ESOP

Environmental Surveillance and Oversight Program

2020 DATA REPORT

dhec
Healthy People. Healthy Communities.

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Purpose

PURPOSE OF THIS REPORT

WHAT: South Carolina's Department of Health and Environmental Control (DHEC) monitors the Department of Energy's Savannah River Site (SRS) for potential contaminants and produces a report of all its annual findings.

WHY: Due to nuclear material testing and lack of environmental regulations during the Cold War era, radioactive and non-radioactive constituents are present on SRS property. SRS personnel have been sampling multiple media for many years. However, to verify the data being collected on and around SRS, DHEC conducts independent monitoring associated with the site to provide a second set of results for comparison.

HOW: In order to have a verification system for SRS's annual data, the Department of Energy-Savannah River (DOE-SR) partnered with DHEC as part of a 1995 Agreement in Principle (AIP) to create the Environmental Surveillance and Oversight Program (ESOP). ESOP is a division of DHEC specific to the Midlands Aiken Environmental Affairs Office. There are 10 team members with varying expertise working in ESOP that collect and analyze samples of air, water, soil, sediment, vegetation, milk, fish, and game for radiological and non-radiological constituents.

WHERE: Samples are collected on site property, around its perimeter, and in background locations. Depending upon the media, some DHEC sample locations coincide with those of DOE-SR. These locations are compared in our report.

WHEN: Samples are collected weekly, quarterly, biannually, and annually and are dependent upon the type of media and can be affected by availability of the resource, accessibility, and weather.

Team Photo (left to right): Richard Burnett, Tim Mettlen, Gregg O'Quinn, Grace Anne Martin, Krista McCuen, Beth Cameron, Greg Mason, Thomas Rolka, Jeffrey Joyner; Not Pictured: Stephanie Jacobs

RADIATION – Occurs when an unstable atom tries to become stable by releasing some of its energy in the form of an alpha or beta particle or gamma wave.

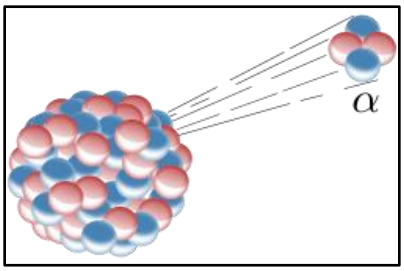
TYPES OF RADIATION

ALPHA – results when the nucleus of an atom releases two protons and two neutrons. Due to this particle being heavier in mass, it can be stopped by the air, skin, or paper. External exposure is not dangerous, but if swallowed, breathed in, or enters a person through a cut, it can harm the human body.

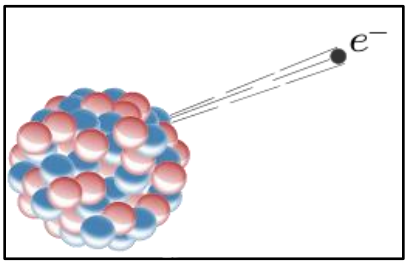
BETA – occurs when an atom releases an electron (negative charge). Since it is lighter in mass and faster moving, it can travel greater distances and can be stopped by a layer of wood or metal but can penetrate the outer layer of skin. It can cause skin burns.

GAMMA – is the release of pure energy that is fast moving and able to travel longer distances until it hits either concrete or lead. It will pass through the human body resulting in internal and external bodily damage.

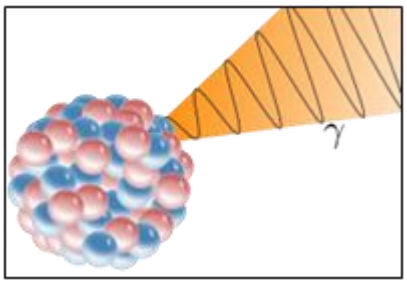
ALPHA RADIATION:



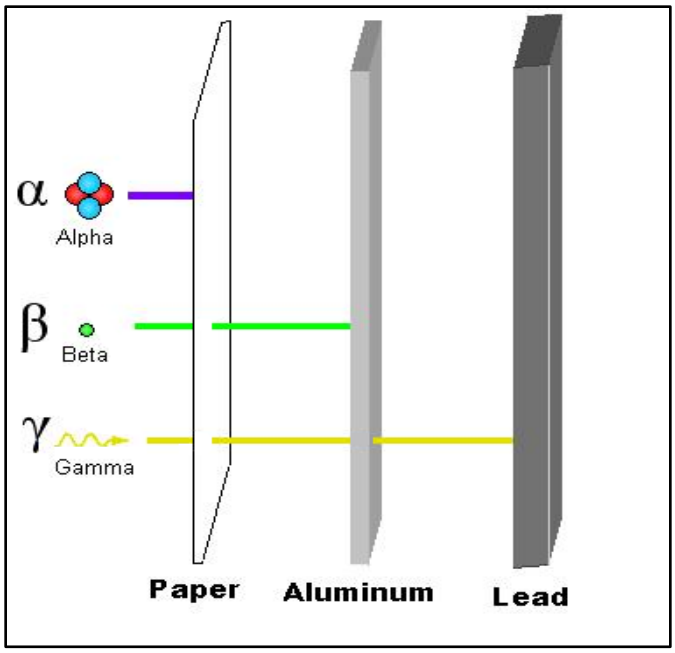
BETA RADIATION:



GAMMA RADIATION:



RADIATION:



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List of Analytes

Table 1. Gamma Analytes

Radioisotope	Abbreviation
Actinium-228	Ac-228
Americium-241	Am-241
Beryllium-7	Be-7
Cerium-144	Ce-144
Cobalt-58	Co-58
Cobalt-60	Co-60
Cesium-134	Cs-134
Cesium-137	Cs-137
Europium-152	Eu-152
Europium-154	Eu-154
Europium-155	Eu-155
Iodine-131	I-131
Potassium-40	K-40
Plutonium-238	Pu-238
Plutonium-239/240	Pu-239/240
Manganese-54	Mn-54
Sodium-22	Na-22
Lead-212	Pb-212
Lead-214	Pb-214
Radium-226	Ra-226
Ruthenium-103	Ru-103
Antimony-125	Sb-125
Thorium-234	Th-234
Yttrium-88	Y-88
Zinc-65	Zn-65
Zirconium-95	Zr-95

Table 2. Metal Analytes

Analyte	Abbreviation
Barium	Ba
Beryllium	Be
Cadmium	Cd
Chromium	Cr
Copper	Cu
Lead	Pb
Manganese	Mn
Mercury	Hg
Nickel	Ni
Zinc	Zn

LIST OF ACRONYMS

ABR	Allendale Barricade
AEI	Average Exposed Individual
AIK	Aiken
AIP	Agreement in Principle
AKN	Sample locations in Aiken County
ALD	Sample locations in Allendale County
ALN	Allendale
ARESD	Analytical and Radiological Environmental Services Division
ATSDR	Agency for Toxic Substances and Disease Registry
B/J	Beaufort-Jasper Water and Sewer Authority
BGN	Burial Grounds North
BOD	Biochemical Oxygen Demand
BWL	Sample locations in Barnwell County
CDC	Centers for Disease Control and Prevention
DIL	Derived Intervention Level
DKH	Dark Horse at the Williston Barricade
DHEC	South Carolina Department of Health and Environmental Control
DNR	South Carolina Department of Natural Resources
DO	Dissolved Oxygen
DOE	Department of Energy
DOE-SR	Department of Energy-Savannah River
DW	Drinking Water
ESOP	Environmental Surveillance and Oversight Program
EPA	United States Environmental Protection Agency
ESV	Ecological Screening Value
FDA	United States Food and Drug Administration
GW	Groundwater
HLW	High Level Waste
Hwy. 17	United States Highway 17
Hwy. 301	United States Highway 301
IAEA	International Atomic Energy Agency
JAK	Jackson
LLD	Lower Limit of Detection
LLW	Low Level Waste
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDL	Minimum Detection Level
MEI	Maximum Exposed Individual
MPN	Most Probable Number
NA	Not Applicable
ND	Not Detected
NEL	New Ellenton
NORM	Naturally Occurring Radioactive Material
NRC	National Regulatory Commission
NS	No Sample
NSBLD	New Savannah Bluff Lock & Dam

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PCB	Polychlorinated Biphenyls
PRG	Preliminary Remediation Goals
RM	River Mile
RSL	Regional Screening Level
RSW	Radiological Surface Water
SCAT	South Carolina Advanced Technology
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
SSL	Soil Screening Level
SW	Surface Water
TKN	Total Kjeldahl Nitrogen
TLD	Thermoluminescent Dosimeter
TSP	Total Suspended Particulates
TSS	Total Suspended Solid
USFS	United States Forestry Service
USGS	United States Geological Survey
VOC	Volatile Organic Compound

LIST OF ISOTOPES AND ABBREVIATIONS

I-129	Iodine-129
Sr-89/90	Strontium-89/90
Sr-90	Strontium-90

UNITS OF MEASURE

<	Less than
±	Plus or minus. Refers to one standard deviation unless otherwise stated
±2	Plus or minus 2 standard deviations.
°C	Temperature in Celsius
Ci	Curie
cnt	Counts
g/mL	Grams per milliliter
hrs/yr	Hours per year
kg/yr	Kilograms per year
L/yr	Liters per year
m^3/yr	Cubic meters per year
mg/day	Milligrams per day
mg/kg	Milligrams per kilogram
mg/L	Milligrams Per Liter
mL	Milliliter
mL/L	Milliliter per liter
MPN	Most Probable Number
mrem	Millirem or milliroentgen equivalent man
NTU	Nephelometric Turbidity Unit
pCi/g	Picocuries per gram
pCi/L	Picocuries per liter
pCi/m^3	Picocuries per cubic meter

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pCi/mL	Picocuries per milliliter
SU	Standard units

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Introduction

In 1950, the U.S. Atomic Energy Commission established the Savannah River Site (SRS) (1954-1992) with the mission of producing nuclear materials, primarily tritium and plutonium. SRS is a Department of Energy (DOE) facility located approximately 20 miles from Aiken, South Carolina. SRS boundaries lie within Aiken, Allendale, and Barnwell counties and span approximately 310 square miles. During legacy operations, radionuclides were released into the surface water, groundwater, soils, and atmosphere. Although the reactors are no longer operating, work continues at SRS with the primary focus being on cleaning up legacy wastes and remediating areas associated with former operations.

Due to the large number of contaminants that could potentially be released from SRS, the Centers for Disease Control and Prevention (CDC) performed a site assessment to determine the potential health effects of any discharged radionuclides to the off-site public. Most of the radiological releases originated from processes associated with the reactor areas (R, K, P, L, and C) and the separations areas (F and H), but there are other areas of releases as a result of the varied processes at SRS.

P Reactor at SRS – No longer in operation

Tritium was one of the principle nuclear materials produced at SRS to multiply the firepower of plutonium in nuclear weapons (Till et al., 2001). Tritium releases originated from processes associated with the reactors, separations areas, D-Area, and tritium facilities. The two main types of tritium releases came from direct site facility releases and migration from seepage basins in the separations areas, the burial ground, and the K-Area containment basin. In the early operational years, nearly 100 percent of the discharges to streams were related to direct releases. Tritiated water's ability to react chemically like nonradioactive water in living cells lends itself to be more hazardous biologically than tritium gas (CDC SRSHES, 1997).

Alpha-emitting and beta-emitting radionuclides were also released to liquid effluent. Alpha-emitting radionuclide releases from M-Area primarily affected Tims Branch, which ultimately flows into Upper Three Runs Creek. Fourmile Branch is the stream most affected by alpha- and beta-emitting releases coming from the separations areas, and releases from the reactor areas affected all streams except for Upper Three Runs Creek (Till et al., 2001). Steel Creek, Pen Branch, and Lower Three Runs Creek were mainly affected by beta-emitting releases from the reactors. Strontium-90 (Sr-90) is a main contributor of beta activity and came primarily from the reactors (Till et al., 2001).

Plutonium was manufactured at SRS in H-Area from fuel rods and in F-Area from targets (Till et al., 2001). Releases at SRS occurred primarily through the discharge of liquid waste into streams. Iodine-129 (I-129) is a fission product of reactor fuel that has a very long half-life. Most occurred during fuel processing (Till et al., 2001). Technetium-99 (Tc-99) was produced in SRS production reactors as a fission by-product of uranium and plutonium. This radionuclide was released to the environment from the separations areas ventilation systems, the aqueous

environment from liquid waste in waste tanks, and the Solid Waste Disposal Facility (Westinghouse Savannah River Company [WSRC], 1993).

Strontium was a fission product in SRS reactors, subsequently released from F-area and H-area (WSRC, 1998). SRS operations have also released strontium into the environment through normal site operations and equipment failures.

H Canyon at SRS – Still in operation at the site
Photo by DOE-SR. CC BY 2.0

Routine operations at SRS have released cesium-137 (Cs-137) to the regional environment surrounding SRS. The most significant releases occurred during the early years of site operation when Cs-137 was released to seepage basins and site streams. The SRS facilities that have documented Cs-137 releases are the production reactors, separations areas, liquid waste facilities, the solid waste disposal facility, central shops, heavy water rework facility, Saltstone Facility, and the Savannah River National Laboratory (SRNL).

Historically, the Department of Energy-Savannah River (DOE-SR) has been self-regulating regarding environmental monitoring. Until 1995, the public had to rely solely on DOE-SR to ensure their health and the environment was protected. DOE-SR formed an Agreement in Principle (AIP) with the South Carolina Department of Health and Environmental Control (DHEC) to perform independent environmental monitoring and oversight of SRS. This partnership provides an extra source of information to the public regarding the effectiveness of the DOE-SR monitoring activities. From this agreement, the Environmental Surveillance and Oversight Program (ESOP) of DHEC was initiated to supplement and compliment monitoring functions of this unique facility. DHEC monitoring provides an added protection due to the potential for environmental releases that pose a threat to the state.

Program development at SRS is stable and evolves based on changing missions. The foremost focus is on legacy waste and materials that are stored or have been disposed of on-site and pose a current risk of release to the environment. Some of DOE-SR's primary activities are concerned with identifying concentrations and migration of radionuclides in the aquatic environment, detecting and verifying accidental releases, characterizing concentration trends, and determining associated impacts on human health and the environment. This report provides results of samples collected by DHEC related to SRS, trending data to document how contaminants are changing, and information on how these changes may impact the surrounding communities. The data reported by DHEC is based on detections only. DHEC's ESOP will continue its mission of monitoring and oversight around SRS to ensure the site's on-going activities continue to be safe for the public and the environment.

Chapter 1 Radiological Atmospheric Monitoring on and Adjacent to SRS

1.1.0 PROJECT SUMMARY

Atmospheric transport has the potential to impact the citizens of South Carolina from releases associated with activities at SRS. The Atmospheric Monitoring Project conducts routine, quantitative monitoring of atmospheric radionuclide releases associated with SRS, which it uses to identify concentration trends that could require further investigation. Air monitoring capabilities in 2020 included 19 dosimeter monitoring locations and seven air monitoring stations that collected samples using glass fiber filters, rain collection pans, and silica gel columns. Glass fiber filters are used to collect total suspended particulates (TSP) in the air. Particulates are screened weekly for gross alpha- and beta-emitting activity. Precipitation, when present, and silica gel distillates of atmospheric moisture are sampled and analyzed monthly for tritium. Dosimeters are collected and analyzed every quarter for ambient beta/gamma levels. Radiological atmospheric monitoring sites were established to provide spatial coverage of the project area (Sections 1.4.0, Map and 1.5.0, Table 1). One air monitoring station is located at the center of the site, three are at the SRS perimeter, and three are found outside of the site boundary within public areas. Thirteen of the dosimeters are on or near the site perimeter, one is in the center of the site, and five are within 25 miles of the site in surrounding population centers. DHEC emphasizes monitoring SRS perimeter locations for radionuclides in atmospheric media for potential public exposure.

