

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

2017 Highlights

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

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

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

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

Chapter 5—Key Terms

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

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

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

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

Environmental monitoring encompasses both effluent monitoring and environmental surveillance.

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

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

5.1 INTRODUCTION

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

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

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

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

SRS conducts environmental monitoring of the following:

- Air (stack emissions and ambient air)

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

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

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

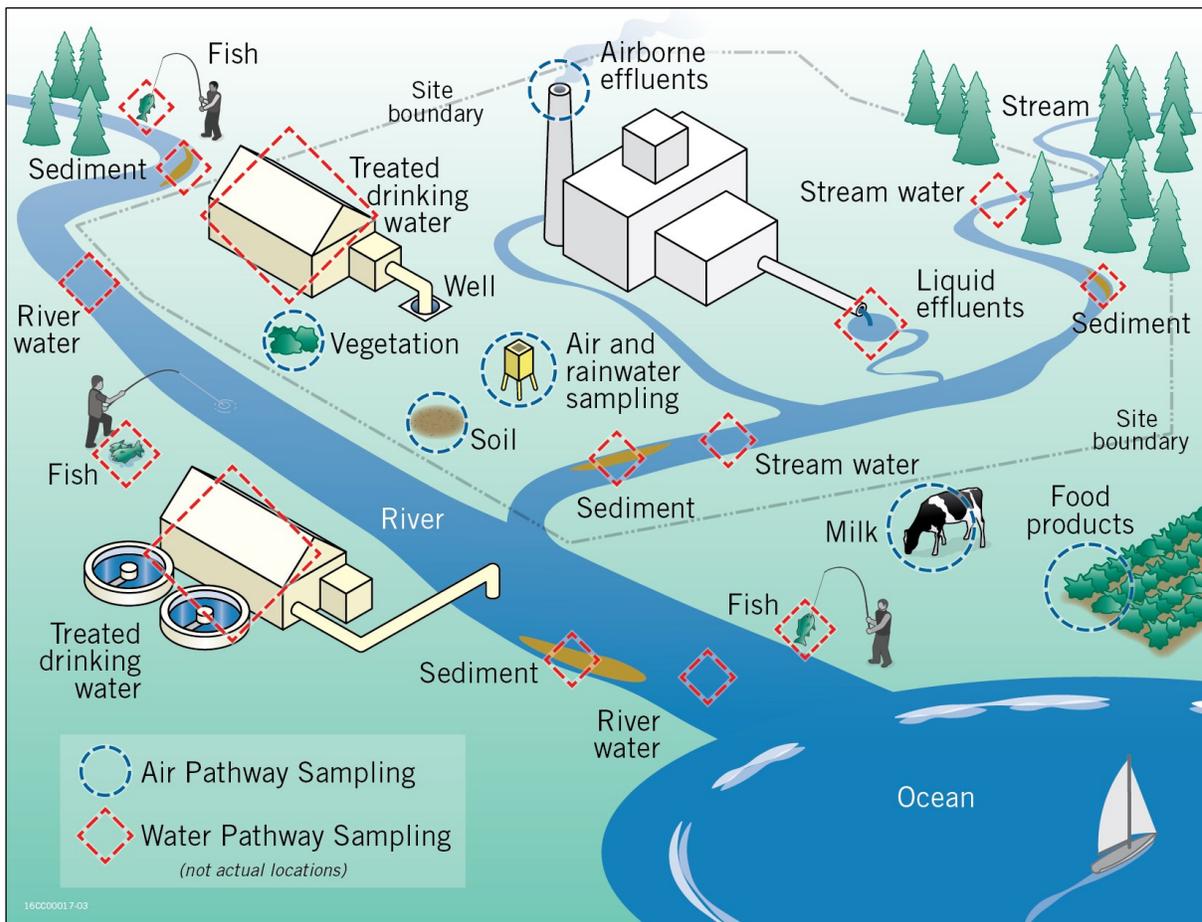


Figure 5-1 Types and Typical Locations of Radiological Sampling

5.2 SRS OFFSITE MONITORING

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

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

Table 5-1 SRS Offsite Radiological Sample Distribution by State

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

Notes:

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

^aThe approximate number of samples and number of locations in South Carolina include the five-year comprehensive Creek Plantation study.

5.3 AIR PATHWAY

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

5.3.1 Air Monitoring

SRS monitors the air to determine whether airborne radionuclides from SRS emissions have reached the environment in measurable quantities and to ensure that radiation exposure to the public remains below regulatory limits. SRS performs effluent monitoring of airborne radionuclides at the point of discharge from operating SRS facilities. This monitoring complies with radiation dose limits that the Environmental Protection Agency (EPA) and DOE established to protect the public. SRS conducts additional air sampling at surveillance stations onsite, along the SRS perimeter, and within communities surrounding SRS.

Radionuclides in and around the SRS environment are from both SRS operations and from events not related to the Site. The events not associated with SRS include 1) natural sources, 2) past atmospheric testing of nuclear weapons, and 3) offsite nuclear power plant operations. Tritium in the elemental (hydrogen gas) and oxide (water vapor) forms make up most of the radionuclide emissions from SRS to the air. The amount of tritium released from SRS varies yearly, based on mission activities and on the annual production schedules of the tritium-processing facilities.

5.3.2 Airborne Emissions

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

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

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

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

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

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

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



Air Emission Stack in L Area

5.3.2.1 Airborne Emissions Results Summary

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

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

In 2017, tritium accounted for more than 73% of the total radiation SRS operations released to the air. Tritium processing facilities are responsible for 76% of SRS tritium releases, while the spent nuclear fuel dissolution in H Canyon accounted for less than 1% of SRS tritium releases. Tritium releases from the separations areas comprise the combination of releases from the tritium processing facilities and the

dissolution in H Canyon. Appendix Table D-1 and Figures 5-2 and 5-3 show the tritium releases from the separations areas, reactors and spent nuclear fuel facilities, and unmonitored sources.

