Chapter 5: **Radiological Environmental Monitoring Program**

The purpose of the Savannah River Site (SRS) Radiological Environmental Monitoring Program is twofold: It monitors 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.

2022 Highlights

Air Pathway—All air contaminants SRS released were below applicable permit and regulatory 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 319 animals.

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 the 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 implement DOE Order 458.1. This document was updated in 2022 (DOE 2022). DCSs are radiological quantities for certain radionuclides specific to a surface or concentration used in surveying or characterizing radiation to comply with 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 called 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 whether 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 the Site's 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 (facility effluents, stream and river water, and stormwater basins)
- Drinking water
- Stream, basin, and river sediment
- Aquatic food products
- Wildlife
- Food products (milk, meat, fruit, nuts, grains, and vegetables)

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 millirem (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.*

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.

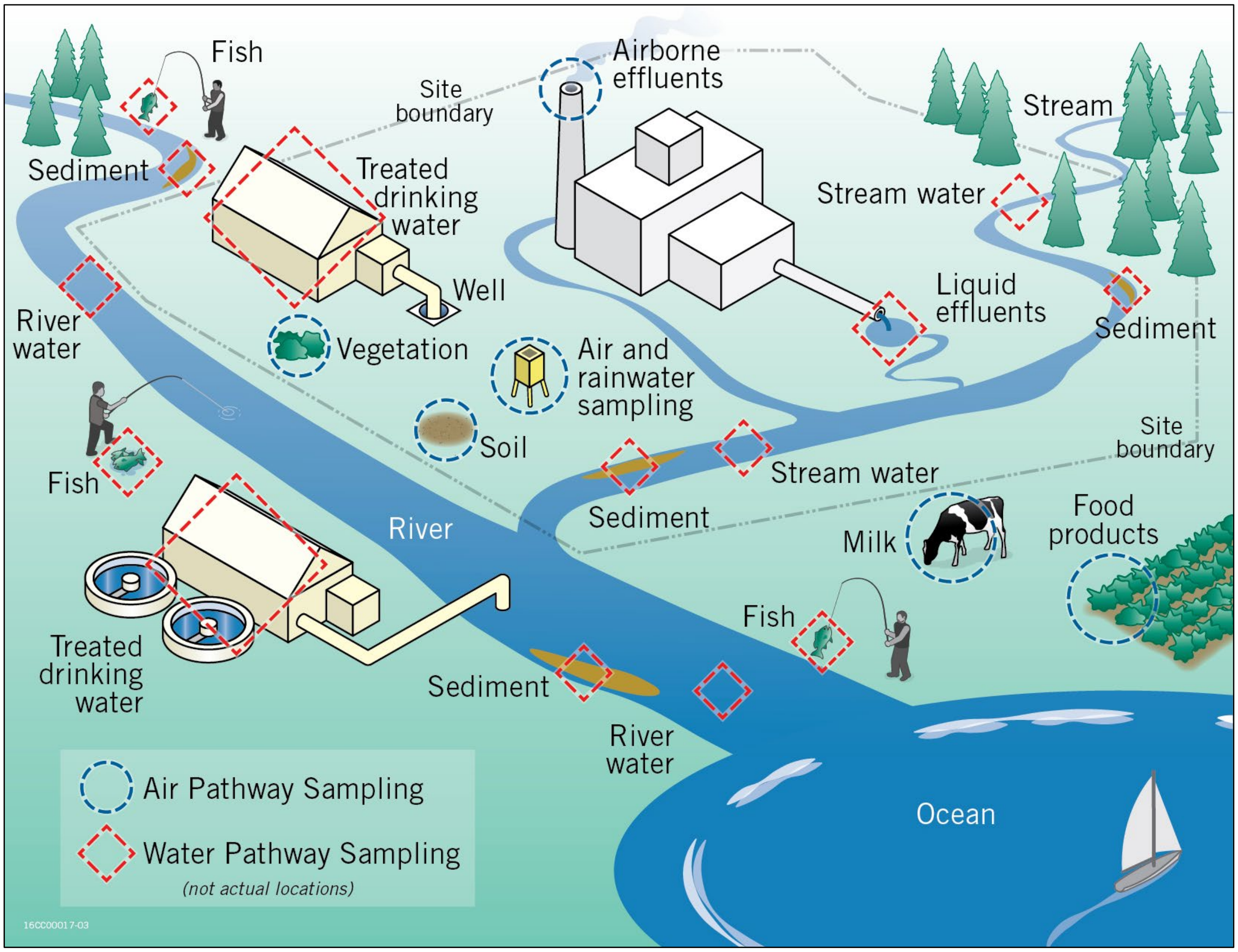


Figure 5-1 Types and Typical Locations of Radiological Sampling

5.2 SRS OFFSITE MONITORING

Offsite monitoring involves collecting and analyzing samples of air, river water, drinking water, soil, sediment, vegetation, milk, food products, fish, and other media from many locations. SRS analyzes these samples for radioactive contaminants to monitor 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-mile intervals. Additionally, SRS collects samples at several population centers in Georgia and South Carolina.

SRS monitors the Savannah River at five locations adjacent to and downriver of SRS. A control location is located above the Site at River Mile (RM) 161. 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 from 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	56 (7)	32 (4)
Rainwater	13 (1)	26 (2)
Food Products	16 (4)	4 (1)
Milk	16 (4)	12 (3)
Soil	4 (4)	2 (2)
Grassy Vegetation	1 (1)	2 (2)
Drinking Water	24 (2)	0 (0)
Total	**182 (25)**	**182 (18)**

Note:
This table excludes groundwater monitoring locations and samples discussed in Chapter 7, *Groundwater Management Program*, 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 EPA and DOE requirements and regulations that are in place 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 both from SRS operations and from sources not related to the Site. The sources not associated with SRS include 1) naturally occurring radioactive material, 2) past atmospheric testing of nuclear weapons, 3) offsite nuclear power plant operations, and 4) offsite medical and industrial activities. Krypton-85 and 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 krypton-85 and tritium released from SRS varies yearly, based on mission activities and on the annual production schedules of the processing facilities.

5.3.2 Airborne Emissions

The 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 spent fuel dissolution
- 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 instruments 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 the 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 for the calendar year (CY). During the past 10 years, the total annual tritium release has ranged from about 7,030 to 40,000 Ci per year, with an annual average tritium release of 18,200 Ci (Figure 5-2). The 2022 SRS tritium releases totaled 9,590 Ci. SRS tritium releases fluctuate from year to year due to deactivation of legacy process buildings, the amount of tritium released during routine operations, and natural decay of tritium (about 5% per year).

Table 5-2 SRS Radiological Atmospheric Releases for CY 2022

Release Type	Total (curies)
Tritium	9.59E+03
Krypton-85 (^{85}Kr)	1.30E+04
Short-Lived Fission and Activation Products (T1/2 < 3 hr)[a,b]	1.69E-05
Fission and Activation Products (T1/2 > 3 hr)[a,b]	5.51E-02
Total Radio-iodine	7.08E-03
Total Radio-strontium[c]	7.01E-03
Total Uranium	5.65E-05
Plutonium[d]	4.83E-04
Other Actinides	2.30E-04
Other	2.96E-06

[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 unidentified beta releases
[d]Includes unidentified alpha releases

In 2022, tritium and krypton-85 accounted for most of the total radiation SRS operations released to the air. Tritium-processing facilities are responsible for most of the SRS tritium releases, and highly enriched uranium reprocessing at H-Area separations facilities is responsible for all krypton-85 releases. Tritium releases from the separations areas are a 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, legacy reactor facilities, and unmonitored sources.

Appendix Table D-2 summarizes the 2022 air effluent-derived concentration standards sum of fractions for continuous sources. The table contains calculated concentrations for tritium from the legacy reactor areas and the tritium-processing facilities, and for krypton-85, carbon-14, and tritium from the H-Canyon facility during the dissolving process. SRS calculates these concentrations based on the annual releases in curies and the annual stack release volume. In 2022, Appendix D-2 includes two tables: 1) using the historical *Derived Concentration Technical Standard* (DOE 2011) and 2) using the updated Standard (DOE 2022). Some dose coefficients and DCSs have moderately significant changes as a result of the improved dosimetry and updated population distribution in the updated standard.

Most SRS stacks and facilities release small quantities of radionuclides at concentrations below the DOE DCSs. The F-Canyon stack analytical results were elevated in 2022, as they were from 2017 to 2021. The elevated levels continue to result in a DCS exceedance (using DOE 2011 Standard) with plutonium-239 as the primary contributing radionuclide. As mentioned earlier in the chapter, compliance with the DCS is when the sum of the ratios of each radionuclide’s observed concentration to its corresponding DCS does not exceed 1.00. Using the DCSs provided in DOE 2011, as has been used in previous ASERs, the DCS sum of fractions exceedance for 2022 is 1.58, a significant decrease from the 2021 value of 2.47. However, using the DOE 2022 standard, the F Canyon DCS sum of ratios is 0.693. The difference in DCS sum of ratios between the 2011 and the 2022 Standards is primarily due to a 220% change in DCS associated with the primary contributing radionuclide, plutonium-239.

