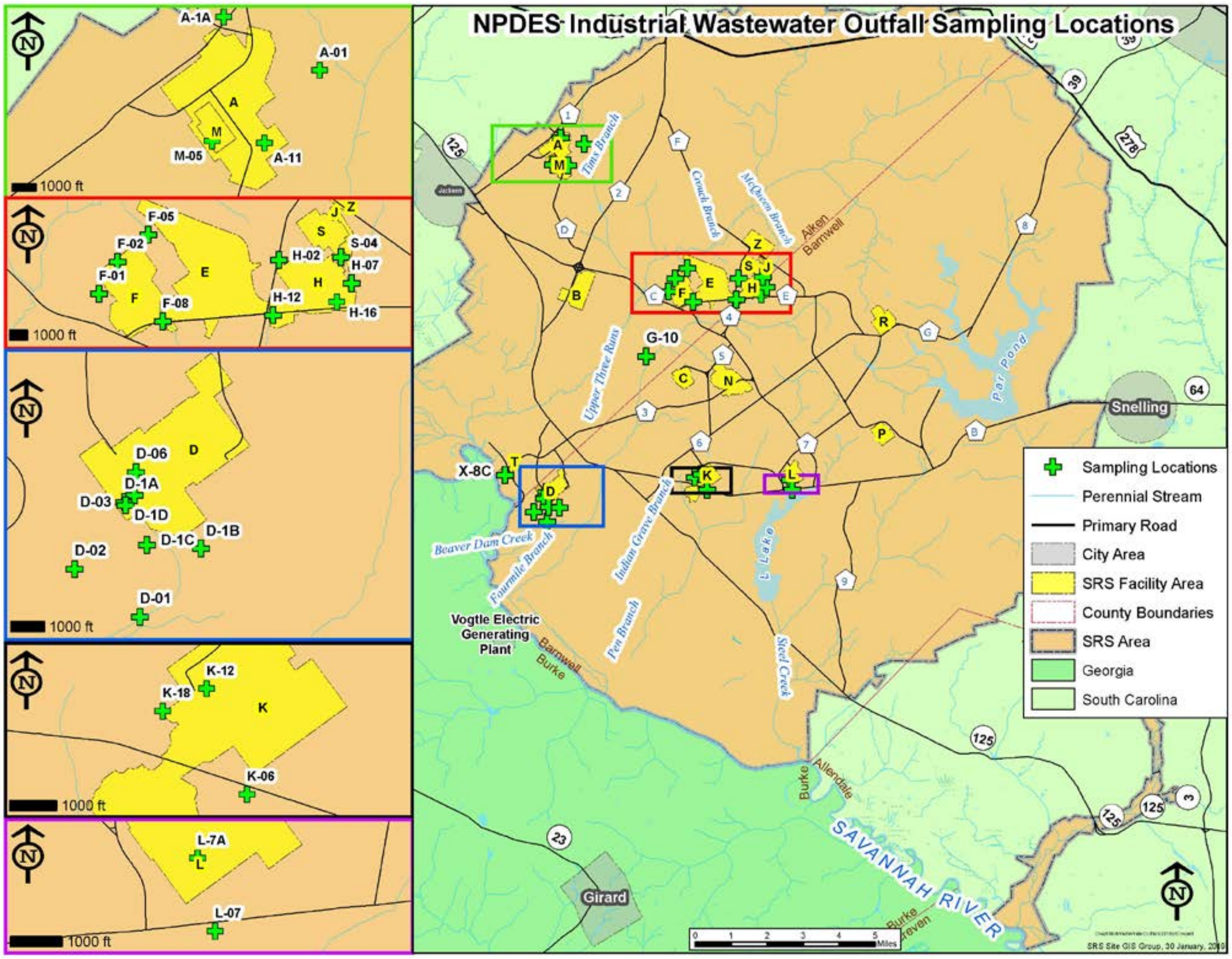


Figure 4-2 NPDES Industrial Wastewater Outfall Sampling Locations

In 2018, SRS monitored 39 industrial stormwater outfalls for ammonia, chemical oxygen demand, cyanide, Escherichia coli (E. coli), metals, nitrite, nitrate, pH, and TSS. In addition, 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 eliminated impaired water sampling—20 outfalls in 11 groupings—for E. coli analysis because SRS processes do not contribute to the E. coli-impaired streams onsite.

The Site 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 collection should occur during the first 30 minutes of the flow event. 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 stormwater flow.

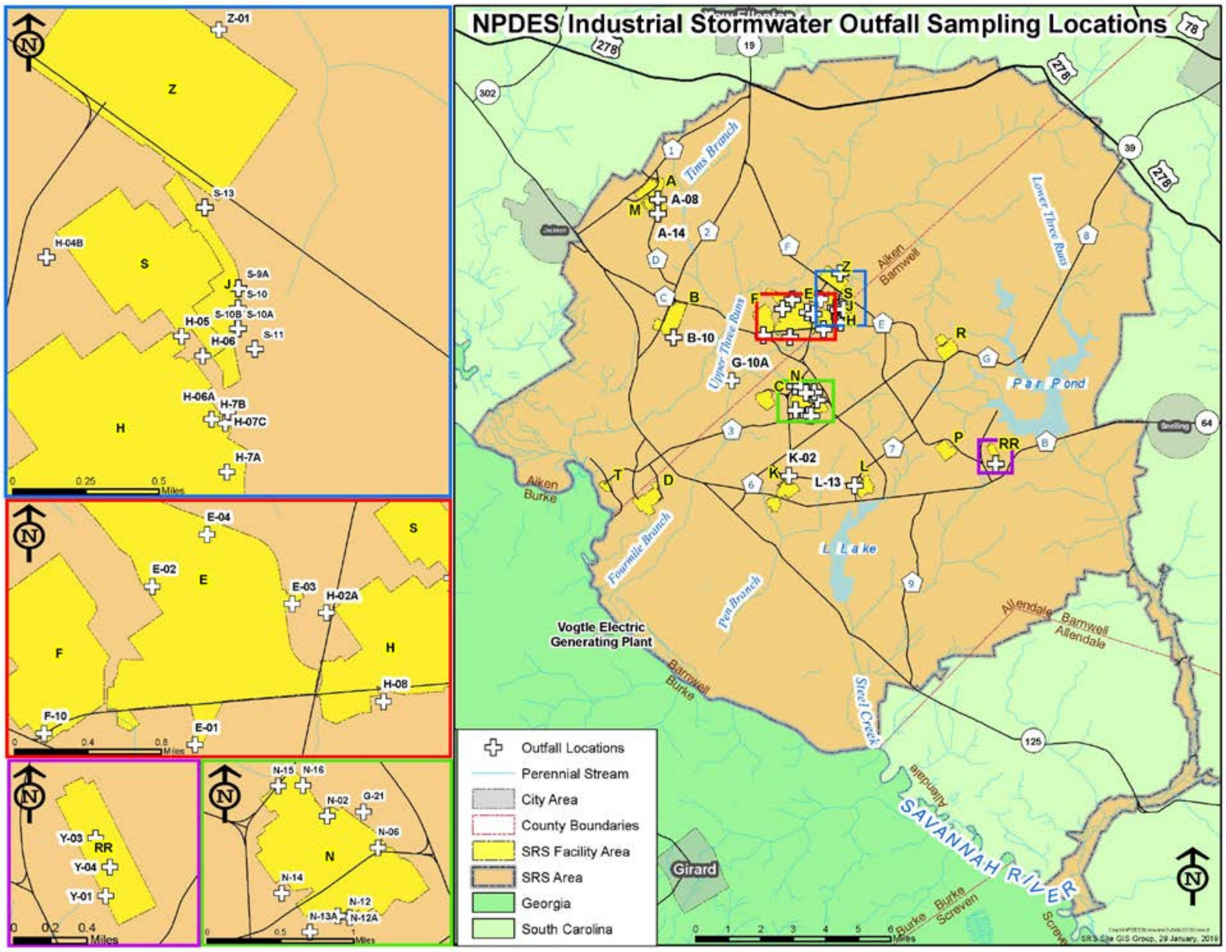


Figure 4-3 NPDES Industrial Stormwater Outfall Sampling Locations

4.3.1.1 Wastewater and Stormwater Results Summary

SRS reports NPDES industrial wastewater analytical results to SCDHEC through monthly discharge monitoring reports. All the approximately 2,610 analyses performed during 2018 were within NPDES permit limits, a 100% compliance rate.

Bone Charcoal Installed to Absorb Metals in Stormwater Runoff

SRS monitored all industrial stormwater outfalls according to permit requirements. The copper average at Outfall N-12A exceeded benchmark limits, triggering corrective actions. To absorb the metals, in October SRS installed bone charcoal on the upstream side of small check dams in the stormwater ditches leading to Outfall N-12A. SRS uses the monitoring results to evaluate and optimize the performance of this treatment method.

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

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 SRS's drinking water. The Site also has four smaller drinking water facilities, each serving fewer than 25 people.

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. All 2018 bacteriological samples for drinking water were collected and met the state and federal drinking water quality standards.

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 attributable to the water discharges Site NPDES permits regulate, and 2) materials coming from inadvertent releases at sources other than routine release points.

SRS sampled 11 streams onsite and 5 Savannah River locations for various physical and chemical properties, including dissolved oxygen, pH, temperature, hardness, herbicides, metals, nitrate, nitrite, pesticides, phosphorus, polychlorinated biphenyls, total organic carbon, and total suspended solids. Figure 4-4 shows the sampling locations. In May 2017, sampling for the upstream location on Upper Three Runs Creek, U3R-1A, temporarily moved upstream to U3R-0. SRS changed the sample location to alleviate the potential impacts to water quality results from the planned bridgework along the stream. The river and stream sampling locations are 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. SRS samples the water quality locations by the conventional grab-collection technique on a monthly and quarterly basis. As discussed in Section 8.4, *Environmental Monitoring Program QA Activities,* beginning in August 2018, SRS changed the analytical method for cadmium and lead, resulting in a lower detection limit. The detection limit now aligns with comparable SCDHEC standards. 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 co-located with SRS sample locations as a quality-control check of the SRS program.

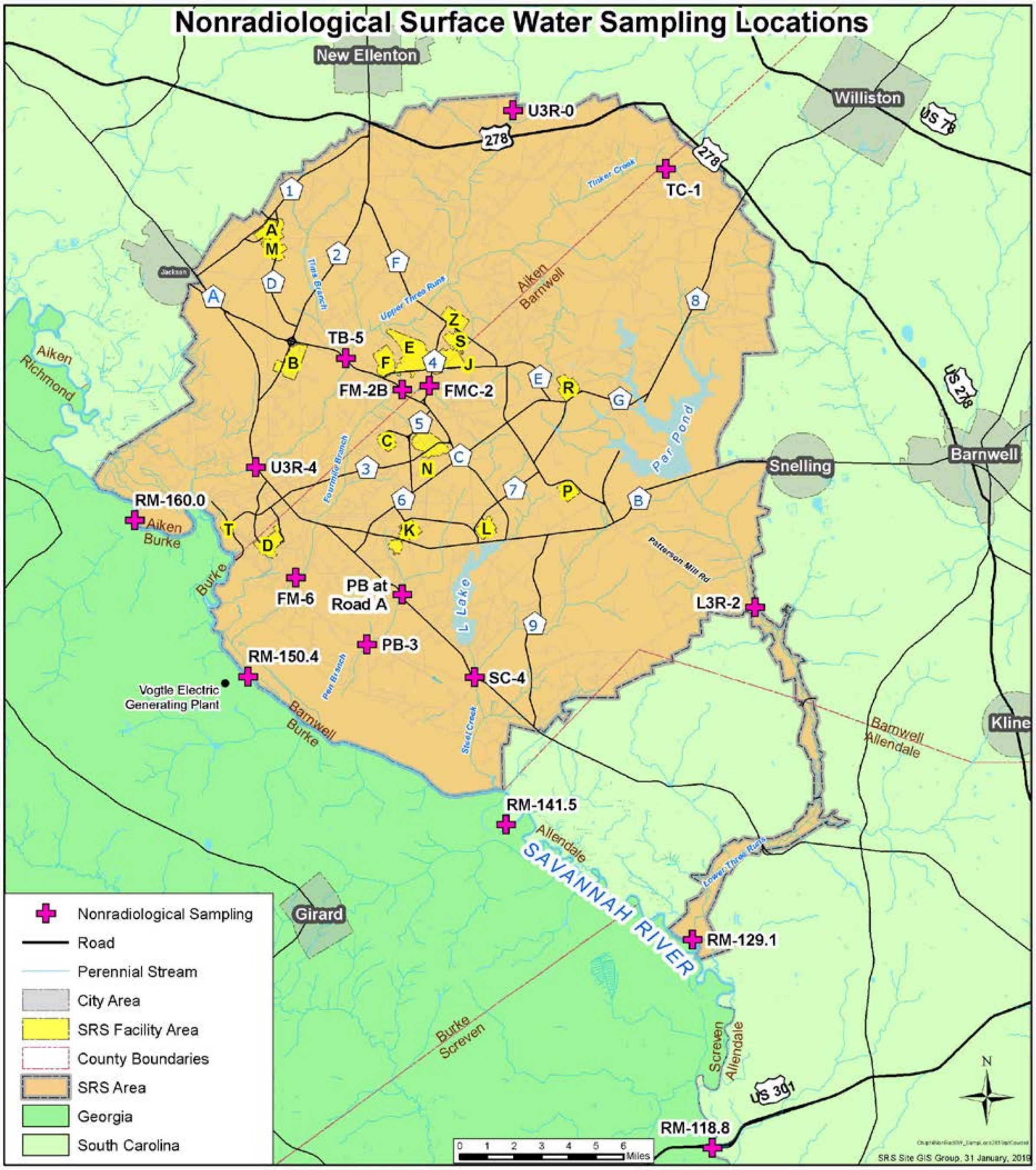


Figure 4-4 Nonradiological Surface Water Sampling Locations

4.3.3.1 River and Stream Water Quality Results Summary

SRS performed 5,760 individual analyses on samples collected from the 16 stream- and river-water quality locations during 2018, with 3,395 of 3,904 (85%) meeting South Carolina Freshwater Quality Standards, as available. Averages for each river and stream location met standards for dissolved oxygen, temperature, chromium, copper, mercury, nickel, nitrate, nitrite, zinc, pesticides, herbicides, and polychlorinated biphenyls. 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 of various inorganic contaminants (metals and cyanide) that are deposited in stormwater basins, stream systems, and the Savannah River, where they accumulate or disperse.

The nonradiological sediment program collects sediment samples annually at various Site 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, which duplicates sampling at several locations onsite as a quality control check of the SRS program. SRS also collects duplicate samples to assess quality control, as documented in Section 8.5, *Environmental Monitoring Program QC Activities*.

4.3.4.1 Stream and River Sediment Results Summary

SRS conducted 425 individual analyses on sediment collected from 25 locations (14 stream, 3 stormwater basin, and 8 Savannah River). The metals measured were aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, uranium, and zinc. Many of these are trace metals that occur naturally in soils and sediments. All results were comparable to those of the previous five years and demonstrate SRS activities are not significantly affecting the metals and cyanide concentrations of onsite basins, streams, or the Savannah River. In addition, SRS compared results to EPA Region 4 Sediment Refinement Screening Values (RSV), as available. The Site uses the RSVs as a benchmark. Ninety-six percent (361 of 375 analyses) of the 2018 results met the benchmarked values. Appendix Table C-2 summarizes the analytical results.

Technicians Collect a Sediment Sample

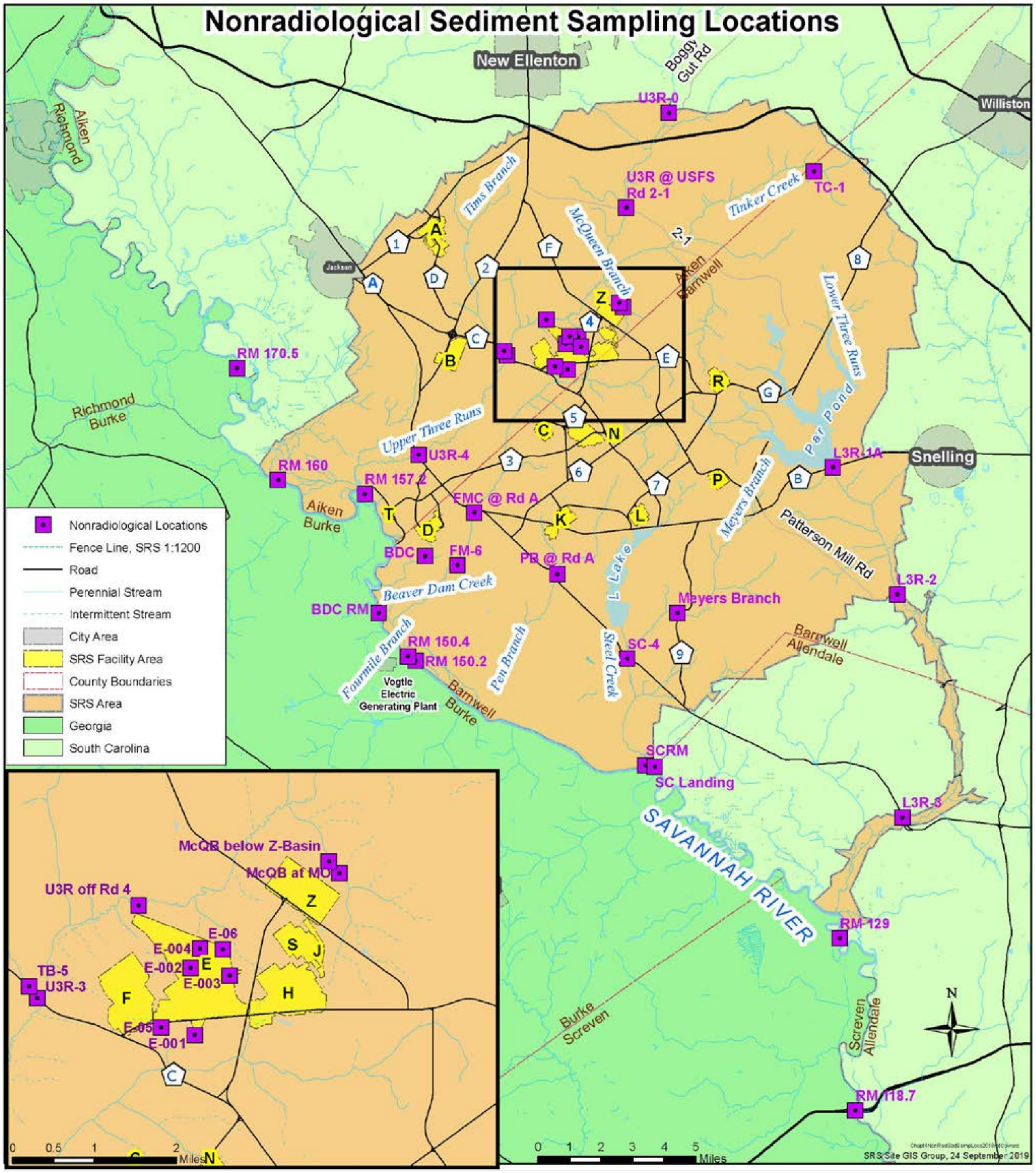


Figure 4-5 Nonradiological Sediment Sampling Locations

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 and gathers saltwater fish (mullet) at the Savannah River mouth near Savannah. SRS analyzes samples of the edible flesh for metals uptake. SRS performs nonradiological analyses for mercury, arsenic, cadmium, chromium, copper, lead, manganese, nickel, zinc, and antimony.

Fish Sample Collected from SRS Creek Mouth

4.3.5.1 Fish Results Summary

In 2018, SRS performed 1,630 individual analyses on 133 fish flesh samples. Forty-two percent (42%) of the results were nondetected (less than the method detection limit). Appendix Tables C-3 and C-4 present summaries of the analytical results. SRS detected and quantified 12%, or 198 results of the 1,630 individual analyses, with the majority being for mercury (60) and zinc (133). The remaining 46% were estimated values, indicating SRS detected the analyte, and the concentration was close to the method detection limit. The 2018 data is comparable to the results for the previous five years. Figure 4-6 shows the average mercury results by fish type for 2014 through 2018.

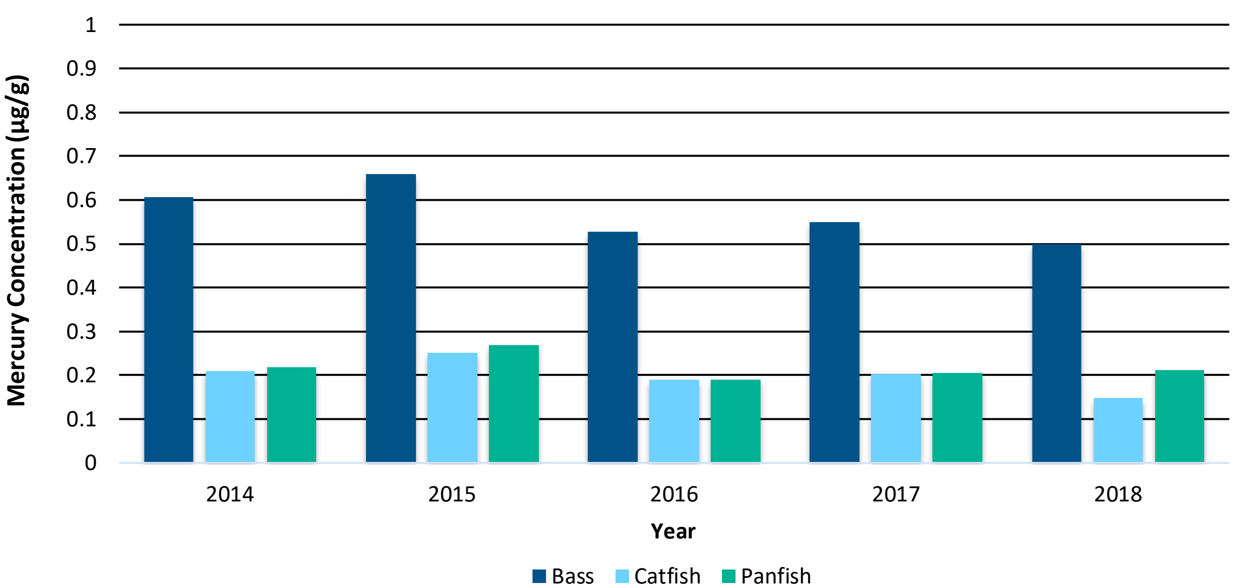


Figure 4-6 Average Mercury Concentration of Fish Species in the Savannah River Adjacent to the Savannah River Site

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 its network of collection locations. This section would have reported 2017 data from the SRS NADP station; however, Savannah River Nuclear Solutions was not able to collect samples in 2017.

SRS sponsors a collection station to support the NADP. This station, located near the center of SRS at the Savannah River National Laboratory 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. Natural sources, including volcanoes and wildfires, emit mercury into the atmosphere and surface waters. Mercury also occurs naturally in some soils, yet most of the attention on mercury in the environment focuses 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.

Chapter 5: **Radiological Environmental Monitoring Program**

The purpose of the Savannah River Site (SRS) Radiological Environmental Monitoring Program is twofold 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. Monitoring substantiates that SRS operations pose no risk to the surrounding population. 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. The Site collects samples 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.

2018 Highlights

Air Pathway—All air contaminants SRS released were below applicable permit and regulation limits. Radiological results for surveillance media associated with the airborne pathway were within historical levels.

Water Pathway—Water contaminants SRS released were all below applicable standards. Radiological results for surveillance media associated with the liquid pathway were within historical levels.

Wildlife Surveillance—All harvested animals SRS monitored during the annual onsite hunts were below the applicable standard. SRS monitored the deer, feral hogs, turkeys, and coyotes harvested during the hunts and released 382 animals.

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 (annual ingestion of water, submersion in air, or inhalation)—would result in a dose of 100 mrem. 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.*

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 is 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 support implementing DOE Order 458.1. SRS demonstrates DCS compliance 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 Site releases, as measured in the effluent monitoring program, may impact. 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)

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

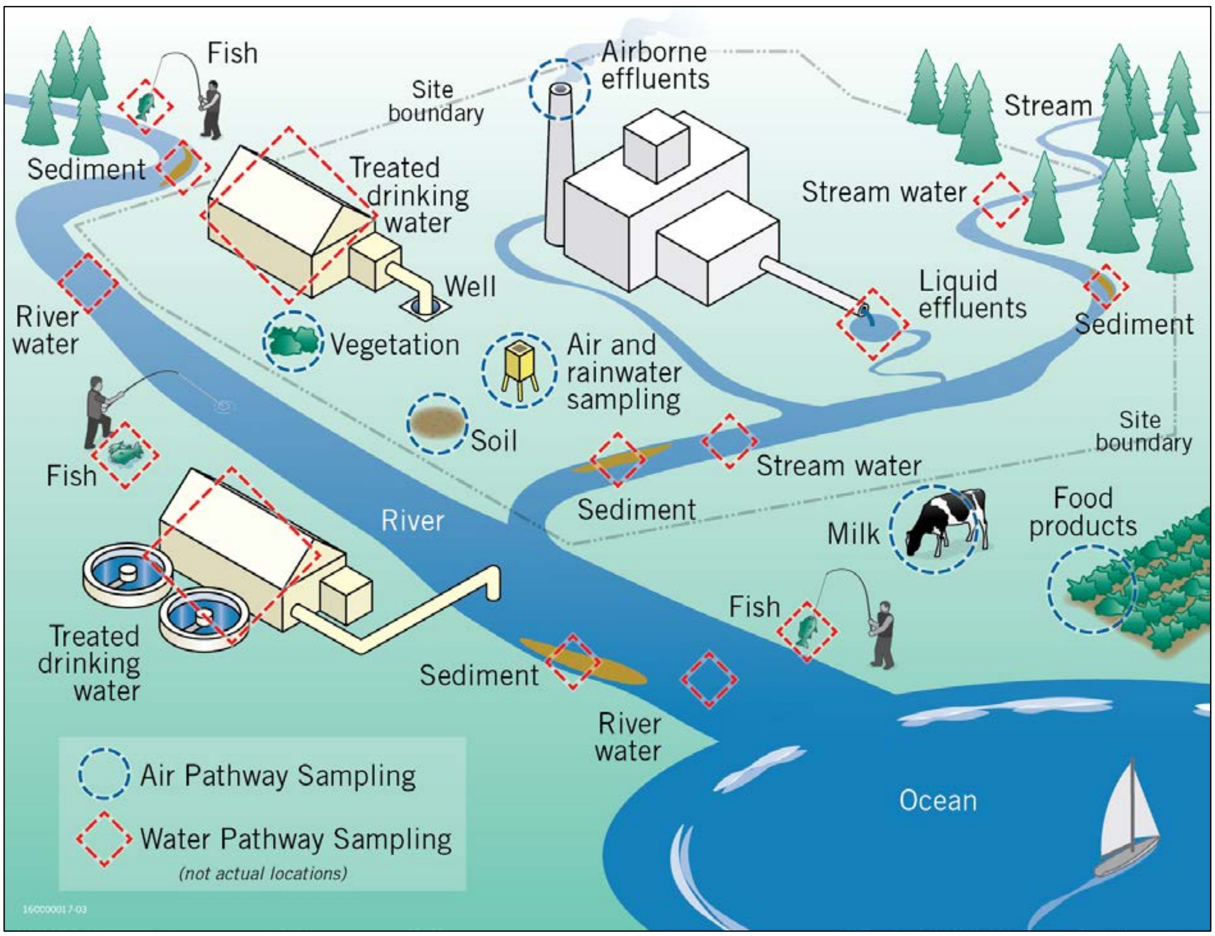


Figure 5-1 Types and Typical Locations of Radiological Sampling

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 RM 161 as a control location. In 2018, SRS changed the control location at RM 160 to RM 161 as a program improvement described in Section 8.4, *Environmental Monitoring Program QA Activities*. 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	28 (7)	16 (4)
Rainwater	12 (1)	24 (2)
Food Products	20 (20)	5 (5)
Milk	16 (5)	15 (4)
Soil	5 (5)	2 (2)
Grassy Vegetation	1 (1)	2 (2)
Drinking Water	24 (2)	0 (0)
Total	**158 (43)**	**168 (23)**

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

5.3 AIR PATHWAY

The media in this section support 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 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. 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. The Site collects airborne effluent samples 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. SRS calculates these emissions and includes them 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 originate from a larger area and not from a single location. 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.