Example of an Air Monitoring Station with Rain Collection Pan and Glass Fiber Filter (on top) and Silica Gel Column (inside)

1.2.0 RESULTS AND DISCUSSION

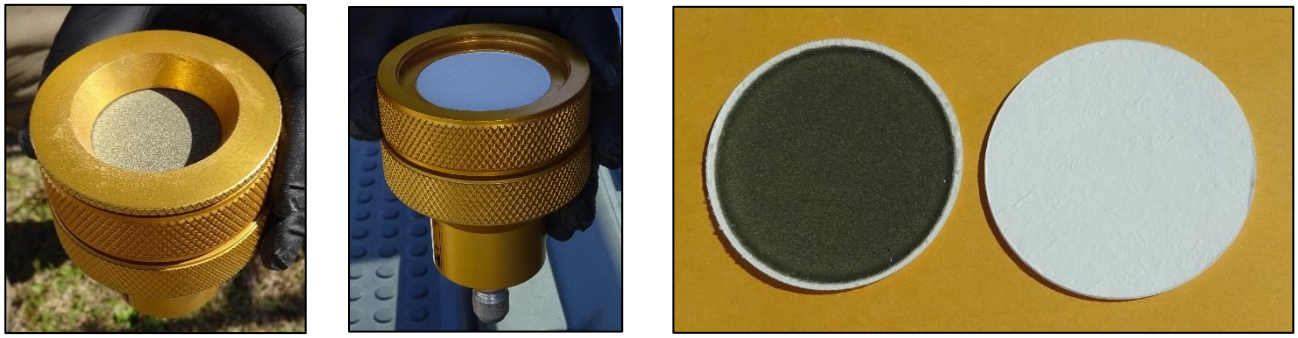
Air Monitoring Summary Statistics can be found in Section 1.6.0 and all Air Monitoring Data can be found in the 2020 DHEC Data File.

1.2.1 Total Suspended Particulates

DHEC and the Department of Energy-Savannah River (DOE-SR) had both gross alpha and gross beta detections in 2020. Small seasonal variations at each monitoring location have been consistent with historically reported DHEC values (DHEC, 2020b). Section 1.5.0 illustrates trends for the last five years for average gross alpha activity (Figure 1) and average gross beta activity (Figure 2) at SRS perimeter locations.

1.2.2 Ambient Beta/Gamma

DHEC conducts ambient beta/gamma monitoring through the deployment of dosimeters around the perimeter of SRS. In 2020, ambient beta/gamma average quarterly totals ranged from 20.08 (TLD-



Glass fiber filter being collected for total suspended particulates: Used filter (left) vs. unused filter (right)

07) to 31.55 (TLD-02) mrem. Section 1.5.0, Figure 3 shows data trends at the SRS perimeter for average ambient beta/gamma values in dosimeters for DHEC and DOE-SR.

1.2.3 Tritium

Tritium continues to be the predominant radionuclide detected in the perimeter samples. Most of the tritium detected in DHEC perimeter samples may be attributed to the release of tritium from tritium facilities, separations areas, and from wide-spread and fleeting sources (SRNS, 2021).

Tritium in Air

Tritium in air values reported by DHEC are the result of using the historical method of calculating an air concentration of tritium based on the upper limit value of absolute humidity (11.5 grams of atmospheric moisture per cubic meter) in the geographic region (National Council on Radiation Protection and Measures [NCRP], 1984). This number is a dose equivalent concentration that would yield approximately 10 mrem to a member of the public at the site boundary (EPA, 1989).

The perimeter average for DHEC tritium in air activity (3.65 pCi/m^3) was lower than the DOE-SR perimeter average activity (12.39 pCi/m^3). These variations could be caused by different sampling locations, number of locations, sample frequency, and method of calculating air concentration.

Average tritium in air activity at the SRS perimeter reported by both DHEC and DOE-SR for 2020 was lower than reported in 2019 and has fluctuated over the last five years. Section 1.5.0, Figure 4 illustrates data trends of atmospheric tritium activity for DHEC and DOE-SR as measured and calculated at the SRS perimeter.

Example of dosimeters present at 19 locations

Tritium in Precipitation

In 2020, DHEC and DOE-SR averages for tritium activity in precipitation were well below the Environmental Protection Agency standard of 20,000 pCi/L for drinking water (EPA, 2020). Section 1.5.0, Figure 5 shows average tritium in precipitation activity for SRS perimeter locations and illustrates trending tritium in precipitation values for DHEC and DOE-SR from the last five years.

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Collecting atmospheric moisture from silica gel through distillation

Silica Gel Column

During the 2020 sampling period, tritium detected in precipitation ranged from 217 pCi/L (Aiken Elementary Water Tower (AIK)) to 4791 pCi/L (found on-site at Burial Ground North (BGN) within November). Neither DHEC nor DOE-SR had perimeter locations with tritium detections (SRNS, 2021).

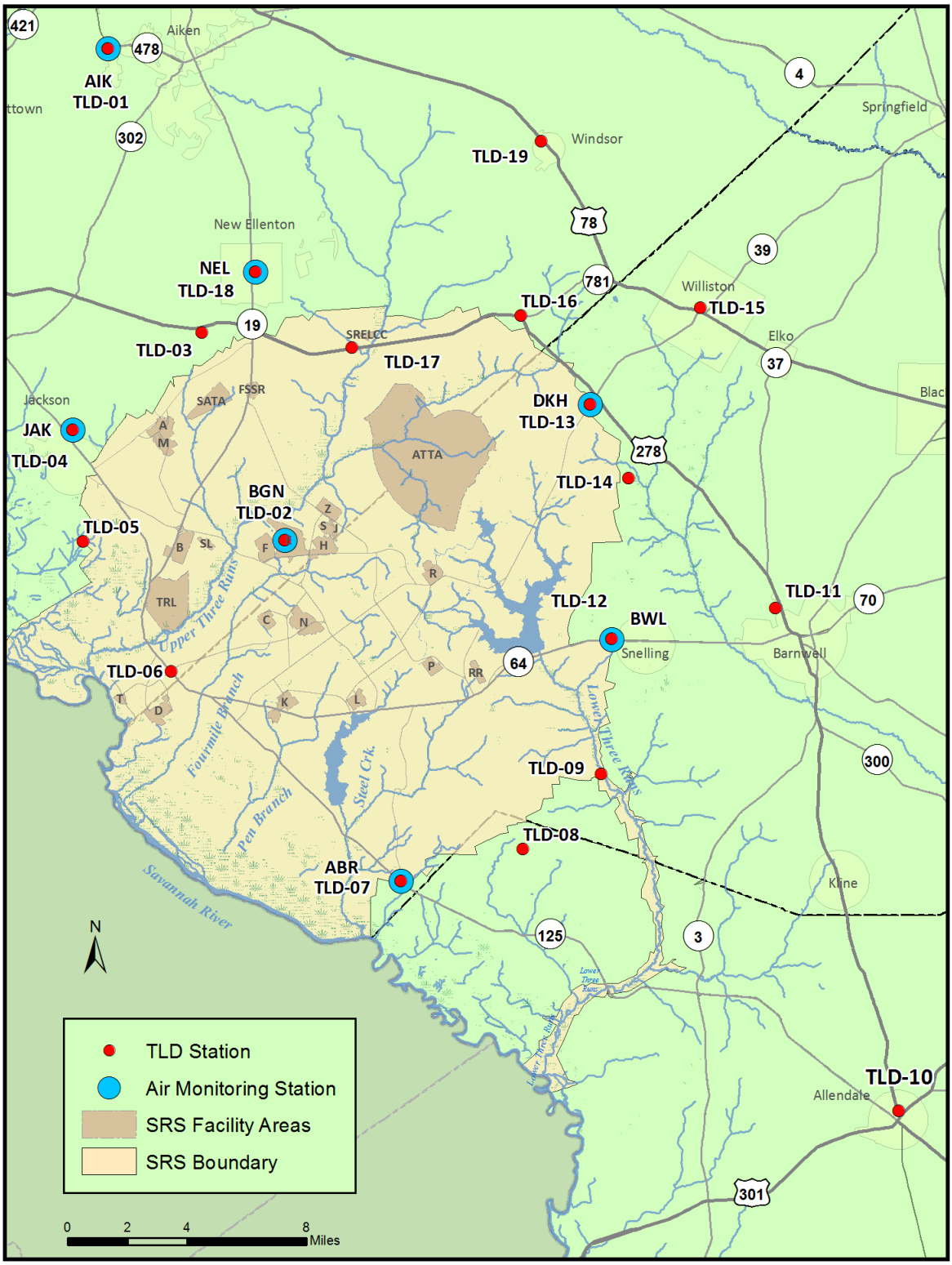
1.3.0 CONCLUSIONS AND RECOMMENDATIONS

All DHEC data collected in 2020 confirmed reported DOE-SR values for gross alpha/beta, ambient beta/gamma, and tritium in the environment at the SRS boundary with no anomalous data noted for any monitored parameters.

Due to continued potential releases from site facilities (tritium facilities, separations areas, etc.), DHEC will continue to collect weekly TSP for gross alpha/beta, monthly atmospheric and precipitation tritium samples, and quarterly ambient beta/gamma samples.

1.4.0 MAP

Radiological Atmospheric Monitoring Sample Locations



2020 ESOP Radiological Air Monitoring Map www.scdhec.gov

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1.5.0 TABLES AND FIGURES

Table 1. Radiological Atmospheric Monitoring Locations

Dosimeter Sample Locations

Sample ID	Location	Proximity to SRS
TLD-01	Collocated with AIK Air Station	Within 25 miles of SRS
TLD-02	Collocated with BGN Air Station	Center of SRS
TLD-03	Savannah River Research Park	SRS Perimeter
TLD-04	Collocated with JAK Air Station	SRS Perimeter
TLD-05	Crackerneck Gate	SRS Perimeter
TLD-06	Ellenton Memorial at Hwy 125	SRS Perimeter
TLD-07	Collocated with ABR Air Station	SRS Perimeter
TLD-08	Junction of Millet Road and Round Tree Road	SRS Perimeter
TLD-09	Patterson Mill Road at Lower Three Runs Creek	SRS Perimeter
TLD-10	Allendale Health Department	Within 25 miles of SRS
TLD-11	Barnwell Health Department	Within 25 miles of SRS
TLD-12	Collocated with BWL Air Station	SRS Perimeter
TLD-13	Collocated with DKH Air Station	SRS Perimeter
TLD-14	Seven Pines Road Collocated with SRS Air Station	SRS Perimeter
TLD-15	Williston Police Department	Within 25 miles of SRS
TLD-16	Junction of US-278 and SC-781	SRS Perimeter
TLD-17	US-278 SREL Conference Center and Hwy 125	SRS Perimeter
TLD-18	Collocated with NEL Air Station	SRS Perimeter
TLD-19	Windsor Post Office	Within 25 miles of SRS

Air Monitoring Stations

Sample ID	Location	Proximity to SRS
BGN	Burial Grounds North, SRS	Center of SRS
BWL	Barnwell Barricade	SRS Perimeter
ABR	Allendale Barricade	SRS Perimeter
DKH	Darkhorse	SRS Perimeter
NEL	New Ellenton, S.C.	SRS Perimeter/ Population Area
JAK	Jackson, S.C.	SRS Perimeter/ Population Area
AIK	Aiken Elementary Water Tower	Within 25 miles of SRS/ Population Area

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TABLES AND FIGURES

Figure 1. DOE-SR and DHEC Comparison of Average Gross Alpha for Total Suspended Particulates at the SRS Perimeter (SRNS, 2017-2021; DHEC, 2018-2020b)

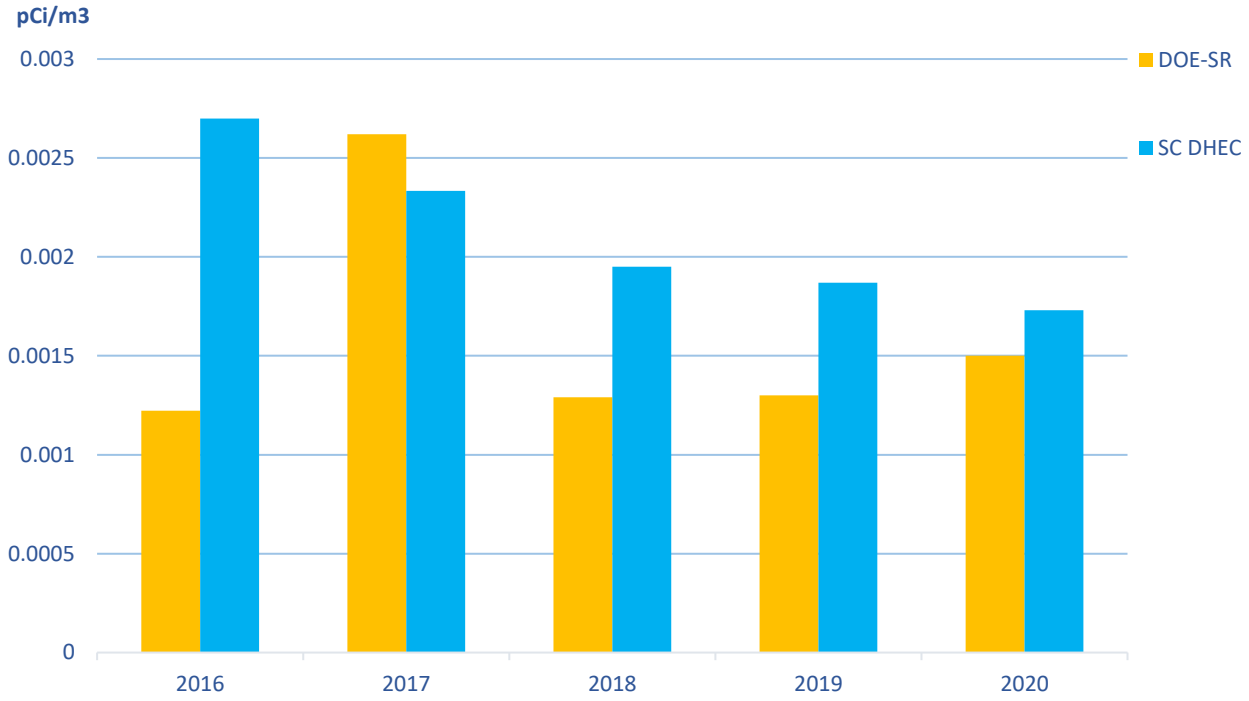

Figure 2. DOE-SR and DHEC Comparison of Average Gross Beta for Total Suspended Particulates at the SRS Perimeter (SRNS, 2017-2021; DHEC, 2018-2020b)