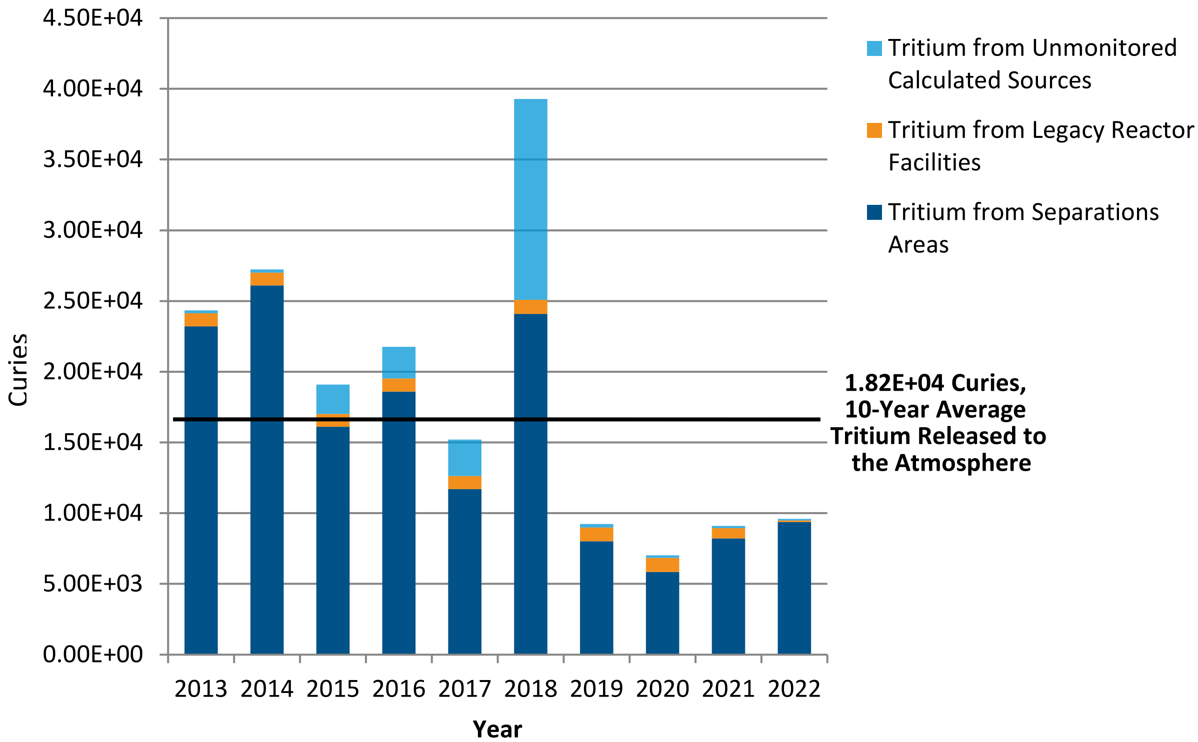


Figure 5-2 10-Year History of SRS Annual Tritium Releases to the Air

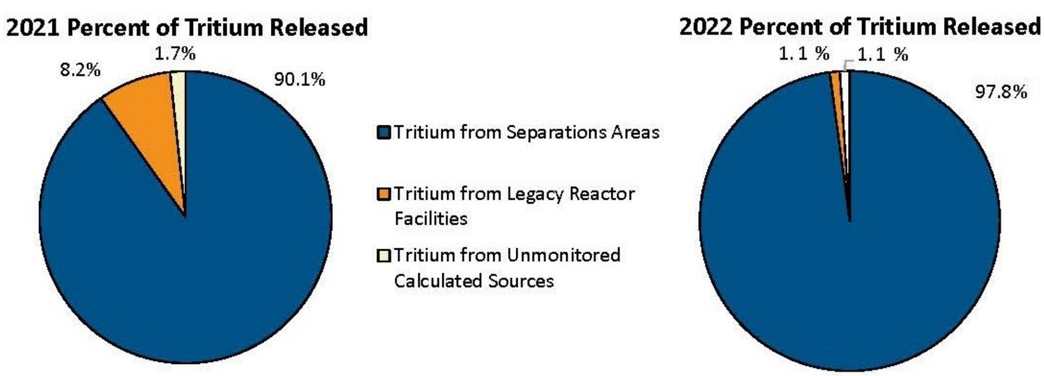


Figure 5-3 Percent of Tritium Released to the Air for 2021 and 2022

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. Thus, the Site maintains tritium releases according to the ALARA principle to comply with DOE Order 458.1. The ALARA process manages radiological activities so that doses to members of the public (both individual and collective) and releases to the environment are kept as low as reasonably achievable.

5.3.3 Air Surveillance

Beyond the operational facilities, SRS maintains a network of 16 air sampling stations (Figure 5-4 and Environmental Maps, *Radiological Air Surveillance Sampling Locations*) in and around SRS to monitor concentrations of radionuclides in the air and rainwater. The air contains radionuclides in various forms (gaseous, particulate matter, water vapor). Rainwater can redeposit radionuclides 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 in the environment. Each air sampling station collects air and rainwater samples as Table 5-3 lists.

SRS selected the radionuclides Table 5-3 presents 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

Appendix Tables D-3 and D-4 summarize results for tritium in air (water vapor) and tritium in rainwater and compare them to the background control location at the U.S. Highway 301 Bridge. The 2022 results for tritium in air showed detectable levels in 52 of the 417 samples, or 12%, compared to 2021 results with detectable levels in 13% of the samples.

The 2022 results for tritium in rainwater showed detectable levels in 16 of the 208 rainwater samples, or 8%, as compared to 2021 results with detectable levels in 13% of the samples. Thirteen of 13 results for Burial Ground North were detected, which is at the center of the Separations Area at SRS. Barricade 8, D Area, and Darkhorse @Williston Gate each had 1 of 13 results detected.

Charcoal canisters analyzed quarterly for radioiodine in 2022 showed one detection of iodine-129. Charcoal canister results for radioiodine were within the historical trends for the previous 10 years. Glass fiber filter results for gamma-emitting radionuclides showed no detectable levels of cesium-137 and no detectable levels of cobalt-60 at any air surveillance stations during 2022. All offsite location results were near the levels observed at the control location at the U.S. Highway 301 bridge. Appendix Table D-5 summarizes the results.

SRS also selected offsite and plant perimeter glass fiber filter samples for actinide and strontium-89/90 analysis. Sample selection was dependent on dates of elevated concentrations at F-Canyon stack and the wind direction during the corresponding time period. Actinide and strontium-89/90 analysis was also performed on glass fiber filter samples collected biweekly at the Burial Ground North onsite. Appendix Table D-5 summarizes all glass fiber filter results, and all are comparable to historical trends.

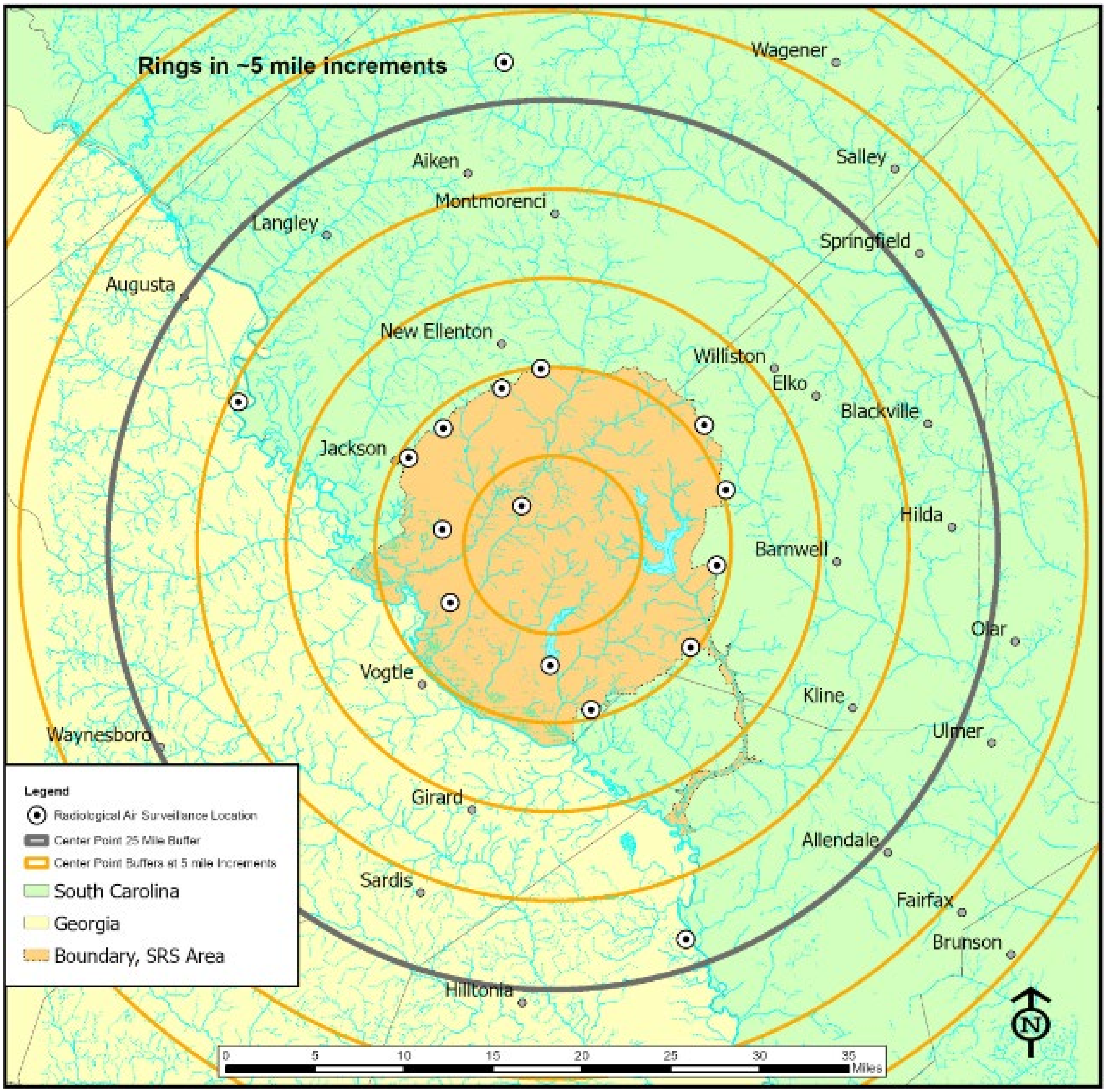


Figure 5-4 Air Sampling Locations Surrounding SRS up to 25 Miles

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
Silica Gel	Tritiated water vapor	Tritium
Rainwater	Tritium in rainwater	Tritium

5.3.4 Ambient Gamma Surveillance

Since 1965, SRS has been monitoring ambient (surrounding) environmental gamma exposure rates. SRS currently measures ambient gamma exposure using optically stimulated luminescent dosimeters (OSLDs), which are passive devices that measure exposure from ionizing radiation. The Site uses data from OSLDs 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 supporting routine and emergency response dose calculations.