5.3.2.1 Airborne Emissions Results Summary

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, the total annual tritium release has ranged from about 15,200 to 40,400 Ci per year, with an annual average tritium release of 26,900 Ci (Figure 5-2). The 2018 SRS tritium releases totaled 39,300 Ci. The increase in tritium releases from 2017 to 2018 is mainly attributed to releases associated with both monitored and unmonitored releases from the Tritium Facilities. The increase in monitored releases is due to short-term maintenance activities in the Tritium Facilities. The increase in unmonitored releases from the Tritium Facilities is due to 1) an increase of material stored in waste containers and 2) a more conservative emission factor being used in the calculation.

To understand the potential environmental impact of the short-term maintenance activities, additional air sampling, as well as sampling of media that would potentially be affected, was conducted in conjunction with these activities. The media sampled were rainwater, surface water, vegetation, and foodstuffs. The sample results, while above the 10-year average values for each media, had little impact to the offsite representative person dose, which was 0.27 mrem in 2018 and 0.25 mrem in 2017, as compared to the 100 mrem DOE dose standard. Chapter 6, *Radiological Dose Assessment,* discusses the dose calculation.

Tritium is released as part of routine SRS operations. 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.

Table 5-2 SRS Radiological Atmospheric Releases for CY 2018 (measured in curies)

Release Type	Totals (in curies)
Tritium	3.93E+04
Krypton-85 (^{85}Kr)	1.03E+04
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]	2.00E-08
Fission and Activation Products ($T_{1/2}$ > 3 hr)[b,c]	6.65E-02
Total Radio-iodine	3.76E-03
Total Radio-strontium[d]	5.17E-03
Total Uranium	1.05E-04
Plutonium[e]	5.90E-04
Other Actinides	2.36E-04
Other	2.00E-02

[a] SRS did not release any radioactive noble gases in CY 2018, 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 unidentified beta releases
[e] Includes unidentified alpha releases

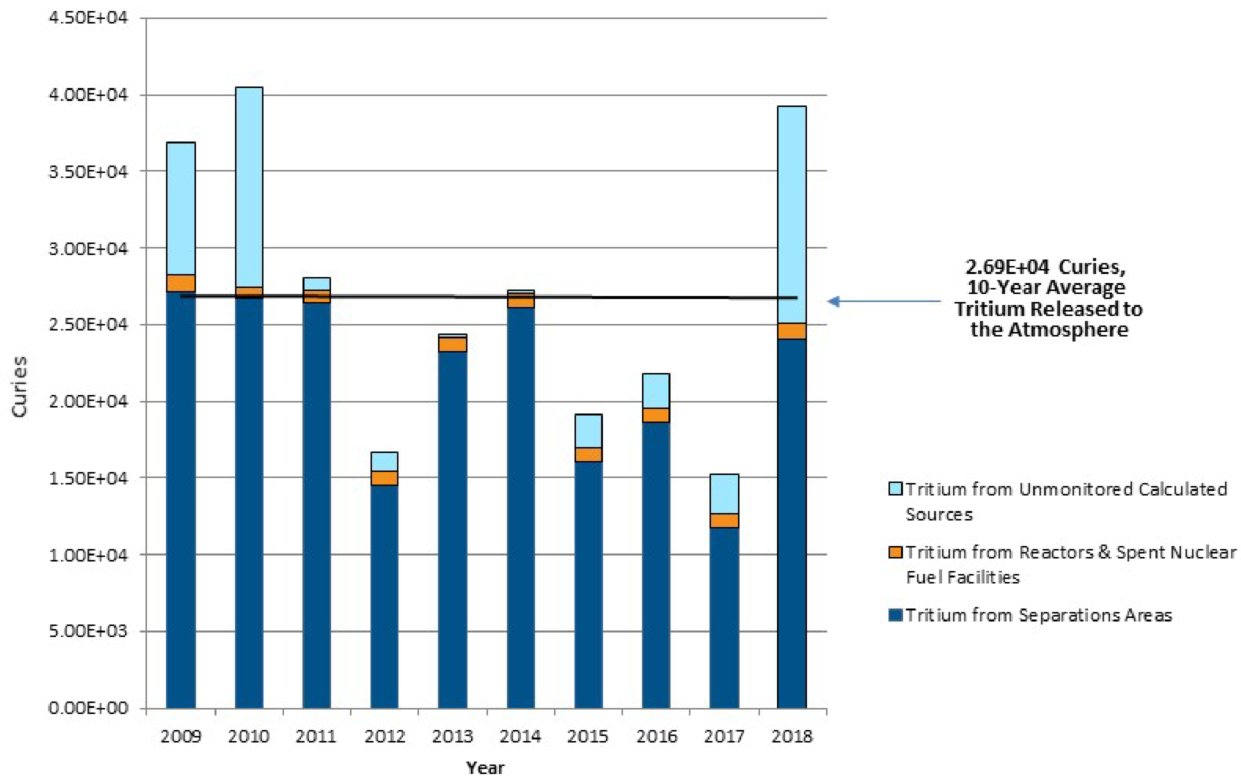


Figure 5-2 10-Year History of SRS Annual Tritium Releases to the Air

In 2018, tritium accounted for a majority of the total radiation SRS operations released to the air. Tritium-processing facilities are responsible for most of the 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 2018 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. The raw data 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 release volume.

Most SRS stacks and facilities release small quantities of radionuclides at concentrations below the DOE DCSs. As in 2017, F-Canyon stack had elevated analytical results in 2018. The elevated results led to a DCS exceedance with plutonium-239 as the primary contributing radionuclide. The DCS sum of fractions exceedance in 2018 is 3.19, which is down from 5.80 in 2017. SRS continues to monitor the decreasing levels of emissions. Dose limits from the levels are well below the 10 mrem EPA standard. SRS will continue to monitor and evaluate emissions to determine if the Site needs to take any action to reduce releases.

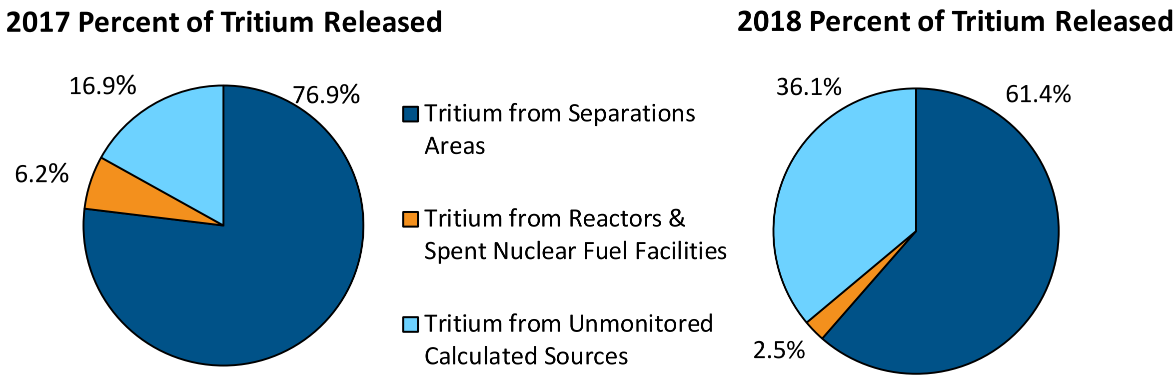


Figure 5-3 Percent of Tritium Released to the Air for 2017 and 2018

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 Reasonably Achievable (ALARA) requirements, that Site procedures implement. 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.

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 vegetation or soil can eventually absorb the radionuclides.

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 included in Table 5-3.

Table 5-3 Air Sampling Media

Media	Purpose	Radionuclides
Glass-Fiber Filter	Airborne particulate matter	Gamma-emitting radionuclides, gross alpha/beta emitting radionuclides, actinides, strontium-89,90
Charcoal Canister	Gaseous states of radioiodine	Iodine-129, gamma-emitting radionuclides
Silica Gel	Tritiated water vapor	Tritium
Rainwater	Tritium in rainwater	Tritium

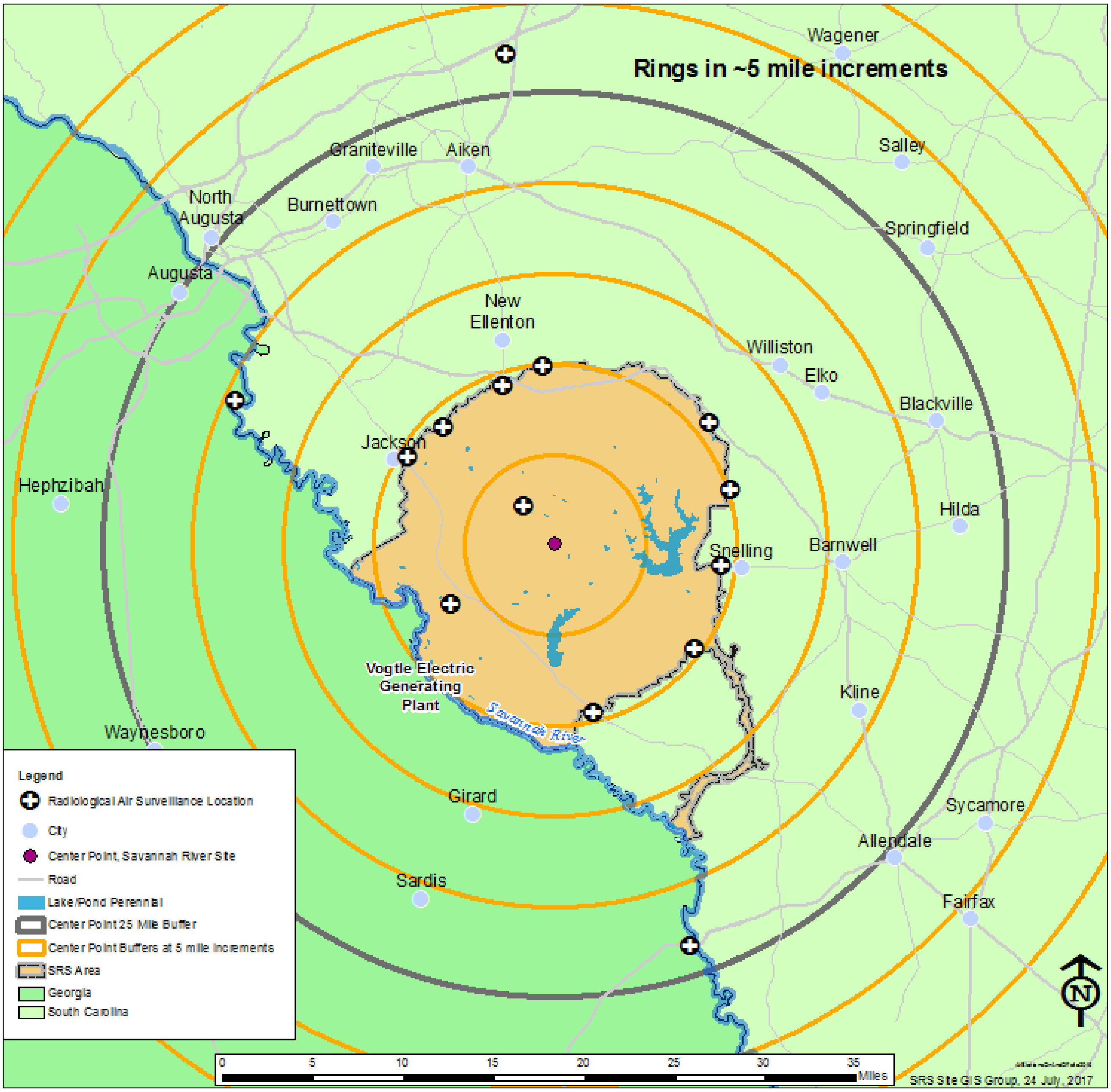


Figure 5-4 Air Sampling Locations Surrounding SRS up to 25 Miles

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-89,90, and cesium-137 [a manmade gamma-emitting radionuclide]).

5.3.3.1 Results Summary

Due to releases at the F-Canyon stack, SRS analyzed existing samples taken from the nearby Burial Ground North air surveillance station for actinides. Results of the additional analyses showed a detectable amount of some actinides, but not at levels that provide any significant dose to the public.

All charcoal canisters analyzed annually for radioiodines and gamma-emitting radionuclides showed no detections of iodine-129 or cobalt-60. However, analyses detected low levels of cesium-137 in 12 out of 29 samples tested but did not detect cesium on the glass fiber filters associated with these samples. Air passes through the glass fiber filter before passing through the charcoal canisters. SRS investigated the cause of the detections and determined that specific lots of vendor-sealed charcoal canisters contain levels of cesium-137 consistent with those observed in canisters deployed in the field.

Technician Verifying Equipment Readings at Air Monitoring Station

For tritium in air (water vapor) and tritium in rainwater, Appendix Tables D-3 and D-4 summarize results and the comparison to the background control location at the U.S. Highway 301 Bridge. The 2018 results for tritium in air showed detectable levels in 96 of the 378 samples (25%), as compared to 2017 results with detectable levels in 11 % of the samples.

The 2018 results for tritium in rainwater showed detectable levels in 27 of the 180 rainwater samples (15%), as compared to 2017 results with detectable levels in 8 % of the samples. As in previous years, the 2018 values were highest near the center of SRS and decreased with distance from the Site.

Tritium results for both air and rainwater were above the 5-year average due to the SRS maintenance activities described in section 5.3.2.1. However, these results had little impact to the offsite representative person dose, which was 0.27 mrem in 2018, as compared to the 100 mrem DOE dose standard. Chapter 6, *Radiological Dose Assessment,* discusses the dose calculation.

The results for radionuclides measured from the charcoal canisters and the glass-fiber filters were within the trends 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.

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.

TLDs are Placed in the Environment for Three Months to Measure Environmental Gamma Exposure Rates

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

Appendix Table D-5 summarizes the gamma results. Ambient gamma exposure rates at all TLD monitoring locations show some variation based on location and natural levels of background radiation in the environment. In 2018, ambient gamma exposure rates onsite varied between 84.5 mR/yr at location NRC2 (onsite southwest) and 159 mR/yr at the BGN (onsite center of the Site). Rates at population centers ranged from 114 mR/yr at the Jackson, South Carolina, location to 149 mR/yr at the Girard, Georgia, location.

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 2018, SRS collected soil samples from 5 onsite locations, 10 Site perimeter locations, and 7 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 ensure they are homogeneous when the laboratory analyzes them for gross alpha, gross beta, gamma-emitting radionuclides, strontium-89,90, and actinides (including neptunium).

5.3.5.1 Soil Results Summary

In 2018, SRS detected radionuclides in soil samples from all 22 sampling locations. Analyses detect uranium isotopes (U-234, U-235, and U-238) 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 about 1-5 pCi/g, with an average concentration of 2 pCi/g in soils in the United States. Uranium results both onsite and at the Site perimeter were below the levels observed at the control location (Highway 301) and are consistent with naturally occurring uranium levels. These levels are within the typical range for soils and are at or below the average concentration in U.S. soils. Many factors affect the uranium concentration in soil over time. These include the 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.

Technician Collecting Soil Sample

The concentrations of other radionuclides at these locations are consistent with historical results, with maximum cesium-137 concentrations of 27.3 pCi/g at the Creek Plantation Trail 1 (1805 ft) location and 0.152 pCi/g at the control location (Highway 301). Appendix Table D-6 summarizes the results.

5.3.6 Grassy Vegetation Surveillance

SRS collects and analyzes grassy vegetation samples annually 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:

Technicians Collecting Grassy Vegetation Sample

- All air sampling locations
- When applicable, locations where SRS expects soil radionuclide concentrations to be higher than normal background levels and
- When applicable, locations receiving potentially contaminated water

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 collected all annual samples plus additional samples, as discussed in section 5.3.2.1. SRS detected various radionuclides in the grassy vegetation samples collected during 2018 at all air sampling locations (1 onsite, 10 at the perimeter, and 3 offsite). Appendix Table D-7 summarizes the results. Results for all radionuclides are within the trends of the previous 10 years for all locations except for tritium at the East Talatha, Aiken Airport, and Talatha Gate locations. The sample results from these three locations, while above the 10-year average value for each location, had little impact to the offsite representative person dose, which was 0.27 mrem in 2018, as compared to the 100 mrem DOE dose standard. Chapter 6, *Radiological Dose Assessment,* discusses the dose calculation.

5.3.7 Terrestrial Food Surveillance

Pecan Sample to be Prepared for Laboratory Analysis

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 that humans eat may contain radionuclides. Livestock and game animals may be exposed if the radionuclides are in the air. Radionuclides in the air can settle on grass, which animals can eat. 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 humans consume, leading to a potential radiation exposure. SRS samples milk, meat, fruit, nuts, and 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 two specific crops a year, rotating through a variety of vegetables, grains, and nuts. Once a quarter, the Site collects milk samples. In 2018, SRS began sampling goat milk, in addition to cow milk. Section 8.4, *Environmental Monitoring Program QA Activities,* provides more information. Food product samples come from each of the four quadrants surrounding SRS, which extend 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.

Laboratory analysis of the food samples include gamma-emitting radionuclides, tritium, strontium-89,90, technetium-99, gross alpha, gross beta, and actinides (including neptunium). Laboratory analysis of the dairy samples include gamma-emitting radionuclides, tritium, and strontium-89,90.

5.3.7.1 Terrestrial Food Results Summary

In 2018, SRS sampled the milk and the following terrestrial foodstuffs: greens, watermelons, beef, pecans, and corn. SRS collected all food types from all four quadrants and the control area. Appendix Tables D-8 and D-9 summarize the foodstuffs and dairy results. The analytical results of the routine terrestrial foodstuffs and milk are consistent with 10-year trends. Results for most foodstuffs (85% for terrestrial foodstuffs and 92% for dairy) did not detect radionuclides. The tritium results from the samples collected to evaluate environmental impacts of the maintenance activities in the Tritium Facilities, as discussed in section 5.3.2.1, while above the 10-year average value for tritium in milk, had little impact to the offsite representative person dose, which was 0.27 mrem in 2018, as compared to the 100 mrem DOE dose standard. Chapter 6, *Radiological Dose Assessment* discusses the dose calculation.

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.

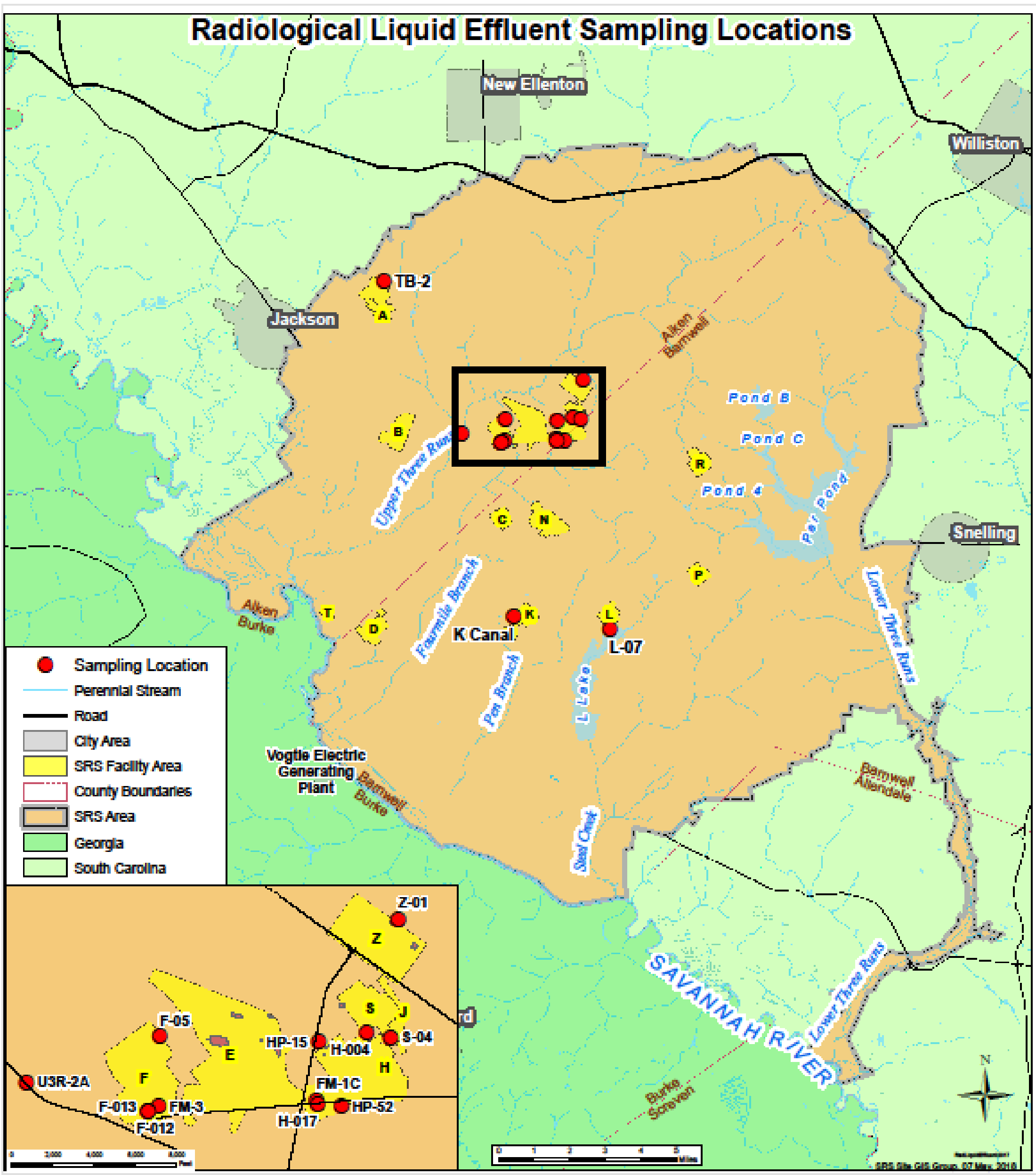


Figure 5-5 Radiological Liquid Effluent Sampling Locations

5.4.1.1 Liquid Effluent Results Summary

Appendix Table D-10 provides SRS liquid radionuclide releases for 2018 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 summarizes the liquid effluent releases of radioactive materials. The direct releases (including migration) of tritium increased by 7.5% (from 494 Ci in 2017 to 531 Ci).

The total amount of tritium released directly from process areas to SRS streams (not including shallow groundwater migration) during 2018 was 91.9 Ci. This is an increase from the 64.9 Ci released in 2017. 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-11 summarizes the 2018 liquid effluent sum of the fractions and radionuclides monitored for each outfall or facility.

Table 5-4 SRS Radiological Liquid Effluent Releases of Radioactive Material for CY 2018 (measured in curies)

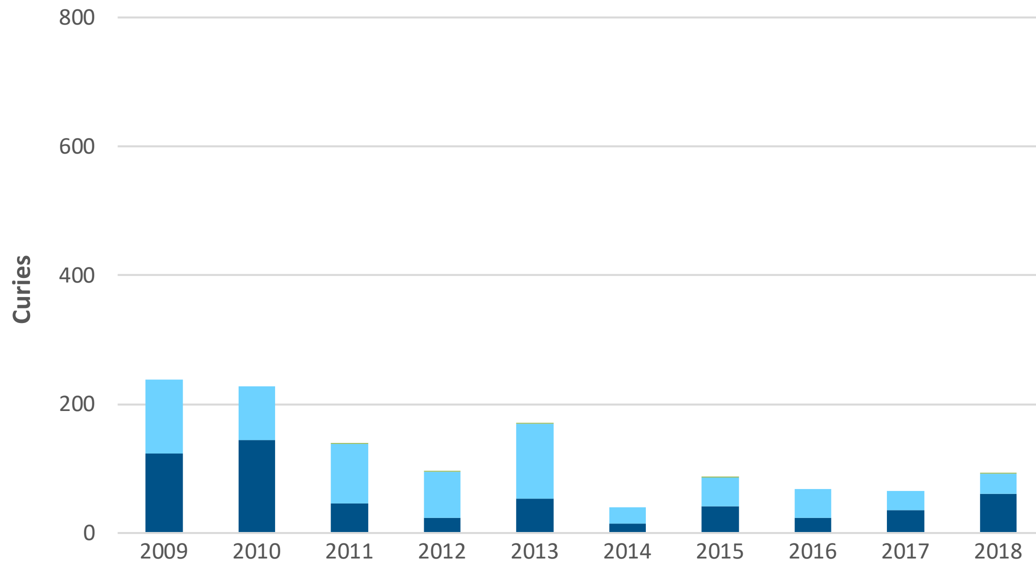
Release Type	Totals (in Curies)
Tritium	5.31E+02
Fission and Activation Products ($T_{1/2}$ > 3 hr)[a,b]	3.71E-02
Total Radioiodine[c]	1.66E-02
Total Radio-strontium[c]	7.69E-02
Total Uranium	6.23E-02
Plutonium[d]	3.27E-03
Other Actinides	2.06E-04
Other	1.03E-03

[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

[d] Includes unidentified beta releases

[e] Includes unidentified alpha releases



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
SRNL	0	0	0.28	0.21	0.12	0	0	0	0.0	0.05
Reactor Areas	114	83	91.5	71.6	116.8	26.1	43.8	45.2	29.9	31.7
Separations Areas	124	144	46.5	24.1	53.3	14.5	41.8	22.9	35	60.1

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 monitors 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. Additional analytes may include actinides (including neptunium). 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.