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

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

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

Notes:

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

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

^c IAEA Common Fission and Activation Products

^d Includes iodine-129 and iodine-131

^e Includes unidentified beta releases

^f Includes unidentified alpha releases

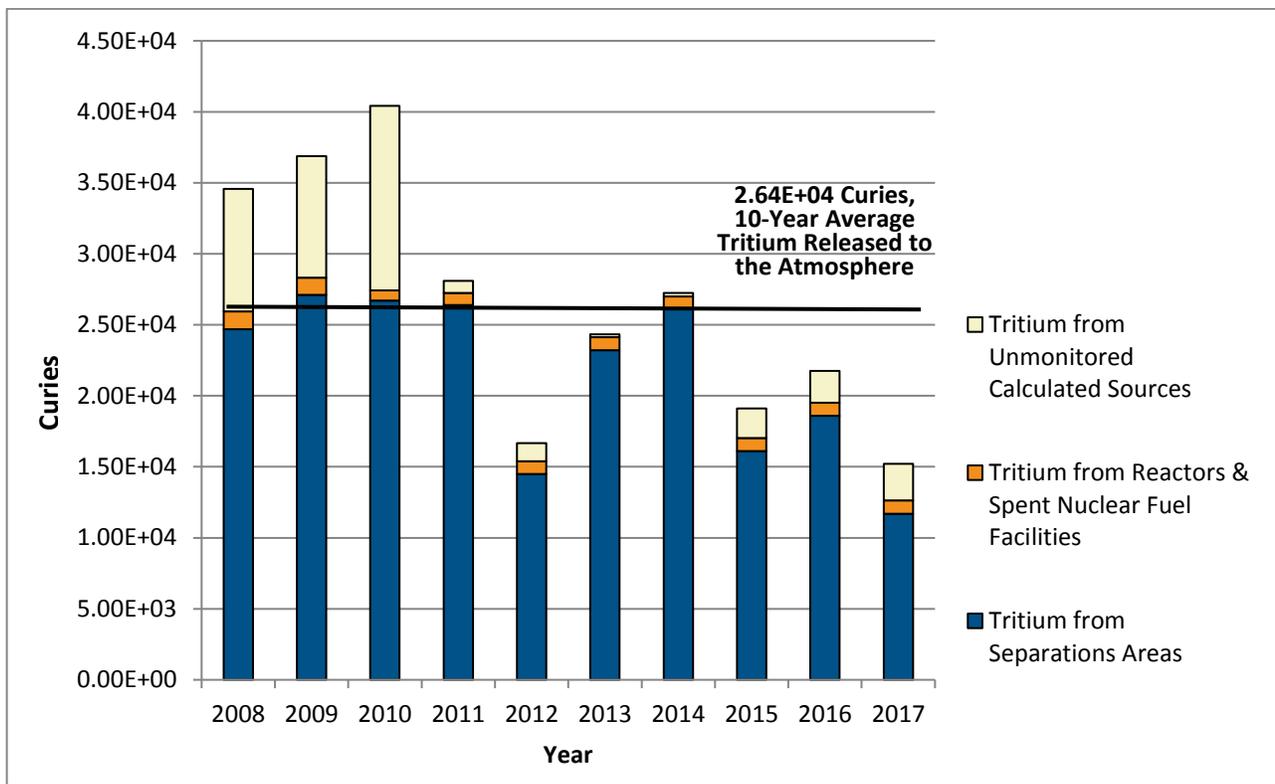


Figure 5-2 10-Year History of SRS Annual Tritium Releases to the Air

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

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

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



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

5.3.3 Air Surveillance

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

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

Table 5-3 Air Sampling Media

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

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

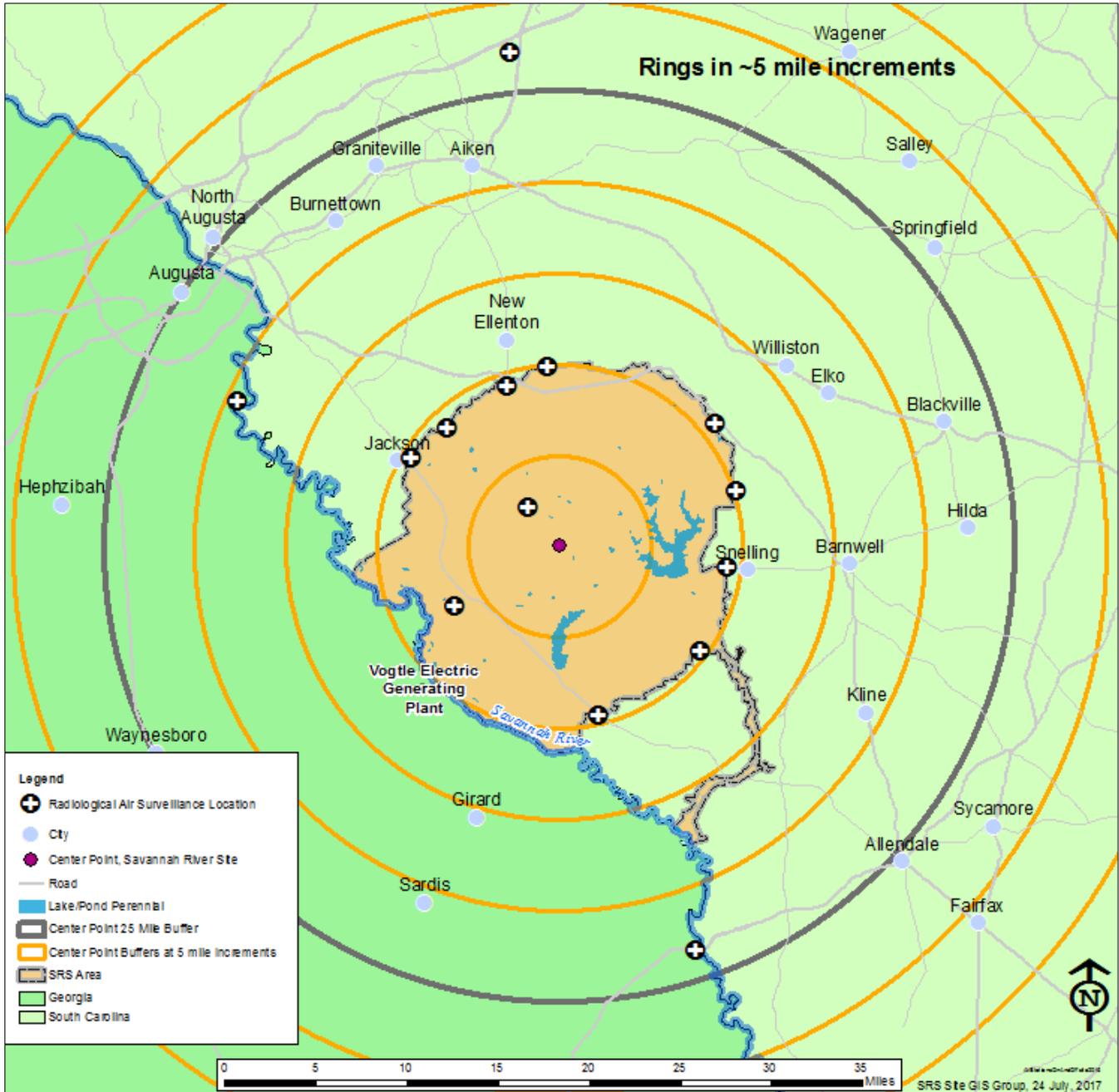


Figure 5-4 Air Sampling Locations Surrounding SRS up to 25 Miles

5.3.3.1 Results Summary

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

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

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

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

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



Equipment Setup within Air Monitoring Station

5.3.4 Ambient Gamma Surveillance

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

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

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

5.3.4.1 Ambient Gamma Results Summary

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

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

5.3.5 Soil Surveillance

SRS conducts soil surveillance to provide the following:

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

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

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

5.3.5.1 Soil Results Summary

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

Organic matter and clay minerals provide exchange sites in soil, which can increase the uranium sorption. All measured uranium levels were below the concentration at the control location.