SRS Employee Measures Environmental Gamma Exposure Rates with OSLDs Placed Across the Site.

An extensive OSLD network in and around SRS monitors external ambient gamma exposure rates (Environmental Maps, *SRS Optically Stimulated Luminescent Dosimeter [OSLD] 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 colocated with Georgia Power's Vogtle Electric Generating Plant's stations. SRS conducts most gamma exposure monitoring onsite and at the SRS perimeter.

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

5.3.4.1 Ambient Gamma Results Summary

Appendix Table D-6 summarizes the gamma results. Ambient gamma exposure rates at all OSLD monitoring locations show some variation based on location and natural levels of background radiation in the environment. In 2022, ambient gamma exposure rates onsite varied between 93 mR/yr at location Allendale Gate and 147 mR/yr at A-14. Rates at population centers ranged from 110 mR/yr at the McBean, South Carolina, location to 157 mR/yr at the Beech Island, South Carolina, 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 2022, SRS collected soil samples from 5 onsite locations, 12 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 samples to a depth of 6 inches at each sampling location. The technicians mix the soil samples from each sampling location to ensure they are homogeneous when the laboratory analyzes them for gross alpha, gross beta, gamma-emitting radionuclides, strontium-89/90, and actinides.

5.3.5.1 Soil Results Summary

Collecting a Soil Sample

In 2022, SRS detected radionuclides in soil samples from all 24 sampling locations. Analyses detect uranium isotopes (uranium-234, uranium-235, and uranium-238) in the soil samples each year. Uranium is naturally occurring in soil and is 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 are consistent with naturally occurring uranium levels. 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.

The concentrations of other radionuclides at these locations are consistent with historical results, with a maximum cesium-137 concentrations of 35.9 pCi/g at the Creek Plantation Trail 1 1805’ location and 0.15 pCi/g at the control location (Highway 301). Appendix Table D-7 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 sample results that the Site uses to evaluate radionuclide accumulation 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:

- All air sampling locations
- When applicable, locations where SRS expects soil radionuclide concentrations to be higher than normal background levels
- 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.

5.3.6.1 Grassy Vegetation Results Summary

SRS collected all 16 annual samples for 2022. SRS detected various radionuclides in the grassy vegetation samples at all air sampling locations (1 onsite, 12 at the perimeter, and 3 offsite). Appendix Table D-8 summarizes the results. All radionuclides are within the trends of the previous 10 years for all locations.

SRS Analyzes Grassy Vegetation Both Onsite and Offsite.

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 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 potential radiation exposure. SRS samples milk, meat, fruit, nuts, grains, and vegetables based on their potential to transport radionuclides to humans through the food chain.

Local gardens, farms, and dairies are the source of 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. 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 those for gamma-emitting radionuclides, tritium, strontium-89/90, technetium-99, gross alpha, gross beta, and actinides (including neptunium). Laboratory analysis of the dairy samples include those for gamma-emitting radionuclides, tritium, and strontium-89/90.

5.3.7.1 Terrestrial Food Results Summary

In 2022, SRS sampled milk and the following terrestrial foodstuffs: greens, fruit (watermelons), beef, cabbage, and grains. Based on availability, the collected grains were wheat. SRS collected all food types from all four quadrants and the control area. Appendix Tables D-9 and D-10 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 (73% for terrestrial foodstuffs and about 94% for dairy) did not detect radionuclides. About 39% of the detected terrestrial foodstuff results were associated with natural uranium.

5.4 WATER PATHWAY

The media presented in this section support the water pathway dose assessment discussed in Chapter 6, *Radiological Dose Assessment.* 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.

5.4.1.1 Liquid Effluent Results Summary

Appendix Table D-11 provides SRS liquid radionuclide releases for 2022. These releases include direct releases plus the shallow groundwater migration (discussed in Section 5.4.3) 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 decreased by 28% (from 483 Ci in 2021 to 348 Ci in 2022).

The total amount of tritium released directly from process areas to SRS streams (not including shallow groundwater migration) during 2022 was 52.1 Ci, compared to 88.4 Ci released in 2021. Figure 5-6 presents the tritium released by source area and shows that while oftentimes variable, the total direct releases of tritium in 2022 is consistent with the 10-year historical measurements.

As the chapter mentions earlier, compliance with the DCS is when the sum of the ratios of each radionuclide’s observed concentration to its corresponding DCS does not exceed 1.00. The DCS sum of fractions for all liquid effluent locations was less than 1.00. Appendix Table D-12 summarizes the 2022 liquid effluent sum of fractions and radionuclides detected at each outfall or facility.

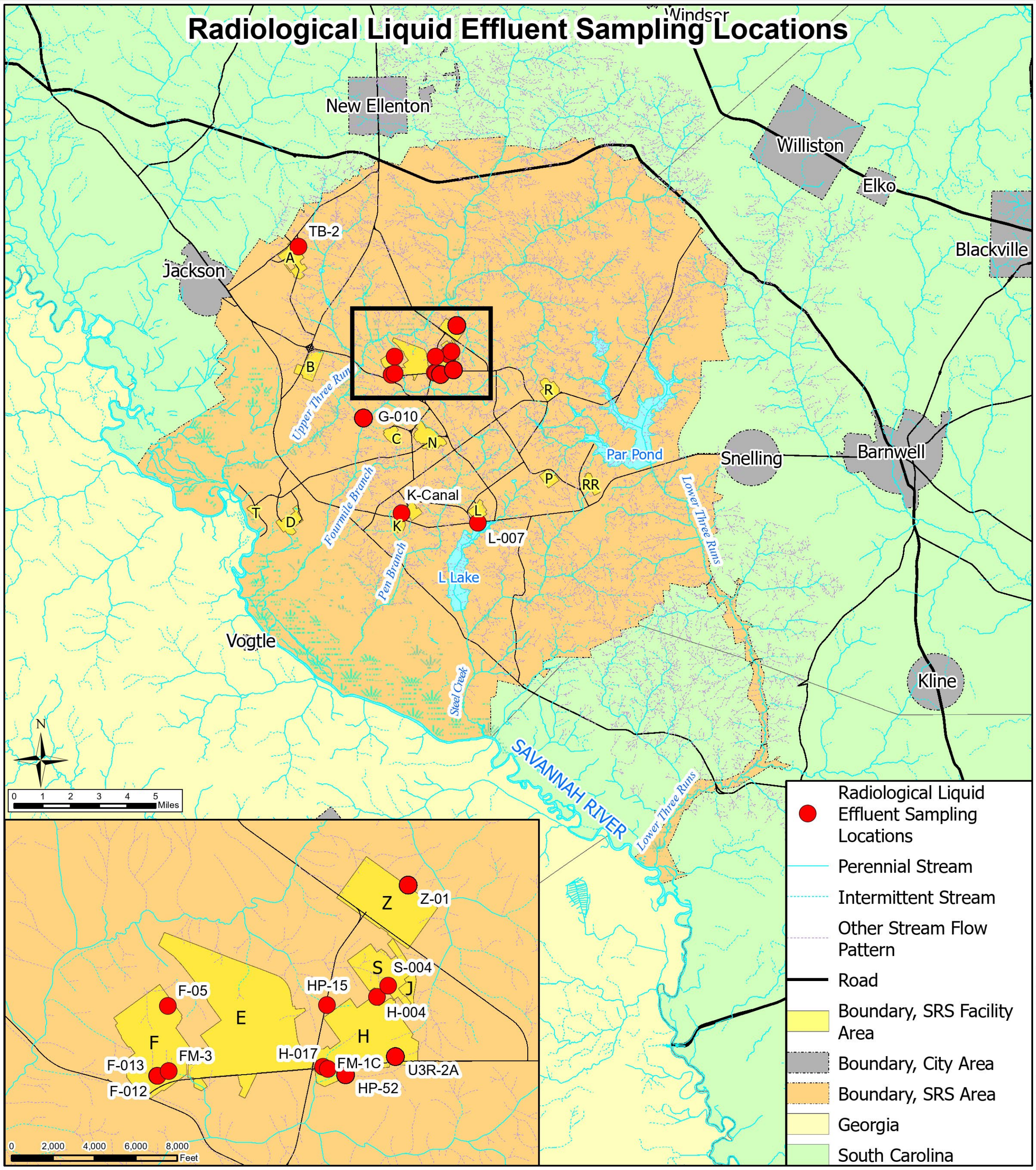
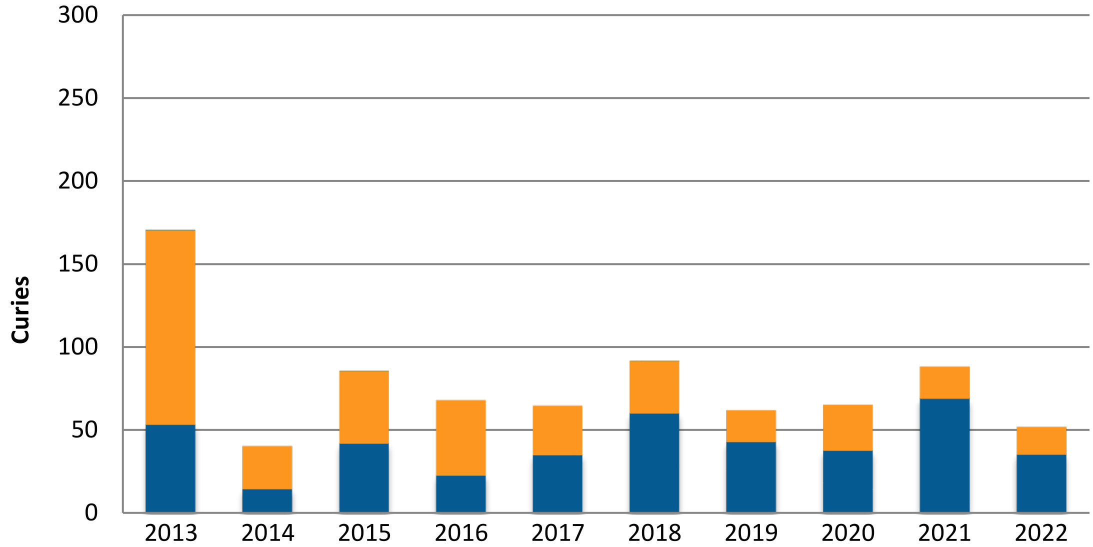