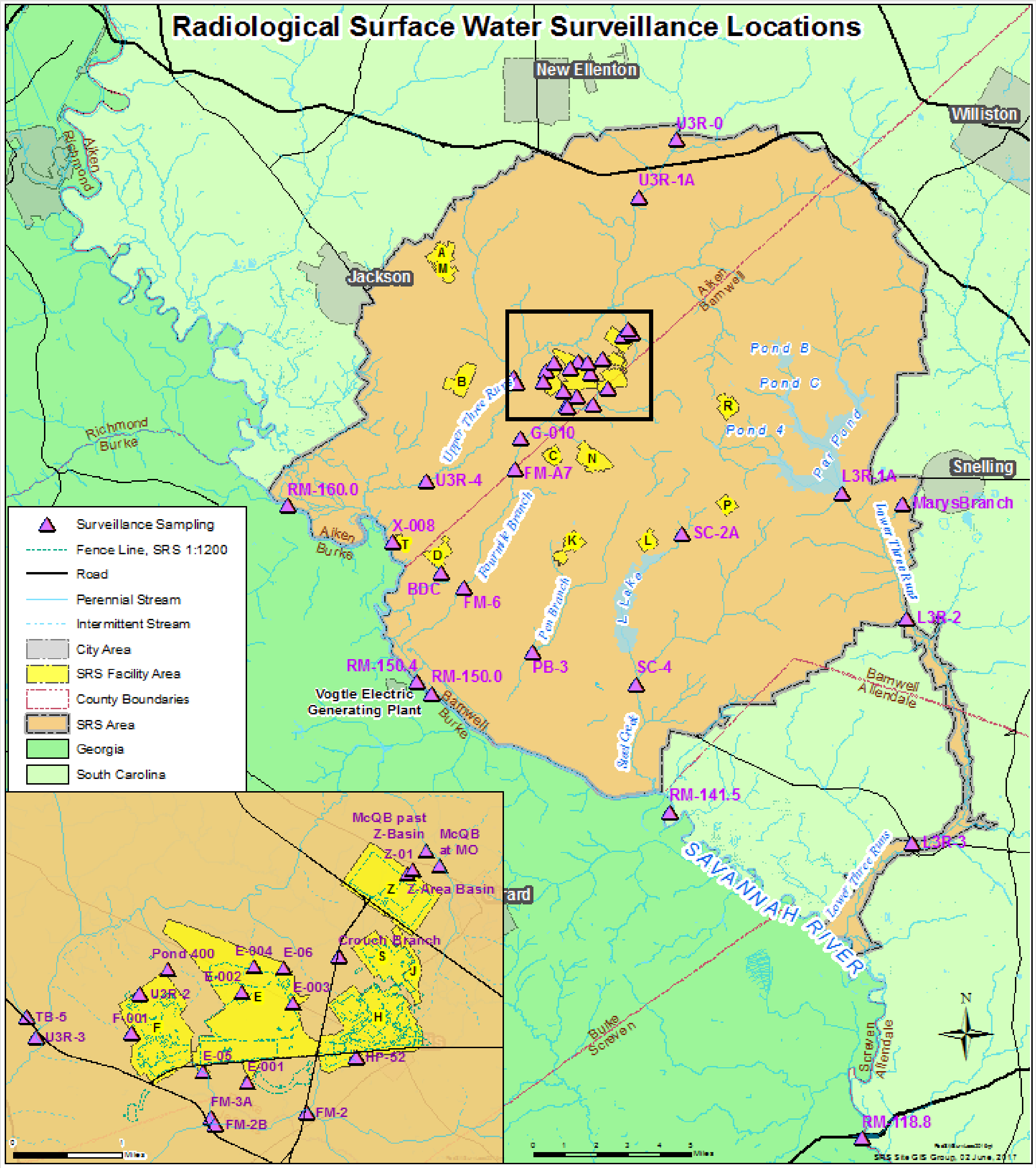


Figure 5-7 Radiological Surface Water Sampling Locations

5.4.2.1 Stormwater Basin Results Summary

In 2018, 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. E-003 Basin had the highest tritium concentration (59,500 pCi/L). The tritium results from the samples collected to evaluate environmental impacts of the SRS maintenance activities as discussed in section 5.3.2.1, while higher than the previous five years, had little impact to the offsite representative person dose, which was 0.27 mrem, in 2018 as compared to the 100 mrem DOE dose standard. Chapter 6, *Radiological Dose Assessment,* discusses the dose calculation.

Table 5-5 Radionuclide Concentrations Summary for Stormwater Basins (pCi/L) for CY 2018

Basin Location	Average Gross Alpha	Average Gross Beta	Average Tritium	Maximum Tritium
E-001	0.218	3.14	6,660	33,200
E-002	0.360	3.75	12,600	35,400
E-003	0.754	2.99	12,000	59,500
E-004	0.418	2.19	9,480	31,100
E-005	0.992	6.00	4,520	7,780
Pond 400	0.635	3.95	503	1,620
Z-Basin	0.294	194	2,830	19,900

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 are 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, the location of the FM 3-A monitoring station. Groundwater from K-Area Seepage Basin migrates into Pen Branch.

Field Personnel Measure Stream Flow Using River Surveyor

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

5.4.3.1 SRS Stream Results Summary

Table 5-6 presents the average 2018 concentrations of gross alpha, gross beta, and tritium, along with the maximum concentrations of 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 all major stream locations. The 10-year trend for the average tritium levels in the streams shows a decrease, which is due to 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 drinking water standard of 20 pCi/mL (20,000 pCi/L), although onsite streams are not a direct source of drinking water.

Table 5-6 Radionuclide Concentrations in the Primary SRS Streams by Location for CY 2018

Location	Average Alpha (pCi/L)	Average Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
Onsite Stream Locations				
Lower Three Runs (L3R-3)	1.08	1.95	396	800
Steel Creek (SC-4)	0.325	1.13	1,490	2090
Pen Branch (PB-3)	0.505	1.01	10,900	15,100
Fourmile Branch (FM-6)	0.873	4.02	27,300	32,200
Upper Three Runs (U3R-4)	4.76	2.77	1,490	5,220
Onsite Control Locations (for comparison)				
Upper Three Runs (U3R-0)	3.87	2.30	107	473

The surveillance program uses the EPA standard as a benchmark for 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 2009 through 2018. 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 2018, the total quantity of tritium migrating from SRS seepage basins and SWDF into SRS streams was 439 Ci, compared to 429 Ci in 2017, which represents a 2.5% increase. The 10-year trend displays a decrease in tritium migration.

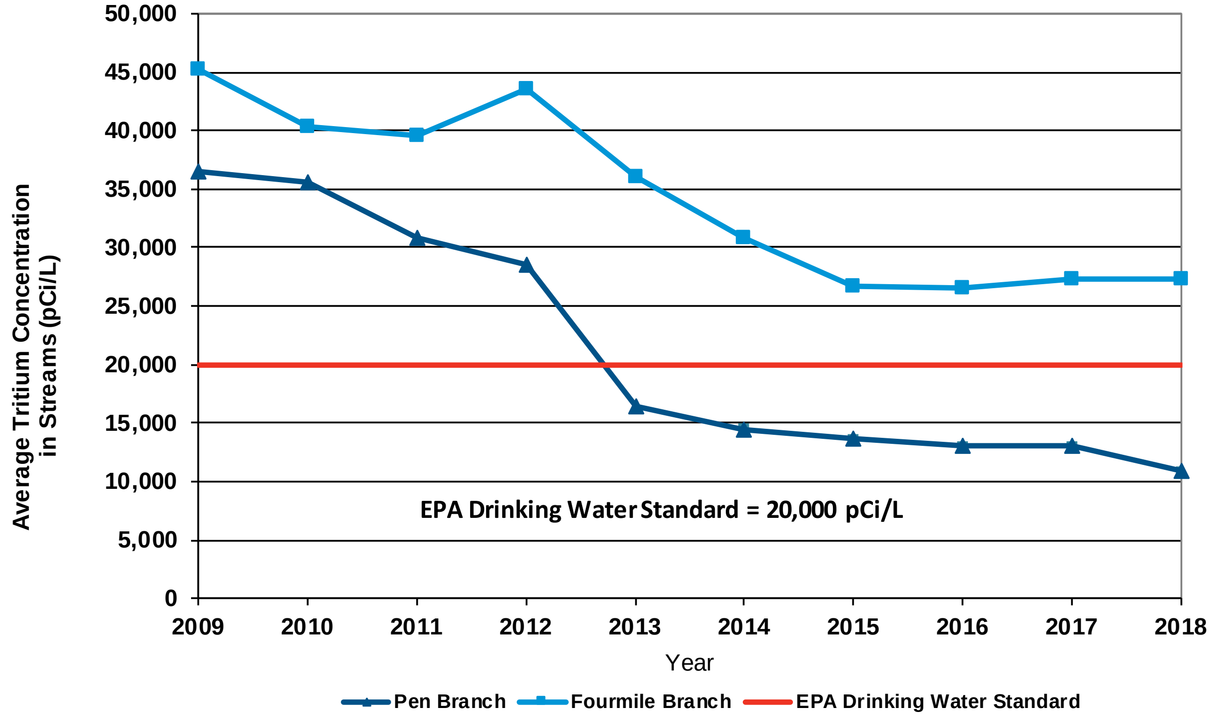


Figure 5-8 10-Year Trend of Tritium in Pen Branch and Fourmile Branch (pCi/L)

Of the 439 Ci of tritium migrating into SRS streams, 228 Ci (52%) was measured in Fourmile Branch. Migration releases of other radionuclides vary from year-to-year but have remained below 0.4 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. An estimated 143 Ci migrated in 2018, which represents a 3.6% increase compared to 138 Ci in 2017. Stream transport also 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).

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. In addition to the monthly samples collected for tritium, gross alpha, gross beta, and gamma analyses, SRS collects samples annually for alpha-specific actinides analyses to provide a more comprehensive suite of radionuclides for annual shallow groundwater migration reporting. All radionuclide results for 2018 showed no elevated levels and are consistent with historical measurements.

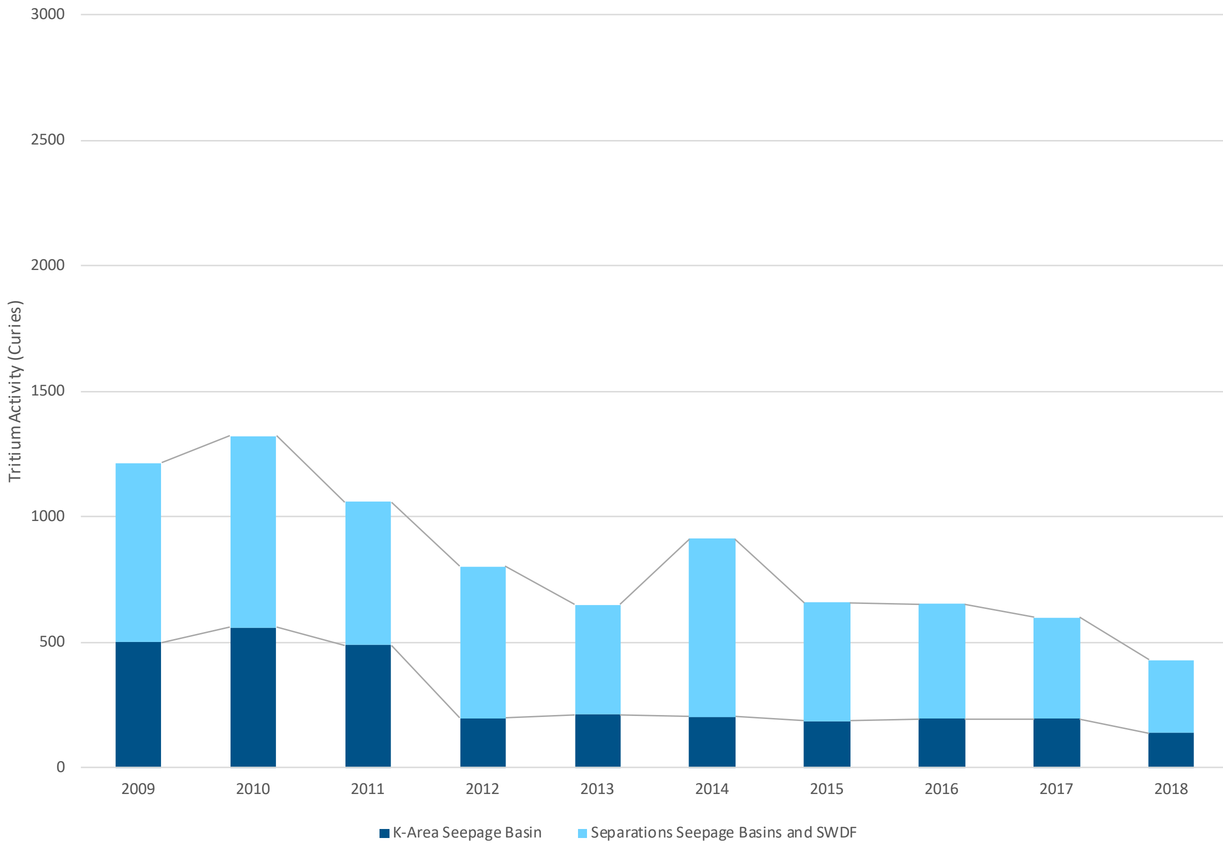


Figure 5-9 Tritium Migration from SRS Seepage Basins and SWDF to SRS Streams

5.4.4 Savannah River Sampling and Monitoring

SRS samples continuously 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 2018. 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 2018 concentrations of gross alpha, gross beta, and tritium, and the maximum 2018 concentrations of tritium at river locations. The tritium concentration levels are well below the EPA drinking water standard of 20 pCi/mL (20,000 pCi/L).

Table 5-7 Radionuclide Concentrations in the Savannah River for CY 2018

Location	Average Gross Alpha (pCi/L)	Average Gross Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
CONTROL (RM-160 and RM-161)	0.121	1.98	154	449
RM-150.4 (VEGP)	0.154	2.03	828	7840
RM-150	0.146	1.98	307	632
RM-141.5	0.246	2.08	495	2970
RM-118.8	0.160	1.97	421	1600

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 2,500 Ci in 2018 compared to 2,893 Ci in 2017. This decrease was due to decreased releases from VEGP. Total releases from VEGP were 1,314 Ci in 2018 compared to 2,337 Ci in 2017, which represents a decrease of greater than 43%. 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. 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, the Site 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

SRS bases its methods for estimating releases 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 2018, tritium levels in streams showed an increase, while river transport showed a decrease, specifically as described below:

- The direct releases (including migration) of tritium increased by 7.5% (from 494 Ci in 2017 to 531 Ci).
- The stream transport of tritium increased by 18% (from 563 Ci in 2017 to 666 Ci).
- The river transport of tritium decreased by greater than 13% (from 2,893 Ci in 2017 to 2,500 Ci). VEGP, BLLDF, and SRS contributed to these values. 36 Ci is attributed to the BLLDF. 1,314 Ci is attributed to VEGP.

SRS tritium transport data from 1960–2018 (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

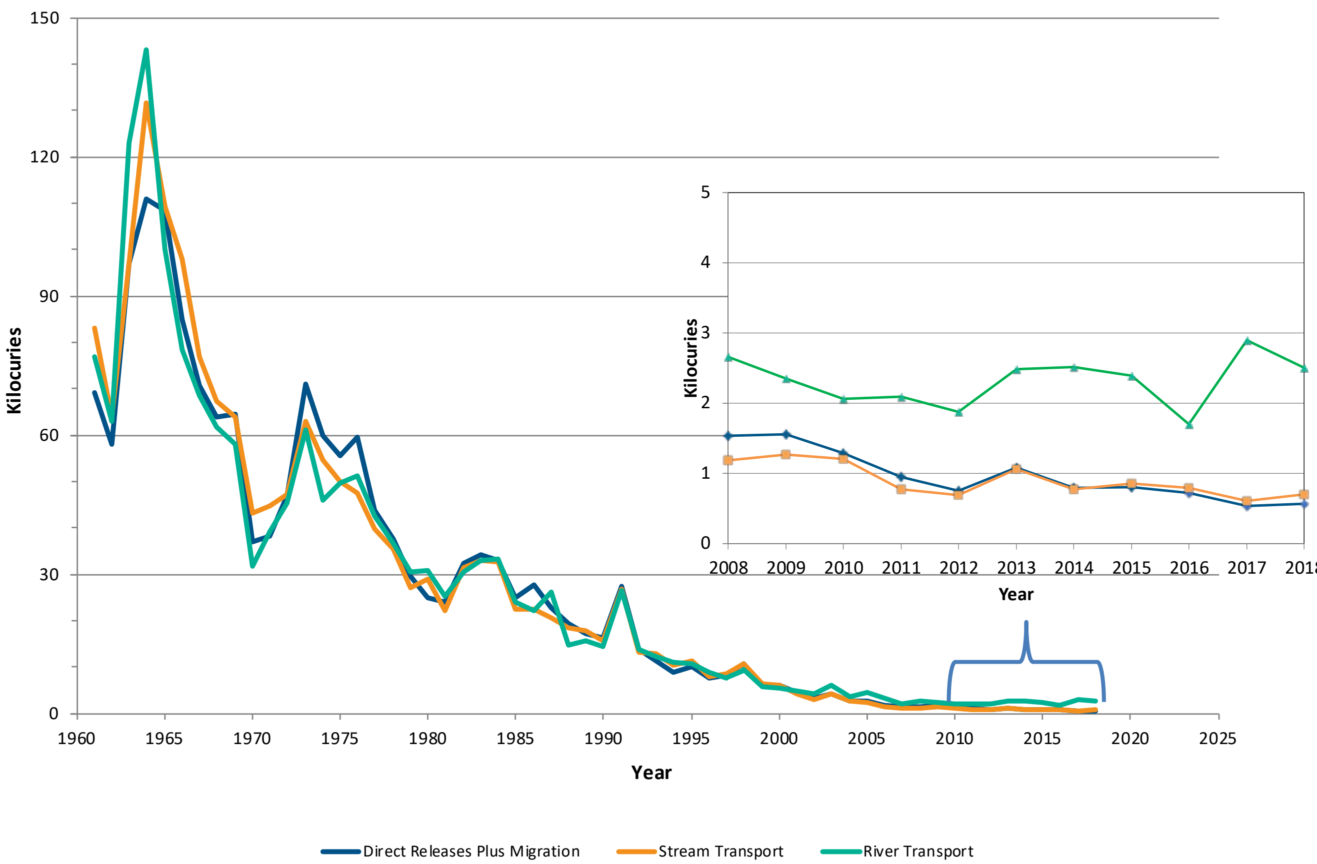


Figure 5-10 SRS Tritium Transport Summary

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 Marys 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 Marys Branch, which is near BLLDF, to account for the tritium BLLDF contributes. SRS estimated the amount of tritium from BLLDF during 2018 to be 36 Ci, which SRS direct release or stream transport totals did not include.

For compliance dose calculations, the Site uses whichever value is higher: SRS direct releases or the stream transport measurements (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, in conjunction with routine sediment monitoring, to determine whether a long-term buildup of radioactive materials occurs in stream systems.

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. Accurately measuring radioactivity levels in settleable solids is impractical in water samples with low total suspended solids (TSS). In 1995, DOE interpreted the radioactivity levels in settleable solids requirement. The interpretation indicated that TSS levels below 40 parts per million comply with the DOE limits.

To determine compliance with these limits, SRS uses TSS results gathered from radiological liquid effluent locations, National Pollutant Discharge Elimination System (NPDES) outfalls co-located at or near radiological liquid effluent locations, and water quality surveillance locations. If TSS results are regularly greater than 40 parts per million, SRS will investigate the cause and take additional water or sediment samples, or both, if necessary to ensure compliance.

5.4.6.1 <u>Settleable Solids Results Summary</u>

In 2018, all TSS averages were below the 40 parts per million limit. The TSS results indicate that SRS remains in compliance with DOE's requirement related to radioactivity levels in settleable solids.

5.4.7 Sediment Sampling

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 continuously moves and deposits 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 2018, SRS collected sediment samples at 11 Savannah River locations, 8 basin or pond locations, and 21 onsite streams or swamp discharge locations (Environmental Maps, *Radiological Sediment Sampling Locations*).

5.4.7.1 <u>Sediment Results Summary</u>

Appendix Table D-12 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 2,640 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 2018

Location	Maximum Location	Maximum Concentration (pCi/g)
Savannah River Sediment	Steel Creek River Mouth	9.63E-01
SRS Stream Sediment	R-Area (Downstream of R-1)	1.51E+01
SRS Basin Sediment	Z Basin	2.64E+03

The levels in SRS streams and the Savannah River show a decreasing trend, which is due to decreases in Site releases and the natural decay of radionuclides. The levels in the basins show no increases, with concentrations being within historical trends. 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 South Carolina locations (Figure 5-11):

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

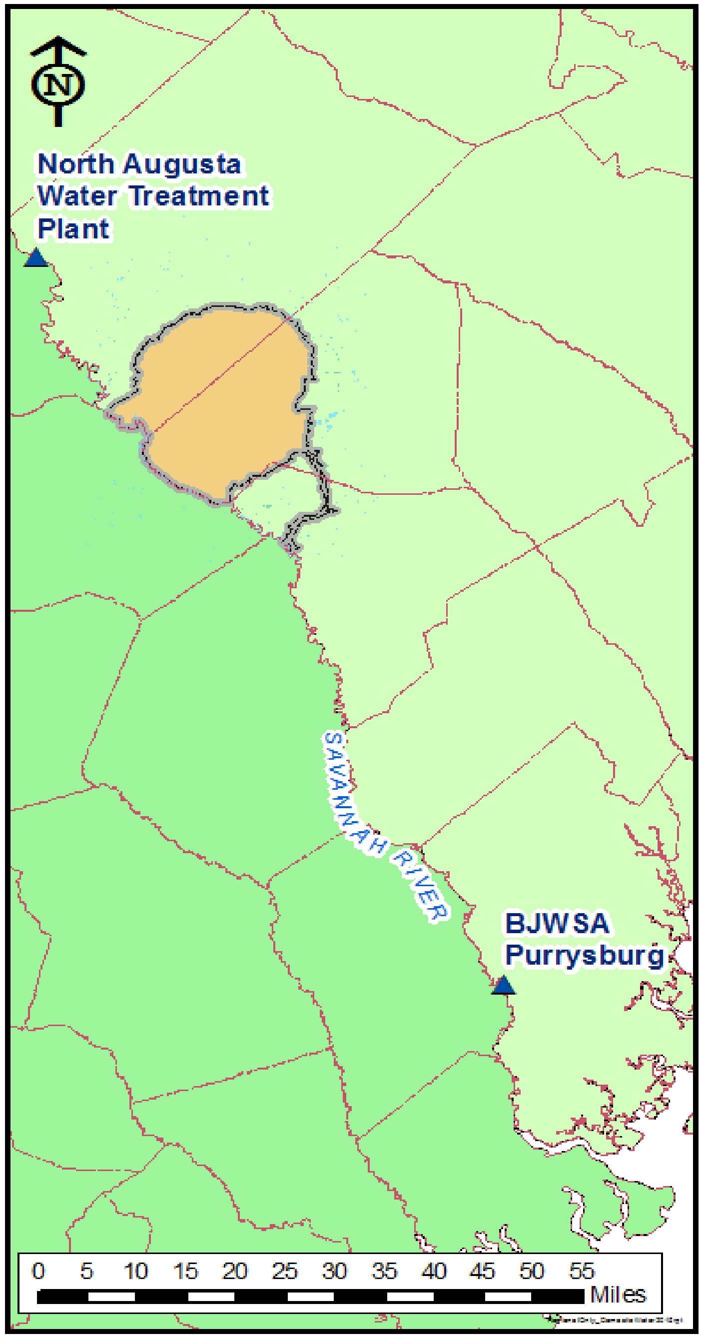


Figure 5-11 Offsite Drinking Water Sampling Locations

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 2018, 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 (20,000 pCi/L) EPA 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 compared to the average of weekly river water samples collected at RM 141.5. The average tritium concentration at RM 141.5 is approximately 2.5% of the EPA standard for tritium and decreases further at the downstream sampling location.

Sample results did not detect tritium, cobalt-60, cesium-137, strontium 89,90, uranium-235, plutonium-238, plutonium-239, and curium-244 in onsite drinking water test locations. Sample results indicated detectable levels of americium-241 in 4 onsite samples, uranium-234 in 8 onsite samples, and uranium-238 in 10 onsite samples. Appendix Table D-13 summarizes the results. Americium-241 concentrations are near the method detection limit, and the uranium is natural. All analytical results are well below the EPA standard.

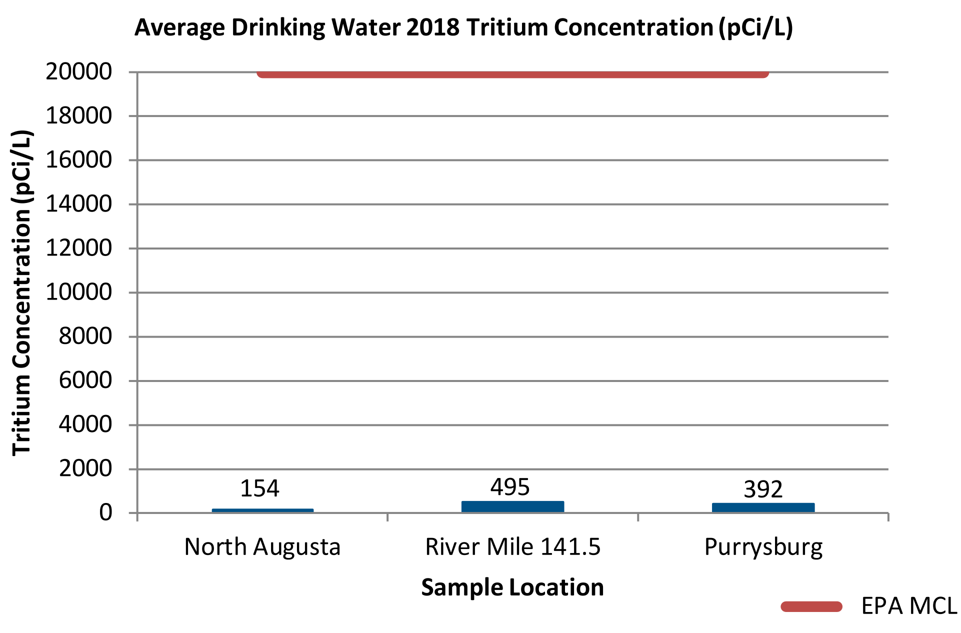


Figure 5-12 Tritium in Offsite Drinking Water and River Mile 141.5

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 or SRS purchases them from vendors in the Savannah area that harvest from local saltwater that waters of the Savannah River potentially influence. Table 5-9 identifies the aquatic products collected in 2018.