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

5.3.6 **Grassy Vegetation Surveillance**

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

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



Technician Preparing Grassy Vegetation Sample

- All air sampling locations

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

5.3.6.1 Grassy Vegetation Results Summary

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

5.3.7 Terrestrial Food Surveillance

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

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

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

5.3.7.1 Terrestrial Food Results Summary

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

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

5.4 WATER PATHWAY

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

5.4.1 Liquid Effluents Monitoring Program

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

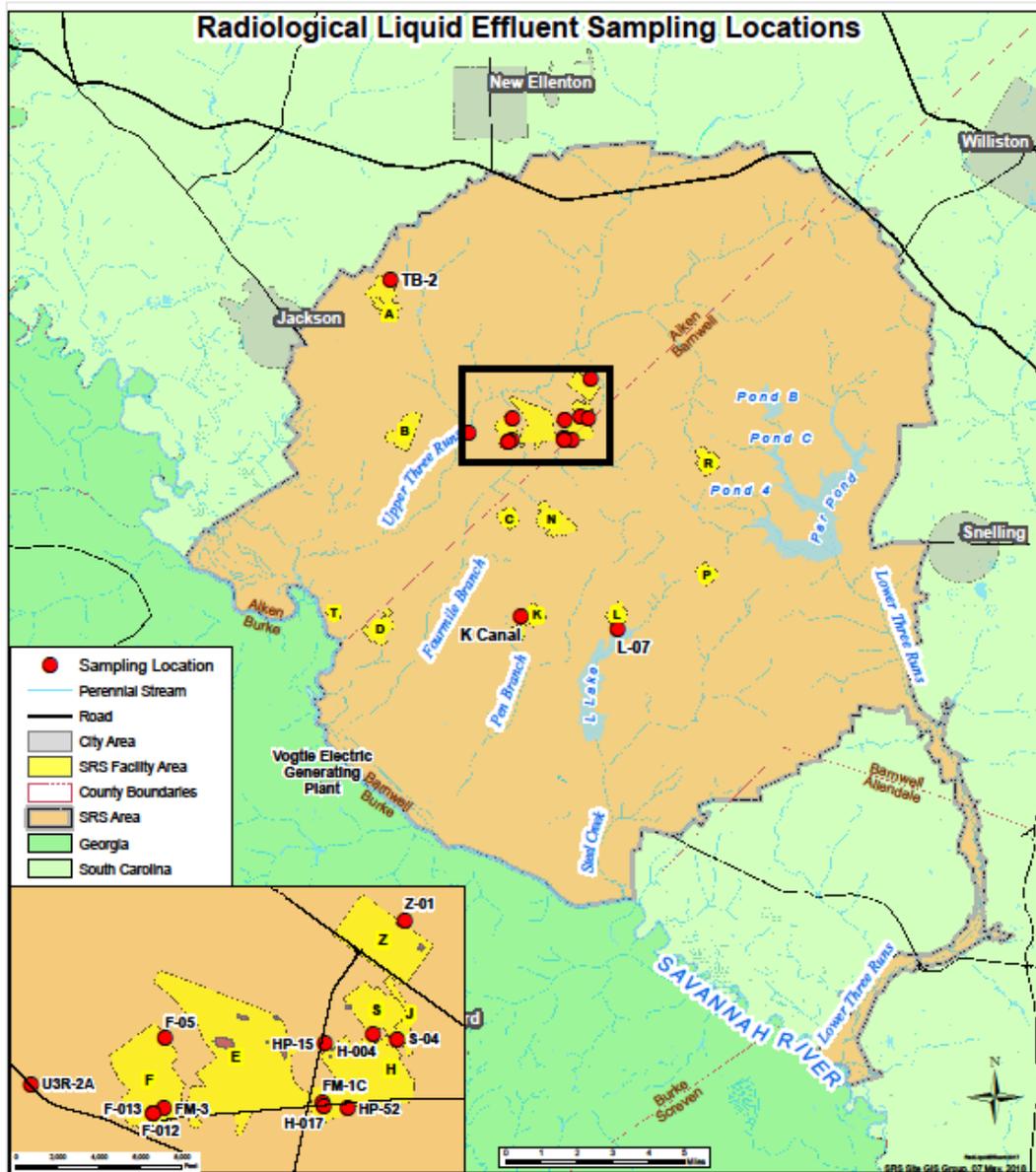


Figure 5-5 Radiological Liquid Effluent Sampling Locations

5.4.1.1 Liquid Effluent Results Summary

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

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

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

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

Notes:

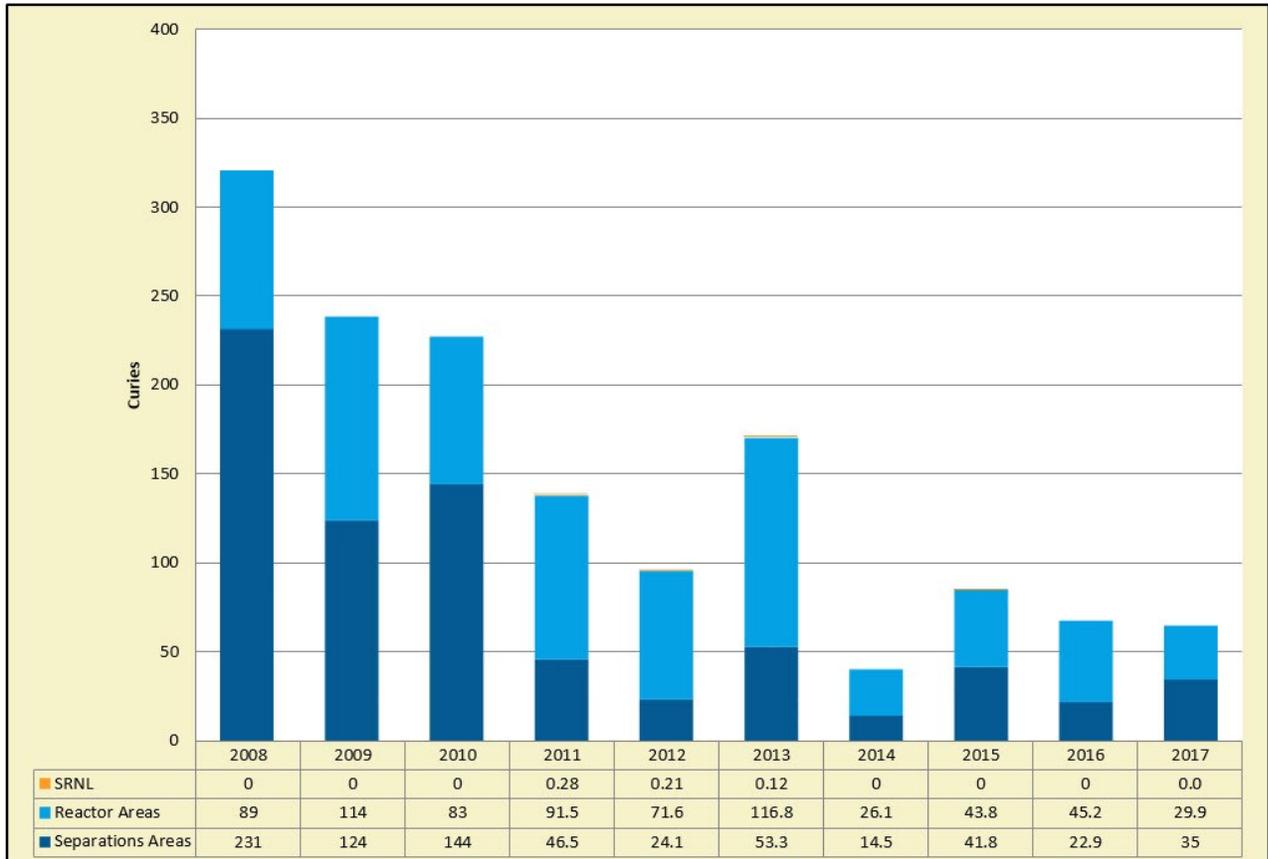
^a International Commission on Radiological Protection (ICRP) 107 Half-life data, *Nuclear Decay Data for Dosimetric Calculations (2008)*

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

^c Includes iodine-129

^d Includes unidentified beta releases

^e Includes unidentified alpha releases



Notes:

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

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

5.4.2 Stormwater Basin Surveillance

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

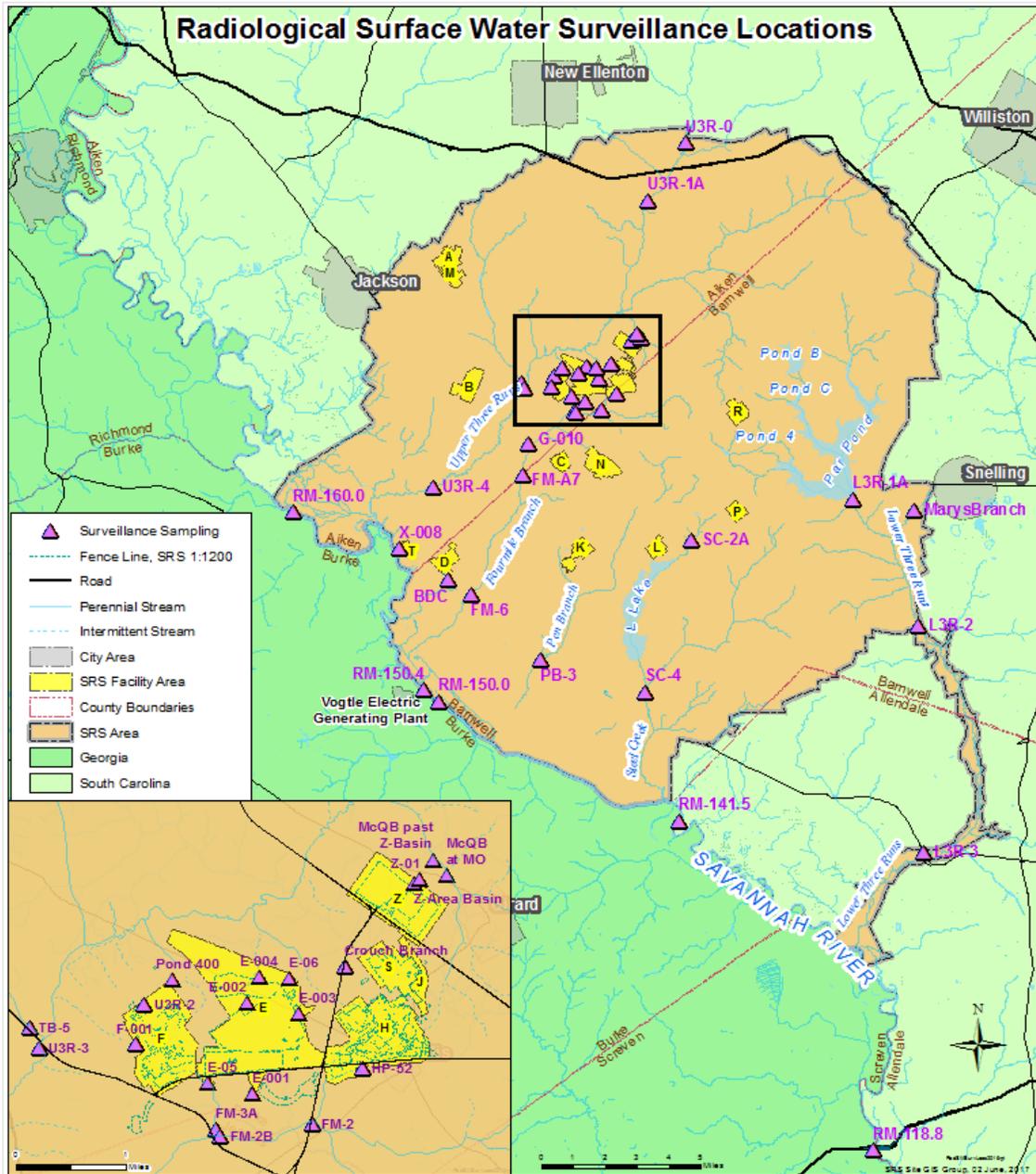


Figure 5-7 Radiological Surface Water Sampling Locations

5.4.2.1 Stormwater Basin Results Summary

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

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

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

5.4.3 SRS Stream Sampling and Monitoring

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

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

5.4.3.1 SRS Stream Results Summary

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

Table 5-6 Radionuclide Concentrations in SRS Streams by Location

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

Note:
ND = nondetect

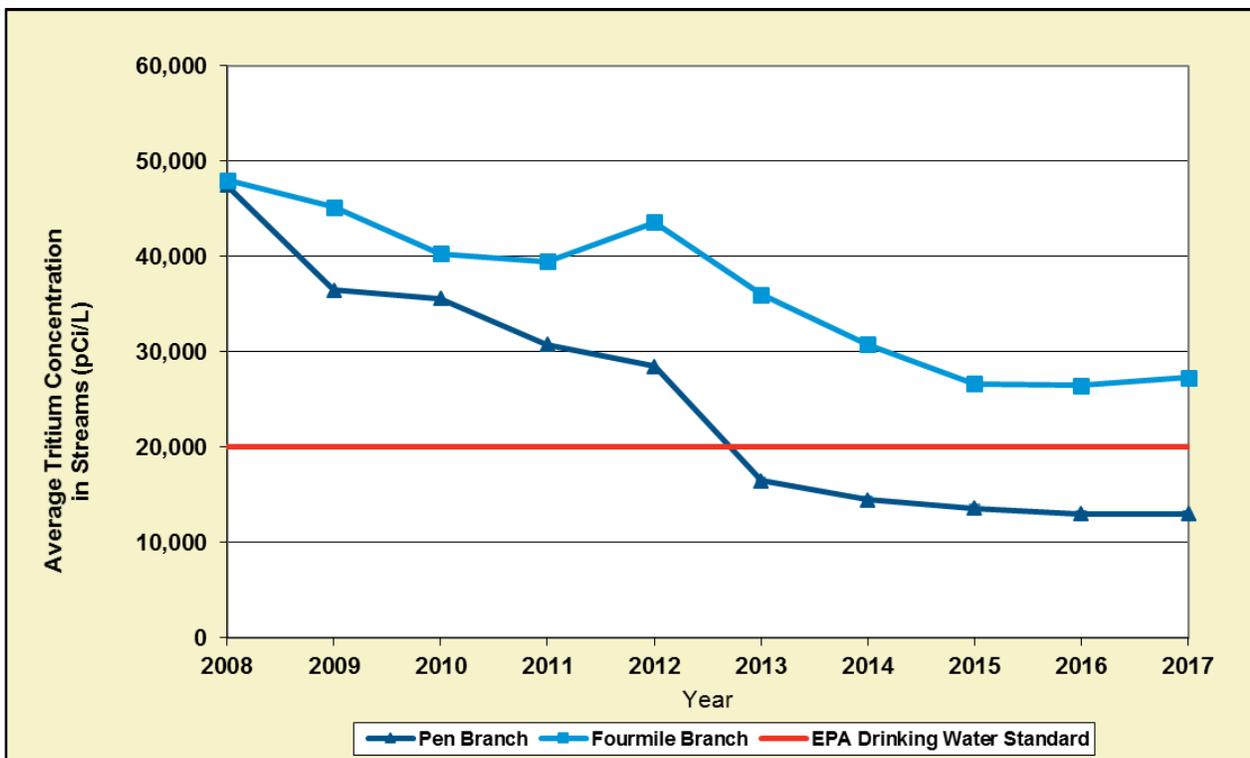


Figure 5-8 10-Year Trend of Tritium in Pen Branch and Fourmile Branch (pCi/L)

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

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

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

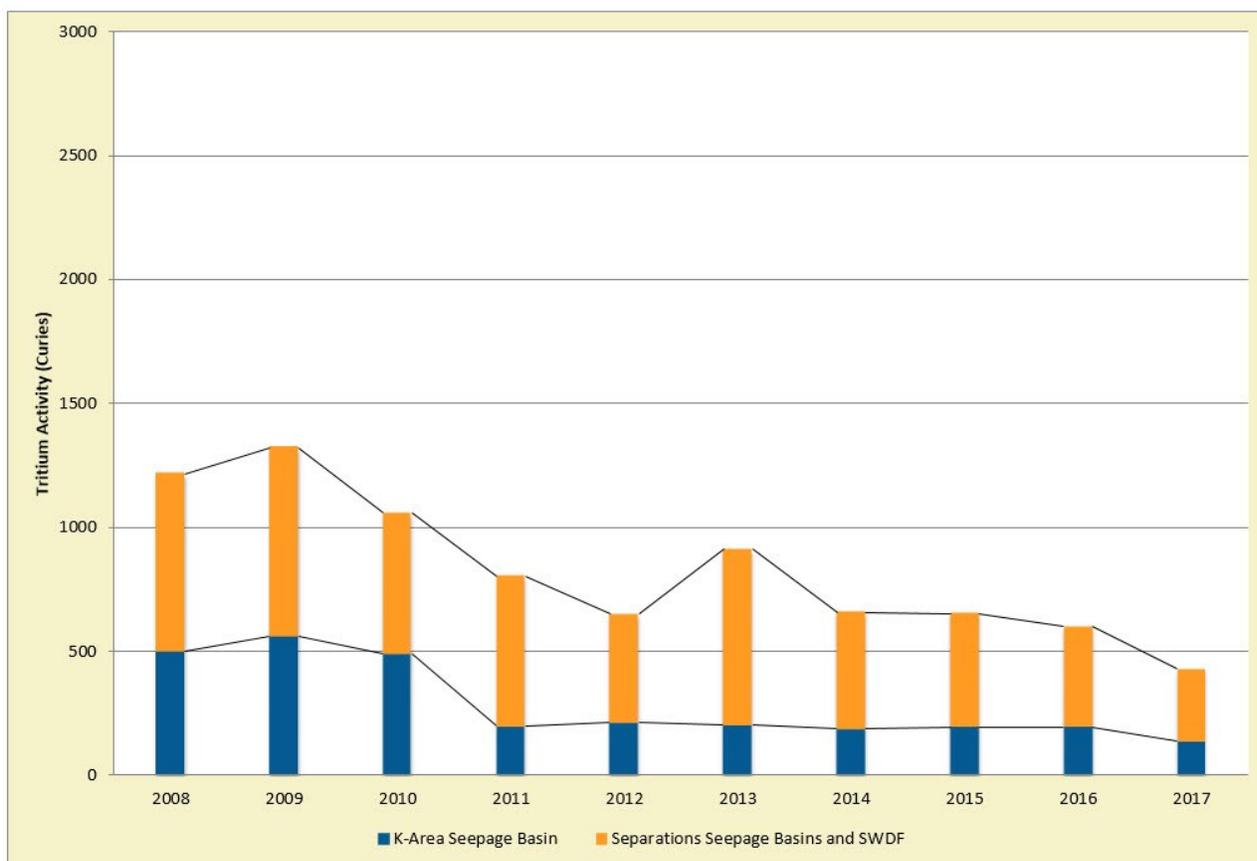


Figure 5-9 Tritium Migration from SRS Seepage Basins and SWDF to SRS Streams

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

5.4.4 Savannah River Sampling and Monitoring

SRS conducts continuous sampling along the Savannah River at locations above and below SRS streams, including at a location where liquid discharges from Vogtle Electric Generating Plant (VEGP) enter the river. Five locations (Figure 5-7) along the river continued to serve as environmental surveillance points in 2017. SRS collects samples at these river locations and analyzes them for gross alpha, gross beta, tritium, strontium, technetium, actinides, and gamma-emitting radionuclides.