Figure 5-5 Radiological Liquid Effluent Sampling Locations



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
SRNL	0.12	0	0	0	0.0	0.05	0	0	0	0
Legacy Reactor Areas	116.8	26.1	43.8	45.2	29.9	31.7	19.3	27.8	19.5	16.8
Separations Areas	53.3	14.5	41.8	22.9	35	60.1	42.8	37.7	68.9	35.33

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

Table 5-4 SRS Radiological Liquid Effluent Releases[a] of Radioactive Material for CY 2022

Release Type	Totals (curies)
Tritium	3.48E+02
Fission and Activation Products (half-life > 3 hr)[b,c]	3.33E-02
Total Radioiodine	1.30E-02
Total Radio-strontium[d]	6.02E-02
Total Uranium	1.39E-01
Plutonium[e]	1.07E-02
Other Actinides	1.27E-04
Other	0

[a] Includes direct releases and shallow groundwater migration from SRS seepage basins and SWDF
[b] International Commission on Radiological Protection (ICRP) 107 half-life data, *Nuclear Decay Data for Dosimetric Calculations (2008)*
[c] International Atomic Energy Agency (IAEA) Common Fission and Activation Products
[d] Includes unidentified beta releases
[e] Includes unidentified alpha releases

5.4.2 Stormwater Basin Surveillance

SRS monitors the accumulated stormwater in the Site's stormwater basins 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 SWDF, the 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 Savannah River Plutonium Processing Facility. Z-Area Stormwater Basin receives stormwater from Z Area (Saltstone processing and disposal facilities). Stormwater basins may release to monitored outfalls during heavy rainfall. As part of the surface water surveillance program, Figure 5-7 identifies all the Site's stormwater basin locations, along with the Site's stream surveillance location, which are discussed later in this chapter.

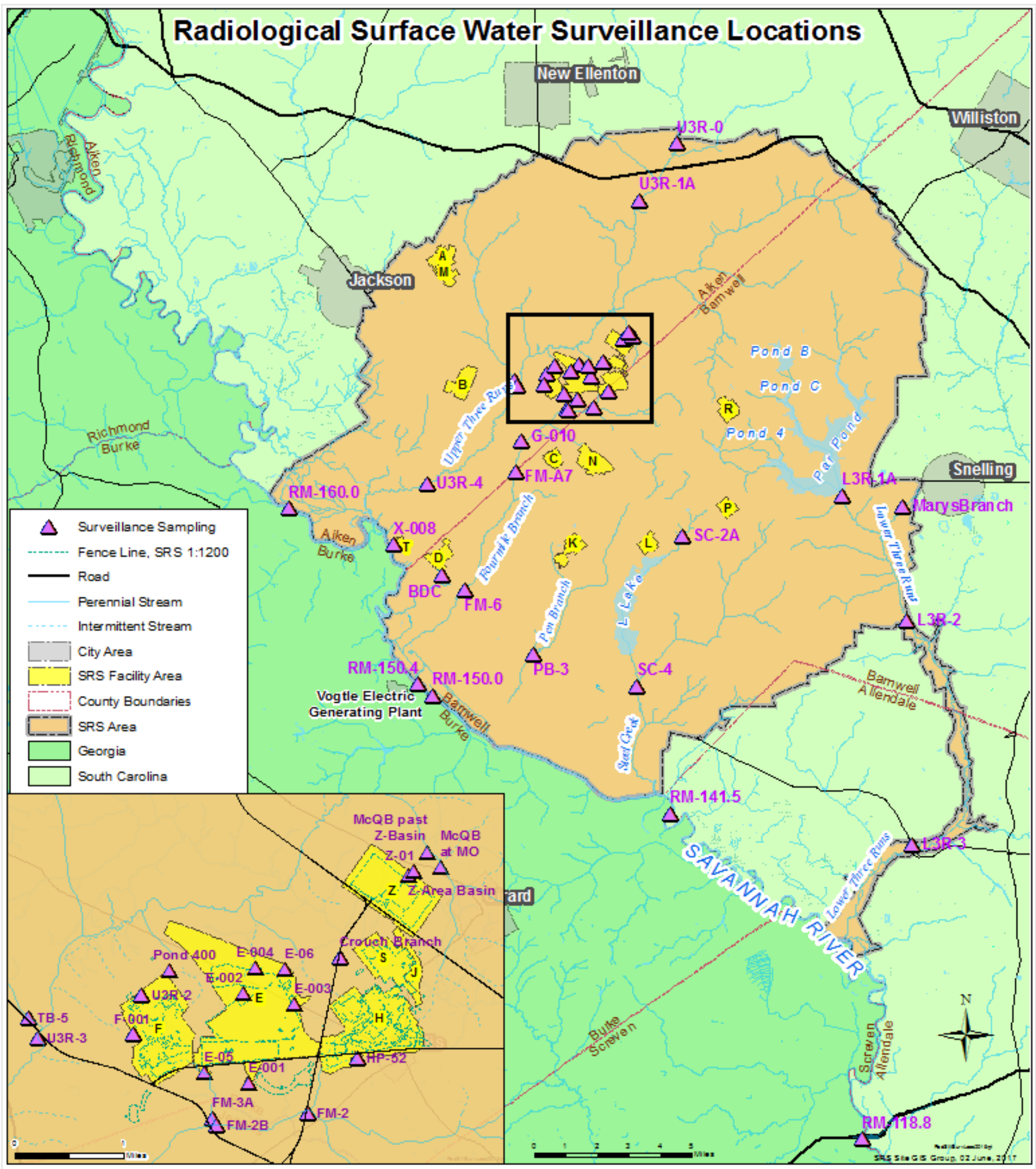


Figure 5-7 Radiological Surface Water Sampling Locations

5.4.2.1 Stormwater Basin Results Summary

In 2022, SRS sampled at six E-Area basins (E-001, E-002, E-003, E-004, E-005, E-006), 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. E-002 Basin had the highest tritium concentration (45,000 picocuries/liter [pCi/L]), which is consistent with the results reported for the E-002 Basin in 2021 (46,800 pCi/L). Tritium results for all basin locations are consistent with the 10-year historical measurements.

Table 5-5 Radionuclide Concentrations Summary for Stormwater Basins for CY 2022

Basin Location	Average Gross Alpha (pCi/L)	Average Gross Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
E-001	0.328	3.07	2,830	3,930
E-002	0.281	3.76	18,300	45,000
E-003	All < DL	25.6	6,598	15,300
E-004	0.314	2.02	11,780	18,200
E-005	0.658	2.11	4,219	8,580
E-006	All < DL	3.10	ALL < DL	ALL < DL
Pond 400	0.904	4.33	826	1,840
Z Basin	All < DL	140	1,300	2,660

Note:

DL = detection limit

5.4.3 SRS Stream Sampling and Monitoring

SRS routinely samples streams down gradient of several process areas to detect and quantify levels of radioactivity that liquid effluents and shallow groundwater transport to the Savannah River (Figure 5-7). 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 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. 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 seepage basins and SWDF continues to migrate through the groundwater and enter SRS streams. Additionally, Table 5-6 provides information on the stream sampling locations used to determine radioactivity migration in streams and the direct release sample locations associated with the contributing migration source. 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.

In addition to the monthly samples collected for tritium, gross alpha, gross beta, and gamma analyses, SRS collects samples annually for alpha-specific actinide analyses to provide a more comprehensive suite of radionuclides for annual shallow groundwater migration reporting.