Table 5-9 Aquatic Products Collected by SRS in 2018 for the Radiological Environmental Monitoring Program

Freshwater Fish	Saltwater Fish	Shellfish
Bass	Mullet	Crab
Catfish		Shrimp
Panfish		

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. 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 2018, SRS collected freshwater fish from the six locations, saltwater fish and shrimp from the Savannah River mouth, and obtained crabs in the Savannah area from a supplier that harvests from saltwater potentially influenced by Savannah River water. SRS analyzed 54 freshwater fish composites, 3 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 (61% for freshwater fish, 78% for saltwater fish, and 90% 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 detected radionuclide. SRS did not detect cobalt-60 and iodine-129 in any fish flesh samples. Appendix Tables D-14, D-15, and D-16 for freshwater fish, saltwater fish and shellfish, respectively, summarize results for all fish and shellfish.

Gross alpha results were below the minimum detectable concentration for all saltwater and freshwater fish. One gross alpha result was above the minimum detectable concentration but less than the trigger value, thus the Site did not analyze for actinides. 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 likely attributed to the naturally occurring radionuclide potassium-40.

Table 5-10 Location and Fish Type for the Maximum Detected Concentration of Specific Radionuclides Measured in Flesh Samples Collected in 2018

Radionuclide	Maximum Concentration	Location	Fish Type
Cesium-137	0.792 pCi/g	Upper Three Runs Creek river mouth	Bass
Strontium-89,90	0.00711 pCi/g	Steel Creek river mouth	Panfish
Technetium-99	0.104 pCi/g	Steel Creek river mouth	Catfish

Determining the potential dose and risk to the public, as reported in Chapter 6, *Radiological Dose Assessment*, includes data from the fish monitoring.

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 no individual exceeds the SRS Annual Administrative Game Animal Release Limit of 22 mrem/yr. Annual game animal hunts for deer, coyote, and feral hogs are open to the public. During 2018, SRS held one turkey hunt for Wounded Warriors and residents with mobility impairments in the spring and 13 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 uses the cesium-137 concentration detected in the edible flesh of the animal to calculate dose. A dose is assigned to each hunter for every animal harvested if the cesium-137 concentration is above the background concentration of 1.97 picocuries per gram (pCi/g) for hogs (Morrison et al., 2019) and 2.59 pCi/g for the deer and coyote (Aucott et al., 2017). 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. SRS collects bone samples at the same frequency as the flesh samples and analyzes them in the laboratory for strontium-89,90.

5.6.1 Wildlife Results Summary

During the hunts in 2018, SRS monitored a total of 275 deer, 66 feral hogs, 14 coyotes, and 27 turkeys. SRS did not assign a dose to any hunter during 2 of the 13 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 1.97 pCi/g for the hogs and 2.59 pCi/g for all others. All animals harvested during the 2018 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 14 coyotes and 6 hogs.

Appendix Table D-17 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 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 2018 field versus laboratory measurement for each deer 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 2018, all 45 deer bone and all 4 hog bone samples had detectable levels of strontium-89,90. Strontium-89,90 was detected in deer bone with an average of 3.35 pCi/g and a maximum of 8.86 pCi/g. Strontium-89,90 was detected in hog bone with an average of 2.53 pCi/g and a maximum of 3.05 pCi/g.

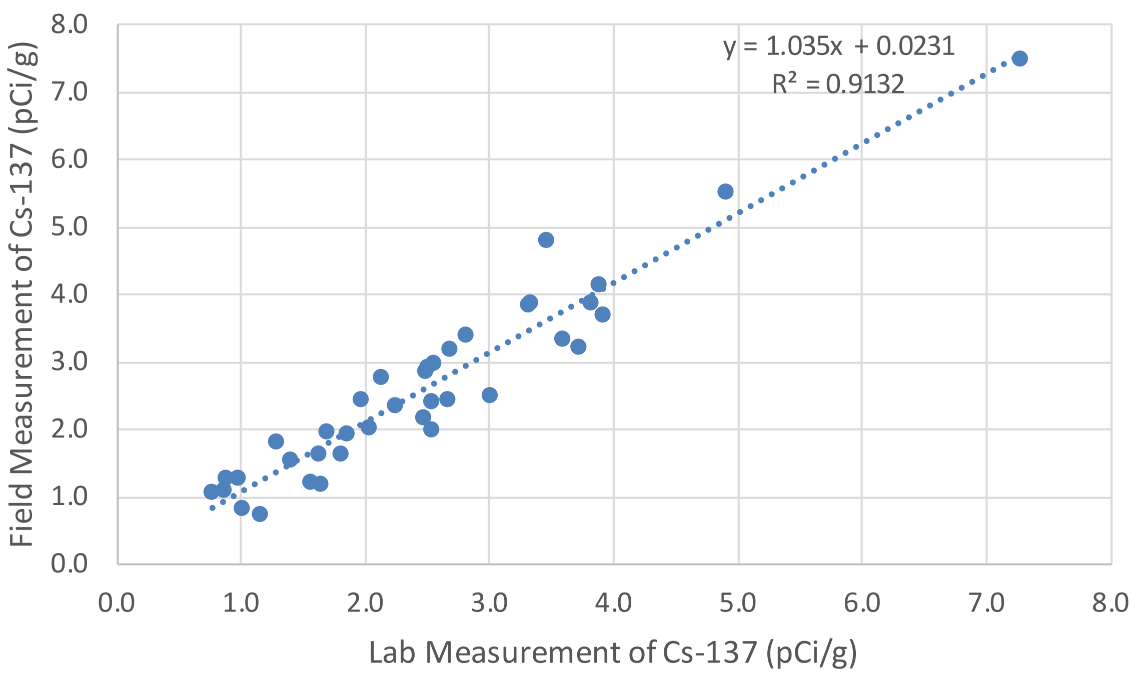


Figure 5-13 Comparison of 2018 Cesium-137 Field Measurements to Laboratory Analyses for Deer Muscle Samples

For the deer muscle tissue samples, 3 out of the 45 muscle tissue samples had levels greater than the minimum detectable concentration for strontium-89,90, with a maximum concentration of 0.014 pCi/g. These average results are similar to those of previous years. All cobalt-60 results were not detectable. One of 45 gross alpha results had levels greater than the minimum detectable concentration, with a maximum concentration of 0.152 pCi/g. Gross beta activity, detected in all samples, is consistent with 2008 through 2017 results.

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

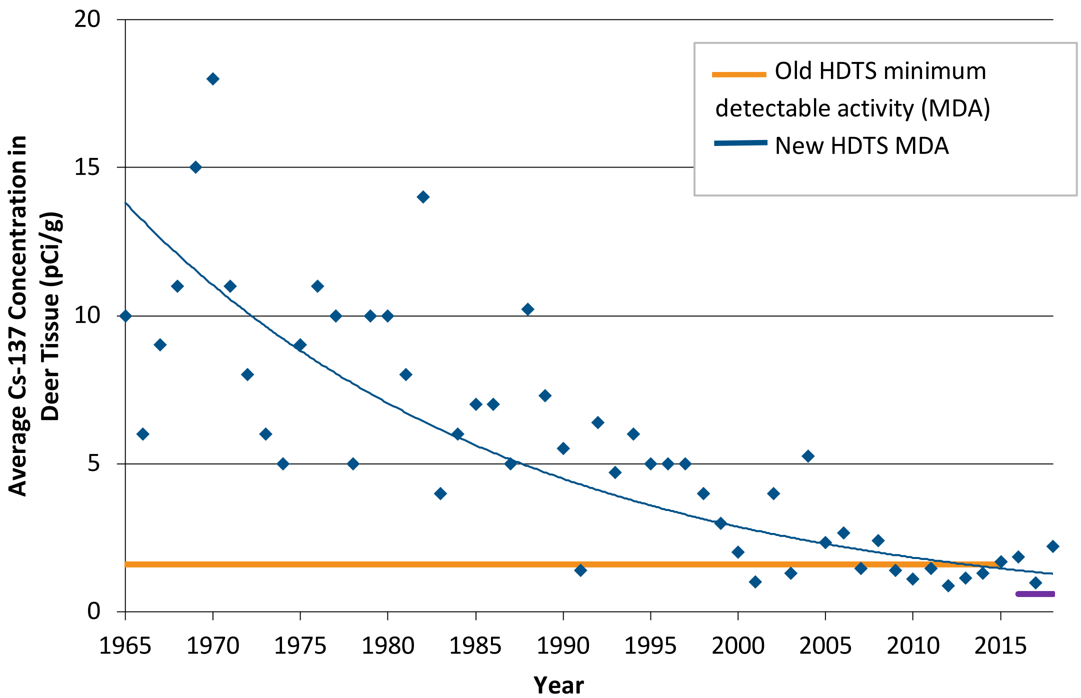


Figure 5-14 Historical Trend of Average Cesium-137 Concentration in Deer Tissue (1965-2018)

Table 5-11 Cesium-137 Results for Laboratory and Field Measurements in Wildlife for CY 2018

	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	275	2.22	7.79	45	44	2.21	7.27
Hog	66	1.58	6.01	4	4	2.35	6.35
Coyote	14	2.92	6.41	-----	-----	-----	-----
Turkey	27	1.14	1.27	-----	-----	-----	-----

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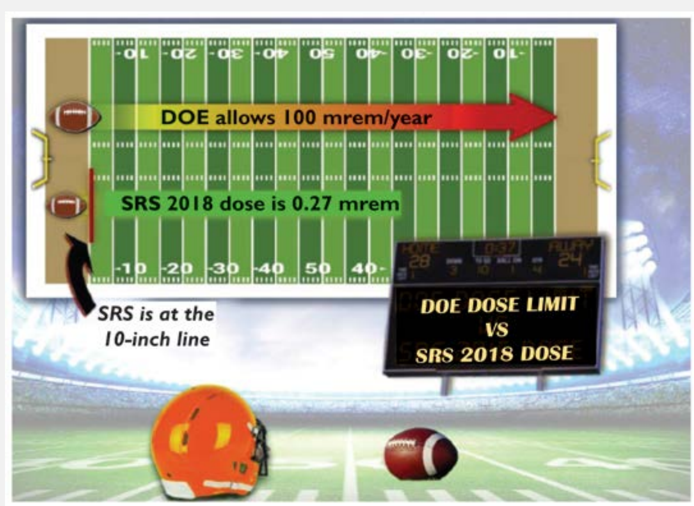
Chapter 6: **Radiological Dose Assessment**

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. 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.

2018 Highlights

Dose to the Offsite Representative Person—To comply with the DOE all-pathway dose limit of 100 mrem/yr, SRS conservatively adds the doses to the offsite representative person from both Site liquid and air pathways. In 2018, the dose to the offsite representative person was 0.19 mrem from liquid releases and 0.082 mrem from air releases. The total representative person dose was 0.27 mrem, which is 0.27% of the 100 mrem/yr DOE dose limit.



Comparison of DOE's 100 mrem/yr Dose Limit to SRS's 2018 All-Pathway Dose of 0.27 mrem

2018 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 11.1 mrem, or 11.1% of the 100 mrem/yr DOE dose limit.
- **Creek Mouth Fisherman**—SRS estimated the maximum potential dose from fish consumption from bass collected at the mouth of Lower Three Runs at 0.398 mrem. This dose is 0.398% of the 100 mrem/yr DOE dose limit. SRS bases this hypothetical dose on the low probability that, during 2018, a fisherman consumed 53 pounds (lbs) of bass 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 2018. SRS unconditionally released 13,774 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 2018, 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 2018.

Radiological Impact of 2018 Operations at the Savannah River Site (Jannik, Stagich, and Dixon 2019) 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 the human body absorbs 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, SRS can calculate dose 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

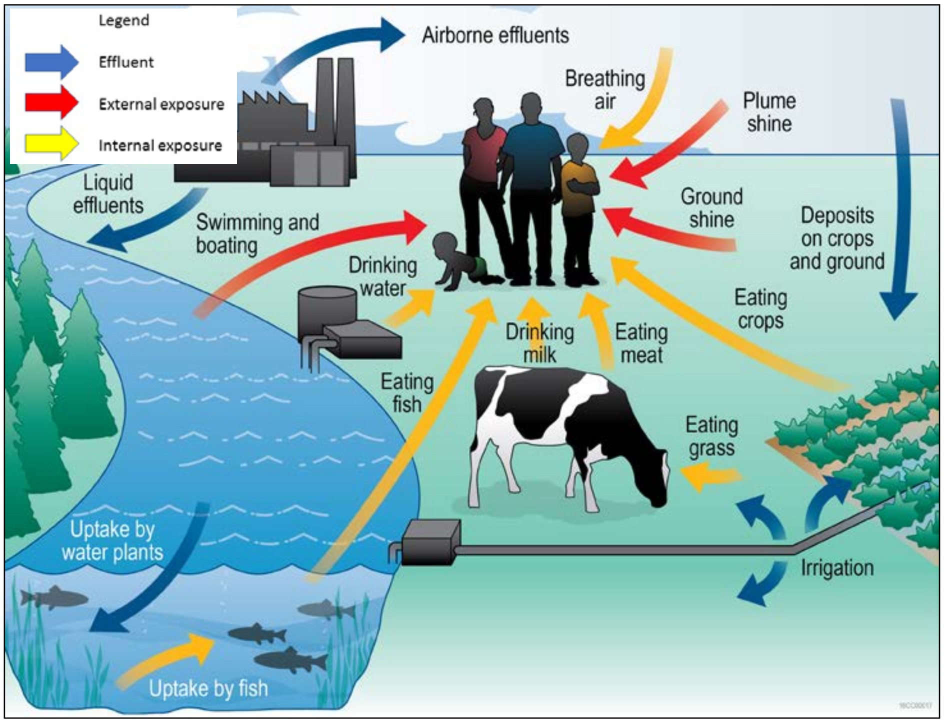


Figure 6-1 Exposure Pathways to Humans from Air and Liquid Effluents

are generally 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. 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.

To determine if the Site is complying with DOE public dose requirements, SRS calculates the potential doses to members of the public 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 for use.

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 6-2 presents the H-Area wind rose plot for 2007-2011 and shows the direction and frequency the wind blows. SRS bases its wind rose plot in H Area because it is where most of SRS's radiological air releases occur. 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.

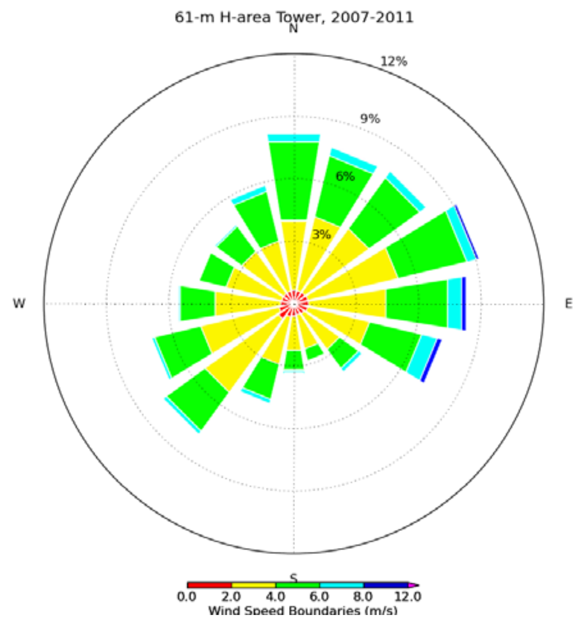


Figure 6-2 2007–2011 Wind Rose Plot for H Area (Showing Direction and Frequency Toward Which the Wind Blows)

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 River Mile (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 downriver of SRS at its RM 118.8 gauging station near the U.S. Hwy 301 Bridge.

Figure 6-3 provides the river flow rates USGS measured at this location from 1954 to 2018. 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 8,023 cfs.

For 2018, SRS used a calculated "effective" Savannah River flow rate of 5,667 cfs in the dose calculations. The 2018 effective flow rate is about 4% more than the 2017 effective flow rate of 5,460 cfs. This effective flow rate (based on actual measured tritium concentrations in the river) is more conservative than the 2018 USGS measured flow rate of 9,787 cfs (based on daily flow rates). By using a more conservative method, the calculated effective flow rate assumes radioactive material is less diluted and, therefore, increases the estimated potential dose.

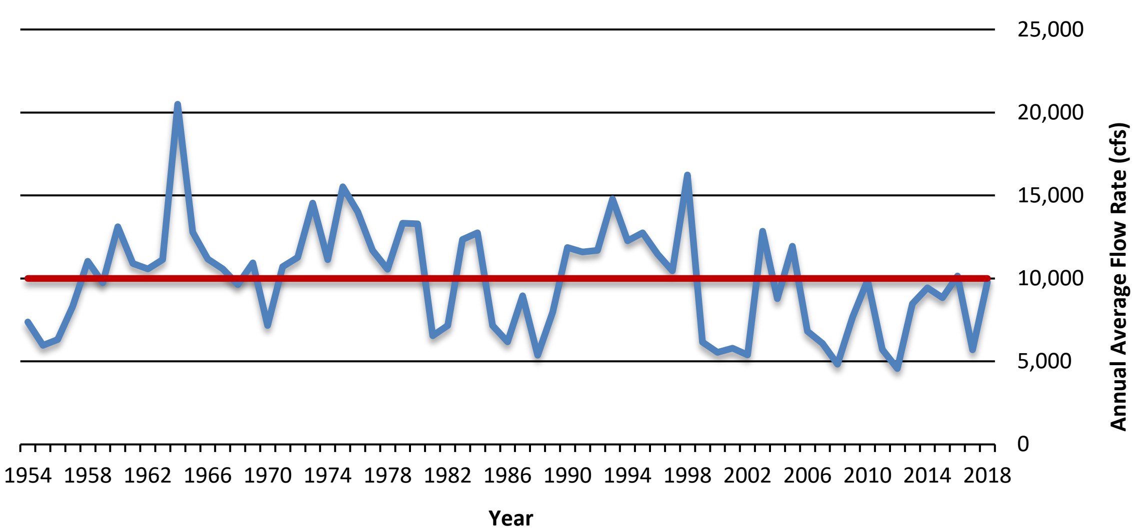


Figure 6-3 Savannah River Annual Average Flow Rates Measured by USGS at River Mile 118.8

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 total representative person dose.

6.4.1 Liquid Pathway

6.4.1.1 Liquid Release Source Terms

Table 6-2 shows, by radionuclide, the amount of radioactivity in liquid form that SRS released in 2018. SRS uses these release amounts in the dose calculations. Chapter 5, *Radiological Environmental Monitoring Program,* discusses these sources of data.

Table 6-2 2018 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]	2.50E+03	4.95E+02	3.92E+02	2.00E+04
C-14	6.22E-04	1.23E-04	9.73E-05	2.00E+03
Sr-90	3.18E-02	6.28E-03	4.97E-03	8.00E+00
Tc-99	2.84E-02	5.61E-03	4.44E-03	9.00E+02
I-129	1.66E-02	3.28E-03	2.60E-03	1.00E+00
Cs-137	1.07E-01	2.11E-02	1.67E-02	2.00E+02
Ra-226	1.03E-03	2.03E-04	1.61E-04	5.00E+00
U-234	2.95E-02	5.82E-03	4.61E-03	1.03E+01
U-235	5.74E-04	1.13E-04	8.98E-05	4.67E-01
U-238	3.22E-02	6.36E-03	5.03E-03	1.00E+01
Np-237	1.82E-06	3.59E-07	2.85E-07	1.50E+01
Pu-238	5.35E-05	1.06E-05	8.37E-06	1.50E+01
Pu-239	5.45E-06	1.08E-06	8.52E-07	1.50E+01
Am-241	1.36E-04	2.69E-05	2.13E-05	1.50E+01
Cm-244	6.81E-05	1.34E-05	1.06E-05	1.50E+01
Alpha	3.21E-03	6.34E-04	5.02E-04	1.50E+01
Beta	4.51E-02	8.90E-03	7.05E-03	8.00E+00

[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.

Tritium accounts for more than 99% of the total amount of radioactivity released from the Site to the Savannah River. In 2018, SRS released a total of 666 curies of tritium to the river, an 18% increase from the 2017 amount of 563 curies. For compliance dose calculations, SRS used the stream transport measurement (666 curies), which was higher than the direct release total (531 curies).

During 2018, in addition to the 666 curies SRS released, the Georgia Power Company's Vogtle Electric Generating Plant (VEGP) released 1,314 curies of tritium to the Savannah River, and about 36 curies migrated from the Barnwell Low-Level Disposal Facility (BLLDF). In Table 6-2, SRS used the "river transport" total of 2,500 curies of tritium, which includes SRS, VEGP, and BLLDF contributions. Refer to Chapter 5, *Radiological Environmental Monitoring Program*, Section 5.4.5 for details concerning these measurements.

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 2018, the 12-month average tritium concentration measured in Savannah River water near RM 141.5 was 495 picocuries per liter (pCi/L). This concentration is well below EPA's MCL for tritium of 20,000 pCi/L. 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 2018, SRS used the Steel Creek fish concentrations to determine the Site's overall cesium-137 release value of 0.107 Ci, which is 26% less than the 2017 value of 0.144 Ci.

6.4.1.2 Dose to the Representative Person

The 2018 potential dose to the representative person from all liquid pathways (including irrigation) was estimated at 0.19 mrem (0.0019 mSv), which is 14% less than the comparable dose in 2017.

Table 6-3 shows that the total liquid pathway dose is 0.19% of the DOE public dose limit of 100 mrem/yr (1 mSv/yr).

About 52% of the 2018 total dose to the representative person is from consuming vegetables that have been grown and meat and milk from animals that have been raised using Savannah River water from RM 141.5. The fish consumption pathway accounted for 40%, and the drinking water pathway accounted for 8%. As Figure 6-4 shows, cesium-137 (43%) and technetium (23%) contributed the most to the liquid pathway dose.

Table 6-3 Potential Dose to the Representative Person from SRS Liquid Releases in 2018

	Committed Dose (mrem)	Applicable Limit (mrem)	Percent of Limit (%)
Near Site Boundary (All Liquid Pathways)			
All Liquid Pathways Except Irrigation	0.092		
Irrigation Pathways	0.099		
Total Liquid Pathways	0.19	100[a]	0.19%

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

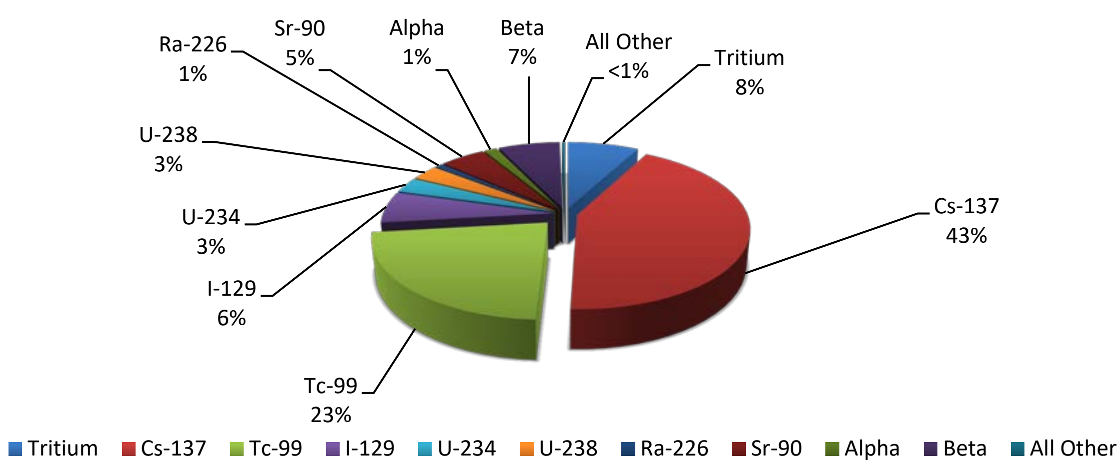


Figure 6-4 Radionuclide Contributions to the 2018 SRS Total Liquid Pathway Dose of 0.19 mrem (0.0019 mSv)

6.4.1.3 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 56%) customers of the three downriver water treatment plants received.

In 2018, SRS-only releases were responsible for a maximum potential drinking water dose of 0.012 mrem (0.00012 mSv). This dose is about 7% less than the 2017 dose of 0.013 mrem. SRS attributes this slight decrease to the 4% increase in the Savannah River effective flow rate during 2018, which caused more dilution. There is not a separate drinking water dose limit, but EPA bases its MCLs, as defined in 40 CFR 141 (EPA 2000), on a potential dose of about 4 mrem/yr for beta and gamma emitters.

6.4.1.4 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 or originate from animals kept 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.

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. In 2018, the collective dose from all liquid pathways was 3.4 person-rem (0.034 person-Sv). This dose didn't change from the 2017 dose of 3.4 person-rem.

6.4.2 Air Pathway

6.4.2.1 Air Release Source Terms

Chapter 5, *Radiological Environmental Monitoring Program*, documents the 2018 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.

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 2018, this comparison showed that the dose models used at SRS were about two to three times more conservative than the actual maximum measured tritium concentrations.

6.4.2.3 Dose to the Representative Person

The 2018 estimated dose from air releases to the representative person is 0.082 mrem (0.00082 mSv), 0.82% 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 of 10 mrem/yr. The 2018 dose is is higher than the 2017 dose of 0.027 mrem (0.00027 mSv). SRS attributes most of this increase to the increase in tritium oxide releases during 2018. The air pathway representative person is located at the SRS boundary in the north compass point direction, near New Ellenton, South Carolina.