5.4.4.1 Savannah River Results Summary

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

Table 5-7 Radionuclide Concentrations in the Savannah River

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

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

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

5.4.5 Tritium Transport in Streams and Savannah River Surveillance

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

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

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

5.4.5.1 Tritium Transport in Streams and Savannah River Results Summary

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

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

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

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

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

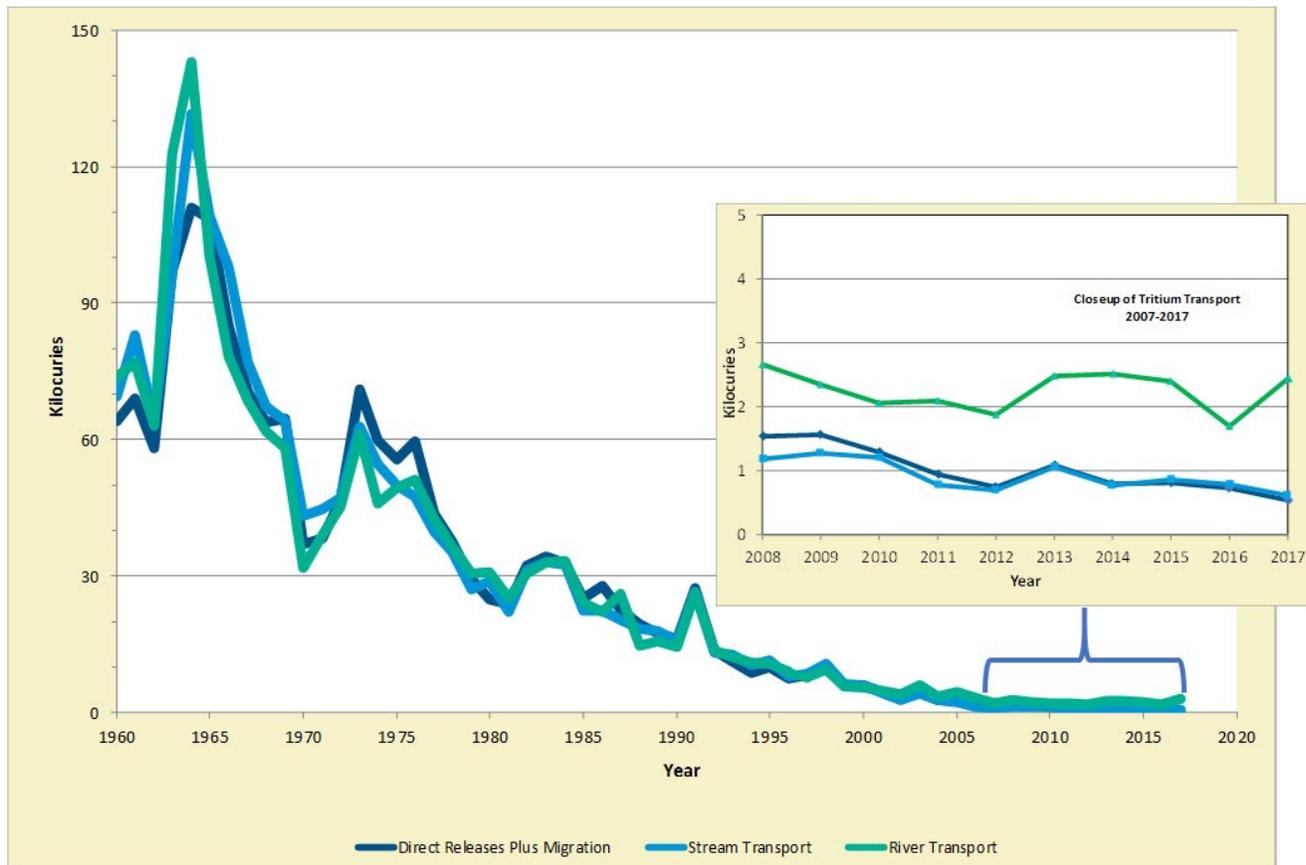


Figure 5-10 SRS Tritium Transport Summary

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

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

5.4.6 Settleable Solids Surveillance

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

results are at or above 40 parts per million for TSS at the NPDES outfall that are collocated at or near radiological effluent points, samples are analyzed for alpha-emitting and beta/gamma-emitting radionuclides or additional samples may be collected and analyzed. The DOE limits for the radioactivity levels in settleable solids are 5 pCi/g above background for alpha-emitting radionuclides and 50 pCi/g above background for beta/gamma-emitting radionuclides.

5.4.6.1 Settleable Solids Results Summary

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

5.4.7 **Sediment Sampling**

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

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

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

5.4.7.1 Sediment Results Summary

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



Field Technician Collecting Sediment Sample from a Stream on SRS

stream, and basin sediments were below detection. Table 5-8 shows the maximum sediment concentrations.

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

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

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

5.4.8 Drinking Water Monitoring

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

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

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

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

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.