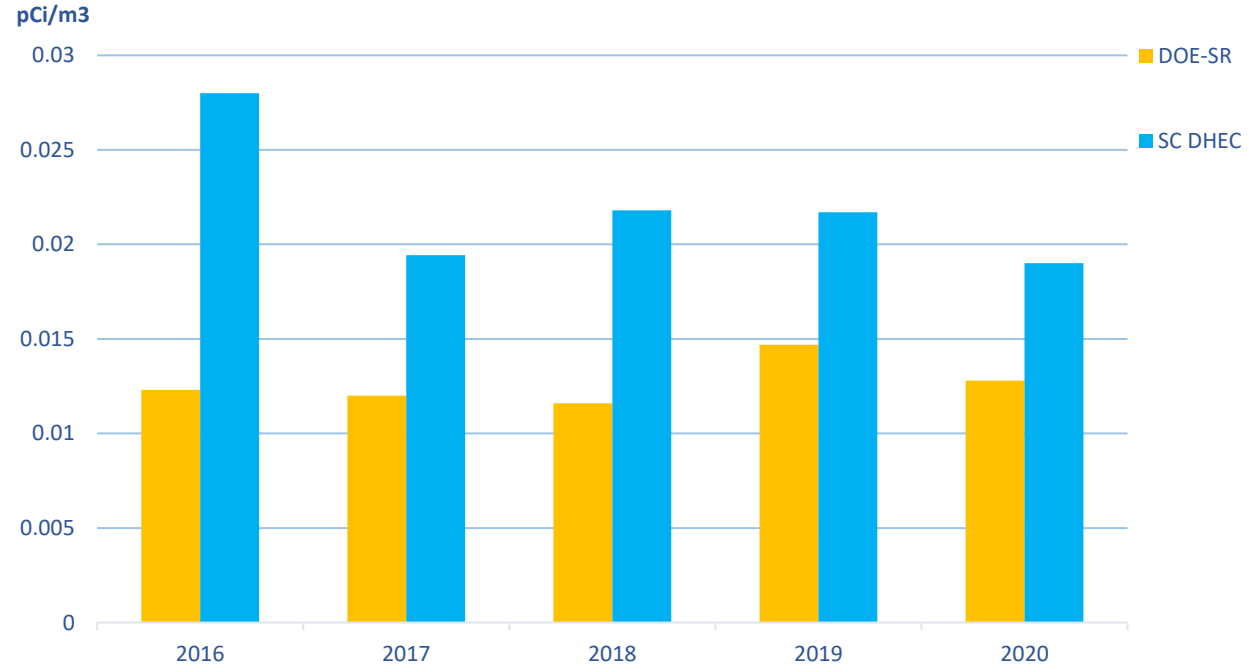

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Figure 3. DOE-SR and DHEC Comparison of Yearly Average Ambient Beta/Gamma in Dosimeters at the SRS Perimeter (SRNS, 2017-2021; DHEC, 2018-2020b)

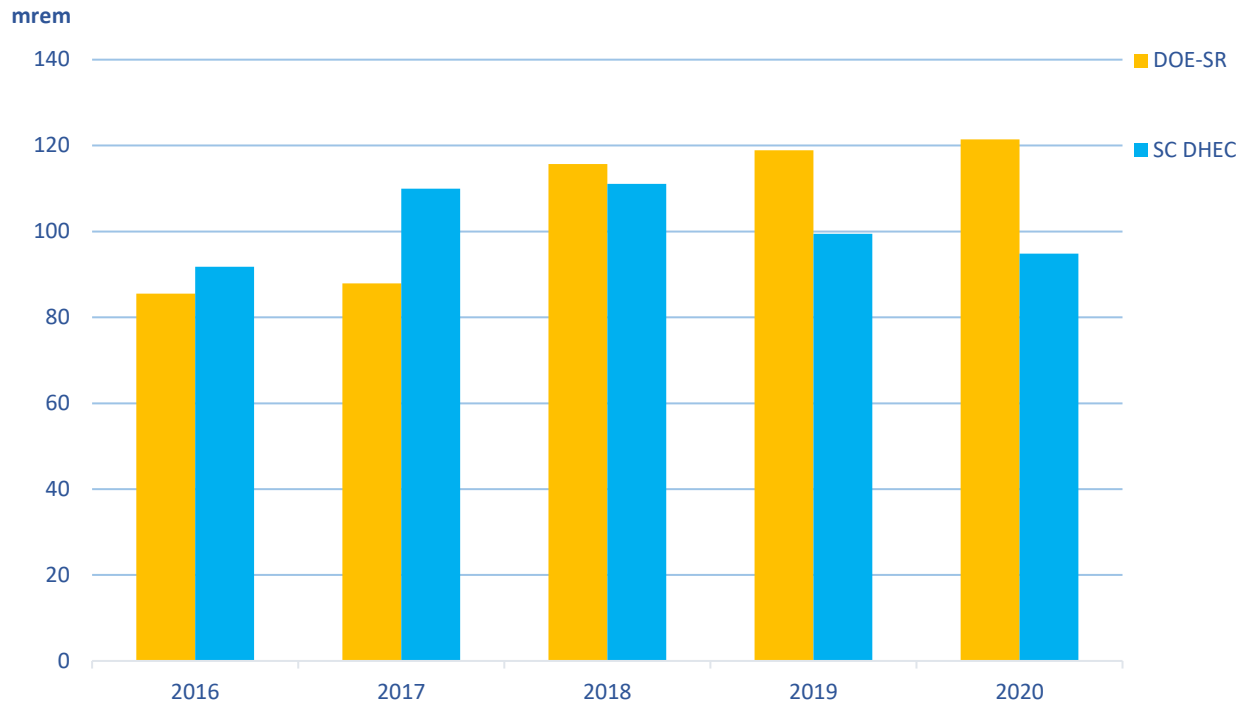

Figure 4. DOE-SR and DHEC Comparison of Average Tritium in Air at the SRS Perimeter (SRNS, 2017-2021; DHEC, 2018-2020b)

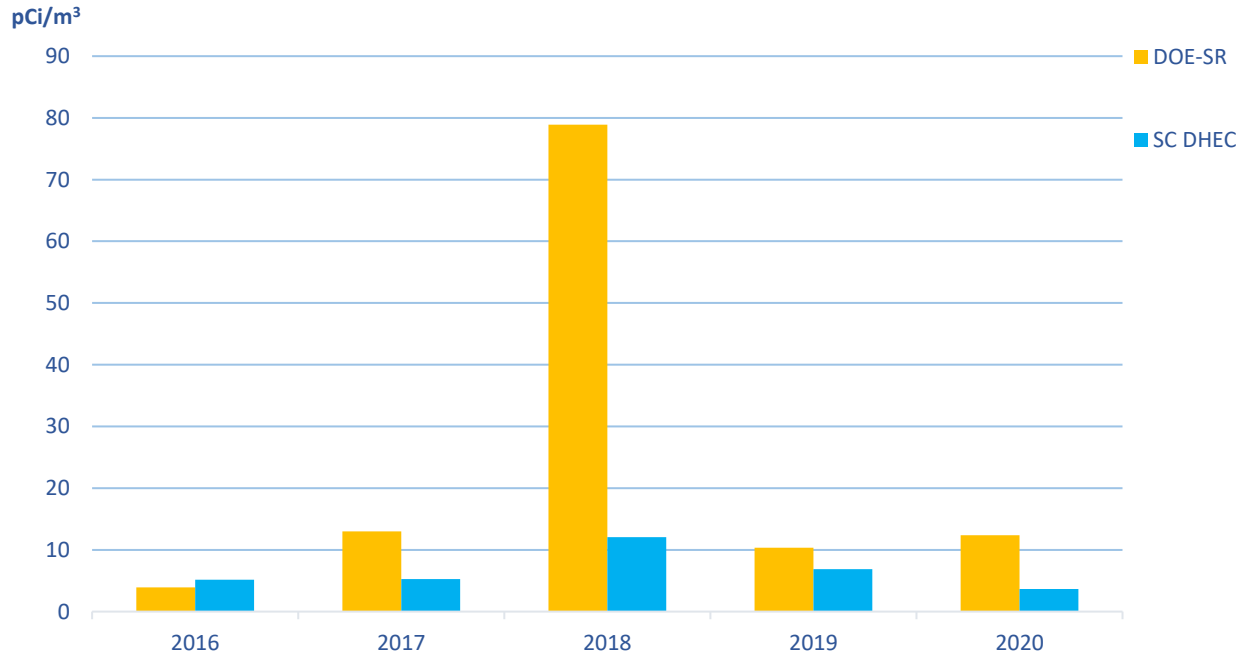

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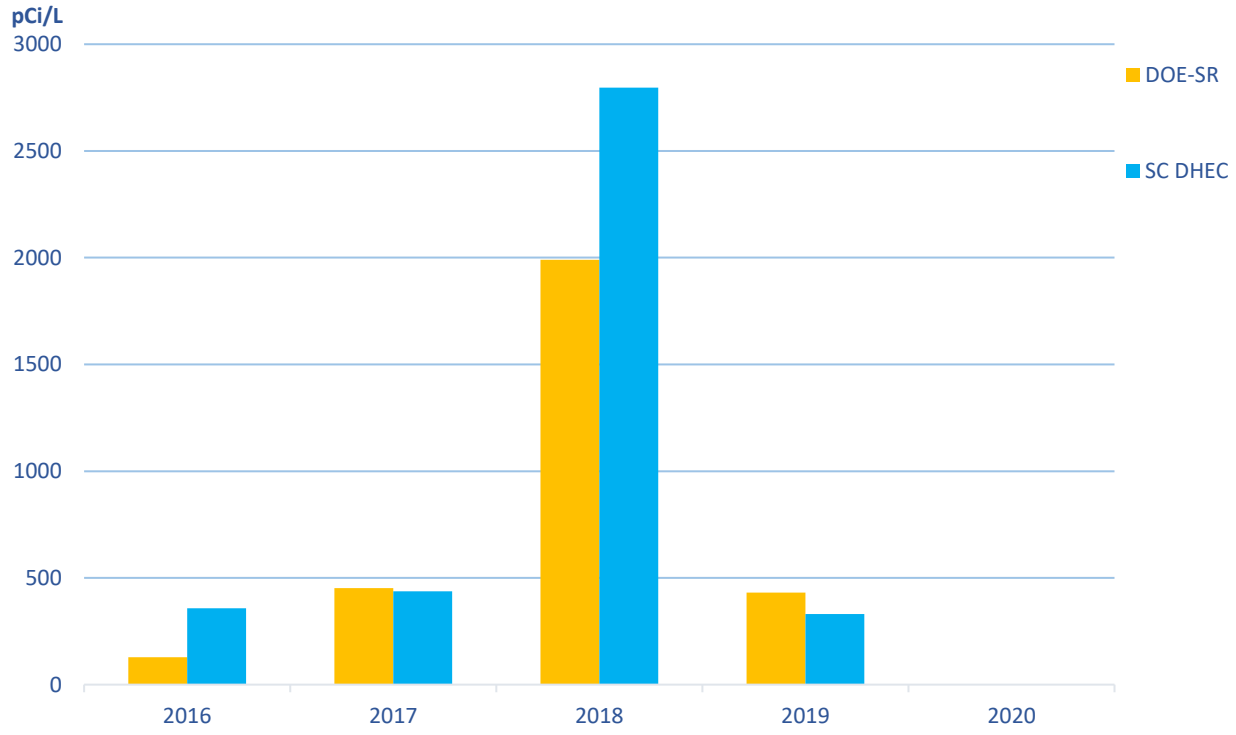
Figure 5. DOE-SR and DHEC Comparison of Average Tritium in Precipitation at the SRS Perimeter (SRNS, 2017-2021; DHEC, 2018-2020b)



Neither DHEC nor DOE-SR had detections above the LLD for tritium in 2020.

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1.6.0 SUMMARY STATISTICS

2020 DHEC Quarterly Averages of Ambient Dosimeter Beta/Gamma Data

Sample ID	Average (mrem)	Standard Deviation (mrem)	Median (mrem)	Minimum (mrem)	Maximum (mrem)
TLD-01	20.43	2.95	20.40	17.50	23.40
TLD-02	31.55	3.58	32.25	26.60	35.10
TLD-03*	23.78	3.11	24.10	19.70	27.20
TLD-04*	20.60	3.47	20.35	17.00	24.70
TLD-05*	26.93	3.35	26.55	23.40	31.20
TLD-06*	21.13	4.20	21.00	17.00	25.40
TLD-07*	20.08	3.21	20.15	16.10	23.90
TLD-08*	26.48	3.84	26.95	21.40	30.60
TLD-09*	27.85	3.35	28.40	23.30	31.30
TLD-10	24.00	2.43	25.20	21.20	25.60
TLD-11	27.38	3.94	27.30	23.60	31.30
TLD-12*	23.43	3.02	23.85	19.50	26.50
TLD-13*	21.93	3.11	21.50	18.90	25.80
TLD-14*	29.53	4.61	29.60	23.80	35.10
TLD-15	27.60	3.27	27.55	23.70	31.60
TLD-16*	22.03	3.00	22.85	17.80	24.60
TLD-17*	26.13	2.35	26.20	23.20	28.90
TLD-18*	23.73	2.97	23.70	20.20	27.30
TLD-19	25.85	2.42	26.40	22.80	27.80

* DENOTES A PERIMETER LOCATION

SUMMARY STATISTICS

2020 DHEC Air Station Gross Alpha Data in pCi/m^3

Location	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Allendale Barricade (ABR)	0.0019	0.0011	0.0017	0.0006	0.0070	51	52
Darkhorse (DKH)	0.0015	0.0008	0.0014	0.0006	0.0057	51	51
Aiken Elementary Water Tower (AIK)	0.0018	0.0012	0.0015	0.0004	0.0069	51	52
New Ellenton, S.C. (NEL)	0.0020	0.0013	0.0017	0.0005	0.0087	51	52
Jackson, S.C. (JAK)	0.0016	0.0011	0.0014	0.0006	0.0082	52	52
Burial Ground North (BGN)	0.0015	0.0013	0.0013	0.0005	0.0086	50	52
Barnwell Barricade (BWL)	0.0016	0.0009	0.0015	0.0005	0.0050	50	51

2020 DHEC Air Station Gross Beta Data in pCi/m^3

Location	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Allendale Barricade (ABR)	0.0216	0.0064	0.0203	0.0110	0.0408	52	52
Darkhorse (DKH)	0.0172	0.0047	0.0162	0.0096	0.0298	51	51
Aiken Elementary Water Tower (AIK)	0.0179	0.0054	0.0170	0.0099	0.0370	52	52
New Ellenton, S.C. (NEL)	0.0203	0.0070	0.0188	0.0089	0.0421	52	52
Jackson, S.C. (JAK)	0.0178	0.0048	0.0168	0.0093	0.0321	52	52
Burial Ground North (BGN)	0.0188	0.0085	0.0167	0.0102	0.0591	52	52
Barnwell Barricade (BWL)	0.0181	0.0051	0.0171	0.0092	0.0326	51	51

NA is Not Applicable
ND is Not Detected

SUMMARY STATISTICS

2020 DHEC Air Station Tritium Data in pCi/m^3

Location	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Allendale Barricade (ABR)	2.63	NA	2.63	2.63	2.63	1	12
Darkhorse (DKH)	3.67	1.17	3.52	2.47	5.76	6	12
Aiken Elementary Water Tower (AIK)	3.04	0.55	3.09	2.34	3.64	6	12
New Ellenton, S.C. (NEL)	3.81	0.53	3.76	3.09	4.45	6	12
Jackson, S.C. (JAK)	4.17	0.76	4.38	2.85	4.66	5	12
Burial Ground North (BGN)	196.24	89.80	167.87	84.91	372.31	12	12
Barnwell Barricade (BWL)	3.10	0.44	2.99	2.62	3.59	5	12

2020 DHEC Tritium in Precipitation Data in pCi/L

Location	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Allendale Barricade (ABR)	ND	ND	ND	ND	ND	0	12
Darkhorse (DKH)	ND	ND	ND	ND	ND	0	12
Aiken Elementary Water Tower (AIK)	NA	NA	NA	217	217	1	12
New Ellenton, S.C. (NEL)	ND	ND	ND	ND	ND	0	12
Jackson, S.C. (JAK)	ND	ND	ND	ND	ND	0	12
Burial Ground North (BGN)	2401	1342	2386	307	4791	12	12
Barnwell Barricade (BWL)	ND	ND	ND	ND	ND	0	12

NA is Not Applicable
ND is Not Detected

Chapter 2 Ambient Groundwater Monitoring Adjacent to SRS

2.1.0 PROJECT SUMMARY

DHEC currently utilizes a regional groundwater monitoring well network consisting of cluster wells (C-wells) and network wells (private wells and public water systems). This groundwater well network consists of approximately 107 wells that are cyclically sampled every five years by DHEC. The C-wells are owned and maintained by the South Carolina Department of Natural Resources (DNR). These cluster wells are screened from shallow surficial aquifers to deeper aquifers up to depths exceeding 1,400 feet below ground surface. The C-well clusters are situated around the perimeter of SRS.