Table 6-4 Potential Doses to the Representative Person and to the MEI from SRS Air Releases in 2018 and Comparison to the Applicable Dose Limit

	MAXDOSE-SR (Using DOE Dose Coefficients)	CAP88-PC (EPA NESHAP)
Calculated dose (mrem)	0.082	0.088
Applicable Limit (mrem)	10[a]	10[b]
Percent of Limit (%)	0.82	0.88

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

As Figure 6-5 shows, tritium releases were 95% of the air pathway dose to the representative person. Iodine-129 and cesium-137 each contributed about 2% to the dose. 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 (40%), consuming vegetables (35%), and consuming cow milk (23%).

In 2017, the Site began to calculate the potential dose for an adult worker at the Three Rivers Landfill near SRS's B Area. The public has direct access to the landfill from Highway 125, which is 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 2,000 hours during the year (8 hours a day, 5 days a week, 50 weeks a year). SRS also assumed that this worker was exposed only from the inhalation and external-exposure pathways. The Site did not consider any locally grown food consumption at this industrial location.

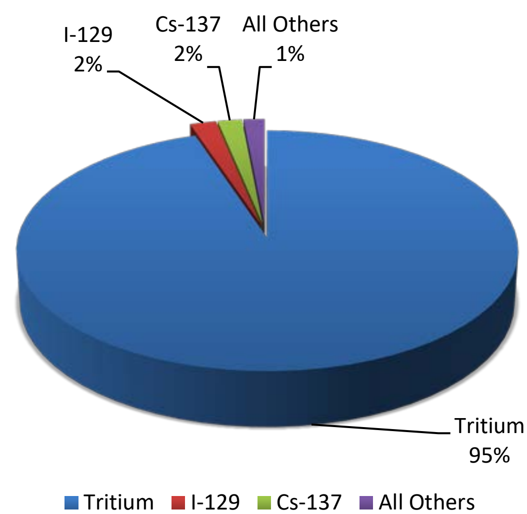


Figure 6-5 Radionuclide Contributions to the 2018 SRS Air Pathway Dose of 0.082 mrem (0.00082 mSv)

For 2018, SRS calculated a potential dose of 0.019 mrem (0.00019 mSv) to a Three Rivers Landfill worker. This dose is less than the representative person dose of 0.082 mrem that DOE reported to comply with DOE Order 458.1.

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 2018, SRS estimated the airborne-pathway collective dose to be 2.6 person-rem (0.026 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 EPA's 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 2018 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 2018, SRS calculated doses to two potential MEIs to demonstrate the Site 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. The second potential MEI was a worker at the Three Rivers Landfill. EPA requires that the Site consider all exposure pathways (including food consumption) for the potential MEI, even for an industrial worker.

NESHAP dose calculations use H Area as the location for all Site releases because a large majority of SRS's radiological air releases are from the area's tritium facilities (Minter et al. 2018).

SRS estimated the MEI dose at the Site boundary to be 0.088 mrem (0.00088 mSv). SRS estimated the MEI dose for the Three Rivers Landfill worker to be 0.087 mrem (0.00087 mSv). For 2018, SRS reported the slightly higher Site boundary dose of 0.088 mrem for NESHAP compliance. This dose is 0.88% of the 10 mrem/yr EPA limit, as Table 6-4 shows.

Tritium oxide releases accounted for 94% of the MEI dose, elemental tritium accounted for 2.9%, and cesium-137 accounted for 2.2%. The 2018 NESHAP compliance dose (MEI dose) is more than the 2017 dose of 0.029 mrem (0.00029 mSv). SRS attributes most of this increase to the increase in tritium oxide releases during 2018.

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.

For 2018, the potential representative person all-pathway dose is 0.27 mrem (0.0027 mSv), calculated as 0.19 mrem from liquid pathways plus 0.082 mrem from air pathways. As Table 6-5a shows, the all-pathway representative person dose is 0.27% of the 100 mrem/yr (1 mSv/yr) DOE dose limit. The all-pathway total dose is slightly more than the 2017 total dose of 0.25 mrem (0.0025 mSv).

Figure 6-6 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 2018, the total potential collective all-pathway dose is 6.0 person-rem (0.06 person-Sv), calculated as 3.4 person-rem from liquid pathways plus 2.6 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 6.0 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 2018

Pathways	Committed Dose (mrem)	Applicable Limit (mrem)	Percent of Limit (%)
Near Site Boundary (All Pathways)			
Total Liquid Pathways	0.19	100[a]	0.19%
Total Air Pathways	0.082	10[a,b]	0.82%
Total All Pathways	0.27	100[a]	0.27%

[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 2018)

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	2.6	Not Applicable	Not Applicable
Total All Pathways	6.0	243,000[a]	< 0.01%

[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).

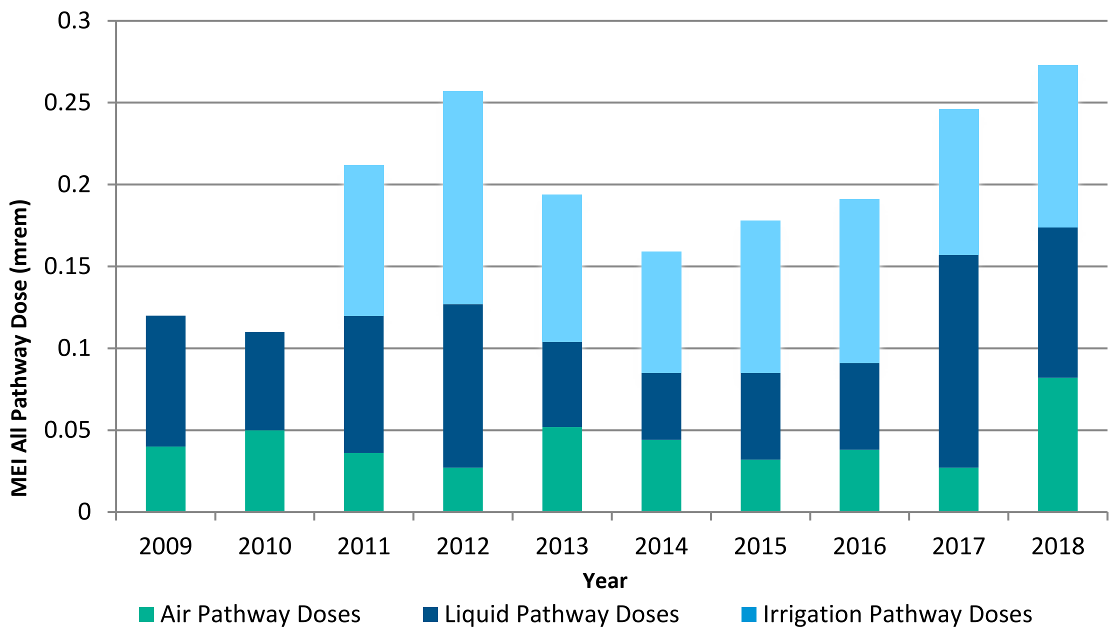


Figure 6-6 10-Year History of SRS Maximum Potential All-Pathway Doses

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 2018 as 11.1 mrem (0.111 mSv), or 11.1% of DOE's 100 mrem/yr dose limit. This dose is for an actual hunter who harvested one deer during the hunts. For the hunter-dose calculation, SRS conservatively assumes that this hunter individually consumed the entire edible portion, about 40 kilogram (kg) (88 lbs).

Turkey Consumption Pathway—SRS hosts a special turkey hunt in April for hunters with mobility impairments. Hunters harvested 27 turkeys in 2018. 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 (2.22 pCi/g) and hogs (1.58 pCi/g) harvested from SRS during 2018, the potential maximum doses from this pathway were estimated to be 7.01 mrem (0.0701 mSv) for the offsite deer hunter and 4.40 mrem (0.044 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. SRS used the soil concentration data obtained during the 2017 comprehensive survey of Creek Plantation for this assessment (SRNS 2018). 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 deer consumption pathway dose (7.01 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 8.87 mrem (0.0887 mSv). This potential dose is about 8.9% of the DOE 100 mrem/yr dose limit.

Table 6-6 2018 Sportsman Doses Compared to the DOE Dose Limit

	Committed Dose (mrem)	Applicable Standard (mrem)[a]	Percent of Standard (%)
Sportsman Dose			
Onsite Hunter	11.1	100	11.1
Creek-Mouth Fisherman[b]	0.398	100	0.398
Savannah River Swamp Hunter			
Offsite Hog Consumption	4.40		
Offsite Deer Consumption	7.01		
Soil Exposure[c]	1.86		
Maximum Offsite Hunter Dose (Deer + Soil Exposure)	8.87	100	8.87
Savannah River Swamp Fisherman			
Steel Creek Fish Consumption	0.159		
Soil Exposure[d]	2.08	100	2.24
Total Offsite Fisherman Dose (Fish + Soil Exposure)	2.24		

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

[b] The 2018 maximum dose to a hypothetical fisherman resulted from consuming bass 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 2018, 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 0.398 mrem (0.00398 mSv) from bass it collected at the mouth of Lower Three Runs. SRS bases this hypothetical dose on the low probability scenario that during 2018, a fisherman consumed 24 kg (53 lb) of bass caught exclusively from the mouth of Lower Three Runs. All 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 (0.159 mrem) and the Savannah River Swamp fisherman soil exposure dose (2.08 mrem) were added to conservatively obtain a total offsite fisherman dose of 2.24 mrem (0.0224 mSv). This potential dose is 2.24% 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 2018, SRS estimated the maximum potential lifetime risk of developing fatal and nonfatal cancer from consuming SRS creek-mouth fish to be 3.02E-07. That is, if 10 million people each received a dose of 0.398 mrem, there is a potential for 3.0 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 DOE approval. SRS did not release any real property in 2018, 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 2018. These measures ensure that radiological material releases from SRS are consistent with DOE Order 458.1 requirements.

SRS unconditionally released 13,774 items of personal property from radiological areas in 2018. Most of these items did not leave the SRS 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 using DOE Order 5400.5-derived supplemental limits for unconditionally releasing equipment and materials.)

In 2003, DOE approved an 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*

2018 Operations at the Savannah River Site (Jannik, Stagich, and Dixon 2019), 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 2018, 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 operate 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
- Riparian animals: 0.1 rad/day
- Terrestrial plants: 1.0 rad/day
- Terrestrial animals: 0.1 rad/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 2017), 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) and Level 2 screenings in 2018 using 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 locations passed the Level 1 or Level 2 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 2018, all land-based locations passed their initial Level 1 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*

2018 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 11,829 pounds (lbs) of volatile organic compounds (VOCs) from groundwater and the vadose zone and prevented 52 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. The well monitoring meets 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 ensures the Site is meeting South Carolina Department of Health and Environmental Control (SCDHEC) and U.S. Environmental Protection Agency (EPA) drinking water quality standards. SRS uses SCDHEC-certified laboratories to analyze groundwater samples.

The monitoring data show that most of the contaminated groundwater is in the central area of SRS, and none extends beyond the SRS boundary. Groundwater contamination at SRS is primarily limited to the Upper 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 range from active treatment, such as using oxidants to destroy the VOCs in-place, to passive measures, such as 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

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. It ranges in size from a few square feet to tens of acres and includes basins, pits, piles, burial grounds, landfills, tank farms, disposal facilities, process facilities, and contaminated groundwater.*

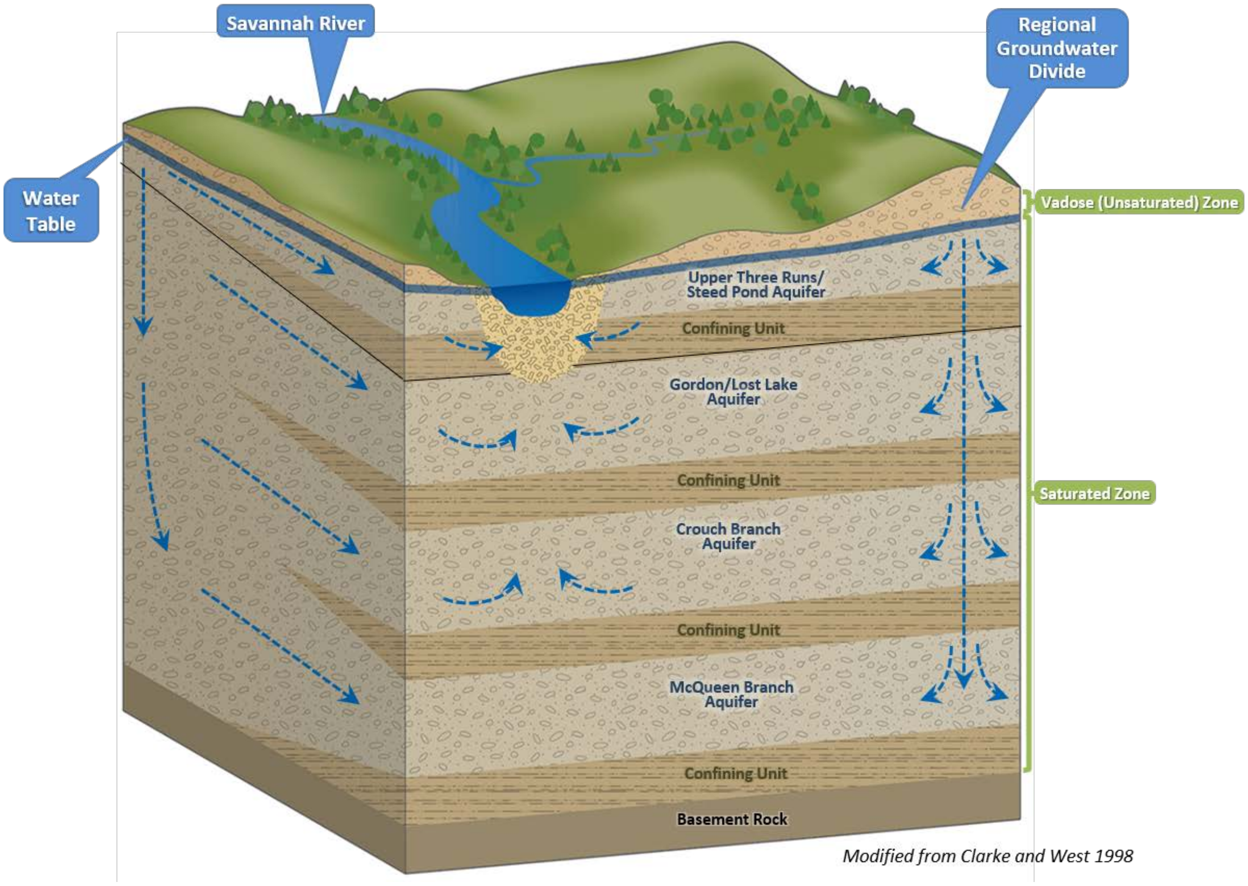


Figure 7-1 Groundwater at SRS

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).

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

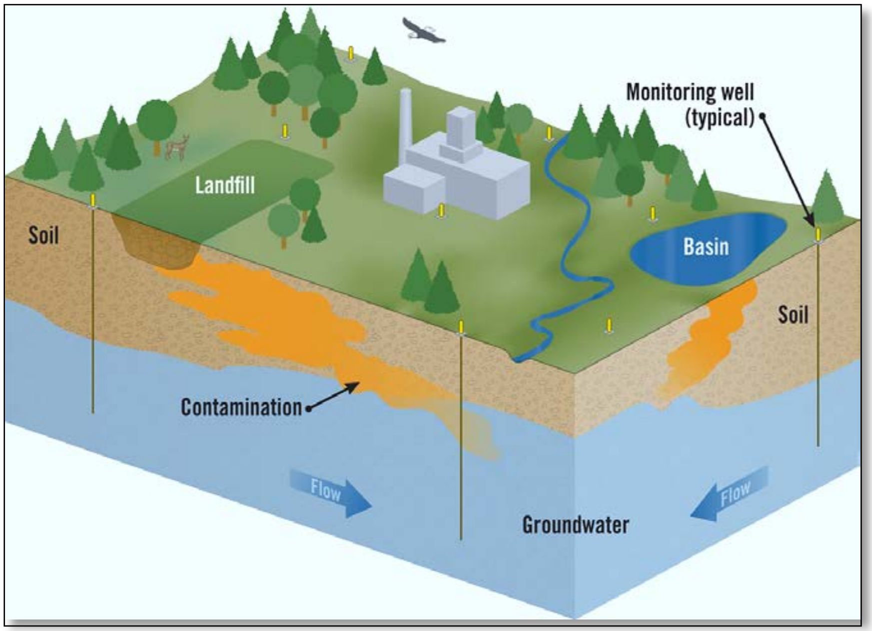


Figure 7-2 How Contamination Gets to Soil and Groundwater

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 receive groundwater flow.

Checking a BaroBall ™ (top photo)
and Sampling Equipment (lower photo)

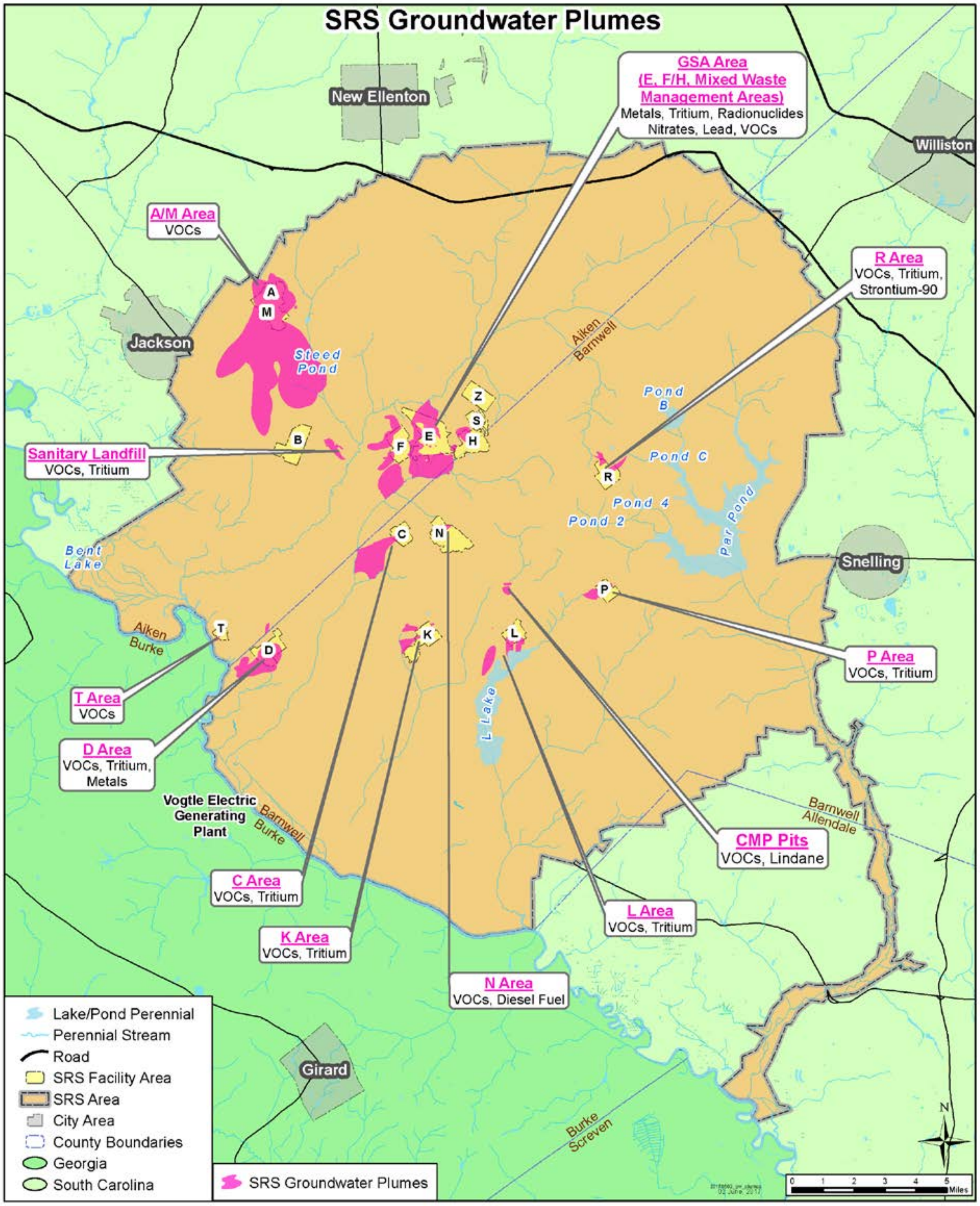


Figure 7-3 Groundwater Plumes at SRS

7.3.2.2 2018 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 2018 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 offsite 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 2018 results had no detectable concentrations of tritium.

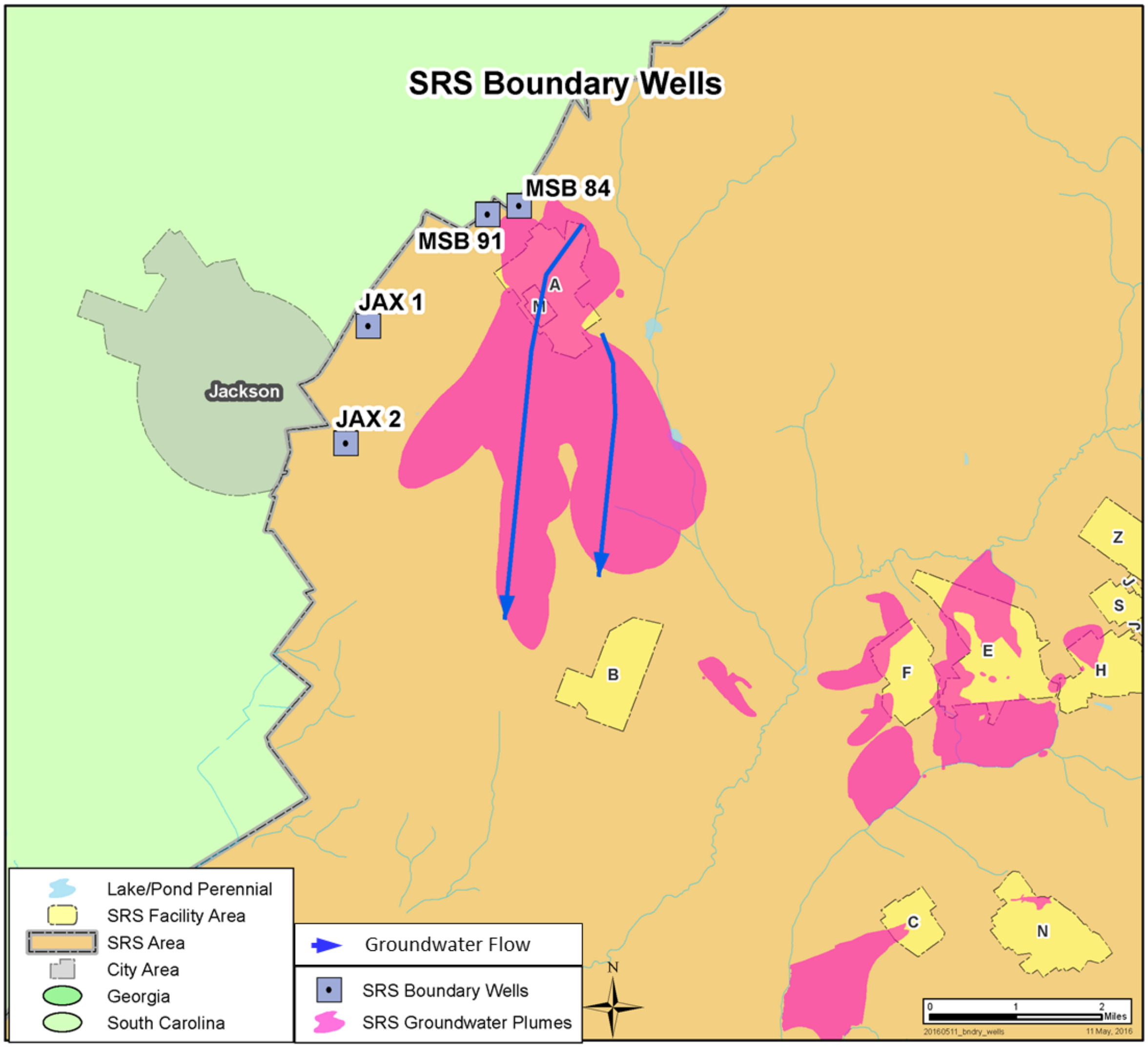


Figure 7-4 Location of Site Boundary Wells at SRS—Between A/M Area and Jackson, South Carolina

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	2018 Max Concentration	Well	MCL/ RSL	Likely Stream Endpoints
A/M Area	Tetrachloroethylene	µg/L	93,000	MSB004BR	5	Tims Branch/Upper Three Runs in Swamp in West
	Trichloroethylene	µg/L	41,900	MSB107B	5	
	1,4-Dioxane	µg/L	230	ARP 1A	6.1[a]	
C Area	Tetrachloroethylene	µg/L	8.9	CRP 5C	5	Fourmile Branch and Castor Creek
	Trichloroethylene	µg/L	2,600	CRP 20CU	5	
	Tritium	pCi/mL	4,110	CRW023C	20	
CMP Pits (G Area)	Tetrachloroethylene	µg/L	1,150	CMP 35D	5	Pen Branch
	Trichloroethylene	µg/L	685	CMP 35D	5	
	Lindane	µg/L	7.07	CMP 35D	0.2	
D Area	Beryllium	µg/L	151	DCB 23C	4	Savannah River Swamp
	Tetrachloroethylene	µg/L	11.1	DCB 45C	5	
	Trichloroethylene	µg/L	146	DCB 62	5	
	Vinyl Chloride	µg/L	16	DOB 15	2	
	Tritium	pCi/mL	298	DCB 26AR	20	
E-Area MWMF	Trichloroethylene	µg/L	280	BGO 35C	5	Upper Three Runs/Crouch Branch in North; Fourmile Branch in South
	1,4-Dioxane	µg/L	610	BSW 6C3	6.1[a]	
	Tritium	pCi/mL	10,300	BGO 35C	20	
	Nonvolatile Beta	pCi/L	46.5	HSP-097A	50[b]	

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

Location	Major Contaminant	Units	2018 Max Concentration	Well	MCL/ RSL	Likely Stream Endpoints
F Area	Trichloroethylene	µg/L	37.2	FGW003C	5	Fourmile Branch
	Tritium	pCi/mL	71.3	FGW012C	20	
	Gross Alpha	pCi/L	1,440	FGW005C	15	
	Nonvolatile Beta	pCi/L	1,170	FGW005C	50[b]	
F-Area HWMF	Trichloroethylene	µg/L	16.6	FSB 78C	5	Fourmile Branch
	Tritium	pCi/mL	1,270	FSB 78C	20	
	Gross Alpha	pCi/L	359	FSB 94C	15	
	Nonvolatile Beta	pCi/L	733	FSB 94C	50[b]	
F-Area Tank Farm	Tritium	pCi/mL	5.64	FTF 19	20	Fourmile Branch/Upper Three Runs
	Nonvolatile Beta	pCi/L	957	FTF 28	50[b]	
	Manganese	µg/L	169	FTF009R	430	
H Area	Trichloroethylene	µg/L	3.97	HGW 2D	5	Upper Three Runs/Crouch Branch in North; Fourmile Branch in South
	Gross Alpha	pCi/L	50.5	HAA 15A	15	
	Nonvolatile Beta	pCi/L	74.7	HAA 15A	50[b]	
	Tritium	pCi/mL	21.4	HAA 12D	20	
H-Area HWMF	Trichloroethylene	µg/L	170	HSB120C	5	Fourmile Branch
	Tritium	pCi/mL	1,340	HSB129C	20	
	Gross Alpha	pCi/L	40.3	HSB102D	15	
	Nonvolatile Beta	pCi/L	561	HSB102D	50[b]	
H-Area Tank Farm	Tritium	pCi/mL	49.9	HAA 12C	20	Fourmile Branch/Upper Three Runs
	Nonvolatile Beta	pCi/L	23.5	HAA 4D	50[b]	
	Manganese	µg/L	484	HAA 10D	430	
K Area	Tetrachloroethylene	µg/L	10	KRP 9	5	Indian Grave Branch
	Trichloroethylene	µg/L	7.1	KRP 9	5	
	Tritium	pCi/mL	2,210	KRB 19D	20	
L Area	Tetrachloroethylene	µg/L	50.7	LSW 25DL	5	L Lake
	Trichloroethylene	µg/L	2.15	LSW030DL	5	
	Tritium	pCi/mL	472	LSW 25DL	20	
P Area	Trichloroethylene	µg/L	6,410	PGW035C	5	Steel Creek
	Tritium	pCi/mL	785	PSC003D2	20	
R Area	Trichloroethylene	µg/L	22.1	RAG008B	5	Mill Creek in Northwest; Tributaries of PAR Pond
	Tritium	pCi/mL	335	RDB 3D	20	
	Strontium-90[c]	pCi/L	264	RSE 10	8	
Sanitary Landfill	1,4-Dioxane	µg/L	190	LFW 62C	6.1[a]	Upper Three Runs
	Trichloroethylene	µg/L	4.02	LFW 59C	5	
	Vinyl Chloride	µg/L	17.4	LFW 10A	2	
TNX	Trichloroethylene	µg/L	52.7	TRW 2	5	Savannah River Swamp
Z Area	Technetium-99	pCi/L	164	ZBG002D	900	Upper Three Runs
	Nonvolatile Beta	pCi/L	100	ZBG002D	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.
µg = micrograms

[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.