Table 5-6 Radionuclide Concentrations in the Primary SRS Streams by Location for CY 2022

	Average Alpha (pCi/L)	Average Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
Onsite Stream Locations				
Lower Three Runs (L3R-3)	1.75	2.42	354	646
Steel Creek (SC-4)	1.78	2.51	1,198	1,710
Pen Branch (PB-3)	3.10	2.86	8,231	9,710
Fourmile Branch (FM-6)	1.63	5.48	17,358	19,900
Upper Three Runs (U3R-4)	15.0	8.45	415	773
Onsite Control Locations (for comparison)				
Upper Three Runs (U3R-1A)	5.71	3.71	66.7	637

5.4.3.1 SRS Stream Results Summary

Table 5-6 presents the average 2022 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 effluent releases, SRS remediation actions, and the natural decay of tritium. Figure 5-8 indicates that average tritium levels in Fourmile Branch are trending 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. 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 2013 through 2022. 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 2022, the total quantity of tritium migrating from SRS seepage basins and SWDF into SRS streams was 296 Ci, compared to 395 Ci in 2021, which represents a 25.1% decrease. Furthermore, the 10-year trend displays an overall decreasing trend in tritium migration.

SRS measured 206 Ci (69.6%) of the 296 Ci of tritium migrating into SRS streams in Fourmile Branch. Migration releases of other radionuclides vary from year-to-year but have remained below 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. An estimated 90 Ci migrated in 2022, compared to 98 Ci in 2021. Stream transport includes tritium migration releases from C Area, L Area, and P Area Seepage Basins. (See Section 5.4.5, *Tritium Transport in Streams and Savannah River Surveillance,* in this chapter.)

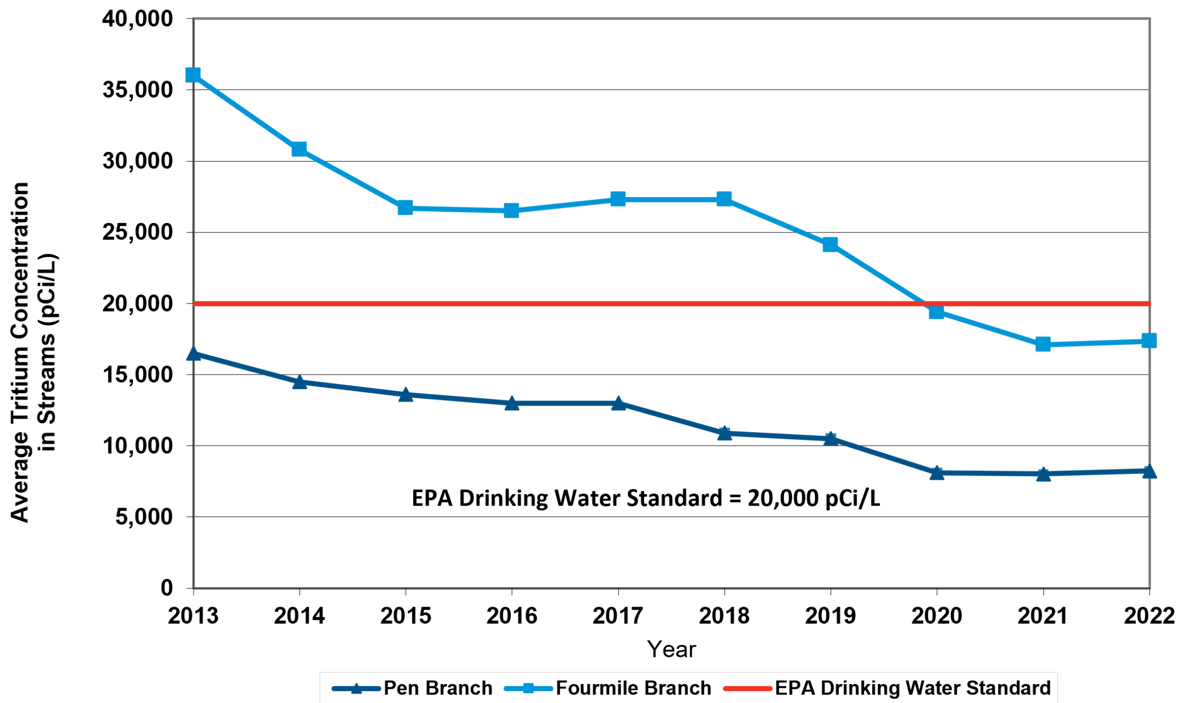


Figure 5-8 10-Year Trend of Tritium in Pen Branch and Fourmile Branch

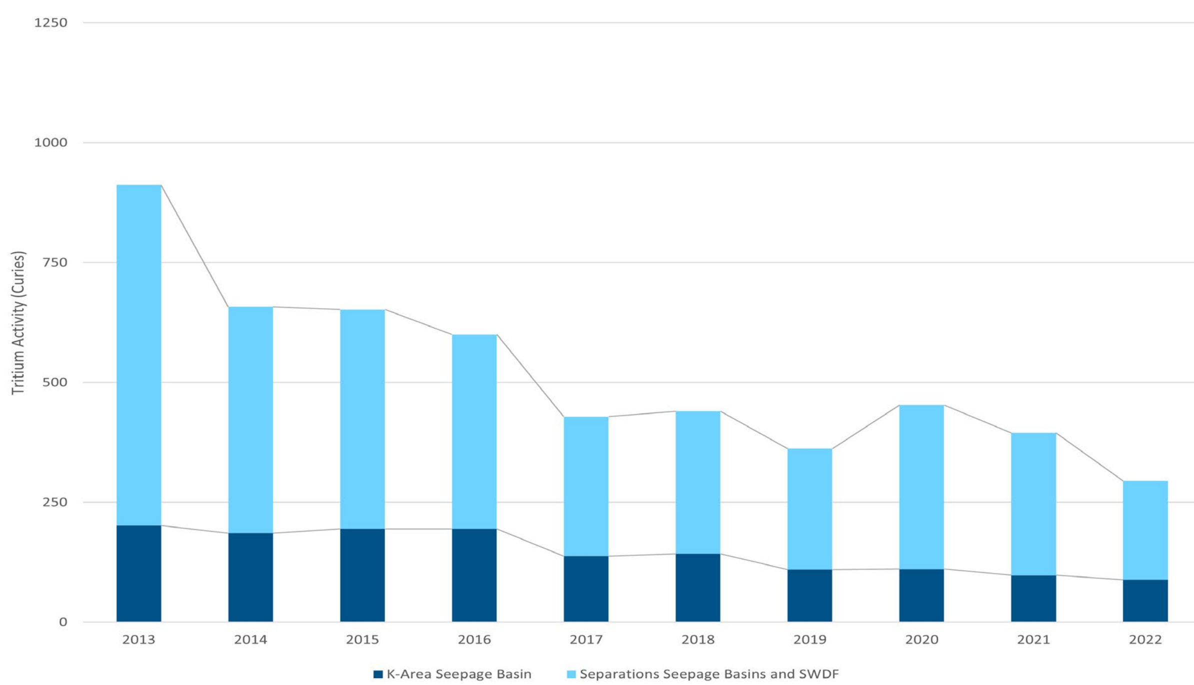


Figure 5-9 10-Year History of Tritium Migration from SRS Seepage Basins and SWDF to SRS Streams

5.4.4 Savannah River Sampling and Monitoring

SRS routinely samples along the Savannah River at locations up and downstream of SRS tributaries, including at a location where liquid discharges from Vogtle Electric Generating Plant (VEGP) enter the river.

Five locations along the river, as Figure 5-7 shows, continued to serve as environmental surveillance points in 2022. SRS collects samples weekly at these river locations for tritium, gross alpha, gross beta, and gamma analyses. SRS also collects samples annually for strontium, technetium, and actinides to provide a more comprehensive suite of radionuclides.

5.4.4.1 Savannah River Results Summary

Table 5-7 lists the average 2022 concentrations of gross alpha, gross beta, and tritium, and the maximum 2022 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).

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 141.5 were 1,556 Ci in 2022 compared to 1,918 Ci in 2021. This decrease was due to decreased releases from SRS and BLLDF. Total releases from SRS were 348 Ci in 2022, compared to 483 Ci in 2021. Total releases from BLLDF were 13 Ci in 2022, compared to 29 Ci in 2021.

Average radionuclide concentrations for gross alpha, gross beta, tritium, strontium-89/90, technetium-99, actinides, and gamma-emitting radionuclides are consistent with the results from the previous 10 years.

Table 5-7 Radionuclide Concentrations in the Savannah River for CY 2022

Location	Average Gross Alpha (pCi/L)	Average Gross Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
CONTROL (RM-161)	0.204	2.06	85.1	737
RM-150.4 (VEGP)	0.253	2.28	478	3,510
RM-150	0.242	2.20	133	275
RM-141.5	0.297	2.26	241	1,210
RM-118.8	0.259	2.11	243	1,080

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 (discussed in Section 5.4.1) and measured shallow groundwater migration (discussed in Section 5.4.3) 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. This includes shallow groundwater migration contributions from C Area, L Area, and P Area Seepage Basins.
- River transport—Tritium transport in the Savannah River, measured downriver of SRS (near RM 141.5) after subtracting any measured contribution above SRS (RM 161.0)

SRS bases its methods for estimating releases on the environmental data reporting guidance 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.

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 2022 to be 13 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.*)

5.4.5.1 Tritium Transport in Streams and Savannah River Results Summary

In 2022, tritium levels in stream transport and river transport showed a decrease, specifically as described below:

- The total liquid effluent releases (including migration) of tritium decreased by 28% (from 483 Ci in 2021 to 348 Ci).
- The stream transport of tritium decreased by 42.5% (from 428 Ci in 2021 to 246 Ci).
- The river transport of tritium decreased by 18.9% (from 1,918 Ci in 2021 to 1,556 Ci). VEGP, BLLDF, and SRS contributed to these values.

Tritium transport in the Savannah River includes the 13 Ci migration value attributed to BLLDF and the 1,430 Ci release value attributed to VEGP.