Groundwater samples are collected from wells within a 20-mile site boundary. A 20-mile sampling perimeter was selected based on regional well availability and comparative review of known or suspected sources of groundwater contamination and local groundwater flow patterns. The project map in Section 2.4.0 depicts the network groundwater well locations, the extent of the study area, and the wells sampled in 2020. DHEC evaluates four aquifer zones (Upper Three Runs, Gordon, Crouch Branch, and McQueen Branch).

2.2.0 RESULTS AND DISCUSSION

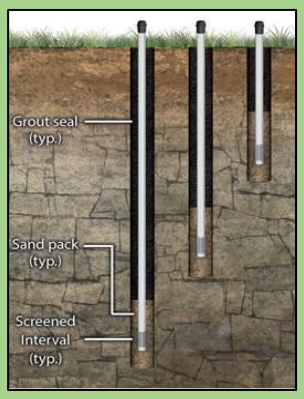
Groundwater Monitoring Data can be found in Section 2.6.0 and in the 2020 DHEC Data File.

DHEC collected groundwater from 35 wells. Based on a review of the tritium, gross alpha, non-volatile beta, and gamma-emitting radioisotope analytical data provided by the DHEC Analytical and Radiological Environmental Services Division (ARESD) laboratories, the only gamma-emitting radioisotope detected was Lead-214 (Pb-214). Pb-214 is a naturally occurring radioactive or NORM contaminant and was detected in seven out of the 35 groundwater wells sampled. See Section 2.5.0, Table 1 for a list of the network of sampling wells with their assigned aquifer.

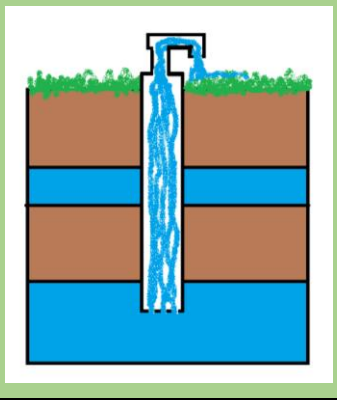
An **AQUIFER** is soil and/or rock containing water below the ground surface.

CLUSTER WELLS vs. NETWORK WELLS

CLUSTER WELLS are multiple wells that are at the same location but are drilled to varying depths to screen different aquifers.



NETWORK WELLS are single wells at a specific location screened in a specific aquifer.



Groundwater investigations performed by state and federal agencies such as DHEC, DNR, and the United States Geological Survey (USGS) have confirmed the presence of naturally occurring radionuclides in groundwater across South Carolina (Agency for Toxic Substances and Disease Registry [ATSDR], 2007). If known contaminants are found in wells located within the DHEC sampling network, the affected wells would be investigated further to help determine the source.

Residential Well

The United States Environmental Protection Agency (EPA) has a drinking water Maximum Contaminant Level (MCL) of 20,000 pCi/L for tritium, 15 pCi/L for gross alpha, and 50 pCi/L minus natural potassium-40 (K-40) for non-volatile beta (EPA, 2020). In 2020, DHEC detected tritium in two wells (G02153 and G02399). Fifteen wells in three different aquifers (Steed Pond, Crouch Branch, and McQueen Branch) had gross alpha detects below the EPA MCL. Two wells in two different aquifers (Crouch Branch and Steed Pond) had non-volatile beta detects well below the EPA MCL. Results for 2020 were compared to the data collected in 2015 which was the previous cycle year for the locations sampled. 2015 and 2020 had comparable data for both gross alpha and non-volatile beta detects. Those results can be found in Section 2.6.0.

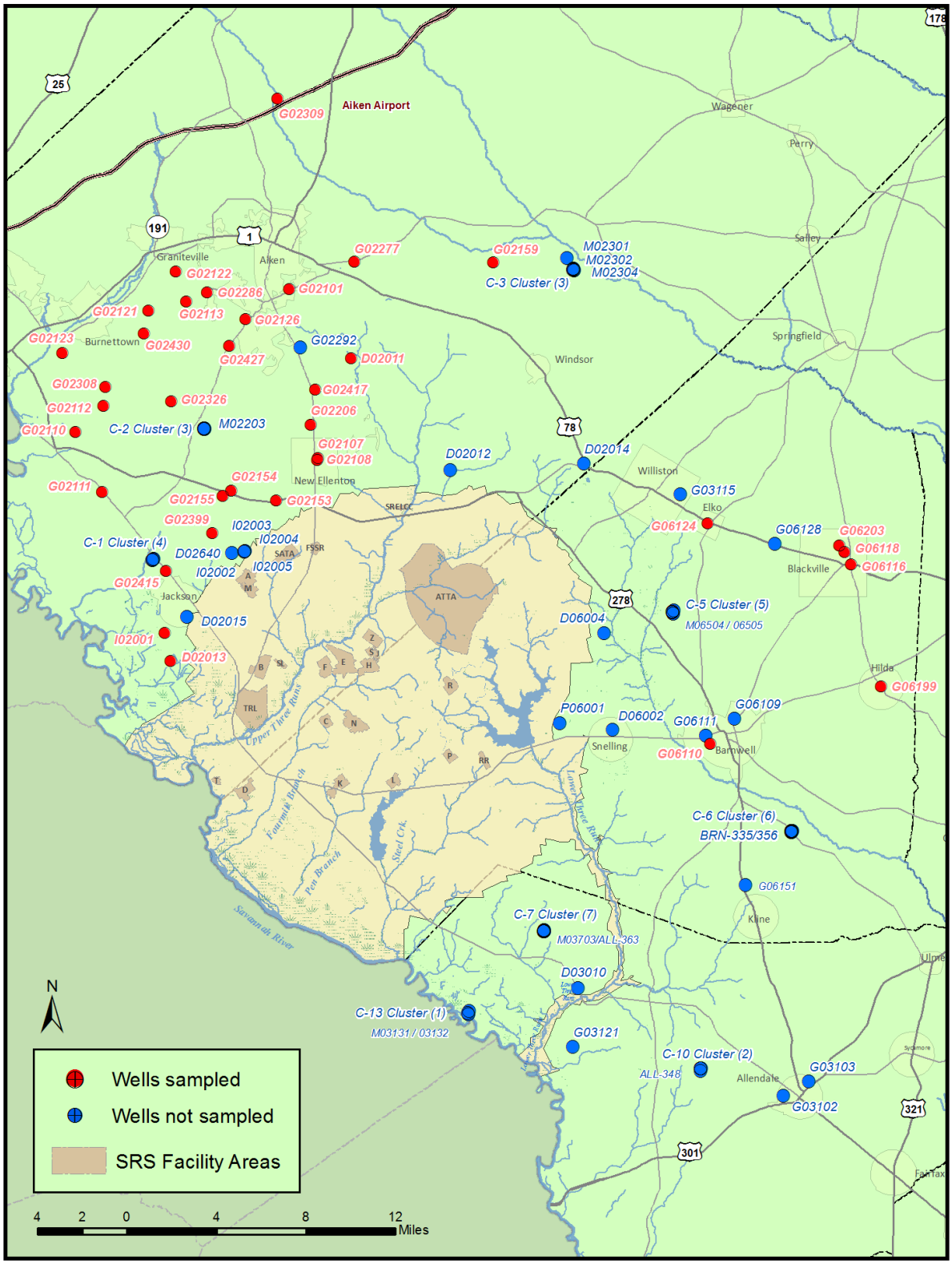
2.3.0 CONCLUSIONS AND RECOMMENDATIONS

DOE-SR collects groundwater samples from a separate on-site monitoring well network; therefore, direct DHEC off-site groundwater comparisons could not be made. However, the 2020 SRS report identifies various contaminants such as volatile organic compounds (VOCs), tritium, and gross alpha/beta radionuclides in numerous areas of groundwater throughout the SRS property (SRNS, 2021).

Collecting well water for analysis

2.4.0 MAP

2020 Groundwater Sampling Locations



2020 ESOP Groundwater Monitoring Map www.scdhec.gov

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2.5.0 TABLES AND FIGURES

Table 1. DHEC Groundwater Monitoring Wells

Well No.	Well Name	Sample Year	Top of Casing Elevation (ft amsl)	Total Depth (ft bgs)	Aquifer
G02292**	Hunter's Glen	2020	unknown	210	SP
G02206	**Oak Hill Subdivision**	**2020**	**445**	**240**	**SP**
G06124	**Elko**	**2020**	**351**	**353**	**UTR**
G06116	**Blackville Lartique St.**	**2020**	**295**	**380**	**UTR**
G06118	**Blackville Greene Well**	**2020**	**292**	**620**	**GOR**
G06203	**Blackville Industrial Park**	**2020**	**273**	**425**	**UTR**
G06199	**Hilda**	**2020**	**271**	**345**	**UTR**
G02309	**Aiken Shiloh Springs**	**2020**	**362**	**50**	**SP**
G02101	**Aiken Pine Log Road**	**2020**	**483**	**407**	**MB**
G02126	**Aiken Town Creek**	**2020**	**508**	**400**	**MB**
G02427	**Aiken Silver Bluff**	**2020**	**467**	**-**	**MB**
G02121	**Valley PSA Gloverville**	**2020**	**413**	**242**	**CB**
G02286	**Valley PSA Walker**	**2020**	**471**	**400**	**MB**
G02122	**Valley PSA Howlandville**	**2020**	**483**	**323**	**CB**
G02123	**Valley PSA Johnstown**	**2020**	**259**	**150**	**CB**
G02153	**Talatha Well #1**	**2020**	**420**	**280**	**SP**
G02154	**Talatha Well #2**	**2020**	**250**	**185**	**CB**
G02155	**Talatha Well #3**	**2020**	**343**	**240**	**SP**
G02399	**Jackson Well #3`**	**2020**	**405**	**450**	**CB**
G02415	**Jackson Well #4**	**2020**	**339**	**400**	**CB**
G02110	**Beech Island Well #2**	**2020**	**417**	**468**	**CB**
G02111	**Beech Island Well #3**	**2020**	**369**	**460**	**MB**
G02112	**Beech Island Well #4**	**2020**	**380**	**600**	**MB**
G02113	**Beech Island Well #5**	**2020**	**508**	**438**	**CB**
G02308	**Beech Island Well #6**	**2020**	**448**	**400**	**CB**
G02430	**Beech Island Well Piney Heights**	**2020**	**453**	**490**	**CB**
G02326	**Boyd Pond (Former ORA)**	**2020**	**300**	**397**	**MB**
D02013	**Cowden Plantation, Well 2**	**2020**	**124**	*****	**SP**
I02001	**Cowden Plantation, Well 1**	**2020**	**132**	*****	**CB**
D02011	**Mettlen Well**	**2020**	**400**	**180**	**SP**
G02108	**New Ellenton Well #1**	**2020**	**422**	**427**	**CB**
G02107	**New Ellenton Well #2**	**2020**	**422**	**425**	**CB**
G02417	**New Ellenton Well #4**	**2020**	**488**	**565**	**MB**
G02277	**Montmorenci WD Office Well**	**2020**	**504**	**363**	**CB**
G02159	**Montmorenci Well 1**	**2020**	**504**	**330**	**CB**
G06110	**Barnwell #10 Shuron**	**2020**	**190**	**276**	**UTR**
G06109	Barnwell, Hwy. 3	2021	230	146	UTR
G06111	Barnwell, Rose St.	2021	220	166	UTR
G06128	Edisto Station	2021	322	360	GOR
G06147	Williston, Halford St.	2021	352	530	CB
D06002	Moore Well	2021	240	*	UTR

P06001	Allied General Nuclear, Well 1	2021	250	*	MB
D03010	Martin Post Office	2022	108	105	UTR
G03102	Allendale, Water St.	2022	201	343	UTR
G03103	Allendale, Googe St.	2022	180	347	UTR
G06151	Chappells Labor Camp	2022	250	260	UTR
G03121	Clariant	2022	180	812	CB
I02002	Greene Irrigation 1	2023	381	278	SP
I02003	Greene Irrigation 2	2023	381	280	SP
I02004	Greene Irrigation 3	2023	373	276	SP
I02005	Greene Irrigation 4	2023	373	236	SP
G03115	Martin District Fire Department	2022	95	*	*
M02101	SCDNR Cluster C-01, AIK-2378	2023	220.3	185	CB
M02102	SCDNR Cluster C-01, AIK-2379	2023	224.2	266	CB
M02103	SCDNR Cluster C-01, AIK-2380	2023	228.9	385	MB
M02104	SCDNR Cluster C-01, AIK-902	2023	231.9	511	MB
M02202	SCDNR Cluster C-02, AIK-825	2023	418.8	231	CB
M02203	SCDNR Cluster C-02, AIK-824	2023	418.6	365	CB
M02204	SCDNR Cluster C-02, AIK-818	2023	418.3	425	MB
M02205	SCDNR Cluster C-02, AIK-817	2023	418.9	535	MB
M02301	SCDNR Cluster C-03, AIK-849	2023	301.6	97	SP
M02302	SCDNR Cluster C-03, AIK-848	2023	299.7	131	CB
M02303	SCDNR Cluster C-03, AIK-847	2023	299	193	CB
M02304	SCDNR Cluster C-03, AIK-846	2023	297.8	255	CB
M02305	SCDNR Cluster C-03, AIK-845	2023	296.9	356	MB
M02306	SCDNR Cluster C-03, AIK-826	2023	294.9	500	MB
M06501	SCDNR Cluster C-05, BRN-360	2023	264.3	140	UTR
M06502	SCDNR Cluster C-05, BRN-359	2023	265.5	214	GOR
M06503	SCDNR Cluster C-05, BRN-367	2023	263.8	285	GOR
M06504	SCDNR Cluster C-05, BRN-368	2024	265.1	443	CB
M06505	SCDNR Cluster C-05, BRN-365	2024	263.5	539	CB
M06506	SCDNR Cluster C-05, BRN-366	2024	266.7	715	MB
M06507	SCDNR Cluster C-05, BRN-358	2024	265.6	847	MB
M03706	SCDNR Cluster C-07, ALL-368	2024	246.6	691	CB
M03707	SCDNR Cluster C-07, ALL-369	2024	242.1	800	CB
M03708	SCDNR Cluster C-07, ALL-370	2024	245.1	975	MB
M03709	SCDNR Cluster C-07, ALL-358	2024	243.1	1123	MB
M03701	SCDNR Cluster C-07, ALL-363	2024	246.1	105	UTR
M03702	SCDNR Cluster C-07, ALL-364	2024	245.2	225	UTR
M03703	SCDNR Cluster C-07, ALL-365	2024	244.3	333	GOR
M03704	SCDNR Cluster C-07, ALL-366	2024	243.5	400	GOR
M03705	SCDNR Cluster C-07, ALL-367	2024	245.7	566	CB
M06601	SCDNR Cluster C-06, BRN-351	2024	207.3	95	UTR
M06602	SCDNR Cluster C-06, BRN-350	2024	207.4	170	UTR
M06603	SCDNR Cluster C-06, BRN-352	2024	207.1	293	GOR
M06604	SCDNR Cluster C-06, BRN-354	2024	207.6	411	GOR
M06605	SCDNR Cluster C-06, BRN-353	2024	207.7	588	CB
M06608	SCDNR Cluster C-06, BRN-349	2024	208.6	1045	MB

M03101	SCDNR Cluster C-10, ALL-347	2024	281.6	1423	MB
M03102	SCDNR Cluster C-10 ALL-372	2024	282	155	UTR
M03103	SCDNR Cluster C-10 ALL-371	2024	282.2	217	UTR
M03113	SCDNR Cluster C-13 (Artesian)	2024	73	*	GOR
M03132	SCDNR Cluster C-13 ALL-378	2024	90	1060	MB
M03131	SCDNR Cluster C-13, Artesian	2024	80	*	GOR
M03104	SCDNR Cluster C-10, ALL-374	2024	280.9	580	GOR

Notes:
ft amsl is feet above mean sea level
ft bgs is feet below ground surface
CB is Crouch Branch
MB is McQueen Branch
SP is Steeds Pond
UTR is Upper Three Runs
GOR is Gordon
** Well was unable to be sampled during the sampling cycle; however, it will remain in the network.