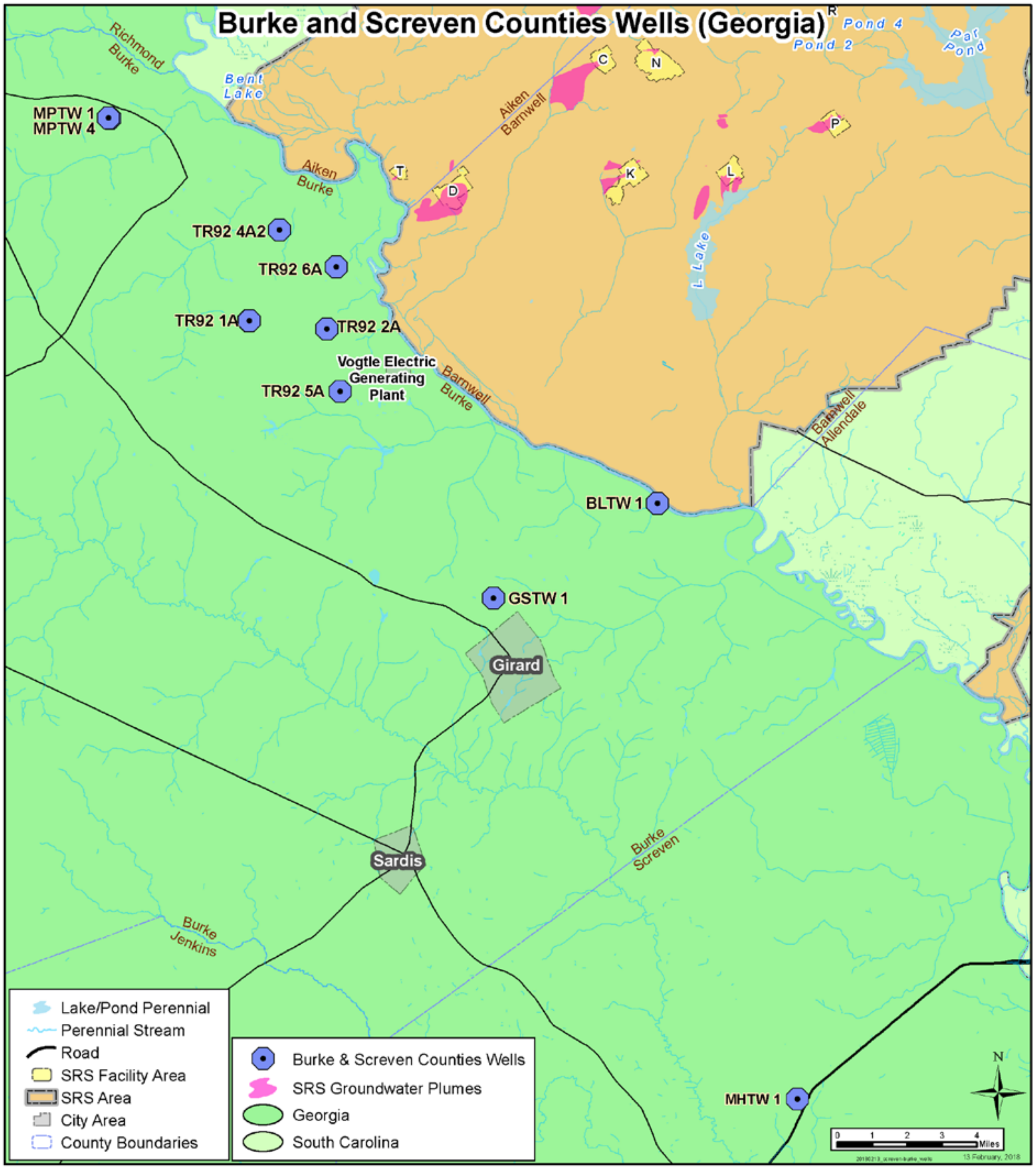


Figure 7-5 Location of Monitoring Wells Sampled for Tritium in Burke and Screven Counties, Georgia

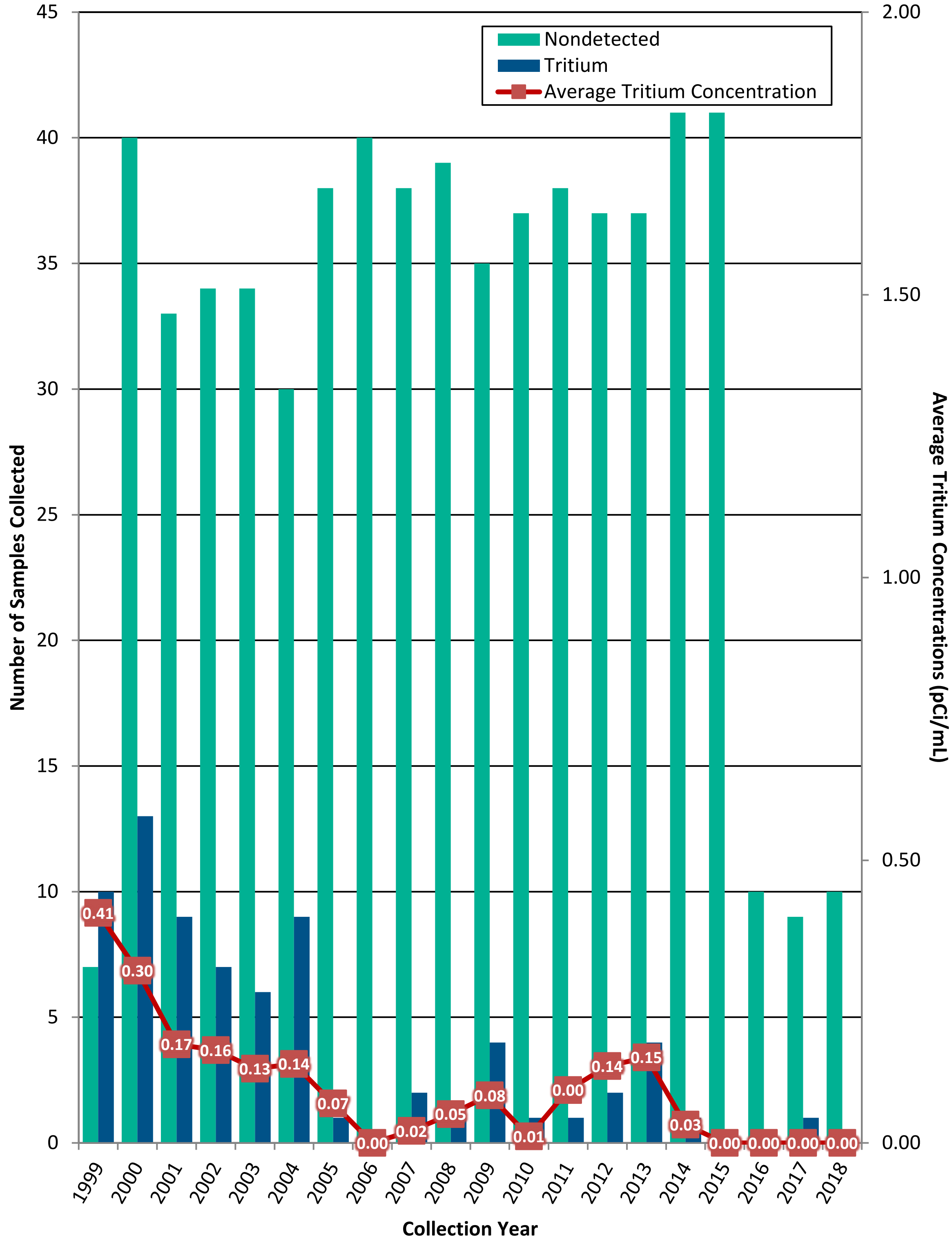


Figure 7-6 Tritium Concentration in Wells Sampled in Burke and Screven Counties, Georgia

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. Recently, SRS has placed an emphasis on converting soil vapor extraction (SVE) systems requiring permanent electrical power to passive systems using solar power or barometric pumping.

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-nine remediation systems are currently operating. In 2018, SRS removed 11,829 lbs of VOCs from the groundwater and the vadose zone and prevented 52 curies of tritium from reaching SRS streams (SRNS 2018). 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 phytoirrigation). 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 Hazardous Waste Management Facility [HWMF]), located in the general proximity of the "M" shown in Figure 7-4. Remediation at these two facilities began in 1983, when groundwater was pumped from wells to an above-ground treatment system, followed by SVE and then by thermal treatment, as shown in Figure 7-7. As of 2018, these technologies have removed 1.55 million pounds of solvent, consisting of TCE and PCE.

Treatment technologies that SRS has recently implemented to address VOCs include the in-place injection of oxidants and the addition of carbon source and microbes to stimulate bioremediation to intercept and destroy VOCs transported by groundwater. An innovative technology the Savannah River National Laboratory developed at SRS to address VOC contamination is humate amendment injection. Humate is an agricultural organic amendment. Humate injection consists of adding dissolved humate directly to the contaminated aquifer. This technology increases the sorption of TCE to aquifer sediment and biodegrades the TCE in the naturally oxygen-rich groundwater. A study investigating using humate amendments to enhance the attenuation of the VOCs began in 2017 and is in progress for the Southern Sector of the A/M Area plume. Humate injection is expected to continue into 2020.

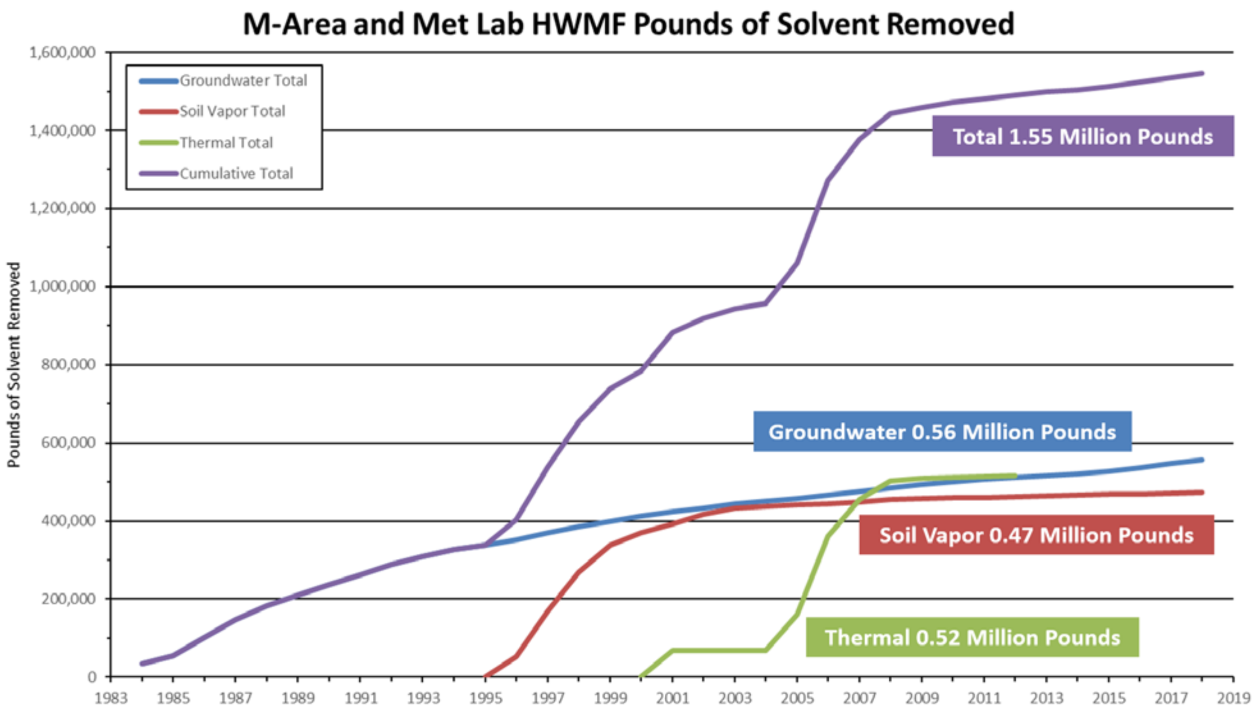


Figure 7-7 Solvent Removed from A/M Area Groundwater Plume

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 2018, SRS used 2.49 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 2018 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 2018 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. SRS uses the makeup water 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.

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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.

2018 Highlights

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

The DOE Consolidated Audit Program (DOECAP) in 2018 began requiring analytical laboratories providing service to DOE be accredited. Therefore, the three SRS subcontract laboratories that analyzed the environmental samples reported in this document obtained their accreditation, enabling them to continue to provide service to SRS.

The DOECAP audited three 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.

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.

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.

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 2018, QA efforts associated with the Environmental Monitoring Program that led to program improvements were as follows:

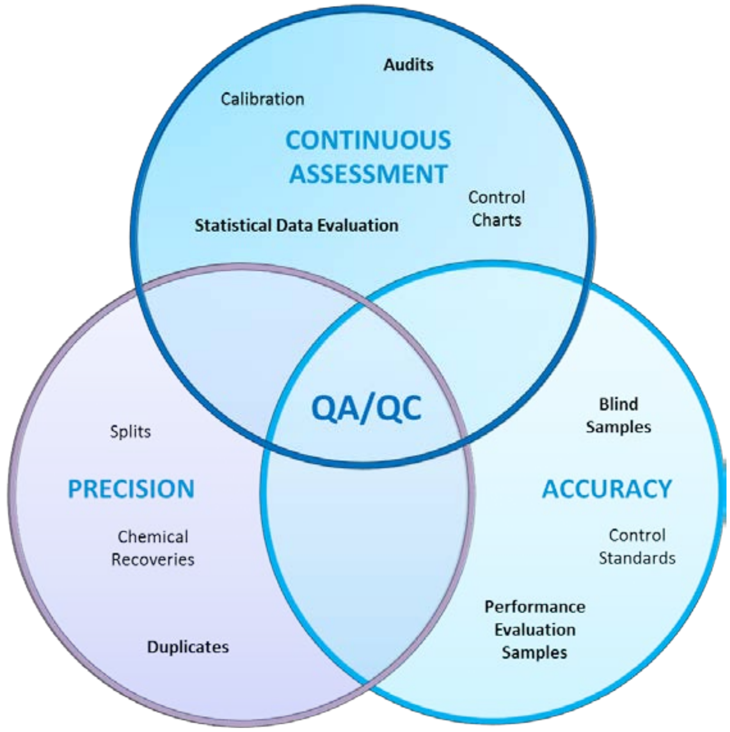


Figure 8-1 Interrelationship between QA/QC Activities

- Implemented monitoring program changes
- Performed DOECAP audits of commercial TSDFs SRS waste generators used

QC activities are the tests and checks that ensure SRS is complying with defined standards. In 2018, 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 2018, SRS implemented the following quality improvements:

- Air Effluent—Modified the sampling and analysis to support the 235-F facility deactivation and decommissioning that commenced in July 2018. SRS discontinued compositing and analyzing two one-week samples. All radionuclide analyses for air effluent samples from this facility are now based on a one-week sample period, allowing better clarity in determining release times.

Neptunium-237 and strontium-89/90 were added to the analysis because they are major contributors to the dose estimate. Updated the sample line collection efficiency, that is a variable in the dose calculation, to comply with requirements in the SCDHEC Construction Permit (Permit No. 0080-0041-C1).

- Air Effluent—Evaluated neptunium-237 results to optimize sampling frequency. In 2014, this analyte was added to the weekly monitoring for F- and H-Area Canyon stacks. The evaluation indicated the sampling frequency will remain weekly.
- Fish Surveillance—Discontinued collecting red drum and sea trout. This improvement is because the cesium-137 results from the past 10 years data are not detected.
- Foodstuff Monitoring—Replaced one milk sampling location that was near another milk sampling location. The replacement location provides sampling in an area that has not been sampled previously and provides the opportunity to collect goat milk. Small producers are typically the source for goat milk, which they sell locally. Due to differences in diet and digestive processes between goats and cows, both sources of milk will be included in the dairy program.
- Radiological Settleable Solids Program—Added 11 locations for total suspended solids analyses. This was based on a 2018 evaluation of current NPDES and radiological liquid effluent locations against DOE Order 458.1 requirements for monitoring settleable solids.
- River and Stream Water Quality Program—Beginning in August 2018, the analytical method for cadmium and lead changed resulting in a lower detection limit. The detection limit is now aligned with comparable SCDHEC standards.
- Savannah River Sampling—During the early summer of 2018, the Savannah River control location at River Mile (RM) 160 was moved one river mile upriver to RM 161. This was because of increased tritium levels observed at the RM 160 location. The hypothesis for these higher levels is that during high flooding events tritium from Upper Three Runs Creek flows to tributaries that are upriver of RM 160, thus, impacting results. The purpose of the control location is that it provides a measure of conditions prior to any SRS influences affecting the river water quality. Thus, it is located upriver of any SRS influence.

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 <u>DOECAP Laboratory Audits</u>

In 2018, the DOECAP evolved from an annual audit comprised of trained volunteer auditors from across the DOE Complex to a formal Accreditation Program. To receive and maintain DOECAP Accreditation, laboratories must be assessed by a DOECAP approved third-party Accreditation Body. Laboratories continue to be evaluated on technical capability and proficiency along with complying with DOE QA requirements. Laboratories are assessed on how well they 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 2018, the three SRS subcontracted laboratories that analyze the environmental samples documented in this annual report acquired their official DOECAP Accreditation. By obtaining (and maintaining) this Accreditation, it is determined that these facilities are acceptable to provide service to DOE or SRS.

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 2018, SRS provided 5 auditors that participated in the DOECAP audits of three commercial TSDFs. 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.

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 2018, 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. SRS also collects duplicate samples for both the radiological and nonradiological sediment samples.

The relative percent difference (RPD) between each sample and its blind or duplicate (comparing only when both values are at least 5 times above the detection limit) should be 20% or less. Table 8-1 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-eight percent (98%) of the blind samples, 95% of the NPDES duplicate samples, 97% of the water quality duplicate samples, and 94% of the sediment duplicate samples met the acceptable difference limit. The 3 NPDES blind samples with a difference greater than 20% represent 3 analytes. The 5 NPDES duplicate samples with a difference greater than 20% represent 4 analytes. The 22 water quality duplicate samples with a difference greater than 20% represent 9 analytes. The 3 sediment duplicate samples with a difference greater than 20% represent 3 analytes. Reasons for results differing for the programs include analytical uncertainties associated with the measurements, such as the precision of the analytical instruments and detection limits of the analytical instruments.

Table 8-1 Summary of Laboratory Blind and Duplicate Sample Analyses

Program and Sample Type	Number of Analyses	Number of Analyzes within Acceptable Limits (RPD between results < 20%)	Number of Analyzes Outside Acceptable Limits (RPD between results $\geq$ 20%)
NPDES Blind	122	119	3
NPDES Duplicate	103	98	5
Water Quality River/Stream Duplicate	648	626	22
River/Stream Sediment Duplicate	53	50	3

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 2018 there were no consistent problems with either sample collection or laboratory analysis techniques.

Table 8-2 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 8-2 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	42	42
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 2018, onsite and subcontracted laboratories participated in water pollution and water supply performance evaluation studies. Onsite laboratories reported proficiency of 100% and subcontracted laboratories reported proficiency greater than 94% for the parameters tested for NPDES and drinking water laboratories. 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 and SRS contracted laboratories 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 2018. The MAPEP studies include soil, vegetation, water, and air filter test samples. The SRS Environmental Laboratory participated in the two studies, receiving 100%

acceptable results in both MAPEP 38 and MAPEP 39. SRS subcontracted laboratories also participated in the MAPEP studies, receiving 100% acceptable results for both water and soil matrices.

When a laboratory fails an analysis, they will develop corrective actions for that failed analysis to prevent a reoccurrence. These corrective actions may include modifying procedures for preparing and analyzing samples.

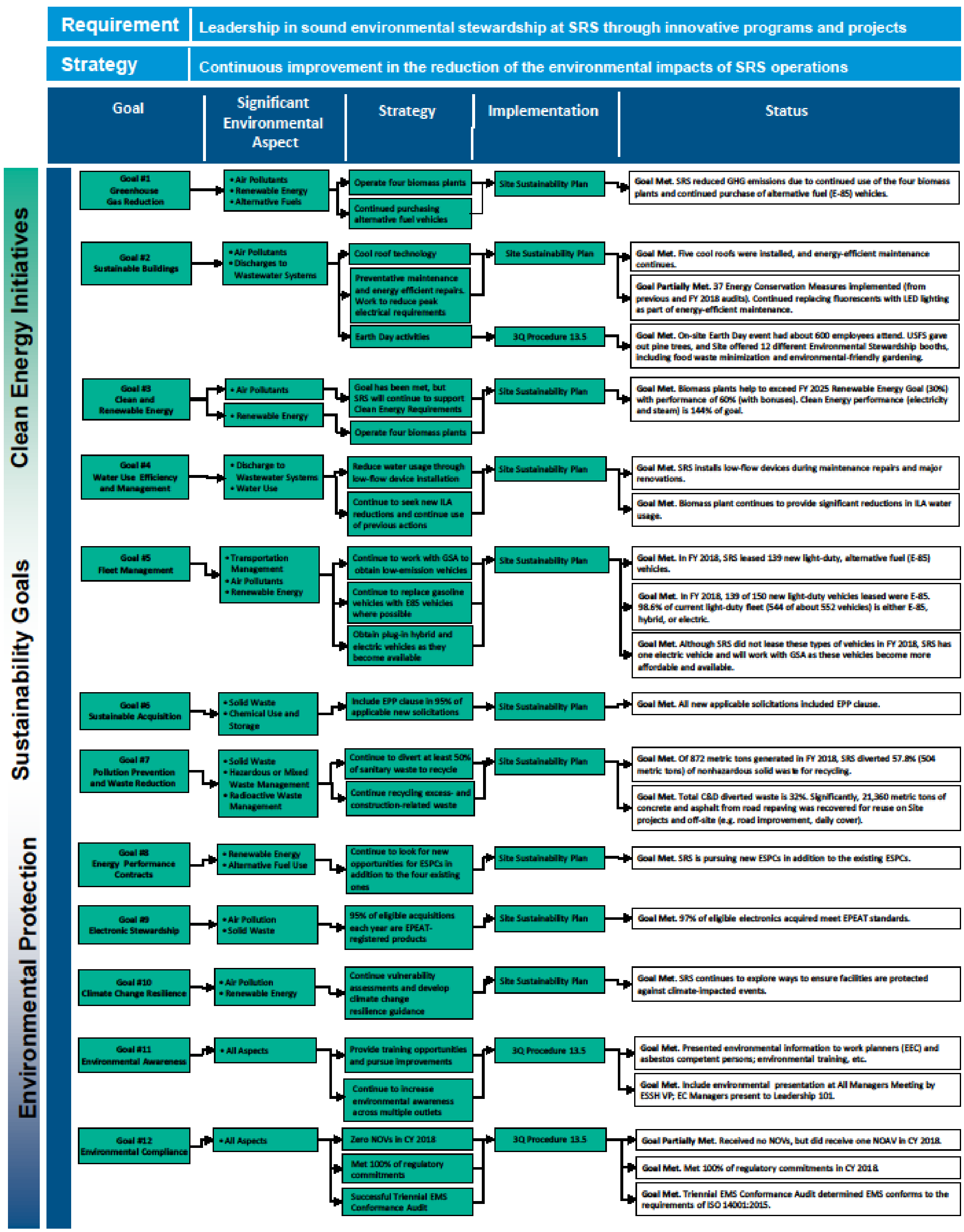
8.6 RECORDS MANAGEMENT

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 2018 EMS Goals and Objectives



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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			✓

[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 basin beds					✓
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 Results Summary

Five river and 11 stream locations were sampled monthly in 2018, totaling 192 samples per analyte or 4,032 records. Field duplicates are not included in the generation of these tables.