SRS tritium transport data from 1960–2022 (Figure 5-10), shows the history of direct releases plus migration, stream transport, and river transport, while Table 5-8 shows a decrease from 2021 to 2022 for most quantified contributors of these three tritium transport categories. The general downward trend over the past 60 years 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

As Chapter 6, *Radiological Dose Assessment*, discusses, the direct plus migration releases value was higher than the tritium stream transport value. Therefore, the compliance dose calculations for 2022 use the direct releases and migration value of 348 Ci.

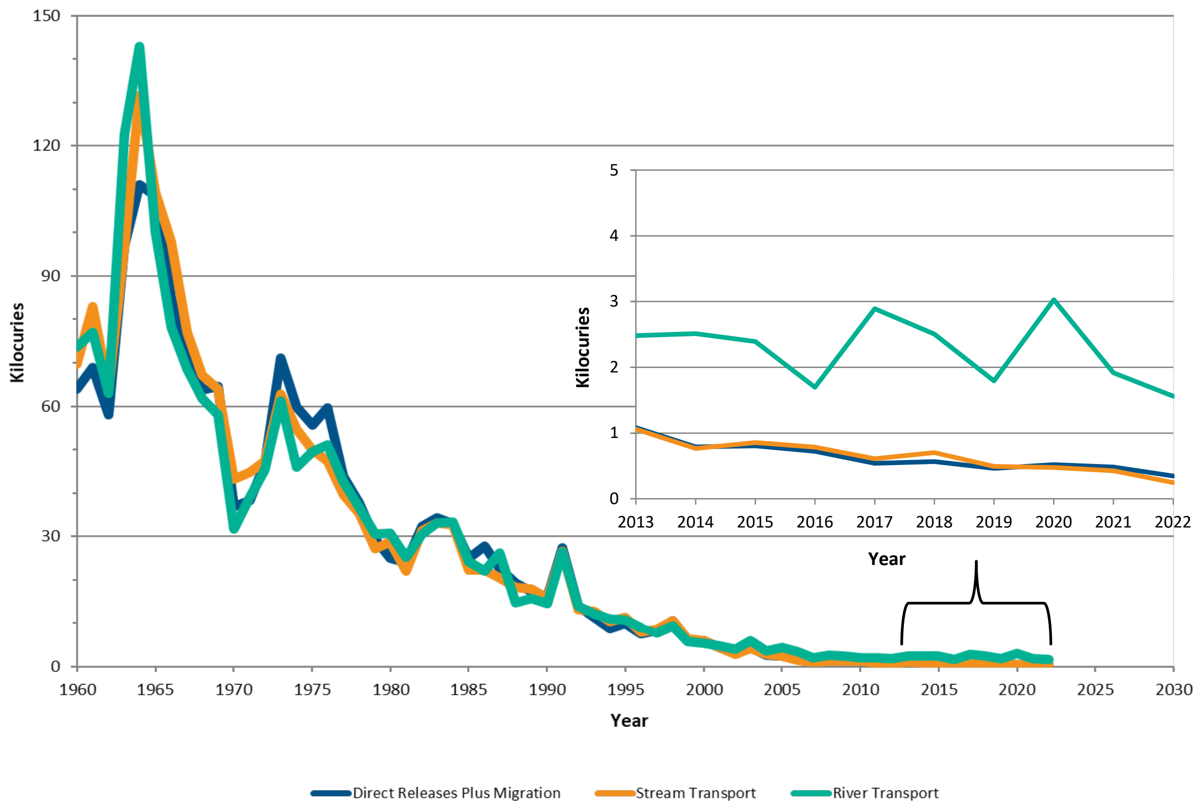


Figure 5-10 History of SRS Tritium Transport (1960 to 2022)

Table 5-8 Liquid Tritium Releases and Transport

Releases/Transport (curies)	CY 2021	CY 2022
Liquid Effluent Releases		
Direct releases	88	52
Shallow groundwater migration from Separations Areas Basins, K-Area Seepage Basins, and Percolation Field below K-Area Retention Basin	395	296
Total Liquid Effluent Releases (direct releases and migration)	**483**	**348**
Total Stream Transport		
Stream transport and shallow groundwater migration from C-Area, L-Area, and P-Area Seepage Basins	428	246
River Transport		
SRS contribution	483	348
VEGP contribution	986	1,430
BLLDF contribution	29	13
Total River Transport (SRS, VEGP, and BLLDF)	**1,918**	**1,556**

Note:
For compliance dose calculations, the Site uses whichever value is higher: SRS direct releases and migration or the stream transport measurements. Therefore, in 2022, SRS used direct releases and migration to calculate the dose. See Chapter 6, *Radiological Dose Assessment.*

5.4.6 Settleable Solids Surveillance

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. Settleable solids are solids in water that are dense enough to sink to the bottom of the collection container.

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 outfalls that are colocated 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 Settleable Solids Results Summary

In 2022, 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 bed of the Savannah River. 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). The Site can use data obtained to observe long-term environmental trends.

In 2022, SRS collected annual 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*). The locations vary from year-to-year, depending on the rotation schedule agreed upon with SCDHEC, which duplicates sampling at several locations as a quality control check of the SRS program. SRS also collects duplicate samples to assess quality control, as Section 8.5, *Environmental Monitoring Program QC Activities,* documents.

5.4.7.1 Sediment Results Summary

Appendix Table D-13 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 1430 pCi/g. Soil contamination areas at SRS are locations where the contamination levels exceed 150 pCi/g for beta and gamma radionuclides. Table 5-9 shows the maximum cesium-137 concentrations found in river, stream, and basin sediment, by sampling location.

Radionuclide concentrations in SRS stream, river, and basin sediment are within historical levels. Results indicate radioactive materials from effluent release points are not accumulating in the sediment at the sampling locations.

Table 5-9 Maximum Cesium-137 Concentration in Sediments Collected in 2022

Location	Maximum Location	Maximum Concentration (pCi/g)
Savannah River Sediment	Steel Creek River Mouth	1.54E+00
SRS Stream Sediment	FM-2	3.37E+01
SRS Basin Sediment	Z Basin	1.43E+03

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, from five small systems, and from groundwater samples from four wells. However, the pump at 905-112G Domestic Water Faucet, one of the small systems, was inoperable for 2022. Onsite sample analyses consist of tritium, gross alpha, gross beta, gamma-emitting radionuclides, strontium-89/90, and actinides.

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 Purrysburg Water Treatment Plant
- North Augusta Water Treatment Plant

SRS collects treated water from these two treatment plants, which supply water to the public. Offsite sample analyses consist of tritium, gross alpha, and gross beta.

The North Augusta Water Treatment Plant samples determine concentrations in drinking water upstream of SRS. The Beaufort-Jasper Water and Sewer Authority's Purrysburg Water Treatment Plant is the furthest downriver sampling location. SRS compares these locations to evaluate potential impacts from upstream sources that include SRS.

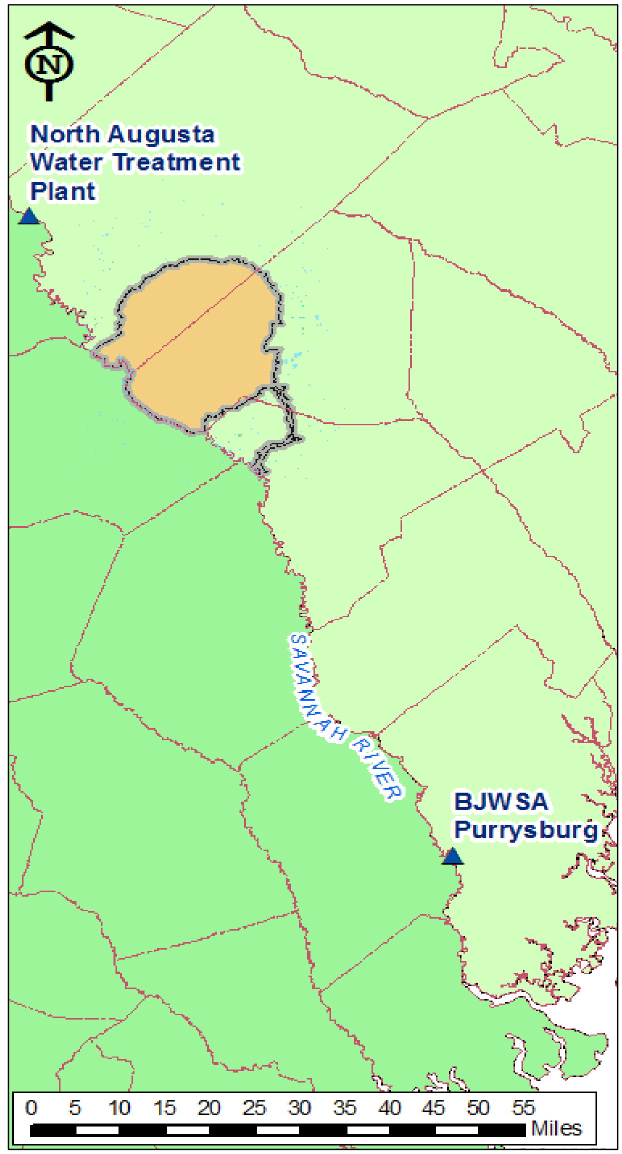


Figure 5-11 Offsite Drinking Water Sampling Locations

5.4.8.1 Drinking Water Results Summary

In 2022, SRS performed gross alpha and gross beta analyses on all onsite and offsite drinking water samples. All results were well below the EPA's 15 pCi/L alpha concentration limit and 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, and no onsite drinking water samples exceeded 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 1.2% of the EPA standard for tritium and decreases slightly at the downstream sampling location.