2.6.0 SUMMARY STATISTICS

2020 DHEC Alpha Detects in Groundwater Data in pCi/L

Location Description	Result	Aquifer	2015 Data
D02011	2.92	SP	2.2
G02206	3.88	SP	3.87
D02013	2.36	SP	<LLD
G02309	6.04	SP	NS
G02121	1.05	CB	NS
G02286	1.46	MB	NS
G02154	<LLD	CB	2.12
G02155	1.96	SP	NS
G02107	<LLD	CB	1.63
G02417	2.35	MB	NS
G02415	1.41	CB	NS
G02110	0.627	CB	NS
G02111	1.2	MB	<LLD
G02112	0.859	CB	NS
G02308	1.18	CB	NS
G02430	2.29	CB	NS
G02113	1.3	CB	NS

2020 DHEC Beta Detects in Groundwater Data in pCi/L

Location Description	Result	Aquifer	2015 Data
D02011	4.80E+00	SP	<LLD
G02121	4.98E+00	CB	NS

A total of 35 wells were sampled in 2020, but only those wells that had gross alpha and non-volatile beta detects above the LLD for either 2020 or 2015 were included in the tables above.

Chapter 3 Radiological Monitoring of Drinking Water Adjacent to SRS

3.1.0 PROJECT SUMMARY

DHEC evaluates drinking water quality to provide information on the radiological impact of SRS to community drinking water systems adjacent to and downstream of the site. DHEC samples five drinking water systems. Monthly composite samples are taken from three Savannah River-fed systems: one upstream location (North Augusta) and two downstream of SRS (Purrysburg Beaufort/Jasper (B/J) and Chelsea B/J). Additionally, two public drinking water systems that are not primarily served by the Savannah River but draw from surface water sources were sampled each month (Aiken Public Shaw Creek Water Works Treatment Plant and Breezy Hill Water Treatment Plant). These systems are located outside of the SRS perimeter and are up to 30 miles from the center of the site (Map, Section 3.4.0).

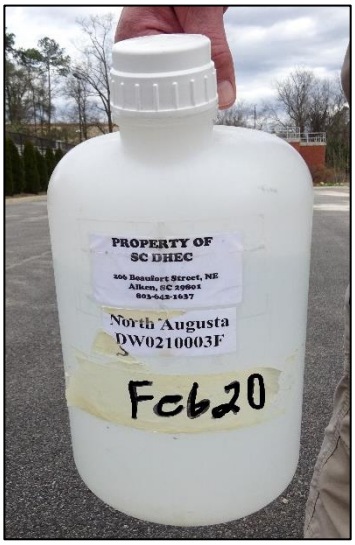
SURFACE WATER – water that collects on the surface of the ground in the form of streams, ponds, lakes, rivers, or the ocean.

GROUNDWATER– water stored underground in sediment pores or crevices in rock. It may eventually be used by plants, taken up through wells by humans, or discharge into another body of water.

DRINKING WATER – surface water or groundwater that has been treated through a cleaning process to be available for healthy consumption by humans.

In 2020, DOE-SR collected drinking water from two surface water fed systems (North Augusta and Purrysburg B/J) that are collocated with the DHEC Savannah River-fed systems. Currently, DOE-SR does not conduct drinking water sampling from other public systems off SRS property. DHEC and DOE-SR analyze and compare all samples for gross alpha, non-volatile beta, gamma-emitting radionuclides, and tritium.

3.2.0 RESULTS AND DISCUSSION



Water sample from North Augusta Water Treatment Plant

In 2020, DHEC and DOE-SR detected tritium above the lower limit of detection (LLD) in some of the Savannah River-fed systems both upstream and downstream of SRS. These activities are well below the EPA established 20,000 pCi/L drinking water limit (EPA, 2020).

Gamma-emitting radionuclides in the List of Analytes, Table 1, page ix, were not detected above the LLD for the drinking water samples collected by DHEC or in DOE-SR's collocated samples in 2020.

Gross alpha, tritium and non-volatile beta sample results are presented in the following tables in Section 3.5.0 and can be found in the 2020 DHEC Data File. All results are below their respective EPA MCLs.

3.3.0 CONCLUSIONS AND RECOMMENDATIONS

Tritium continues to be the most abundant radionuclide detected in public drinking water supplies potentially impacted by SRS. Observed tritium activities were low when compared to the EPA MCL for tritium in drinking water, which is 20,000 pCi/L. Detections of gross alpha and non-volatile beta were all below their respective MCLs. DOE-SR does not sample systems not served by the Savannah River; therefore, DHEC will continue to monitor these off-site public water systems in the event these wells are impacted by contaminated groundwater from SRS.

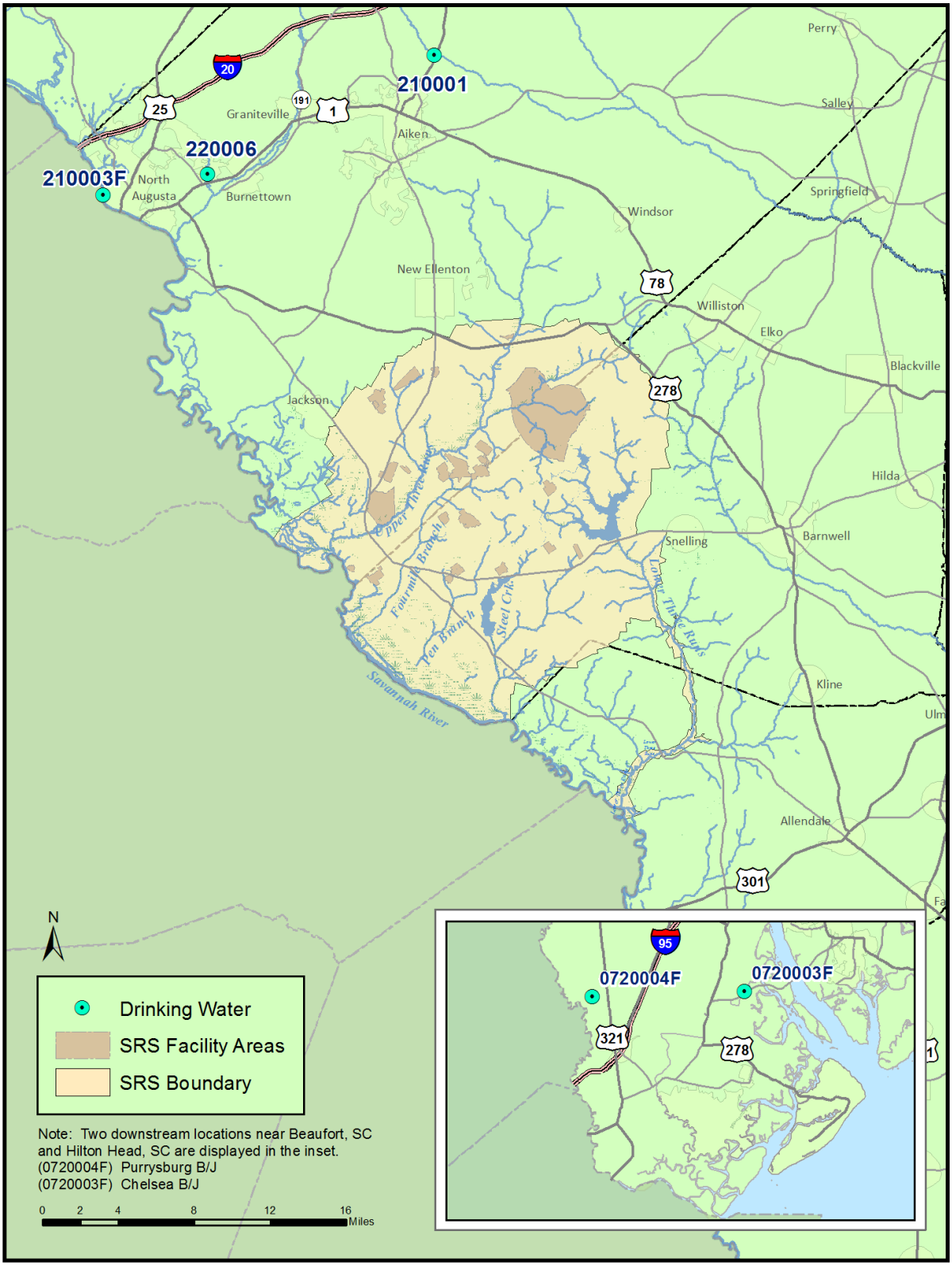
Water sample from Breezy Hill Water Treatment Plant

The DHEC Drinking Water Monitoring Project continues to be an important source of essential data for assessing human health exposure pathways. DHEC will continue to monitor surface water quality due to the extent of the surface water contamination on SRS, and its potential to migrate, and potentially impact, drinking water systems downstream from SRS. Continued sampling will also provide the public with an independent source of radiological data for drinking water systems within the SRS study area.

DHEC continues to reevaluate the drinking water systems monitored by the drinking water project. Primary and background drinking water systems will be added and removed from the list of sampled drinking water systems as deemed necessary to maintain monitoring coverage.

3.4.0 MAP

Drinking Water Sampling Locations



2020 ESOP Drinking Water Monitoring www.scdhec.gov

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3.5.0 TABLES AND FIGURES

Table 1. Drinking Water Systems Sampled by DHEC

System Number	System Name	Number of Taps	Population
0210001	Aiken	19,444	42,286
0220006	Breezy Hill Water District	6,871	15,282
0210003F	North Augusta	12,424	29,280
0720003F	Chelsea B/J	55,661	168,036
0720004F	Purrysburg B/J	96	280
	Total		
	Savannah River-fed systems downstream from SRS	55,757	168,316
	Systems not fed from the Savannah River downstream of SRS	38,739	86,848

Data was obtained from DHEC's Environmental Facility Information System database

Note for Table 2-6: Summary statistics are not shown for locations whose analytes had either no detections or only one detection. If a location did have multiple detections for a specific analyte, the summary statistics are written as a note below its table.

Table 2: 2020 DHEC and DOE-SR DW Data for North Augusta (DWO210003F) in pCi/L (SRNS, 2021)

Month	DHEC Total Alpha	DHEC Nonvolatile Beta	DHEC Tritium	DOE-SR Total Alpha	DOE-SR Nonvolatile Beta	DOE-SR Tritium
JAN	ND	ND	ND	ND	1.64	ND
FEB	ND	ND	ND	ND	1.55	ND
MAR	ND	ND	ND	ND	2.48	ND
APR	ND	ND	ND	ND	1.31	ND
MAY	ND	ND	ND	ND	1.66	135
JUN	ND	ND	ND	ND	1.72	159
JUL	ND	ND	ND	ND	1.46	121
AUG	ND	ND	ND	ND	1.85	163
SEP	ND	ND	ND	ND	1.93	ND
OCT	ND	ND	ND	ND	1.82	ND
NOV	ND	ND	ND	ND	1.80	ND
DEC	ND	ND	303	ND	1.63	ND

TABLES AND FIGURES CONT.

Table 3: 2020 DHEC and DOE-SR DW Data for Purrysburg B/J Water Treatment Plant (DW0720004F) in pCi/L (SRNS, 2021)

Month	DHEC Total Alpha	DHEC Nonvolatile Beta	DHEC Tritium	DOE-SR Total Alpha	DOE-SR Nonvolatile Beta	DOE-SR Tritium
JAN	ND	ND	ND	ND	2.14	153
FEB	ND	ND	ND	ND	1.85	188
MAR	ND	ND	ND	ND	2.15	ND
APR	ND	ND	453	ND	1.97	359
MAY	ND	ND	ND	ND	1.73	129
JUN	ND	ND	ND	ND	2.03	ND
JUL	ND	ND	492	ND	2.17	451
AUG	ND	ND	837	ND	2.11	697
SEP	ND	ND	443	ND	1.6	322
OCT	ND	ND	243	ND	1.23	ND
NOV	1.59	ND	226	ND	1.89	158
DEC	ND	ND	232	ND	1.68	130

Note: DHEC Tritium had multiple detections and summary statistics in pCi/L were calculated as: Average = 418.05, Standard Deviation = 217.80, Median = 443.07, Minimum = 226.05, Maximum = 836.75, Number of Detections = 7.

Table 4: 2020 DHEC DW Data for Chelsea B/J Water Treatment Plant (DW0720003F) in pCi/L

Month	Total Alpha	Nonvolatile Beta	Tritium
JAN	ND	ND	ND
FEB	ND	ND	245
MAR	ND	ND	ND
APR	ND	ND	334
MAY	ND	ND	ND
JUN	ND	ND	ND
JUL	ND	ND	395
AUG	ND	ND	789
SEP	ND	ND	344
OCT	ND	ND	275
NOV	ND	ND	276
DEC	ND	3.72	288

Note: Tritium summary statistics in pCi/L were calculated as: Average = 368.14, Standard Deviation = 176.73, Median = 310.83, Minimum = 244.94, Maximum = 789.11, Number of Detections = 8.

TABLES AND FIGURES CONT.

Table 5: 2020 DHEC DW Data for Aiken Public Shaw Creek Water Works Treatment Plant (DW0210001) in pCi/L

Month	Total Alpha	Nonvolatile Beta	Tritium
JAN	4.52	ND	ND
FEB	1.90	ND	ND
MAR	ND	ND	ND
APR	ND	ND	ND
MAY	ND	ND	ND
JUN	ND	ND	ND
JUL	ND	ND	ND
AUG	3.95	ND	ND
SEP	ND	ND	ND
OCT	ND	ND	ND
NOV	2.76	ND	ND
DEC	2.30	ND	ND

Note: Alpha summary statistics in pCi/L were calculated as: Average = 3.09, Standard Deviation = 1.11, Median = 2.76, Minimum = 1.90, Maximum = 4.52, Number of Detections = 5.

Table 6: 2020 DHEC Raw DW Data for Breezy Hill Water Treatment Plant (DW0220006) in pCi/L

Month	Total Alpha	Nonvolatile Beta	Tritium
JAN	ND	ND	ND
FEB	ND	ND	ND
MAR	ND	ND	ND
APR	ND	ND	212
MAY	ND	ND	ND
JUN	ND	ND	ND
JUL	ND	ND	ND
AUG	ND	ND	ND
SEP	ND	ND	ND
OCT	ND	ND	ND
NOV	ND	ND	ND
DEC	ND	ND	ND

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Chapter 4 Radiological Monitoring of Surface Water on and Adjacent to SRS

4.1.0 PROJECT SUMMARY

The focus of the Radiological Monitoring of Surface Water (RSW) project is to test and survey the streams and creeks on SRS as well as the Savannah River. Since the Savannah River is the primary drinking water source for some downstream communities, it is important to monitor radionuclide concentrations in the river. Surface water samples are collected and analyzed for radionuclides, and the results are compared to DOE-SR data. DHEC supports DOE-SR's objectives to ensure that the primary goal of drinking water safety is established and met.

Collecting samples to be tested for tritium using the early detection system at SV-118

DHEC collects surface water samples from 12 specific locations within and outside of the SRS boundary as part of an ambient sampling network (Section 4.4.0, Map). Section 4.5.0, Table 1, identifies sample ID, location, rationale, and frequency. Some locations were chosen because they are considered public access locations. All but one of the public access locations are downstream of SRS, which provide a potential means for exposure to radionuclides. Jackson Boat Landing (SV-2010) is upstream from SRS activities and is a public access location.