DL-Detection Limit

DO-Dissolved Oxygen

TOC-Total Organic Carbon

TSS-Total Suspended Solids

Analytical methods for cadmium and lead were changed beginning in August 2018, resulting in lower detection limits. Section 8.4 *Environmental Monitoring Program QA Activities* discusses this quality improvement. The result of this change is that average values for these two analytes at some locations are greater than the maximum value.

Note: The DO value in the maximum column is a minimum value because the SC Freshwater Quality Standard is based on a minimum value.

Four River Locations (excluding control)

Analyte	SC Freshwater Quality Std. (µg/L)	Unit	Number of Results Outside Std.	Number of Results > DL	Control RM 160.0		Highest River Location			
					Avg.[a]	Max.[b]	Avg.[a]		Max.[b]	
DO [c]	min. 4.0	mg/L	0 of 60	60 of 60	8.9	7.0	RM-129.1	8.3	RM-129.1	5.4
pH [d]	6.0-8.5	SU	0 of 60	60 of 60	6.1	7.4	RM-118.8	6.1	RM-141.5	7.4
Temperature	< 5° F (2.8° C) above nat. cond. & not > 90° F (32.2° C)	° C	0 of 60	60 of 60	18	29	RM-118.8	19	RM-118.8	26
Aluminum	87 [e]	µg/L	44 of 60	52 of 60	248	1,770	RM-150.4	262	RM-150.4	1,140
Beryllium	none	µg/L	no standard	4 of 60	All < DL		RM-129.1	0.2	RM-129.1	1.2
Cadmium	0.1	µg/L	37 of 60	11 of 60	0.3	0.1	RM-129.1	0.7	RM-129.1	4.1
Chromium	11	µg/L	0 of 60	2 of 60	All < DL		RM-129.1	2	RM-129.1	4
Copper	2.9	µg/L	1 of 60	5 of 60	2.1	3.2	RM-141.5	2.1	RM-141.5	2.8
Hardness (total)	none	mg/L	no standard	58 of 60	17	18	RM-129.1	42	RM-129.1	270
Iron	1,000 [f]	µg/L	4 of 60	60 of 60	531	2,650	RM-129.1	608	RM-150.4	1,720
Lead	0.54	µg/L	38 of 60	26 of 60	6.02	1.43	RM-141.5	6	RM-141.5	10
Manganese	none	µg/L	no standard	60 of 60	78	200	RM-118.8	82	RM-150.4	167
Mercury	0.91	µg/L	0 of 60	2 of 60	0.02	0.03	RM-118.8	0.02	RM-118.8	0.02
Nickel	16	µg/L	0 of 60	4 of 60	3	3	RM-129.1	3	RM-129.1	4
Nitrate-Nitrogen	1 [g]	mg/L	0 of 60	60 of 60	0.2	0.3	RM-118.8	0.3	RM-118.8	0.5
Nitrite-Nitrogen	1 [g]	mg/L	0 of 60	54 of 60	0.01	0.01	RM-150.4	0.01	RM-150.4	0.02
Thallium	none	µg/L	no standard	1 of 60	15	19	All < DL		All < DL	
TOC	none	mg/L	no standard	60 of 60	4	7	RM-129.1	4	RM-129.1	8
Phosphorus	0.06	mg/L	49 of 60	60 of 60	0.14	0.23	RM-150.4	0.14	RM-150.4	0.26
TSS	none	mg/L	no standard	60 of 60	8	43	RM-118.8	8	RM-150.4	30
Zinc	37	µg/L	1 of 60	38 of 60	5	16	RM-141.5	8	RM-141.5	38

Nine Stream Locations (excluding two controls)

Analyte	SC Freshwater Quality Std. (µg/L)	Unit	Number of Results Outside Std.	Number of Results > DL	Control TC-1		Control U3R-0		Highest Stream Location			
					Avg.[a]	Max.[b]	Avg.[a]	Max.[b]	Avg.[a]		Max [b]	
DO [c]	min. 4.0	mg/L	6 of 132	132 of 132	8.8	6.6	8.9	7.6	FMC-2	4.7	FMC-2	1.1
pH [d]	6.0-8.5	SU	5 of 132	132 of 132	6.1	7.7	5.7	8.5	FMC-2	5.6	U3R-4	8.1
Temperature	< 5° F (2.8° C) above nat. cond. & not > 90° F (32.2° C)	° C	0 of 132	132 of 132	18	29	19	32	SC-4	20	SC-4	28
Aluminum	87 [5]	µg/L	99 of 132	117 of 132	113	240	161	477	PB-3	294	TB-5	737
Beryllium	none	µg/L	no standard	16 of 132	All < DL		0.1	0.2	FMC-2	0.3	FMC-2	1.7
Cadmium	0.1	µg/L	80 of 132	16 of 132	All < DL		0.3	0.6	FMC-2	0.8	FMC-2	5.8
Chromium	11	µg/L	0 of 132	4 of 132	2	2	All < DL		FMC-2	2	FMC-2	3
Copper	2.9	µg/L	2 of 132	7 of 132	All < DL		All < DL		FMC-2	2.5	FMC-2	7.0
Hardness (total)	none	mg/L	no standard	60 of 132	6	16	All < DL		L3R-2	31	FM-2B	250
Iron	1,000[6]	µg/L	41 of 132	132 of 132	554	953	463	765	FMC-2	3,243	FMC-2	8,370
Lead	0.54	µg/L	80 of 132	56 of 132	5.97	0.48	6.00	0.67	PB at Rd A	6	PB at Rd A	12
Manganese	none	µg/L	no standard	132 of 132	25	54	9	20	FM-2B	265	FM-2B	1,020
Mercury	0.91	µg/L	0 of 132	7 of 132	0.02	0.02	All < DL		FMC-2	0.022	FMC-2	0.05
Nickel	16	µg/L	0 of 132	8 of 132	All < DL		All < DL		TB-5	4	TB-5	8
Nitrate-Nitrogen	1[g]	mg/L	2 of 132	132 of 132	0.1	0.3	0.4	0.6	FM-6	0.8	FM-6	1.1
Nitrite-Nitrogen	1[g]	mg/L	0 of 132	55 of 132	0.003	0.005	0.003	0.0034	FM-6	0.01	FM-6	0.03
Thallium	none	µg/L	no standard	0 of 132	All < DL		All < DL		All < DL		All < DL	
TOC	none	mg/L	no standard	132 of 132	6	11	3	11	FMC-2	8	FMC-2	14
Phosphorus	0.06	mg/L	106 of 132	130 of 132	0.16	0.32	0.08	0.20	FM-6	0.16	PB at Rd A	0.34

Analyte	SC Freshwater Quality Std. (µg/L)	Unit	Number of Results Outside Std.	Number of Results > DL	Control TC-1		Control U3R-0		Highest Stream Location			
					Avg.[a]	Max.[b]	Avg.[a]	Max.[b]	Avg.[a]		Max [b]	
TSS	none	mg/L	no standard	129 of 132	6	17	11	57	TB-5	14	PB-3	72
Zinc	37	µg/L	4 of 132	106 of 132	8	34	6	13	FMC-2	15	L3R-2	73

Note:
The following pesticides, herbicides and PCBs were sampled quarterly in 2018: Aldrin, Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC (Lindane), Chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Heptachlor, Heptachlor epoxide, Toxaphene, 2,4-D and 2,4,5-TP (Silvex). 1,728 analytical records were reviewed. All results were < DL except three Lindane and one beta-BHC.

[a] When results fell below the detection limit, the detection limit value was used to determine average
[b] Maximum detected value
[c] Min. (versus Max.) value reported
[d] Min. (versus Avg.) value reported
[e] EPA Region 4 Ecological Risk Assessment Supplemental Guidance Interim Draft, 2015
[f] EPA National Recommended Water Quality Criteria - Aquatic Life
[g] Per DHEC Environmental Surveillance and Oversight Program 2017 Data Report (CR-004111 2/19) and Oversight Program

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

SRS collected annual sediment samples at 25 locations in 2018—8 Savannah River, 14 stream, and 3 stormwater basins, totaling 476 analytes. Locations sampled are as follows: Savannah River locations (BDC RM, RM 118.7, RM 129, RM 150.2, RM 150.4 [Vogtle discharge], RM 157.2, RM 160.0, and SC RM), SRS Stream locations (BDC, FMC @ Rd A, L3R-2, L3R-3, McQB below Z-Basin, McQB @ MO, Meyers Branch, PB @ Rd A, SC-4, TC-1, U3R-0, U3R-4, U3R off Rd 4, and U3R @USFS Rd 2-1), and SRS Stormwater Basin locations (E-001, E-002, and E-003). The control location for the river samples was changed from RM 160.0 to RM 161.0 mid-year 2018 as documented in chapter 8, *Quality Assurance*. The control location for the stream and stormwater basin sediment samples is Upper Three Runs U3R-0 (U3R-0_SED).

The table compares all results to EPA Region 4 Refinement Screening Values (RSV) for Sediment and shows the maximum value of each analyte for the river, stream, and stormwater basin samples. Locations exceeding RSVs are shown in red text.

The field duplicate samples are included in the data evaluations performed when generating the tables.

River Sediment Results

8 River Locations (including control) + 1 Field Duplicate @ RM 157.2

Analyte	Number of Detected Results		Control RM 160 (mg/kg)	Location of Maximum Result	Maximum Conc (mg/kg)	EPA Region 4 Refinement Screening Value (RSV) for Sediment (mg/kg)	Number of Results > RSV
Aluminum	9 of 9		6,900	RM 150.4 (Vogtle discharge)	22,000	58,000	0
Arsenic	5 of 9	<	1.1	RM-150.2 & RM 150.4 (Vogtle discharge)	2.0	33	0
Barium	9 of 9		56	RM-150.2	160	60	8*
Chromium	9 of 9		11	RM-150.2	25.0	111	0
Copper	9 of 9		7.9	RM 150.4 (Vogtle discharge)	15.0	149	0
Iron	9 of 9		8,800	RM-150.2	21,000	40,000	0
Lead	9 of 9		4	RM-150.2 & RM 150.4 (Vogtle discharge)	11.0	128	0
Magnesium	9 of 9		770	RM-150.2	2,500	NA	NA
Manganese	9 of 9		640	RM-150.2	1,600	1,100	1
Nickel	9 of 9		4.8	RM-150.2	12	48.6	0
Zinc	9 of 9		76	RM-150.2 & RM 150.4 (Vogtle discharge)	55	459	0

Note: Cadmium, cyanide, mercury, selenium, silver, and uranium were nondetects.

* Two results greater than the RSV are the original and duplicate sample from one location.

Stream Sediment Results

14 Stream Locations (including control) and 2 Field Duplicates (L3R-3 and U3R@USFS Rd 2-1)

Analyte	Number of Detected Results	Control U3R-0 (mg/kg)	Location of Maximum Result	Maximum Conc (mg/kg)	EPA Region 4 Refinement Screening Value (RSV) for Sediment (mg/kg)	Number of Results > RSV
Aluminum	16 of 16	8,800	PB-Road A	15,000	58,000	0
Arsenic	7 of 16	< 3.2	U3R-USFS-RD2-1	3.3	33	0
Barium	16 of 16	94	L3R-3	104	60	6*
Chromium	16 of 16	13	L3R-3	29.9	111	0
Copper	15 of 16	7.1	L3R-3	8.4	149	0
Cyanide	3 of 16	< 2.3	U3R-Road 4	2.0	NA	NA
Iron	16 of 16	4,800	BDC & PB-Road A	12,000	40,000	0
Lead	16 of 16	19	L3R-3	12.5	128	0
Magnesium	6 of 16	< 1100	U3R-USFS-RD2-1	630	NA	NA
Manganese	16 of 16	18	L3R-3	897	1,100	0
Mercury	4 of 16	< 0.37	L3R-3	0.08	1.1	0
Nickel	9 of 16	< 8.5	BDC	12.0	48.6	0
Selenium	3 of 16	< 4.3	L3R-3	5.2	2.9	2*
Zinc	16 of 16	17	PB-Road A	45	459	0

Note:
Cadmium, silver, and uranium were nondetects.
* Two results greater than the RSV are the original and duplicate sample from one location.

Stormwater Basin Sediment Results

4 Locations (3 basins and the control)

Analyte	Number of Detected Results		Control U3R-0 (mg/kg)	Location of Maximum Result	Maximum Conc (mg/kg)	EPA Region 4 Refinement Screening Value (RSV) for Sediment (mg/kg)	Number of Results > RSV
Aluminum	4 of 4		8,800	E-001	17,000	58,000	0
Arsenic	2 of 4	<	3.2	E-001	3.0	33	0
Barium	4 of 4		94	E-002	45	60	0
Chromium	4 of 4		13	E-001	20	111	0
Copper	4 of 4		7.1	E-002	9.2	149	0
Iron	4 of 4		4,800	E-001	14,000	40,000	0
Lead	4 of 4		19	E-002	9.1	128	0
Magnesium	2 of 4	<	1100	E-002	1200	NA	NA
Manganese	4 of 4		18	E-002	80	1,100	0
Nickel	3 of 4	<	8.5	E-002	5.6	48.6	0
Zinc	4 of 4		17	E-002	71	459	0

Note:
Cadmium, cyanide, mercury, selenium, silver, and uranium were nondetects.

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 (µg/g)	SQL (µg/g)	MDC (µg/g)	Fish Type with Maximum Concentration	Location of Maximum Concentration
Mercury	124	64	1.84	0.2	0.02	Bass	Lower Three Runs Creek Mouth
Arsenic	20	20	1.51	7.34	0.734	Panfish	Augusta Lock and Dam (also known as New Savannah Bluff Lock and Dam)
Cadmium	4	4	0.728	0.769	0.077	Catfish	Hwy 301 Bridge
Chromium	116	114	0.851	0.527	0.053	Catfish	Upper Three Runs Creek Mouth
Copper	97	95	3.38	1.57	0.157	Catfish	Hwy 301 Bridge
Lead	1	1	0.808	7.03	0.703	Panfish	Hwy 301 Bridge
Manganese	93	92	3.39	0.750	0.075	Panfish	Fourmile Creek Mouth
Nickel	34	34	0.365	1.54	0.154	Panfish	Hwy 301 Bridge
Zinc	126	0	15.8	1.12	0.112	Bass	Upper Three Runs Creek Mouth

Note:

126 freshwater tissue samples were collected and analyzed for metals and 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, Georgia

All Results are for Mullet

Analyte	Number of Detected Values (above the MDC)	Number of Estimated Values (above the MDC, below the SQL)	Maximum Concentration (µg/g)	SQL (µg/g)	MDC (µg/g)
Chromium	7	7	0.22	0.693	0.069
Copper	4	4	0.159	1.40	0.140
Manganese	6	6	0.152	0.693	0.069
Zinc	7	0	3.68	1.39	0.139

Note:
Seven saltwater tissue samples were collected and analyzed for metals and mercury.

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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	1.42E+04	9.79E+02	2.27E+04		**3.78E+04**
H-3 (elemental)	12.3	y			1.49E+03		**1.49E+03**
H-3 Total	12.3	y	1.42E+04	9.79E+02	2.41E+04		**3.93E+04**
C-14	5700	y	5.34E-08		5.00E-02		**5.00E-02**
Hg-203	46.6	d	5.48E-10				**5.48E-10**
Kr-85	10.8	y			1.03E+04		**1.03E+04**
I-129	1.57E+07	y	7.66E-05		3.68E-03	1.42E-06	**3.76E-03**
I-131	8.02	d	1.13E-09				**1.13E-09**
Particles							
Ag-110m	250	d	1.48E-11				**1.48E-11**
Am-241	432	y	1.13E-05	2.44E-11	8.72E-06		**2.00E-05**
Am-243	7370	y	4.11E-09				**4.11E-09**
Ba-133	10.5	y	8.03E-07				**8.03E-07**
Cd-109	461	d	1.18E-08				**1.18E-08**
Ce-139	138	d	5.20E-10				**5.20E-10**
Ce-141	32.5	d	4.94E-11				**4.94E-11**
Ce-144	285	d	2.00E-08				**2.00E-08**
Cm-243	29.1	y	2.77E-09				**2.77E-09**
Cm-244	18.1	y	2.75E-07	0.00E+00	1.63E-07		**4.38E-07**
Co-57	272	d	4.76E-10				**4.76E-10**
Co-58	70.9	d			0.00E+00		**0.00E+00**
Co-60	5.27	y	6.40E-07	0.00E+00	2.31E-07	0.00E+00	**8.71E-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	4.26E-03	0.00E+00	8.86E-03	0.00E+00	**1.31E-02**
Eu-152	13.5	y	1. 39E-09				**1.39E-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	2.00E-02				**2.00E-02**
Fe-55	2.74	y	5.69E-09				**5.69E-09**
Mn-54	312	d	4.46E-10				**4.46E-10**
Nb-94	2.03E+04	y	2.42E-07				**2.42E-07**

Appendix Table D-1 Summary of Radioactive Atmospheric Releases by Source (continued)

Radionuclide	Half-Life [b]		Calculated [c]	Reactors	Separations [d]	SRNL	Total
Particles							
Nb-95	35.0	d	3.63E-07				**3.63E-07**
Ni-59	1.01E+05	y	5.76E-11				**5.76E-11**
Ni-63	100	y	5.05E-09				**5.05E-09**
Np-237	2.14E+06	y	1.54E-06	0.00E+00	1.81E-07		**1.72E-06**
Pa-233	27.0	d	1.42E-06				**1.42E-06**
Pb-212	10.6	h	8.43E-07				**8.43E-07**
Pm-147	2.62	y	2.89E-06				**2.89E-06**
Pm-148m	41.3	d	1.90E-12				**1.90E-12**
Pr-144	17.3	m	2.00E-08				**2.00E-08**
Pu-236	2.86	y	5.28E-10				**5.28E-10**
Pu-238	87.7	y	3.14E-05	9.50E-11	9.11E-06		**4.05E-05**
Pu-239	2.41E+04	y	6.67E-05	6.75E-10	1.18E-04		**1.85E-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	3.11E-06				**3.11E-06**
Ra-226	1600	y	1.21E-06				**1.21E-06**
Ra-228	5.75	y	1.19E-06	0.00E+00	0.00E+00		**1.19E-06**
Rh-106 [e]	29.8	s	3.04E-06				**3.04E-06**
Ru-103	39.3	d	5.11E-10				**5.11E-10**
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	6.47E-10				**6.47E-10**
Sn-123	129	d	6.66E-12				**6.66E-12**
Sn-126	2.30E+05	y	1.70E-07				**1.70E-07**
Sr-85	64.8	d	6.24E-10				**6.24E-10**
Sr-89	50.5	d	5.10E-10				**5.10E-10**
Sr-90	28.8	y	3.28E-03	0.00E+00	6.73E-05		**3.35E-03**
Tc-99	2.11E+05	y	5.08E-05				**5.08E-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	1.71E-09			**1.53E-08**
Th-229	7340	y	1.31E-09				**1.31E-09**
Th-230	7.54E+04	y	9.94E-11	5.14E-09			**5.24E-09**
Th-231	25.5	h	2.12E-04				**2.12E-04**
Th-232	1.41E+10	y	3.97E-12	2.38E-09			**2.38E-09**

Appendix Table D-1 Summary of Radioactive Atmospheric Releases by Source (continued)

Radionuclide	Half-Life[b]		Calculated[c]	Reactors	Separations[d]	SRNL	Total
Particles							
Tl-208	3.05	m	1.41E-06				**1.41E-06**
U-232	68.9	y	5.65E-09				**5.65E-09**
U-233	1.59E+05	y	3.36E-09				**3.36E-09**
U-234	2.46E+05	y	4.21E-07	2.27E-09	4.02E-05		**4.06E-05**
U-235	7.04E+08	y	1.37E-08	1.72E-10	2.53E-06		**2.54E-06**
U-236	2.34E+07	y	3.01E-08				**3.01E-08**
U-238	4.47E+09	y	2.75E-07	1.92E-09	6.18E-05		**6.20E-05**
Y-88	107	d	4.34E-10				**4.34E-10**
Y-90 [e]	64.1	h	3.28E-03	0.00E+00	6.73E-05		**3.35E-03**
Y-91	58.5	d	7.98E-10				**7.98E-10**
Zn-65	244	d	9.02E-10				**9.02E-10**
Zr-95	64.0	d	1.22E-07				**1.22E-07**
Unidentified alpha	N/A		1.41E-04	5.17E-06	1.35E-07	0.00E+00	**1.46E-04**
Unidentified beta	N/A		1.47E-03	7.56E-05	2.80E-04	1.39E-06	**1.83E-03**
TOTAL	N/A		1.42E+04	9.79E+02	3.45E+04	2.81E-06	**4.96E+04**

[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, Rh-106, & Y-90) in secular equilibrium with source terms (Sn-126, Ru-106, & 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	DCS Sum of Fractions Excluding Tritium
A Area (791-A Sandfilter Discharge)	I-129	1.42E-04	1.42E-04
C Area (C-Area Main Stack [148'])	H-3 (oxide)	1.76E+00	0.00E+00
F Area (235-F Sandfilter Discharge)	Sr-89/90, U-234, U-238, Pu-238, Pu-239, Am-241	3.66E-03	3.66E-03
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	3.19E+00	3.19E+00
F Area (772-4F Stack)	U-234, U-238, Pu-238, Pu-239, Am-241	1.46E-03	1.46E-03
H Area (291-H Stack Isokinetic)	H-3 (oxide), C-14, Kr-85, Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244	9.49E-01	8.33E-01
K Area (K-Area Main Stack)	H-3 (oxide)	1.72E+00	0.00E+00
L Area (L-Area Disassembly)	H-3 (oxide)	1.75E+00	0.00E+00
L Area (L-Area Main Stack)	H-3 (oxide)	1.90E+00	0.00E+00
Tritium (232-H)	H-3 (elemental), H-3 (oxide)	1.80E+01	0.00E+00
Tritium (233-H)	H-3 (elemental), H-3 (oxide)	7.21E+01	0.00E+00
Tritium (234-H)	H-3 (elemental), H-3 (oxide)	4.83E+00	0.00E+00
Tritium (238-H)	H-3 (oxide)	1.53E+00	0.00E+00
Tritium (264-H)	H-3 (elemental), H-3 (oxide), Co-60	1.00E+01	1.13E-05

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.

Location	Number of Detected Results	Mean Conc. (pCi/m^3)	Minimum Conc. (pCi/m^3)	Maximum Conc. (pCi/m^3)
Onsite				
Burial Ground North	27 of 27	2.61E+02	**5.32E+01**	**2.14E+03**
Site Perimeter				
Allendale Gate	3 of 27	1.11E+01	-2.70E+00	**1.81E+02**
Barnwell Gate	5 of 27	1.27E+01	-2.56E+00	**1.99E+02**
D Area	5 of 27	1.33E+01	-3.86E+00	**2.16E+02**
Darkhorse @ Williston Gate	11 of 27	1.31E+01	-2.97E+00	**8.97E+01**
East Talatha	6 of 27	1.77E+01	-5.00E+00	**1.88E+02**
Green Pond	6 of 27	3.71E+01	-2.08E+00	**7.54E+02**
Highway 21/167	4 of 27	1.69E+01	-2.89E+00	**2.97E+02**
Jackson	5 of 27	3.16E+01	-1.46E+00	**5.03E+02**
Patterson Mill Road	3 of 26	5.04E+00	-3.73E+00	**1.68E+01**
Talatha Gate	10 of 27	4.35E+01	-2.26E+00	**7.19E+02**
25-Mile Radius				
Aiken Airport	6 of 28	1.78E+01	-3.14E+00	**2.16E+02**
Augusta Lock and Dam 614	2 of 26	7.52E+00	-4.49E+00	**8.73E+01**
Highway 301 at State Line (control location)	3 of 27	1.32E+01	-3.27E+00	**2.47E+02**

Appendix Table D-4 Summary of Tritium in Rainwater

Samples were collected approximately every 4 weeks at each of 14 locations. Typically, 13 samples are collected from each location. This was the case in 2018, except for the Barnwell Gate and Darkhorse at Williston Gate sample locations where 12 samples were collected at each. 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, and Highway 21/167) and 25-Mile Radius (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. (pCi/L)	Minimum Conc. (pCi/L)	Maximum Conc. (pCi/L)
Onsite				
Burial Ground North	12 of 13	5.92E+03	2.78E+02	**2.73E+04**
Site Perimeter				
D Area	2 of 13	2.23E+01	-2.95E+02	**6.11E+02**
Darkhorse @ Williston Gate	1 of 12	1.03E+01	-1.78E+02	**3.57E+02**
East Talatha	2 of 13	6.53E+02	-2.12E+02	**6.97E+03**
Green Pond	3 of 13	7.58E+02	-2.36E+02	**7.78E+03**
Jackson	3 of 13	3.54E+02	-2.14E+02	**2.37E+03**
Patterson Mill Road	1 of 13	2.80E+00	-2.41E+02	**5.43E+02**
Talatha Gate	2 of 13	3.00E+02	-1.28E+02	**2.33E+03**
		25-Mile Radius		
Aiken Airport	1 of 13	5.73E+01	-2.70E+02	**9.14E+02**

Appendix Table D-5 Summary of Gamma Surveillance

Samples were collected approximately every quarter (12 weeks) at each of 50 locations. Typically five samples are collected from each location. This was the case in 2018, except for SRS site perimeter location, PP_57D, where samples were not retrieved during the first and second quarters of the calendar year.

Station Location Type	# of Stations	Quarter 1 Average mR/day	Quarter 2 Average mR/day	Quarter 3 Average mR/day	Quarter 4 Average mR/day	Annual Total Average mR/year	Annual Minimum mR/year	Annual Maximum mR/year
Population Centers	9	0.29	0.45	0.32	0.36	129	114.4	149.3
Site Perimeter	9	0.23	0.51	0.27	0.28	116	97.5	140.8
Air Surveillance Stations	14	0.24	0.41	0.29	0.30	113	91.8	159.0
Plant Vogtle Vicinity	18	0.22	0.36	0.26	0.29	103	84.5	135.7

Appendix D-6 Summary of Radionuclides in Soil

Samples are collected annually from 22 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: Creek Plantation Trail 1 (1175 ft), Creek Plantation Trail 1 (1600 ft), Creek Plantation Trail 1 (1805 ft), Creek Plantation Trail 6 (2000 ft), 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, Augusta Lock and Dam 614, and Highway 301 @ State Line). The Highway 301 @ State Line is the control location.