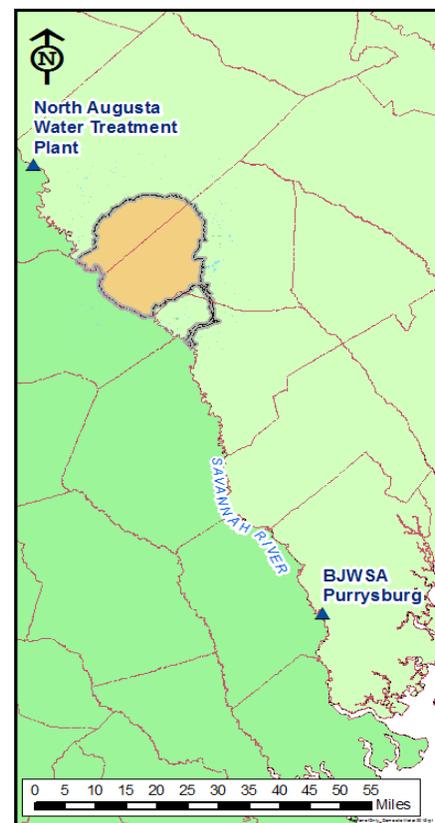


Figure 5-11 Offsite Drinking Water Sampling Locations

5.4.8.1 Drinking Water Results Summary

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

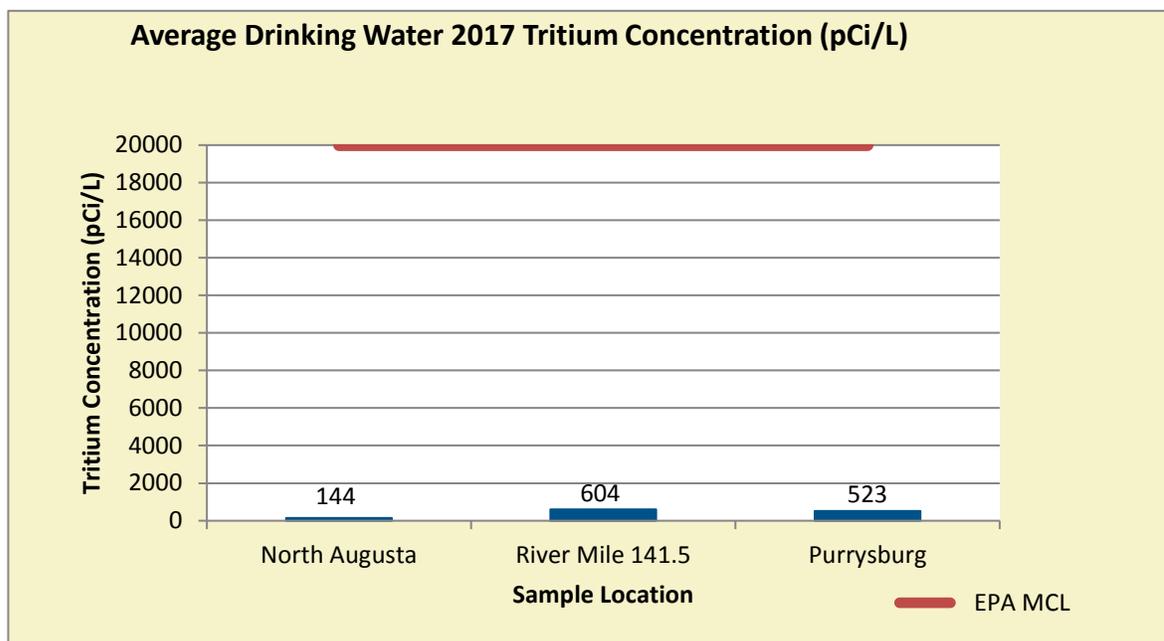


Figure 5-12 Tritium in Offsite Drinking Water and River Mile 141.5

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

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

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

5.5 AQUATIC FOOD PRODUCTS

5.5.1 Fish Collection in the Savannah River

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

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

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

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

5.5.1.1 Fish in Savannah River Results Summary

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



Collecting Fish by Netting

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

detected. The uranium is associated with decay of naturally occurring uranium. The Cm-244 result is between the instrument method detection limit and the sample quantitation limit, indicating the amount is very small.

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

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

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

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

5.6 WILDLIFE SURVEILLANCE

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

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

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



SRS Personnel Calibrate the Wildlife Monitoring System

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

5.6.1 Wildlife Results Summary

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

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

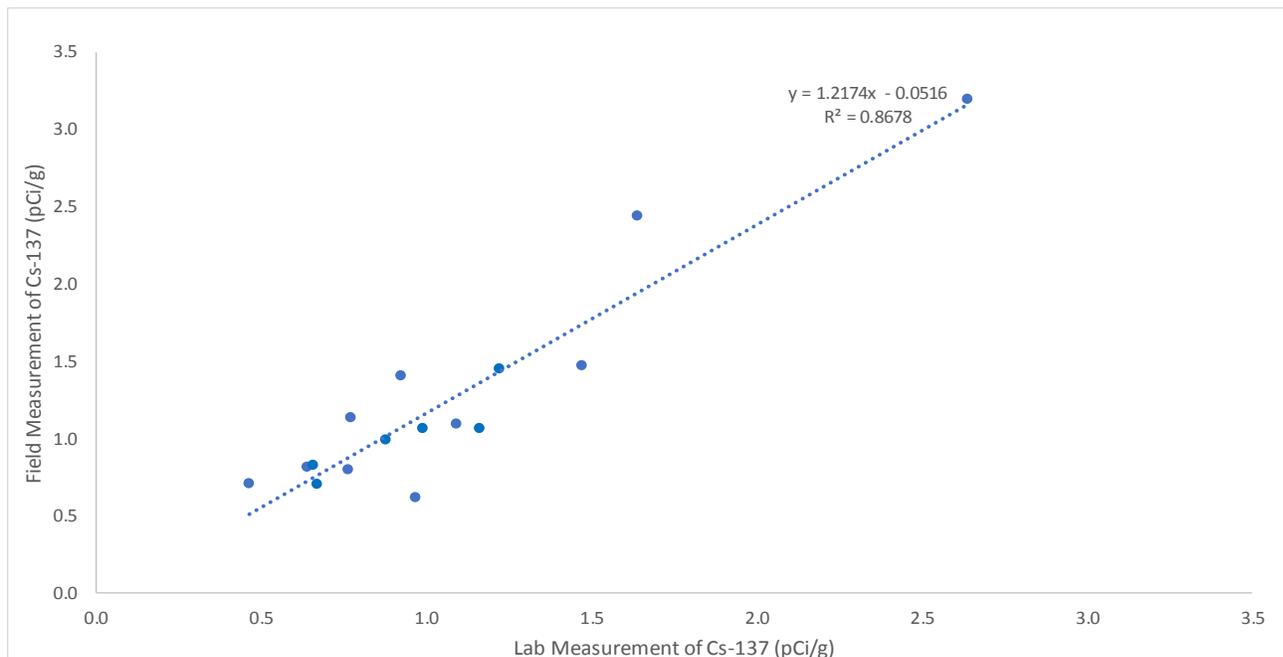
Generally, the cesium-137 concentration field detectors measure is similar to that of laboratory methods. Figure 5-13 compares the 2017 field versus laboratory measurement for each muscle sample collected. Table 5-11 summarizes all field and laboratory measurements. Average cesium-137 concentrations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