Quarterly samples are collected for tritium analysis from the five creek mouths that flow from SRS directly into the Savannah River (Upper Three Runs Creek, Fourmile Branch, Steel Creek Little Hell Boat Landing, and Lower Three Runs Creek). Pen Branch is not sampled because the Savannah River Swamp interrupts the flow of this creek and there is no creek mouth access.

Example of a Composite Sample

An enhanced surface water monitoring program was implemented to provide downstream drinking water systems with advance notice of the potential for increased tritium levels in the Savannah River. This early detection facet is possible because of the continuous monitoring of the five SRS streams that flow to the Savannah River. Samples for tritium analysis are collected from seven locations with automatic water samplers. Additionally, a grab sample is collected from Johnson's Boat Landing (SV-2080) and U.S. Highway 301 at the Savannah River (SV-118).

In 2019, the Supplemental Surface Water Monitoring Program was modified from serving as an early detection system for unplanned releases from SRS source term areas to being collected monthly. Samples from Upper Three Runs, Fourmile Branch, McQueen Branch, and Steel Creek are analyzed for gamma-emitting radionuclides. The McQueen Branch location serves to monitor the Saltstone low-level

waste operations and is a monthly composite that is collected by DOE and split with DHEC. Beginning in 2019, Steel Creek (SV-2052) is sampled on a weekly basis and analyzed for tritium.

In August of 2007, DHEC began collecting ambient grab samples from a location on Lower Three Runs. This sampling was conducted in response to elevated tritium levels detected in groundwater samples near the Energy Solutions (formerly Chem-Nuclear) facility in Snelling, South Carolina. The purpose of adding this location was to differentiate any potential tritium contributions to Lower Three Runs from Energy Solutions and SRS activities.

Quarterly sampling for I-129 and Tc-99 is conducted at the supplemental location on Fourmile Branch at Road C (SV-2044) due to concerns that these are possible constituents related to effluent from the burial grounds, which could enter the surface water.

Example of a Grab Sample

4.2.0 RESULTS AND DISCUSSION

Radiological Monitoring of Surface Water Summary Statistics can be found in Section 4.6.0 and all Radiological Monitoring of Surface Water Data can be found in the 2020 DHEC Data File.

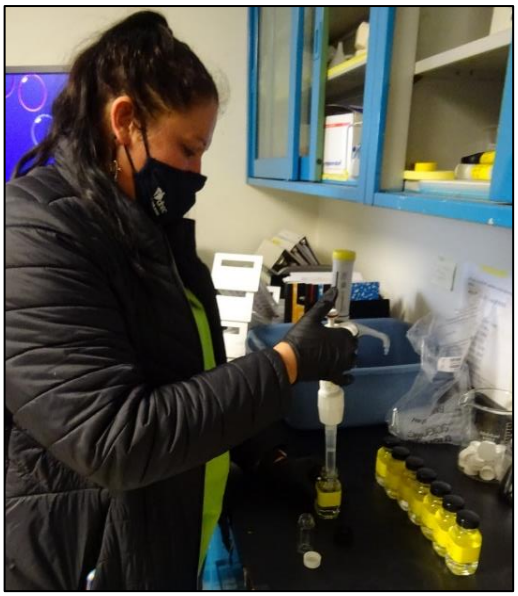
Pouring a sample to be tested for tritium

The data presented in this section concerns the DHEC ambient sampling network including the Savannah River and on-site streams. The enhanced sample data are not displayed in the annual report and data file due to their sole purpose of serving as an early detection system for downstream drinking water users.

DHEC data from 2020 was compared to DOE-SR reported results (Section 4.5.0, Tables 2, 3, and 4). The DHEC and DOE-SR collocated sampling sites were Tims Branch at Road C, Upper Three Runs Creek at Road A, Fourmile Branch at Road A-12.2, Pen Branch at Road A-13.2, Steel Creek at Road A, the Savannah River at U.S. Highway 301 Bridge, and Lower Three Runs Creek at Road B. DOE-SR sampled at several other locations along these streams. However, the data comparisons are only for the collocated sample sites.

Tritium

In 2020, DHEC and DOE-SR had detections for tritium at all collocated sample locations (Section 4.5.0, Table 2). DHEC average tritium activities at Jackson Boat Landing (SV-2010) and Upper Three Runs Creek at United States Forestry Service (USFS) Road 2-1 (SV-2027)



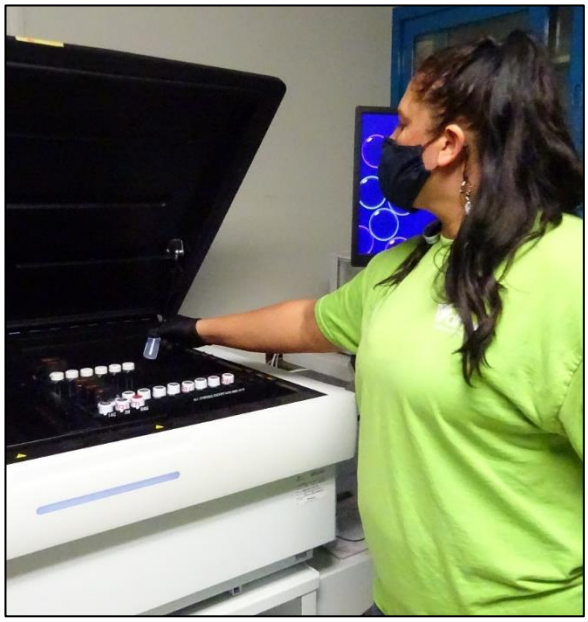
Pipetting samples in preparation for tritium analysis

were not directly affected by SRS operations. These locations are upstream from SRS impacts and are considered background locations. DHEC and DOE-SR samples indicate that Fourmile Branch (SV-2039) and Pen Branch (SV-2047) have the highest average tritium activity of all SRS streams. The 2020 DHEC and DOE-SR tritium results appear to be consistent with historically reported data values (Section 4.5.0, Figures 2-7). Section 4.5.0, Figure 1 shows trending data for DHEC tritium averages for the past five years.

Tritium activity in the Savannah River at the creek mouths of the four SRS streams are typically monitored on a quarterly basis; however, due to excessive rainfall contributing to dangerous river conditions in one of the quarters in 2020, samples were only collected three times during the year. Samples collected at the creek mouth of Fourmile Branch (SV-2015) had the highest average tritium activity of 21,232 pCi/L of all creek mouth locations.

Gamma

As part of a gamma spectroscopy analysis, samples were analyzed monthly for gamma-emitting radionuclides (List of Analytes, Table 1, page ix). DHEC had no Cs-137 or other gamma detections above the minimum detectable activity (MDA). DOE-SR had a single detect of Cs-137 at Upper Three Runs at Road A (8.14 pCi/L) and Am-241 was found at four locations with an average of 0.02 pCi/L. Pu-238, U-234, U-235, and U-238 were detected in DOE-SR samples but are considered NORM.



Placing water samples into the Liquid Scintillation Counter to analyze for tritium

Iodine-129 and Technetium-99

I-129 and Tc-99 samplings of the supplemental location on Fourmile Branch at Road C (SV-2044) were monitored on a quarterly basis by DHEC. All four quarterly I-129 samples had a detection above the MDA with an average of 1.15 pCi/L. All quarterly samples had Tc-99 detections with an average of 2.38 pCi/L. DHEC and DOE-SR do not have collocated sampling sites for I-129 and Tc-99.

I-129 and Tc-99 are included under the EPA established MCL of 4 millirem per year. The average concentration of I-129, which is assumed to yield 4 millirem per year, is 1 pCi/L. If other

radionuclides emitting beta particles and photon radioactivity are present in addition to I-129 and Tc-99, the sum of the annual dose from all the radionuclides shall not exceed 4 millirem/year (EPA, 2020).

Alpha

Pouring off a composite sample to be used for monthly alpha, beta, and gamma analysis

DHEC's and DOE-SR's Upper Three Runs Creek at SC 125 samples exhibited the highest alpha activity of the collocated locations with an average of 2.61 pCi/L (DHEC) and 4.36 pCi/L (DOE-SR) (Section 4.5.0, Table 3, SRNS, 2021). Historically, Upper Three Runs Creek at SC 125 (SV-325) yields detections for alpha activity (DHEC, 2016-2020). Isotopic analysis performed by DOE-SR revealed the source to be natural uranium (SRNS, 2013). This may contribute to the common occurrence of alpha detections at this location. The 2020 average alpha activity was below the EPA MCL for drinking water of 15 pCi/L (EPA, 2020). Beginning in 2009, samples collected at this location exhibited particles of sediment and detritus. This increase in turbidity seems to be related to storm events. Samples with high turbidity can have potential interferences during alpha/beta analysis. Alpha particles, and to a lesser extent, beta particles, are reduced by salts and solids dried onto a sampling planchet (Floeckher, 2000). Pump tubing is evaluated during each sample collection at all locations to ensure no blockage of sediment has occurred.

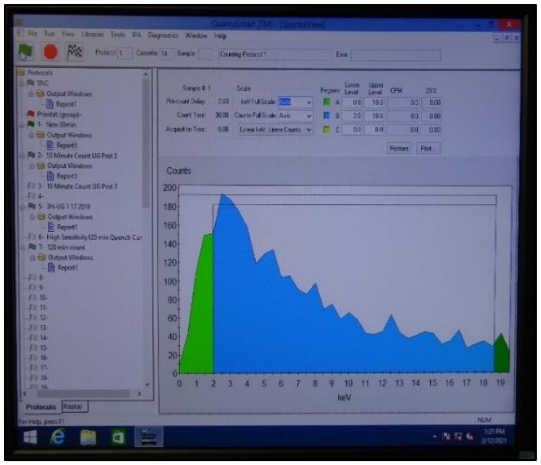
Beta

The sample exhibiting the highest average gross beta activity for both DHEC and DOE-SR were from Fourmile Branch at Rd. A-12.2 (SV-2039) with an average of 14.72 pCi/L (DHEC) and 14.93 pCi/L(DOE-SR) (SRNS, 2021). DOE-SR also reported a single detect of Sr-89/90 at Fourmile Branch at Rd A-12.2 (6.48 pCi/L) (SRNS, 2021). EPA has established a Maximum Contaminant Level (MCL) of 4 millirem per year for beta particle and photon radioactivity from man-made radionuclides in drinking water. The EPA screening MCL for gross beta-emitting particles for drinking water systems is 50 pCi/L minus natural potassium-40 (K-40) (EPA, 2020). All averages were below this limit.

4.3.0 CONCLUSIONS AND RECOMMENDATIONS

Differences in average values between DHEC and DOE-SR could be attributed, in part, to the nature of the medium and the specific point and time of when the sample was collected. DHEC will continue independent collection and analysis of surface water on and adjacent to SRS. This monitoring effort will provide an improved understanding of radionuclide levels in SRS surface waters. DHEC will periodically evaluate modifying the monitoring activities to better

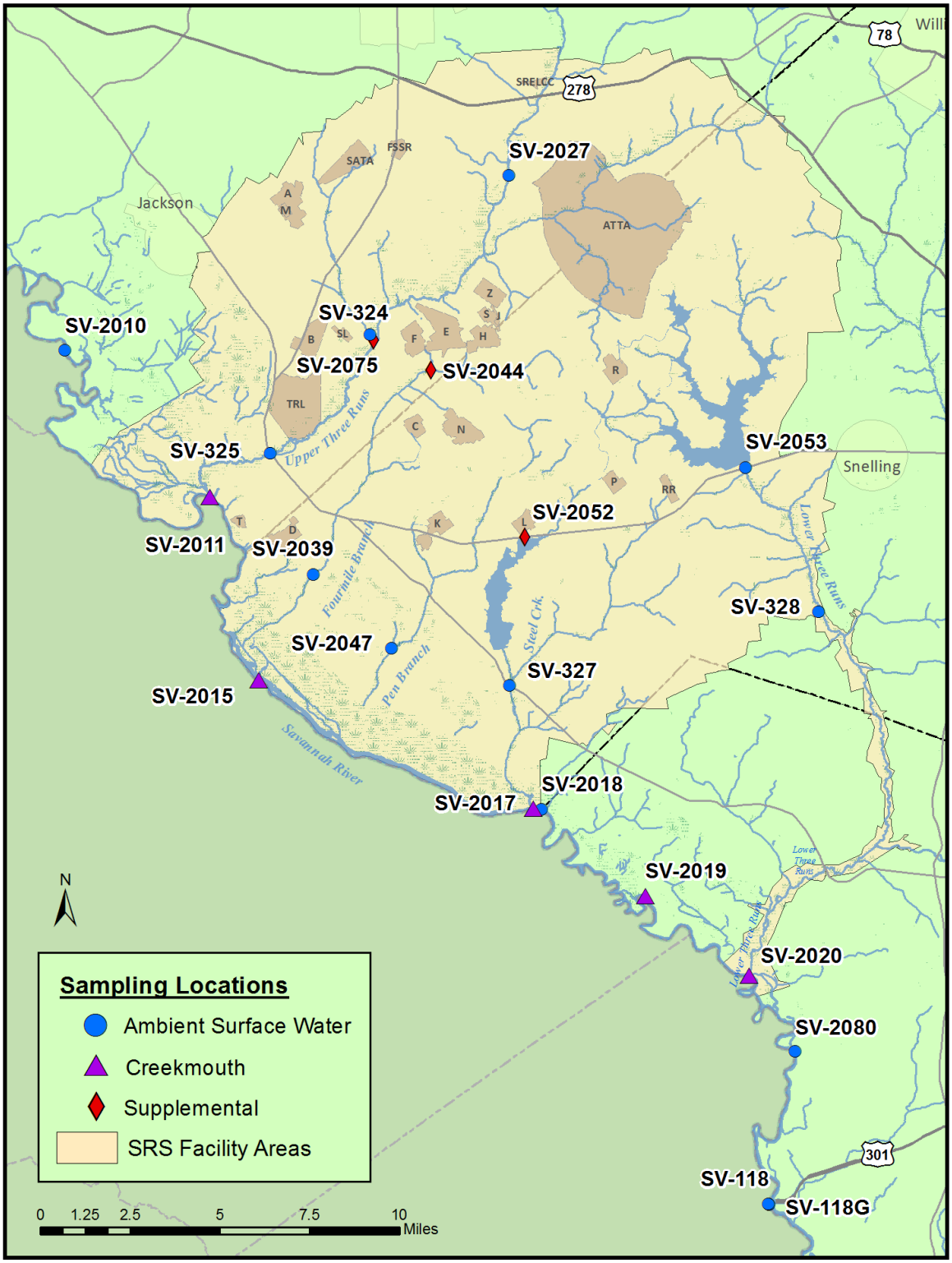
accomplish the project's goals and objectives. Further refinement of the RSW project may result in additional sampling locations being incorporated into the ambient or enhanced monitoring regimes. Monitoring will continue for as long as there are activities at SRS that create the potential for contamination to enter the environment, as well as past radioactive contamination that still exists due to unexpired half-lives.



Tritium counts being tracked by the Liquid Scintillation Counter

4.4.0 MAP

Radiological Surface Water Monitoring Locations



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4.5.0 TABLES AND FIGURES

Table 1. 2020 Surface Water Sampling Locations and Frequency

Ambient Monitoring Locations

ID	Location	Rationale	Frequency
SV-2010	Savannah River at RM 170.5 (Jackson Boat Landing)	Accessible to public; upstream all SRS operations; Near Jackson population center; Up-river control; River monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-324*	Tims Branch at SRS Road C	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-325*	Upper Three Runs Creek at S.C. 125 (SRS Road A)	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2039*	Fourmile Branch at Road A-12.2	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2047*	Pen Branch at Road A-13.2	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-327*	Steel Creek at S.C. 125 (SRS Road A)	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2018	Savannah River at RM 141 (Steel Creek Boat Landing)	Accessible to the public; Adjacent to SRS perimeter; Downstream of SRS operations; River monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2080	Savannah River at RM 125 (Johnson's Boat Landing)	Accessible to the public; Downstream of SRS operations and tributaries; River monitoring	Tri-weekly tritium grab
SV-118*	Savannah River at RM 118.8 (Hwy 301 Bridge)	Accessible to the public; Downstream of SRS operations and tributaries; River monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-328	Lower Three Runs Creek at Patterson Mill Road	Within SRS perimeter; Downstream of SRS operations and Par Pond; Tributary monitoring	Weekly tritium grab
SV-2053*	Lower Three Runs Creek at Road B	Within SRS perimeter; Downstream of SRS operations and Par Pond; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2027	Upper Three Runs Creek at SRS Road 2-1	Within SRS perimeter; Upstream from SRS operations; Upstream control; Tributary monitoring	Weekly tritium grab

TABLES AND FIGURES

Table 1. (Cont.)