Sample results did not detect tritium, cobalt-60, cesium-137, strontium-89/90, uranium-235, plutonium-239, and curium-244 in onsite drinking water test locations. Sample results indicated detectable levels of americium-241 in one onsite sample, plutonium-238 in two onsite samples, uranium-234 in two onsite samples, and uranium-238 in three onsite samples. Appendix Table D-14 summarizes the results. Americium-241 and plutonium-238 concentrations are near the method detection limit, and the uranium is natural. All analytical results are well below the EPA standard.

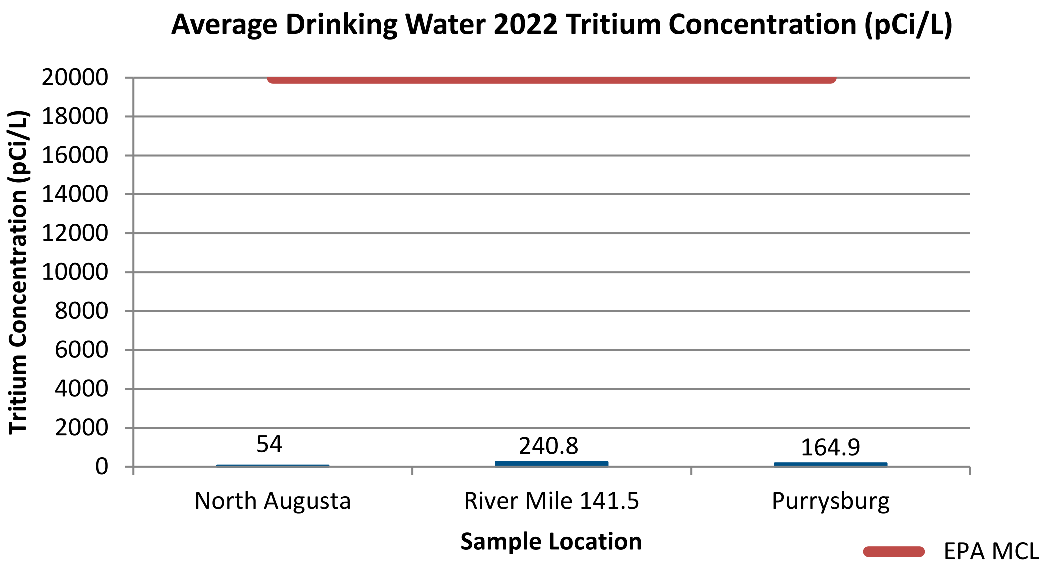


Figure 5-12 Tritium in Offsite Drinking Water and River Mile 141.5

5.5 AQUATIC FOOD PRODUCTS

5.5.1 Fish Collection in the Savannah River

SRS collects aquatic food from the Savannah River, including freshwater fish, saltwater fish, and shellfish. During 2020, the flathead fish was added to the routine freshwater fish types collected. 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 Savannah-area vendors that harvest from local saltwater that waters of the Savannah River potentially influence. Table 5-10 identifies the aquatic products collected in 2022. 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.

Table 5-10 Aquatic Products Collected by SRS in 2022 for the Radiological Environmental Monitoring Program

Freshwater Fish		Saltwater Fish	Shellfish
Bass	Catfish	Mullet	Crab
Flathead	Panfish		Shrimp

5.5.1.1 Fish in Savannah River Results Summary

In 2022, SRS collected freshwater fish from the six locations along the Savannah River in the vicinity of SRS, saltwater fish from the Savannah River mouth, and obtained crabs and shrimp in the Savannah area from a supplier that harvests from saltwater potentially influenced by Savannah River water. SRS analyzed 69 freshwater fish composites, 3 saltwater fish composites, and 2 shellfish composites. The freshwater and saltwater composites consisted of three to eight fish each. The shellfish composites comprised separate composites: one from a bushel of crab and another from one bushel of shrimp. The analytical results of the freshwater and saltwater fish, and shellfish collected are consistent with results for the previous 10 years. Most of the results for the specific radionuclides associated with SRS operations were nondetectable (63% for freshwater fish, 71% for saltwater fish, and 86% for shellfish). Table 5-11 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, iodine-129 in any fish flesh samples. Appendix Tables D-15, D-16, and D-17 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 freshwater and saltwater fish and shellfish. 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 due to the naturally occurring radionuclide potassium-40.

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

Table 5-11 Location and Fish Type for the Maximum Detected Concentration of Specific Radionuclides Measured in Flesh Samples Collected in 2022

Radionuclide	Maximum Concentration	Location	Fish Type
Cesium-137	0.814 pCi/g	Lower Three Runs Creek Mouth	Catfish
Strontium-89/90	0.00576 pCi/g	Four Mile Creek River Mouth	Catfish
Technetium-99	0.0681 pCi/g	Lower Three Runs Creek Mouth	Bass

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 2022, SRS held one turkey hunt for Wounded Warriors and residents with mobility impairments in the spring and nine 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. The Site assigns a dose 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), decay corrected for hunt date. 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 activity concentration, 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 2022, SRS monitored a total of 261 deer, 39 feral hogs, 12 coyotes, and seven turkeys. SRS did not assign a dose to any hunter during the turkey hunt and two of the nine game animals hunts. This indicates that all animals harvested during those hunts were at or below the decay corrected background cesium-137 concentration of 1.97 pCi/g for the hogs and 2.59 pCi/g for all other animals. All animals harvested during the 2022 hunts were below the administrative game animal release limit of 22 mrem. SRS released all animals to the hunters.

Appendix Table D-18 summarizes the muscle and bone laboratory 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 field detector results are similar to that of laboratory methods. Figure 5-13 compares the 2022 field versus laboratory measurement for each deer muscle sample collected. Table 5-12 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.

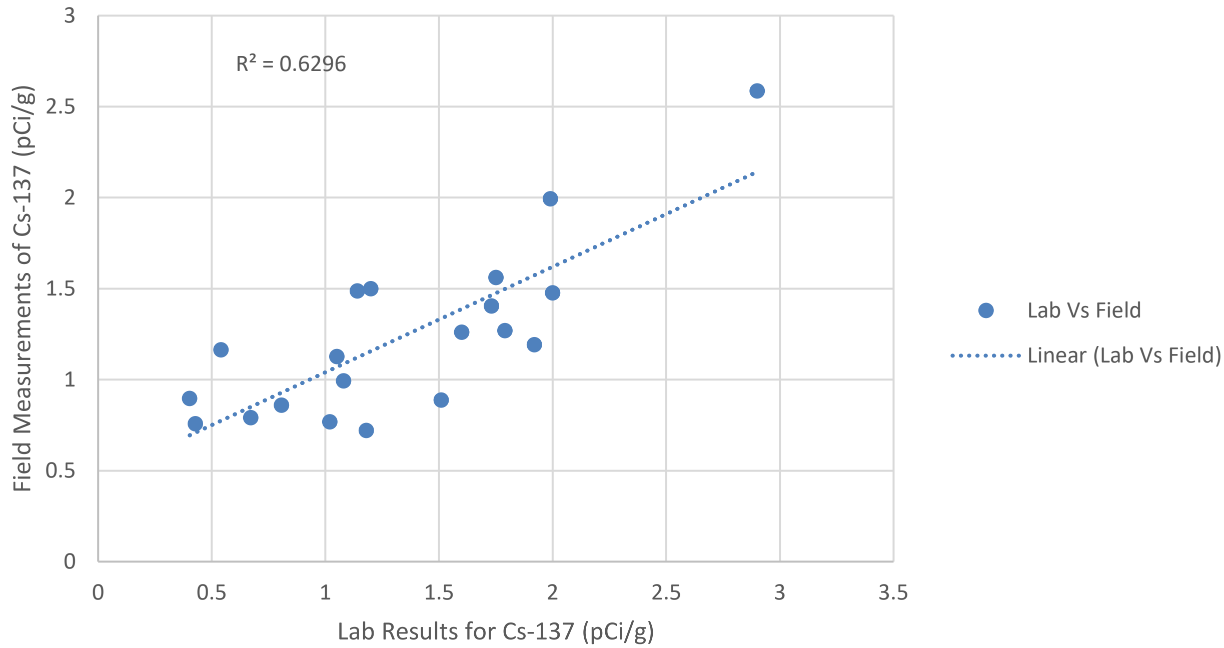


Figure 5-13 Field Results versus Laboratory Results for Cs-137

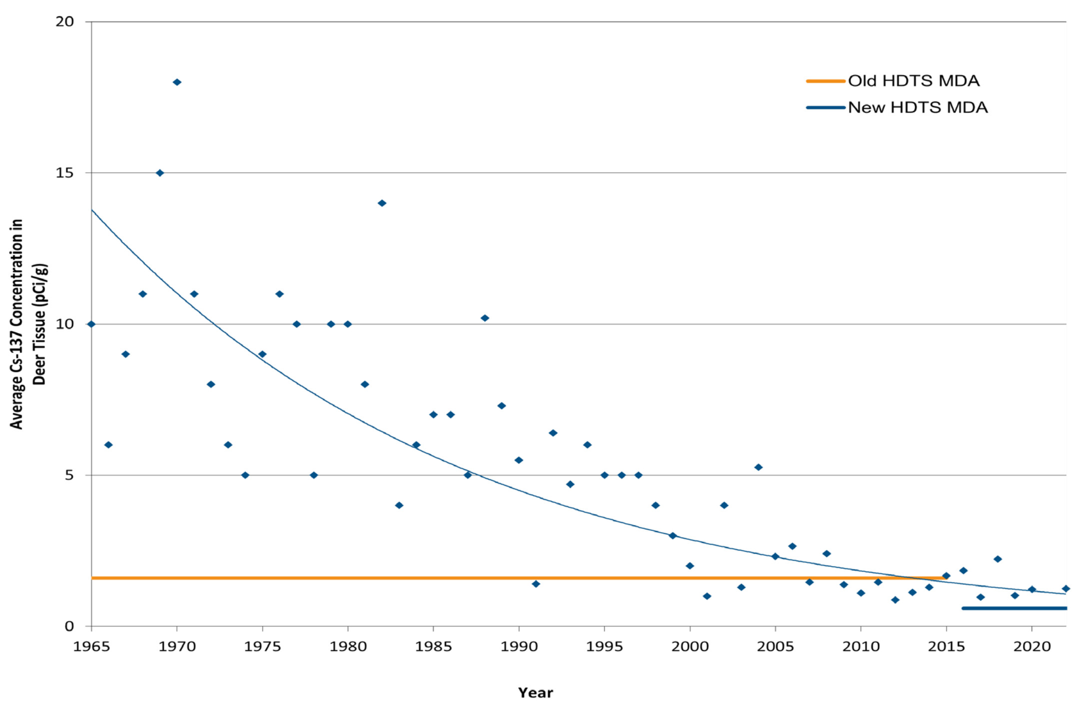


Figure 5-14 Yearly Average Cs-137 Concentration in Wildlife, 1965-2022

Table 5-12 Cesium-137 Results for Laboratory and Field Measurements in Wildlife for CY 2022