All Co-60 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	21 of 23	**1.52E-01**	Burial Ground (643-26E-2)	-1.41E-02	Creek Plantation Trail 1 (1805 ft)	**2.73E+01**
U-234	19 of 19	**1.57E+00**	Allendale Gate	**4.08E-01**	Augusta Lock and Dam 614	**1.36E+00**
U-235	18 of 19	**8.89E-02**	Aiken Airport	1.31E-02	Augusta Lock and Dam 614	**6.68E-02**
Np-237	1 of 18	1.11E-03	H Area (2000 feet east)	-5.05E-04	East Talatha	**2.46E-03**
U-238	19 of 19	**1.62E+00**	Allendale Gate	**4.24E-01**	Augusta Lock and Dam 614	**1.23E+00**
Pu-238	5 of 18	**5.70E-03**	Barnwell Gate	-2.84E-04	F Area (2000 feet west)	**2.68E-02**
Pu-239	16 of 18	**1.10E-02**	Burial Ground (643-26E-2)	4.46E-04	F Area (2000 feet west)	**4.27E-02**
Am-241	10 of 16	**6.03E-03**	Patterson Mill Road	2.09E-04	Burial Ground (643-26E-2)	**3.54E-02**
Cm-244	3 of 16	6.86E-04	H Area (2000 feet east)	-3.05E-04	Burial Ground (643-26E-2)	**6.95E-03**
Gross Beta	16 of 19	**6.24E+00**	Highway 21/167	1.40E+00	Burial Ground North	**2.73E+01**
Gross Alpha	19 of 19	**1.05E+01**	Patterson Mill Road	**2.73E+00**	Burial Ground North	**1.14E+01**

Appendix Table D-7 Summary of Radionuclides in Grassy Vegetation

Samples are collected annually from 14 locations. In 2018, 22 samples were collected 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, Np-237, Pu-238, Am-241, Cm-244, and gross alpha 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).

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	11 of 22	-8.59E-03	Patterson Mill Road	-1.04E-02	Burial Ground North	**9.49E+00**
Cs-137	4 of 15	1.55E-03	Burial Ground North	-2.45E-02	Highway 21/167	**3.70E-01**
Sr-89/90	15 of 15	**9.81E-02**	Talatha Gate	**9.05E-02**	East Talatha	**5.35E-01**
U-234	15 of 15	**2.32E-03**	Highway 21/167	**6.78E-04**	Burial Ground North	**4.14E-02**
U-235	3 of 15	1.42E-04	Allendale Gate	-3.86E-05	Burial Ground North	**2.19E-03**
U-238	14 of 15	**9.97E-04**	Highway 21/167	3.16E-05	Burial Ground North	**4.00E-02**
Pu-239	1 of 15	3.46E-05	Aiken Airport	-1.49E-04	Burial Ground North	**1.03E-03**
Tc-99	13 of 15	**3.32E-01**	Allendale Gate	7.81E-02	Burial Ground North	**9.46E-01**
Gross Beta	15 of 15	**7.22E+00**	Allendale Gate	**5.86E+00**	Green Pond	**1.54E+01**

Appendix Table D-8 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. Corn and pecans were the rotational crop samples collected in 2018.

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	5.65E-02	2.87E-02	**1.06E-01**
	U-234	5	4	6.63E-05	**4.54E-05**	**1.14E-04**
	U-238	5	5	1.02E-04	**5.19E-05**	**1.35E-04**
	Gross Beta	5	5	1.90E+00	**1.35E+00**	**2.16E+00**
	Cs-137, Co-60, Tc-99, 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	3	1.88E-02	6.16E-03	**3.19E-02**
	Sr-89,90	5	5	1.77E-01	**2.81E-02**	**3.38E-01**
	U-234	5	5	4.98E-03	**1.88E-03**	**6.51E-03**
	U-235	5	1	5.00E-04	-6.62E-06	**1.51E-03**
	U-238	5	5	5.00E-03	**2.61E-03**	**7.76E-03**
	Tc-99	5	5	5.04E-01	**3.05E-01**	**1.13E+00**
	Cm-244	5	1	3.39E-05	-1.16E-04	**3.43E-04**
	Gross Beta	5	5	2.14E+01	**1.61E+01**	**2.70E+01**
	Gross Alpha	5	1	5.94E-01	-4.08E-02	**1.70E+00**
	H-3, Co-60, Np-237, Pu-238, Pu-239, and Am-241 were not detected in greens					
Fruit (watermelon)	H-3	5	4	5.71E-02	-1.61E-03	**1.29E-01**
	Sr-89,90	5	1	2.82E-03	2.00E-03	**5.62E-03**
	Tc-99	5	4	3.45E-02	2.28E-02	**3.92E-02**
	Gross Beta	5	5	2.91E-01	**1.45E-01**	**4.46E-01**
	Cs-137, Co-60, Np-237, Pu-238, Pu-239, Am-241, Cm-244, U-234, U-235, U-238, and gross alpha were not detected in fruit.					
Corn	H-3	5	4	7.39E-02	-2.28E-02	**2.20E-01**
	Cs-137	5	1	3.47E-03	-2.56E-04	**1.13E-02**
	Sr-89,90	5	1	1.99E-02	-6.92E-03	**4.51E-02**
	Gross Beta	5	5	7.49E+00	**5.43E+00**	**1.04E+01**
	Co-60, U-234, U-235, U-238, Pu-238, Pu-239, Am-241, Cm-244, Np-237, Sr-89,90, Tc-99, and gross alpha were not detected in corn.					
Pecans	Gross Beta	5	5	3.94E+00	**2.64E+00**	**4.41E+00**
	Gross Alpha	5	2	1.53E-01	3.05E-03	**2.72E-01**
	H-3, Cs-137, Co-60, U-234, U-235, U-238, Am-241, Cm-244, Np-237, Pu-238, Pu-239, Sr-89,90, and Tc-99 were not detected in pecans.					

Appendix Table D-9 Summary of Radionuclides in Dairy

SRS collects cow's and goat'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 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 (5) – cow milk	H-3	16	2	6.95E+01	-1.32E+02	**7.85E+02**
SC-Dairies (2) – goat milk	H-3	4	2	8.01E+02	4.30E+01	**1.80E+03**
GA-Dairies (4)	H-3	15	0			
SC-Dairies (4) – cow milk	Cs-137	14	2	1.46E+00	-5.11E-01	**3.81E+00**
SC-Dairies (1) – goat milk	Cs-137	2	1	4.27E+00	1.32E+00	**7.22E+00**
GA-Dairies (4)	Cs-137	15	0			
SC-Dairies (4) – cow milk	Sr-90	14	2	5.48E-01	-5.51E-01	3.35E+00*
SC-Dairies (1) – goat milk	Sr-90	2	1	1.74E+00	4.70E-01	**3.00E+00**
GA-Dairies (4)	Sr-90	15	0			

Note:
* Due to large uncertainties this value is considered not significant although the value is greater than the analytical method detection limit.

Appendix Table D-10 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	1.75E+02	3.56E+02	5.27E-02	5.31E+02
C-14	5700	y		6.22E-04	0.00E+00	6.22E-04
Sr-90	28.8	y	0.00E+00	3.18E-02		3.18E-02
Tc-99	2.11E+05	y		2.79E-02	5.07E-04	2.84E-02
I-129	1.57E+07	y		1.66E-02	0.00E+00	1.66E-02
Cs-137 [c]	30.2	y	0.00E+00	8.06E-03	0.00E+00	8.06E-03
Ra-226	1600	y		1.03E-03		1.03E-03
U-234	2.46E+05	y		2.95E-02	5.33E-05	2.95E-02
U-235	7.04E+08	y		5.71E-04	3.07E-06	5.74E-04
U-238	4.47E-09	y		3.22E-02	4.48E-05	3.22E-02
Np-237	2.14E+06	y		1.82E-06		1.82E-06
Pu-238	87.7	y		4.91E-05	4.40E-06	5.35E-05
Pu-239	2.41E+04	y		5.45E-06	0.00E+00	5.45E-06
Am-241	432	y		1.36E-04		1.36E-04
Cm-244	18.1	y		6.81E-05		6.81E-05
Alpha [d]	N/A		1.79E-03	1.00E-03	4.17E-04	3.21E-03
Beta-Gamma [e]	N/A		4.18E-02	2.47E-03	8.00E-04	4.51E-02
					Sum	**5.31E+02**

[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 Steel Creek mouth fish near RM 141.5 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-11 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	DCS Sum of Fractions Excluding Tritium
A Area (TB-2 Outfall at Road 1A)	H-3, U-234, U-235, U-238, Pu-238, Tc-99	1.58E-03	1.47E-03
F Area (F-013 200-F Cooling Basin)	H-3, Cs-137, U-234, U-238, Pu-238, Pu-239, Tc-99	3.51E-03	2.09E-03
F Area (F-05)	H-3, Sr-89/90, U-234, U-235, U-238, Pu-238, Pu-239, Am-241, Cm-244, Tc-99	1.33E-02	1.22E-02
F Area (FM-3 F-Area Effluent)	H-3, I-129, U-234, U-235, U-238, Pu-238, Pu-239, Am-241, Cm-244, Tc-99	2.95E-03	2.02E-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	6.83E-03	5.35E-03
H Area (FM-1C H-Area Effluent)	H-3, Sr-89/90, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244	6.44E-03	2.97E-03
H Area (H-004)	H-3, U-234, U-235, U-238, Pu-238	6.59E-03	1.84E-03
H-ETP (U3R-2A ETP Outfall at Road C)	H-3, C-14, Sr-89/90, U-234, U-238	9.96E-01	1.17E-03
H-Tank Farm (H-017 281-8H Retention Basin)	H-3, Sr-89/90, I-129, Cs-137, U-234, U-238, Pu-238, Pu-239, Am-241, Tc-99	1.77E-02	1.45E-02
H-Tank Farm (HP-52 H-Area Tank Farm)	H-3, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Am-241	3.92E-03	2.08E-03
K Area (K Canal)	H-3	5.98E-04	4.75E-04
L Area (L-07)	H-3	7.12E-04	6.31E-04
S Area (S-004)	H-3, Sr-89/90, Cs-137, U-234, U-238, Pu-238	1.15E-02	3.22E-03
Tritium (HP-15 Tritium Facility Outfall)	H-3	6.98E-02	4.72E-05

Appendix Table D-12 Summary of Radionuclides in Sediments

SRS collected annual sediment samples at 40 locations in 2018—11 Savannah River, 21 stream, and 8 stormwater basins, totaling 478 analytes. Locations sampled are as follows: Savannah River locations (mouths of Beaver Dam Creek [BDC] and Steel Creek [SC], River Miles [RM] 118.7, 129, 134.0, 150.2, 150.4, 151, 157.2, 160.0, and 160.5), SRS Stream locations (downstream of R-1, FM-2, FM-3A, FM-A7, FM-A7A, FMC @ Rd A, FMC Swamp, L3R-1A , L3R-2, L3R-3, McQB below Z-Basin, Meyers Branch, PB Swamp, SC-2A, SC-4, TB-5, TC-1, U3R @USFS Rd 2-1, U3R off Rd 4, U3R-0, and U3R-4), and SRS Stormwater Basin locations (E-001, E-002, E-003, E-004, E-05, E-06, Pond 400, and Z-Area Basin).

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.

The streams and stormwater basins have the same control location, U3R-0. The river control location is RM 160.5.

The field duplicate samples are included in the data evaluations performed when generating the tables.

For the river and basin sediment analyses, all results for Co-60, Np-237, and Sr-90 were below the detection limit. For the stream sediment, all results for Co-60 were below the detection limit. Therefore, these results are not presented in the sediment tables below.

River Sediment Results

11 River Locations (including control) + 1 Field Duplicate @ RM 157.2

Analyte	# > MDA	Control RM 160.5 (pCi/g)	Location of Maximum Result	Maximum Conc (pCi/g)
Americium-241	6 of 10	**1.06E-03**	RM 157.2	**2.07E-02**
Cesium -137	9 of 12	4.67E-02	SC RM	**9.63E-01**
Curium-243/244	2 of 10	3.66E-04	RM 118.7	**8.10E-03**
Gross Alpha	12 of 12	**1.21E+01**	RM 157.2	**3.13E+01**
Nonvolatile Beta	12 of 12	**2.32E+01**	RM 157.2	**2.88E+01**
Plutonium-238	3 of 10	4.76E-04	RM 118.7	**3.55E-03**
Plutonium-239/240	2 of 10	5.28E-04	RM 157.2	**5.84E-03**
Uranium-233/234	10 of 10	**9.67E-01**	RM 160.0	**1.71E+00**
Uranium-235	10 of 10	**3.95E-02**	RM 160.0	**8.16E-02**
Uranium-238	10 of 10	**9.81E-01**	RM 160.0	**1.71E+00**

Stream Sediment Results

21 Stream Locations (including control) and 2 Field Duplicates (L3R-3 and U3R@USFS Rd 2-1)

Analyte	# >MDA	Control U3R-0 (pCi/g)	Location of Maximum Result	Maximum Result (pCi/g)
Americium-241	12 of 16	**4.39E-03**	FM-A7	**1.34E-01**
Cesium-137	18 of 23	7.75E-02	Downstream of R-1	**1.51E+01**
Curium-243/244	6 of 16	4.20E-04	FM-A7	**1.02E-01**
Gross Alpha	22 of 23	**3.36E+01**	SC-2A	**3.58E+01**
Neptunium-237	4 of 16	5.12E-04	FMC Swamp	**1.16E-02**
Nonvolatile Beta	23 of 23	**2.57E+01**	U3R @ USFS Rd 2-1	**3.90E+01**
Plutonium-238	10 of 16	1.20E-03	FM-2	**4.20E-01**
Plutonium-239/240	13 of 16	**4.65E-03**	FM-A7	**1.27E-01**
Strontium-90	4 of 16	1.15E-01	FM-A7	**5.95E-01**
Uranium-233/234	16 of 16	**1.70E+00**	TB-5	**4.30E+00**
Uranium-235	15 of 16	**6.49E-02**	TB-5	**2.48E-01**
Uranium-238	16 of 16	**1.84E+00**	TB-5	**4.51E+00**

Stormwater Basin Sediment Results

9 Locations (8 basins and the control)

Analyte	#>MDA	Control U3R-0 (pCi/g)	Location of Maximum Result	Maximum Result (pCi/g)
Americium-241	6 of 9	**4.39E-03**	E-002	**1.05E-01**
Cesium-137	4 of 9	7.75E-02	Z-Area Basin	**2.64E+03**
Curium-243/244	2 of 9	4.20E-04	Pond 400	**6.47E-03**
Gross Alpha	9 of 9	**3.36E+01**	Pond-400	**2.33E+01**
Nonvolatile Beta	9 of 9	**2.57E+01**	Z-Area Basin	**2.36E+03**
Plutonium-238	4 of 9	1.28E-03	Pond-400	**6.01E-02**
Plutonium-239/240	6 of 9	**4.65E-03**	Pond-400	**1.62E-01**
Uranium-233/234	9 of 9	**1.70E+00**	E-004	**1.78E+00**
Uranium-235	9 of 9	**6.49E-02**	E-004 & Pond 400	**1.12E-01**
Uranium-238	9 of 9	**1.84E+00**	E-004	**1.74E+00**

Appendix Table D-13 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. Samples are collected at one onsite location quarterly for tritium, Co-60, Cs-137, gross beta and gross alpha analyses and collected annually for Sr-90 and actinides analyses. 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, Sr-90, U-235, Pu-238, Pu-239, and Cm-244 were below detection limits; and thus, not presented in the table below.

Treatment Plants—Finished Water Summary

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	3.91E+02	**1.89E+02**	**7.92E+02**
North Augusta Public Water Works	12	8	1.54E+02	4.32E+01	**2.44E+02**

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	1.87E+00	**1.49E+00**	**2.53E+00**
North Augusta Public Water Works	12	12	1.80E+00	**1.38E+00**	**2.28E+00**

Onsite Location Summary—Quarterly Samples

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	1.35E+00	**9.24E-01**	**2.14E+00**

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	3	7.81E-01	2.66E-01	**1.49E+00**

Onsite Location Summary—Annual Samples

		U-234	**U-238**	**Am-241**	**Gross Beta**	**Gross Alpha**
Location	**Number of Samples**	**Conc. (pCi/L)**	**Conc. (pCi/L)**	**Conc. (pCi/L)**	**Conc. (pCi/L)**	**Conc. (pCi/L)**
617-G	1	**2.61E-02**	**1.91E-02**	**1.07E-02**	**9.14E-01**	2.08E-01
681-3G Dom. Water Faucet	1	3.68E-03	**1.42E-02**	3.24E-03	**3.00E+00**	**5.68E-01**
704-16G	1	9.93E-03	**1.56E-02**	**8.49E-03**	**9.41E-01**	**6.57E-01**
709-1G	1	**3.00E-02**	**1.02E-02**	**1.05E-02**	**5.57E-01**	4.32E-02
737-G	1	**1.36E-02**	**1.11E-02**	8.03E-03	**1.37E+00**	-4.30E-03
782-3A (annual)	1	**2.86E-02**	**4.38E-02**	**7.30E-03**		
905-112G Well	1	**1.82E-02**	**1.96E-02**	6.22E-03	**5.24E-01**	**6.22E-01**
905-113G Well	1	**4.41E-02**	**5.22E-02**	3.97E-03	**2.00E+00**	**1.95E+00**
905-125B	1	**6.84E-02**	**8.38E-02**	6.73E-03	**2.02E+00**	**2.35E+00**
905-67B	1	**1.68E-02**	**1.57E-02**	6.86E-03	**1.52E+00**	**1.28E+00**

Appendix Table D-14 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. Sr-89/90 is the only analysis performed in both flesh (edible) and bone (nonedible) samples. 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	1.96E-02	1.00E-02	**2.66E-02**	3.20E-02	**2.76E-02**	**3.84E-02**	3.63E-02	1.19E-02	**8.32E-02**
Upper Three Runs Creek River Mouth	2.85E-01	1.76E-02	**7.92E-01**	3.74E-02	**2.10E-02**	**4.81E-02**	0.00E+00	5.46E-03	1.73E-02
Four Mile Creek River Mouth	6.24E-02	**4.27E-02**	**9.32E-02**	3.90E-02	**1.72E-02**	**7.46E-02**	5.43E-02	**3.30E-02**	**6.92E-02**
Steel Creek River Mouth	1.24E-01	**8.00E-02**	**2.11E-01**	4.04E-02	**3.62E-02**	**4.62E-02**	2.56E-02	**1.92E-02**	**3.30E-02**
Lower Three Runs Creek River Mouth	3.37E-01	**4.30E-02**	**7.76E-01**	4.16E-02	**3.32E-02**	**5.05E-02**	6.61E-02	**2.20E-02**	**1.43E-01**
Hwy 301 Bridge Area	3.05E-02	**2.60E-02**	**3.68E-02**	3.74E-02	**1.50E-02**	**6.43E-02**	1.90E-02	**1.41E-02**	**2.47E-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	2.59E-03	1.39E-03	**4.14E-03**	2.00E-03	1.26E-03	**3.27E-03**	0.00E+00	1.77E-03	2.38E-03
Upper Three Runs Creek River Mouth	1.95E-03	-3.53E-04	**5.65E-03**	0.00E+00	3.51E-04	8.65E-04	0.00E+00	7.81E-04	6.97E-03
Four Mile Creek River Mouth	2.51E-03	1.60E-03	**3.03E-03**	0.00E+00	6.46E-04	2.06E-03	4.77E-03	4.30E-03	**5.41E-03**
Steel Creek River Mouth	1.82E-03	9.11E-04	**2.86E-03**	2.93E-03	1.68E-03	**4.54E-03**	3.09E-03	-1.03E-03	**7.11E-03**
Lower Three Runs Creek River Mouth	0.00E+00	1.21E-03	4.27E-03	0.00E+00	1.88E-03	3.27E-03	0.00E+00	1.15E-03	2.78E-03
Hwy 301 Bridge Area	0.00E+00	1.58E-03	2.73E-03	2.04E-03	3.35E-04	**3.84E-03**	0.00E+00	1.13E-03	3.46E-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	7.34E-01	**6.51E-01**	**7.78E-01**	8.27E-01	**6.32E-01**	**9.27E-01**	9.42E-01	**8.05E-01**	**1.08E+00**
Upper Three Runs Creek River Mouth	7.33E-01	**5.62E-01**	**9.97E-01**	7.52E-01	**6.84E-01**	**8.68E-01**	8.53E-01	**5.81E-01**	**9.97E-01**
Four Mile Creek River Mouth	9.92E-01	**6.89E-01**	**1.26E+00**	7.26E-01	**6.59E-01**	**7.86E-01**	1.28E+00	**1.01E+00**	**1.55E+00**
Steel Creek River Mouth	7.73E-01	**6.22E-01**	**9.03E-01**	5.97E-01	**4.76E-01**	**8.08E-01**	9.51E-01	**9.08E-01**	**9.76E-01**
Lower Three Runs Creek River Mouth	3.62E-01	**3.30E-01**	**4.11E-01**	4.79E-01	**4.46E-01**	**5.00E-01**	4.95E-01	**4.16E-01**	**5.68E-01**
Hwy 301 Bridge Area	5.59E-01	**5.03E-01**	**6.03E-01**	5.46E-01	**4.43E-01**	**6.49E-01**	6.22E-01	**6.08E-01**	**6.35E-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	3.97E-02	4.92E-02	5.89E-02	**8.51E-02**	**8.46E-02**	6.64E-02	4.24E-02	**8.35E-02**
Upper Three Runs Creek River Mouth	0.00E+00	3.54E-02	4.35E-02	0.00E+00	1.14E-02	1.56E-02	0.00E+00	8.03E-03	3.89E-02
Four Mile Creek River Mouth	0.00E+00	4.76E-02	5.81E-02	0.00E+00	5.89E-02	7.27E-02	0.00E+00	4.14E-02	6.57E-02
Steel Creek River Mouth	7.85E-02	5.57E-02	**9.92E-02**	7.76E-02	6.03E-02	**1.04E-01**	5.68E-02	3.41E-02	**7.11E-02**
Lower Three Runs Creek River Mouth	0.00E+00	2.13E-02	5.38E-02	0.00E+00	1.52E-02	4.89E-02	0.00E+00	-5.27E-03	2.95E-02
Hwy 301 Bridge Area	5.58E-02	4.81E-02	**6.97E-02**	7.67E-02	**7.19E-02**	**8.51E-02**	6.06E-02	4.65E-02	**7.59E-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	1.73E+00	**1.39E+00**	**2.41E+00**	2.20E+00	**1.85E+00**	**2.41E+00**	1.64E+00	**1.53E+00**	**1.80E+00**
Upper Three Runs Creek River Mouth	2.34E+00	**1.95E+00**	**2.62E+00**	2.39E+00	**1.90E+00**	**2.81E+00**	2.06E+00	**2.00E+00**	**2.13E+00**
Four Mile Creek River Mouth	2.08E+00	**1.98E+00**	**2.24E+00**	2.32E+00	**1.94E+00**	**2.59E+00**	1.73E+00	**1.44E+00**	**2.03E+00**
Steel Creek River Mouth	1.43E+00	**1.11E+00**	**1.75E+00**	1.88E+00	**1.73E+00**	**2.02E+00**	1.51E+00	**1.32E+00**	**1.73E+00**
Lower Three Runs Creek River Mouth	2.75E+00	**2.17E+00**	**3.65E+00**	2.49E+00	**1.87E+00**	**3.00E+00**	2.06E+00	**1.87E+00**	**2.39E+00**
Hwy 301 Bridge Area	2.64E+00	**2.30E+00**	**2.86E+00**	2.70E+00	**2.55E+00**	**2.89E+00**	2.20E+00	**1.95E+00**	**2.45E+00**

Appendix Table D-15 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. Sr-89/90 is the only analysis performed in both flesh (edible) and bone (nonedible) samples. Beginning in 2018, red drum and sea trout are no longer collected. Beginning in 2017, tritium (H-3) is no longer analyzed in fish. Results of all samples for Co-60, Cs-137, I-129, 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).

		Marine Mullet		
Analyte	**Number of Samples**	**Mean (pCi/g)**	**Minimum (pCi/g)**	**Maximum (pCi/g)**
Tc-99	3	4.99E-02	6.11E-03	**8.41E-02**
Sr-89/90 Nonedible	3	1.67E-01	**1.29E-01**	**2.08E-01**
Gross Beta	3	1.53E+00	**1.46E+00**	**1.65E+00**

Appendix Table D-16 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 2018 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	2.96E-03	5.49E-04	**5.38E-03**
Gross B	2	2	1.15E+00	**5.43E-01**	**1.76E+00**
Gross A	2	1	1.46E-01	3.38E-02	**2.57E-01***

Note:
* The gross alpha maximum value is less than the trigger value of 0.951 pCi/g that SRS uses as the basis for performing analysis of alpha-emitting radionuclides. When results are less than the trigger value, no actinide analyses are performed.

Appendix Table D-17 Summary of Radionuclides in Wildlife

Bolded 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 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	45	44	2.21E+00	3.68E-02	**7.27E+00**
Hog Flesh	Cs-137	4	4	2.35E+00	**5.03E-01**	**6.35E+00**
Deer Flesh	Sr-89/90	45	3	2.04E-03	-2.22E-03	**1.37E-02**
Hog Flesh	Sr-89/90	4	0	2.16E-03	-4.00E-04	5.41E-03
Deer Bone	Sr-89/90	45	45	3.35E+00	**7.86E-01**	**8.86E+00**
Hog Bone	Sr-89/90	4	4	2.53E+00	**1.85E+00**	**3.05E+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

Appendix Table E-1 Summary of Documents that Report Groundwater Monitoring Data (continued)

Document Title	Submittal Frequency
Effectiveness Monitoring Report (EMR) for the Monitored Natural Attenuation (MNA) at the Chemicals, Metals, and Pesticides (CMP) Pits Operable Unit	Annual
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 Environmental Report	Not applicable[a]

[a] The SRS Environmental Report is not submitted to the regulatory agencies as a regulatory requirement. The report is a publicly available document. The SRS 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, that is, 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 or 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 (for example, 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 (that is, 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 or 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 or 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 for example, 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.

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 to standardize 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 (for example, plutonium-239 and uranium-235) and beta- emitting (for example, 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 noncontact 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 (for example, 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.

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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
mi²	square mile	R	roentgen
ft²	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)

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