Creek Mouth Locations

ID	Location	Rationale	Frequency
SV-2011	Upper Three Runs Creek Mouth at RM 157.4	Accessible to public; Adjacent to SRS; Downstream of SRS operation areas; Tributary monitoring	Quarterly tritium
SV-2015	Fourmile Branch at RM 150.6	Accessible to public; Adjacent to SRS; Downstream of SRS operation areas; Tributary monitoring	Quarterly tritium
SV-2017	Steel Creek Mouth at RM 141.5	Accessible to public; Adjacent to SRS; Downstream of SRS operation areas; Tributary monitoring	Quarterly tritium
SV-2019[a]	Savannah River at RM 134.5 (Little Hell Boat Landing)	Accessible to the public; Downstream of SRS operations and tributaries; River monitoring	Quarterly tritium
SV-2020	Lower Three Runs Creek at RM 129.1	Accessible to public; Adjacent to SRS; Downstream of SRS operation areas; Tributary monitoring	Quarterly tritium

Supplemental Locations

ID	Location	Rationale	Frequency
SV-2070*	McQueen Branch	Downstream from Saltstone LLW Operations	Monthly gamma composite
SV-2075*	Upper Three Runs Creek at Road C	Downstream from F-and H-Areas HLW Tanks	Monthly gamma composite
SV-2044*	Fourmile Branch at Road C	Downstream from F-and H-Areas HLW I Tanks	Monthly gamma composite
SV-2052*	Steel Creek at the top of L-Lake	Downstream from P- and L- Areas	Weekly tritium, Monthly gamma composite

ID is Sampling Location Identification Code Number
RM is River Mile
HLW is High-Level Waste
LLW is Low-Level Waste
Tri-Weekly Enhanced sample data is used for detection purposes only
* Indicates a location that is collocated with DOE sampling
[a] Indicates that SV-2019 is not a creek mouth; however, it is included in this chart as it is a boat landing collected quarterly and analyzed for tritium.

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TABLES AND FIGURES

Table 2. 2020 Tritium Data Comparison for DHEC and DOE-SR Collocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Detect (pCi/L)	Maximum Detect (pCi/L)	Number of Detects	Number of Samples
Tims Branch at Road C	SV-324	316	58	312	211	460	44	52
	TB-5	413	56	403	362	473	3	12
Upper Three Runs Creek at Road A	SV-325	616	210	556	270	1365	52	52
	U3R-4	554	124	505	386	757	7	12
Fourmile Branch at Road A-12.2	SV-2039	21232	4215	21448	9030	27661	52	52
	FM-6	19372	3987	19750	12300	25000	18	18
Pen Branch at Road A-13.2	SV-2047	9192	3364	9794	1898	13349	52	52
	PB-3	8102	2916	8975	3240	11500	12	12
Steel Creek at Road A	SV-327	1547	347	1511	958	2544	52	52
	SC-4	1387	367	1450	822	2120	12	12
Highway 301 Bridge at RM 118.8	SV-118	467	404	319	202	1982	37	51
	RM 118	332	265	223	124	1260	43	56
Lower Three Runs Creek at Road B	SV-2053	241	34	236	193	324	20	52
	L3R-1A	NA	NA	NA	335	335	1	12

Shaded areas represent DHEC data and unshaded areas represent DOE-SR data
DOE-SR data is from the SRS Environmental Data Report for 2020 (SRNS, 2021)
ND is Not Detected
NA is Not Applicable

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Table 3. 2020 Alpha Data Comparison for DHEC and DOE-SR Collocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Detect (pCi/L)	Maximum Detect (pCi/L)	Number of Detects	Number of Samples
Tims Branch at Road C	SV-324	2.49	1.00	2.31	1.58	3.74	4	12
	TB-5	2.27	0.98	2.23	1.07	4.62	12	12
Upper Three Runs Creek at Road A	SV-325	2.61	0.93	2.36	1.84	4.62	7	12
	U3R-4	4.36	3.74	2.42	1.12	13.40	12	12
Fourmile Branch at Road A-12.2	SV-2039	ND	NA	NA	<LLD	<LLD	0	12
	FM-6	2.01	1.84	1.01	0.33	6.05	17	18
Pen Branch at Road A-13.2	SV-2047	NA	NA	NA	1.53	1.53	1	12
	PB-3	1.00	0.70	1.05	0.28	2.29	11	12
Steel Creek at Road A	SV-327	ND	NA	NA	<LLD	<LLD	0	12
	SC-4	1.63	1.88	0.78	0.30	5.92	8	12
Highway 301 Bridge at RM 118.8	SV-118	ND	NA	NA	<LLD	<LLD	0	12
	RM 118	0.38	0.12	0.35	0.22	0.70	17	56
Lower Three Runs Creek at Road B	SV-2053	ND	NA	NA	<LLD	<LLD	0	12
	L3R-1A	0.98	0.69	0.72	0.50	2.20	5	12

Shaded areas represent DHEC data and unshaded areas represent DOE-SR data
DOE-SR data is from the SRS Environmental Data Report for 2020 (SRNS, 2021)
ND is Not Detected
NA is Not Applicable

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Table 4. 2020 Beta Data Comparison for DHEC and DOE-SR Collocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Detect (pCi/L)	Maximum Detect (pCi/L)	Number of Detects	Number of Samples
Tims Branch at Road C	SV-324	ND	NA	NA	<LLD	<LLD	0	12
	TB-5	1.68	0.45	1.69	0.84	2.42	12	12
Upper Three Runs Creek at Road A	SV-325	NA	NA	NA	7.66	7.66	1	12
	U3R-4	2.98	2.33	1.82	0.92	8.54	12	12
Fourmile Branch at Road A-12.2	SV-2039	14.72	8.05	14.10	5.38	32.00	10	12
	FM-6	14.93	7.81	15.00	3.24	31.40	18	18
Pen Branch at Road A-13.2	SV-2047	ND	NA	NA	<LLD	<LLD	0	12
	PB-3	1.21	0.42	1.19	0.68	2.06	11	12
Steel Creek at Road A	SV-327	ND	NA	NA	<LLD	<LLD	0	12
	SC-4	1.70	1.23	1.25	0.93	5.27	12	12
Highway 301 Bridge at RM 118.8	SV-118	ND	NA	NA	<LLD	<LLD	0	12
	RM 118	1.94	0.27	1.92	1.21	2.86	56	56
Lower Three Runs Creek at Road B	SV-2053	ND	NA	NA	<LLD	<LLD	0	12
	L3R-1A	1.44	0.49	1.31	0.74	2.49	12	12

Shaded areas represent DHEC data and unshaded areas represent DOE-SR data
DOE-SR data is from the SRS Environmental Data Report for 2020 (SRNS, 2021)
ND is Not Detected
NA is Not Applicable

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TABLES AND FIGURES

Figure 1. DHEC Average Tritium Data Trends for 2016-2020 (DHEC, 2018-2020b)

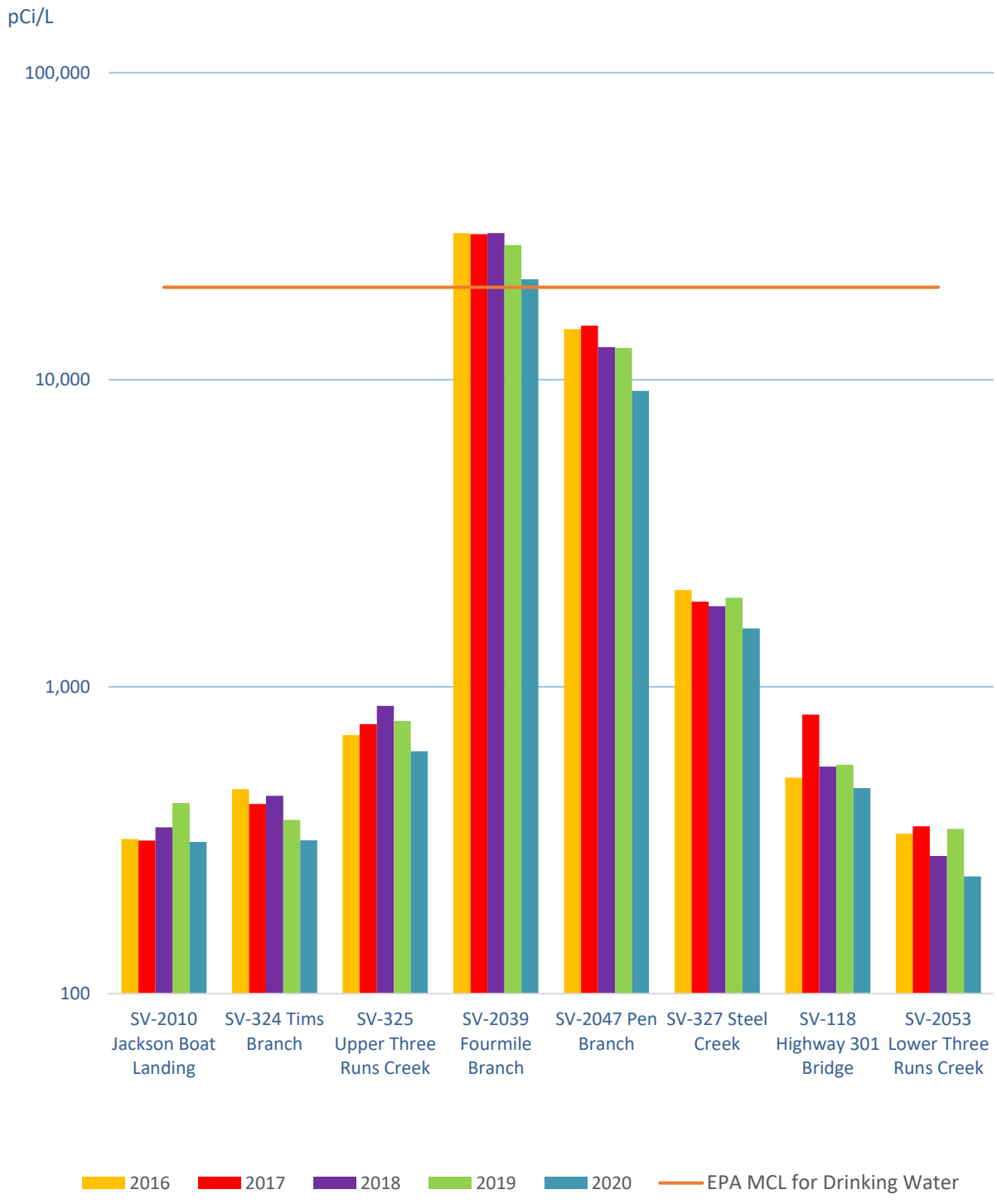

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Figure 2. 2016-2020 Average Tritium Data Trends for DHEC and DOE-SR for Upper Three Runs Creek at S.C. Highway 125 (SRNS, 2017-2021; DHEC, 2018-2020b)

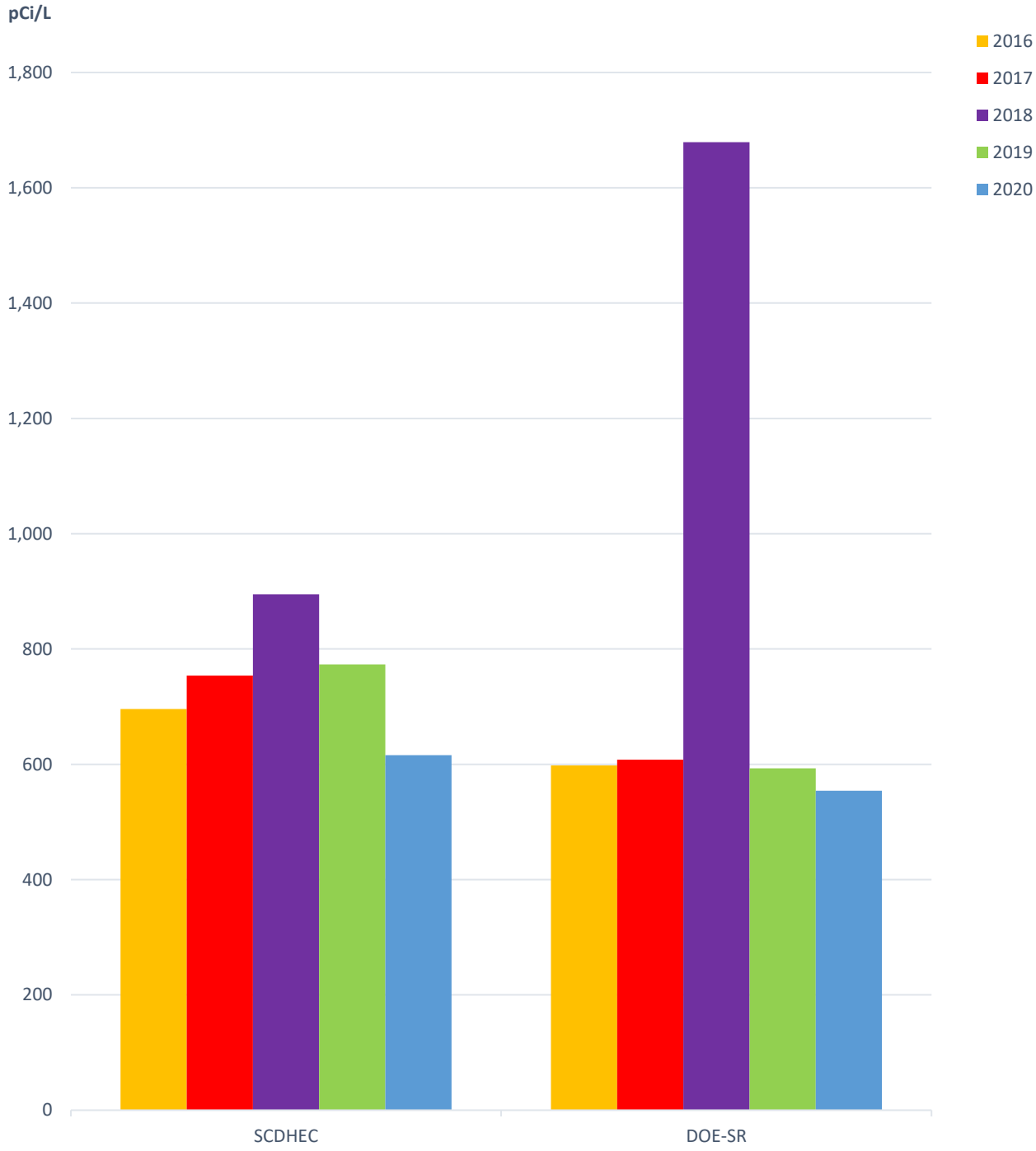

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Figure 3. 2016-2020 Average Tritium Data Trends for DHEC and DOE-SR for Fourmile Branch at Road A-12.2 (SRNS, 2017-2021; DHEC, 2018-2020b)