	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	261	1.25	6.9	34	34	1.02	2.9
Hog	39	1.29	2.38	6	6	1.39	3.05
Coyote	12	0.98	2.09	-----	-----	-----	-----
Turkey	7	0.69	0.75	-----	-----	-----	-----

Because its chemistry is similar to that of calcium, strontium is found in higher concentration in bone than in muscle tissue. In 2022, all 34 deer bone and all 6 hog bone samples had detectable levels of strontium-89/90. Strontium-89/90 was detected in deer bone with an average of 2.41 pCi/g and a maximum of 5.83 pCi/g. Strontium-89/90 was detected in hog bone with an average of 4.36 pCi/g and a maximum of 11.1 pCi/g.

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

5.7 ENHANCEMENTS TO THE CREEK PLANTATION MONITORING PROGRAM

The Creek Plantation property is a privately owned area located in Allendale County, South Carolina, along the Savannah River that borders the southeast portion of SRS (Figure 5-15). The property includes undeveloped and agricultural land use supporting equestrian, cattle-related operations, and timber production. The portion of the Creek Plantation property that runs adjacent to the Savannah River is within the Savannah River floodplain and includes low-lying swamp habitat. It is uninhabited, not easily accessible, and is of monitoring interest because historically during the 1960s approximately 25 curies (Ci) of cesium-137, 1 Ci of cobalt-60, and trace amounts of strontium-89/90 deposited in the area during high rain and flood events. During high river stage, water from Steel Creek transported radioactive materials that were deposited in the Creek Plantation Floodplain (CPF). CPF is bounded to the northwest by Steel Creek, the source of contamination, and by Little Hell Landing to the southeast (Figure 5-13). It has been part of the SRS Environmental

Savannah River Swamp at Creek Plantation

Monitoring Program since 1974. The concentration of cesium-137 found vegetation within the CPF has decreased since 1974.

Creek Plantation Trail 5

In general, the long-term monitoring of the CPF has consisted of annual cursory surveys, supplemented by a comprehensive survey every five years. The subsequent cursory field sampling entails soil and vegetation samples analyzed for cobalt-60, cesium-137, and strontium-89/90, as well as dosimeter deployment to measure ambient gamma exposure levels. The comprehensive survey entails multiple soil and vegetation sampling locations along 10 trails located within the CPF, with each trail beginning at the edge of the Savannah River and progressing inland (Figure 5-15). The annual cursory surveys focus on field sampling and dosimeter deployment from the locations with the highest cesium-137 soil activities that the previous five-year comprehensive study identified. In 2011, gamma overflight surveys of the CPF were initiated and conducted again in 2016 to supplement the comprehensive field survey. The gamma overflight measurements are obtained using gamma spectroscopy instrumentation mounted from a helicopter flying over the floodplain at low altitudes and slow ground speeds. The purpose of the gamma survey is to determine whether the vegetation sampling locations should move or if additional survey locations are warranted. The 2016 gamma overflight survey indicated an additional potential area of contamination between Trails 6 and 7. An additional sampling trail location (Trail-6 Special) was added to account for this area. The last comprehensive survey was completed in 2017, and the results of annual monitoring activities have shown that cesium-137 activity concentrations are decreasing in soil and vegetation in the CPF.

With technological advancements and the potential availability of further SRS overflight surveying, enhancements to the monitoring program were envisioned to: 1) identify areas of elevated activities of cesium-137 in the CPF; and 2) use SRS resources more efficiently to target areas with elevated cesium-137 activity for long-term monitoring. Conducting the comprehensive field surveys requires extensive up-front planning. It is labor-intensive and difficult to implement because of river stage, hard to navigate swampy terrain, and increased costs for adequate worker protection measures. Timber production in the area results in additional access, safety, and maneuverability and navigation concerns including lost or missing OSLDs and signs marking trails and access areas.

5.7.1 Creek Plantation Results Summary

SRS collected soil samples at four creek plantation trail locations: three on Trail 1 and one on Trail 6. Annual soil sample results are summarized in Section 5.3.5.1 and displayed in Appendix D-7. The maximum cesium-137 soil concentration at Creek Plantation was 36 pCi/g on Trail 1 – 1805 feet. Figure 5-15 presents the 2022 gamma flyover results, showing cesium-137 activity in counts per second. The survey confirmed trail locations are still in the optimal location for soil sampling.

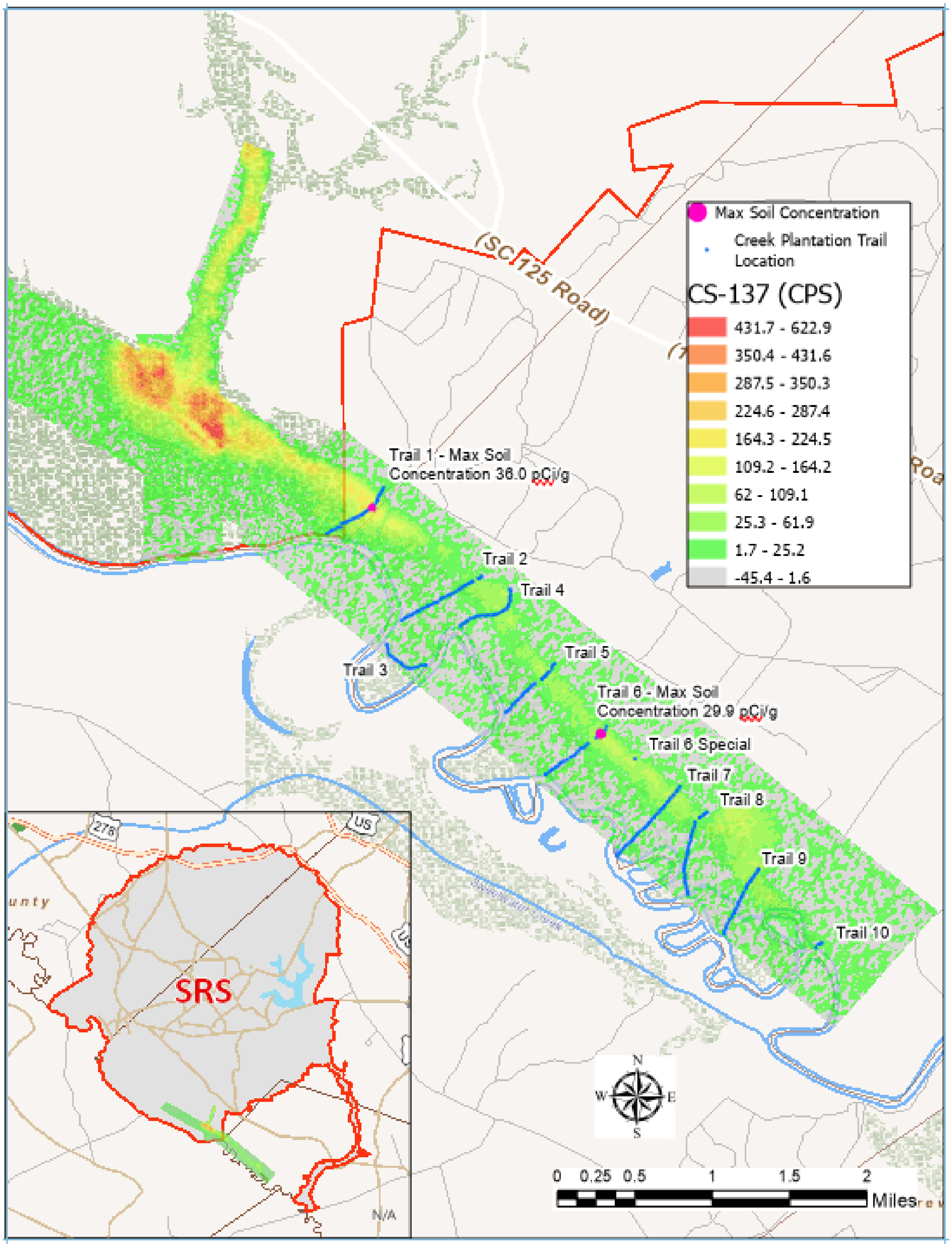


Figure 5-15 2022 Gamma Overflight Survey of Creek Plantation
(Gamma Activity in Counts Per Second [CPS], maximum Cs-137 Concentrations Found in 2022 Annual Soil Samples are Displayed Next to Trail Name)