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

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

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

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



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

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

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

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

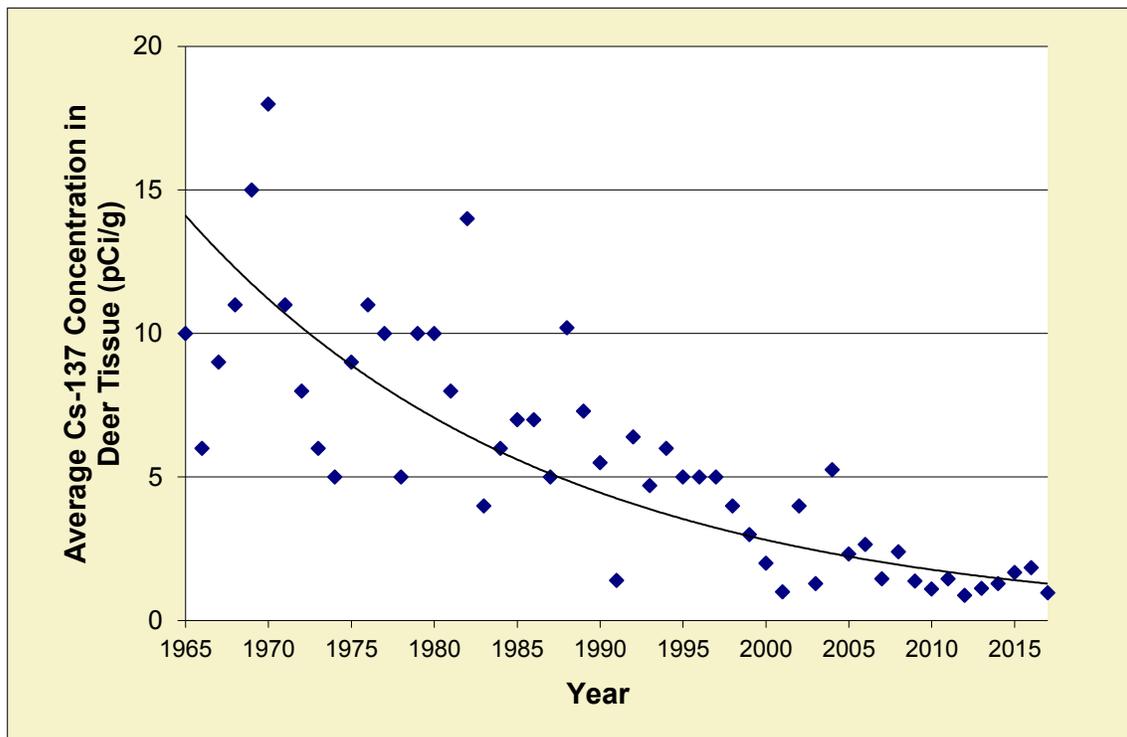


Figure 5-14 Historical Trend of Average Cesium-137 Concentration in Deer Tissue (1965–2017)

5.7 FIVE-YEAR COMPREHENSIVE SAMPLING

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

The 5-Year Comprehensive Survey sampling is performed at multiple locations along 10 trails located between Steel Creek Landing to below Little Hell Landing, with each trail beginning on the Savannah River edge and progressing inland. The annual samples are collected from the locations with the historically highest cesium-137 concentration and the highest concentration from the previous five-year comprehensive study, which is typically on Trail 1. High water levels in the river may result in moving and

redepositing radioactive materials. To support sampling areas of contamination, SRS employs gamma overflight data to verify that the sampling locations will support representative sampling of contamination and identify any additional sampling trails to support a comprehensive evaluation. Gamma overflight measurements are obtained using gamma spectroscopy instrumentation from a helicopter flying over the Creek Plantation at slow speeds. The gamma spectroscopy instrumentation obtains an average of spectral counts for a footprint over time. These measurements provide the levels of gamma-emitting radionuclides such as cesium-137. The soil and vegetation samples obtained from locations verified by the gamma-overflight data are analyzed for cobalt-60, cesium-137, and strontium-89,90.

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

5.7.1 Five-Year Comprehensive Survey Results Summary

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

The 2017 survey confirmed previous observations that cesium-137 is the primary man-made radionuclide detected in Creek Plantation. No cobalt-60 was detected in any of the soil samples.

Cesium-137 was detected in nearly all soil samples. Historically, the highest soil

concentrations occur on Trail 1; however, some sample locations on Trail 1 were not collected in 2017 but were collected after the flooding during 2016 and are included in this dataset. With the 2017 comprehensive survey, the highest soil concentrations were found at Trail 6 (Table 5-12), and concentrations decreased with depth. The highest overall soil concentration was collected on Trail 1 after the 2016 flooding event (Table 5-12, Figure 5-15).

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



Savannah River Swamp at Creek Plantation

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

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

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

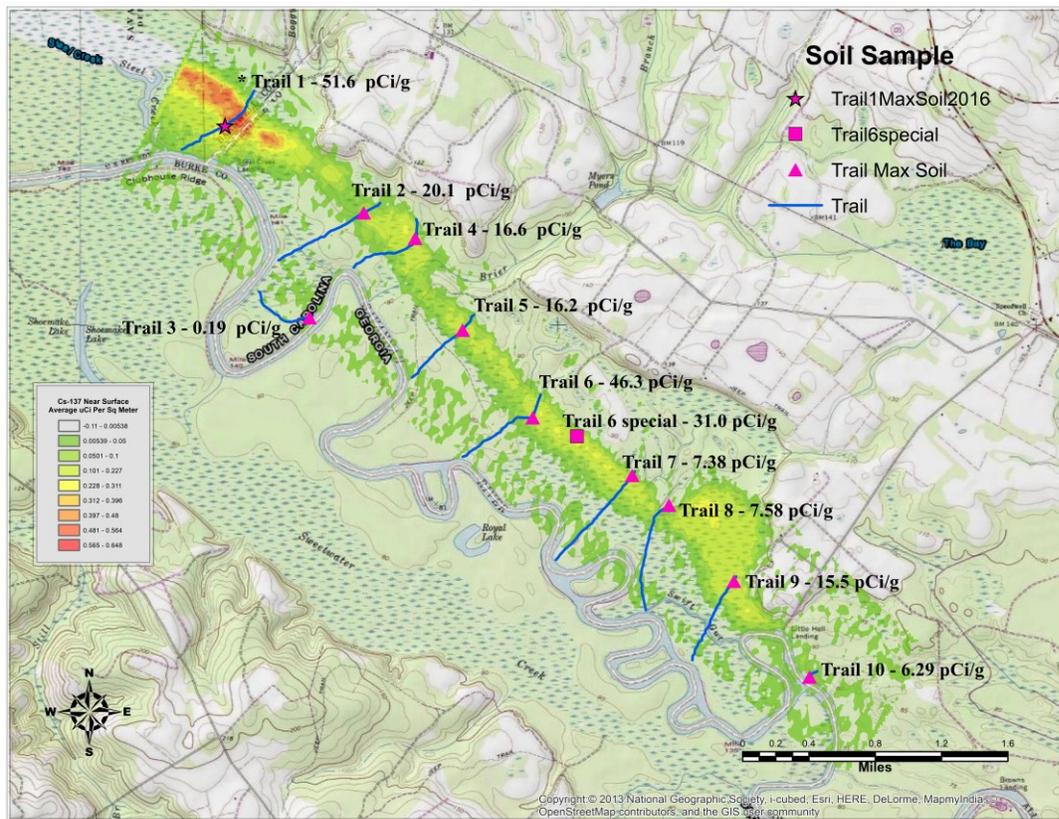


Figure 5-15 Gamma Overflight Survey of Creek Plantation with Maximum Cesium-137 Soil Concentrations from 2016 Annual Sampling and 2017 Comprehensive Survey

Table 5-12 Results of 2017 Creek Plantation Comprehensive Survey

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

Notes:

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