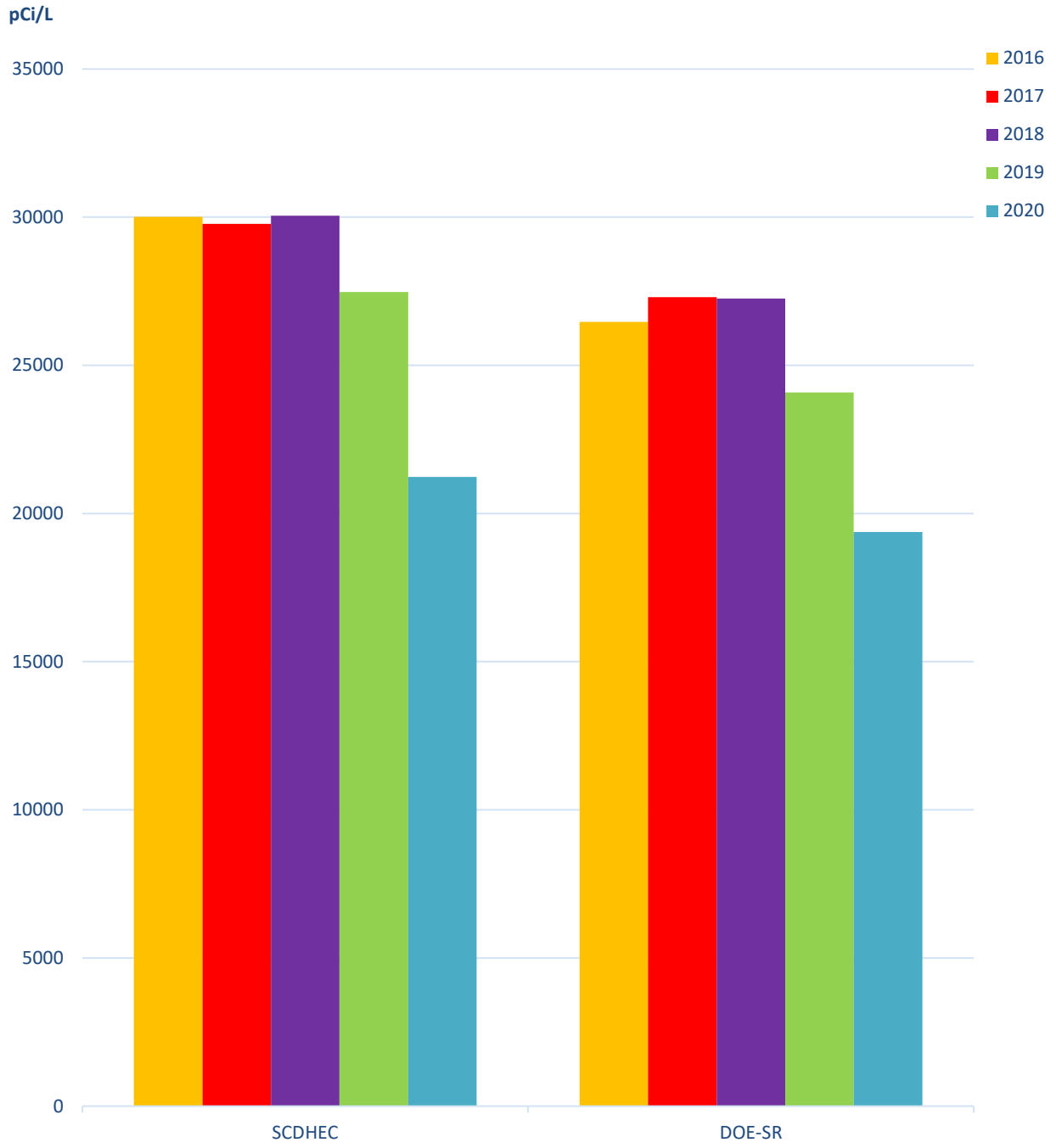

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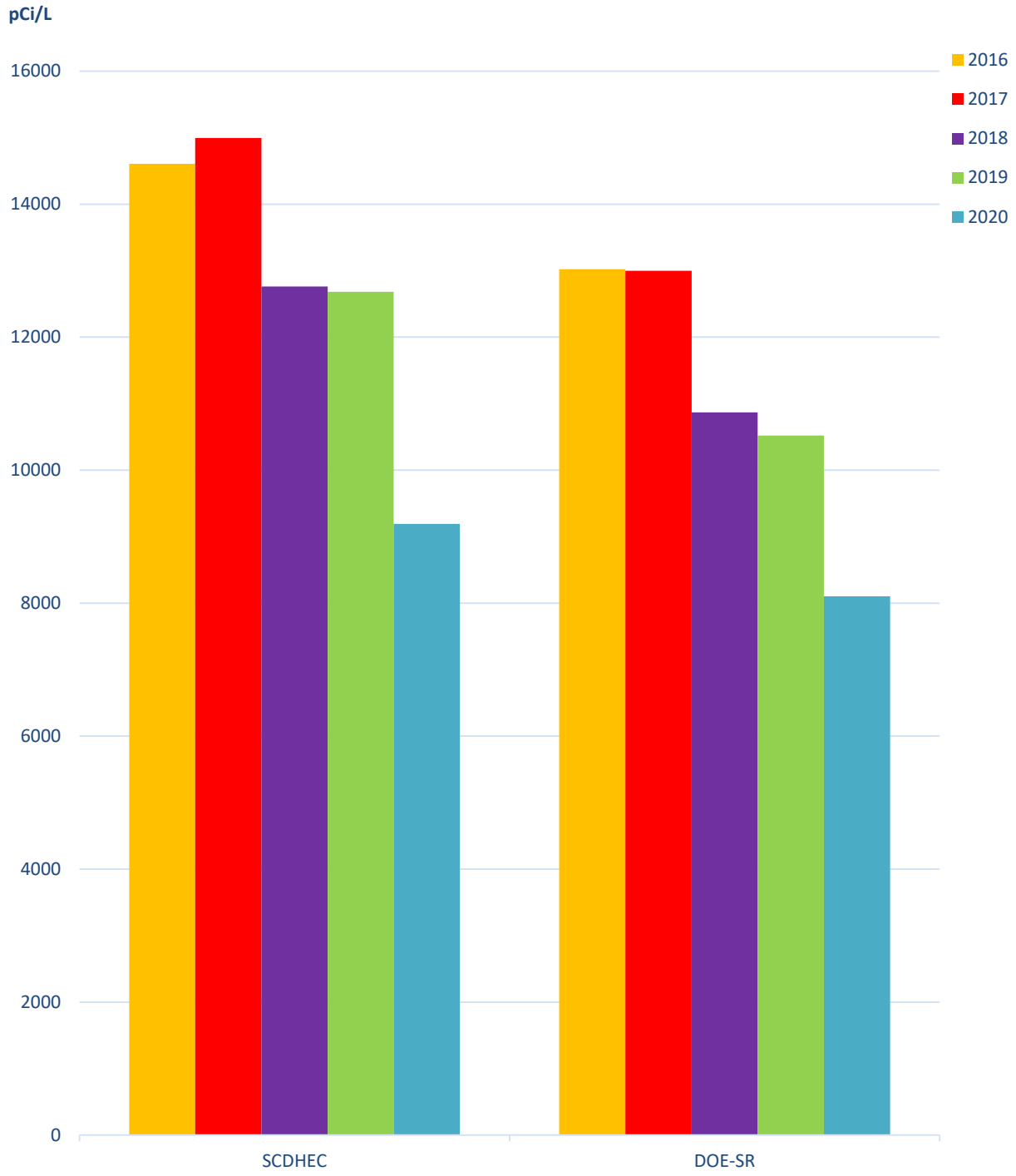
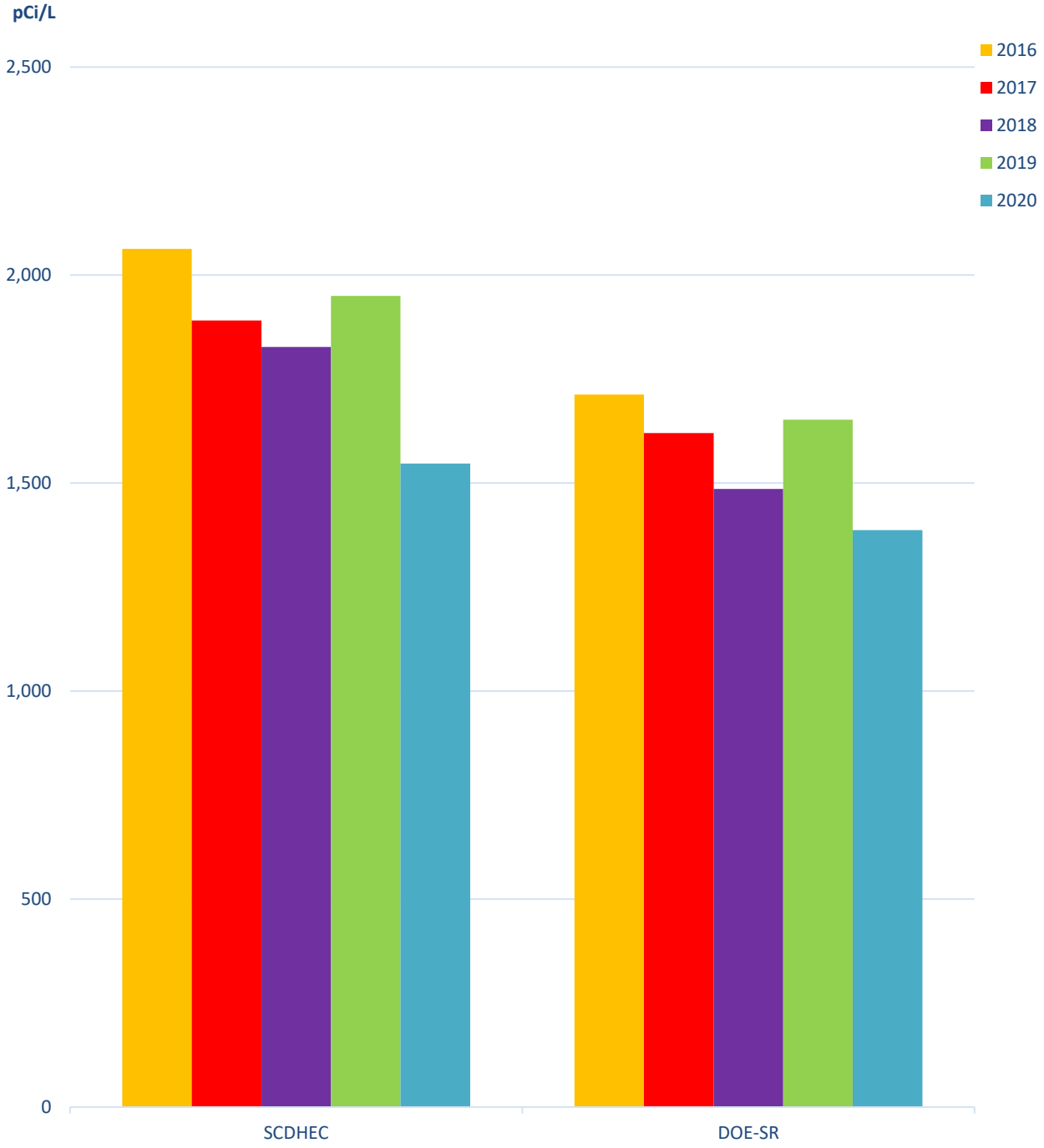
Figure 4. 2015-2019 Average Tritium Data Trends for DHEC and DOE-SR for Pen Branch at Road A-13.2 (SRNS, 2017-2021; DHEC, 2018-2020b)



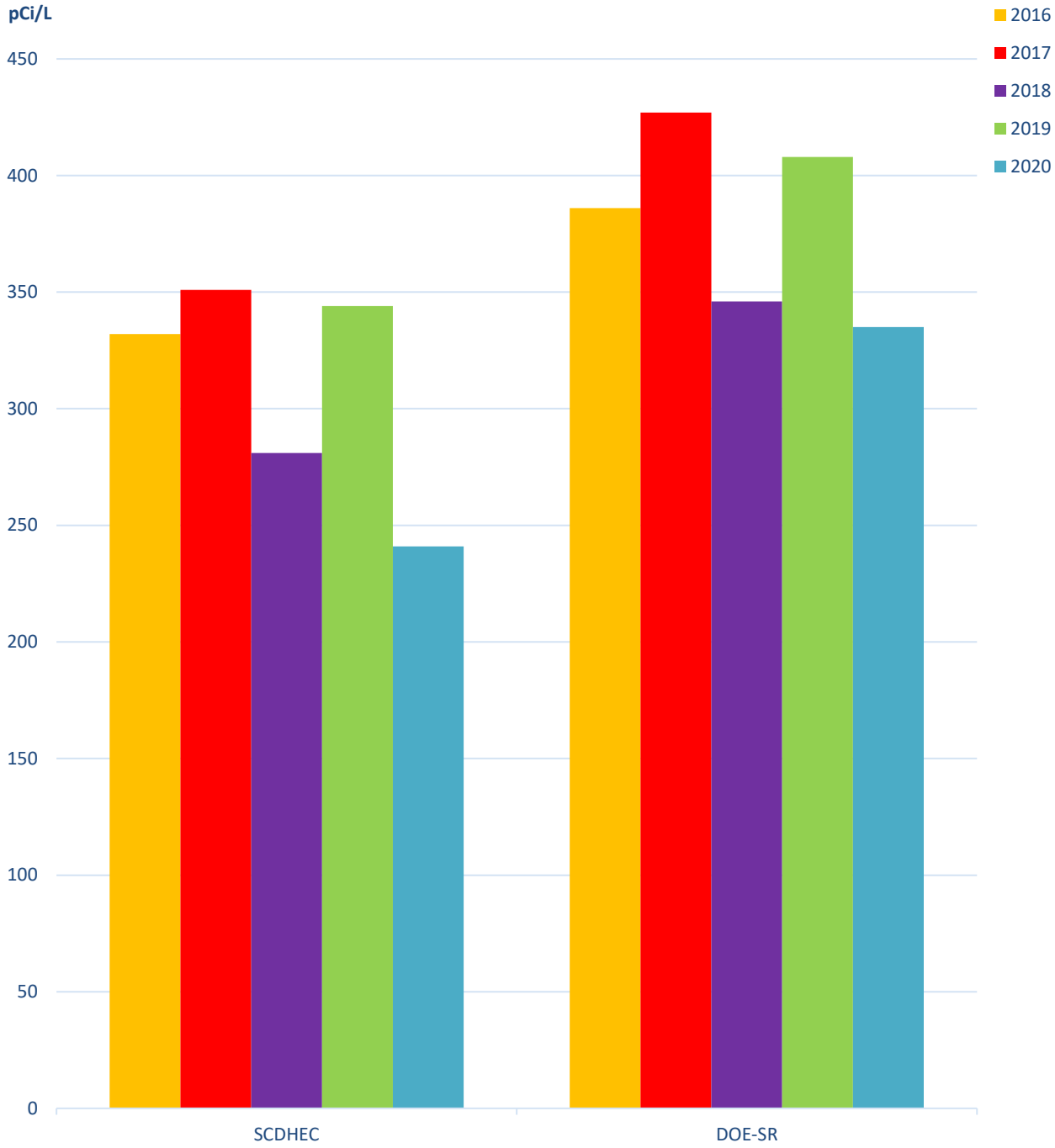
TABLES AND FIGURES

Figure 5. 2016-2020 Average Tritium Data Trends for DHEC and DOE-SR for Steel Creek at S.C. Highway 125 (SRNS, 2017-2021; DHEC, 2018-2020b)



TABLES AND FIGURES

Figure 6. 2016-2020 Average Tritium Data Trends for DHEC and DOE-SR for Lower Three Runs Creek at SRS Road B (SRNS, 2017-2021; DHEC, 2018-2020b)



DOE-SR's data is not an average due to there only being one detection during the year with a reading of 335 pCi/L.

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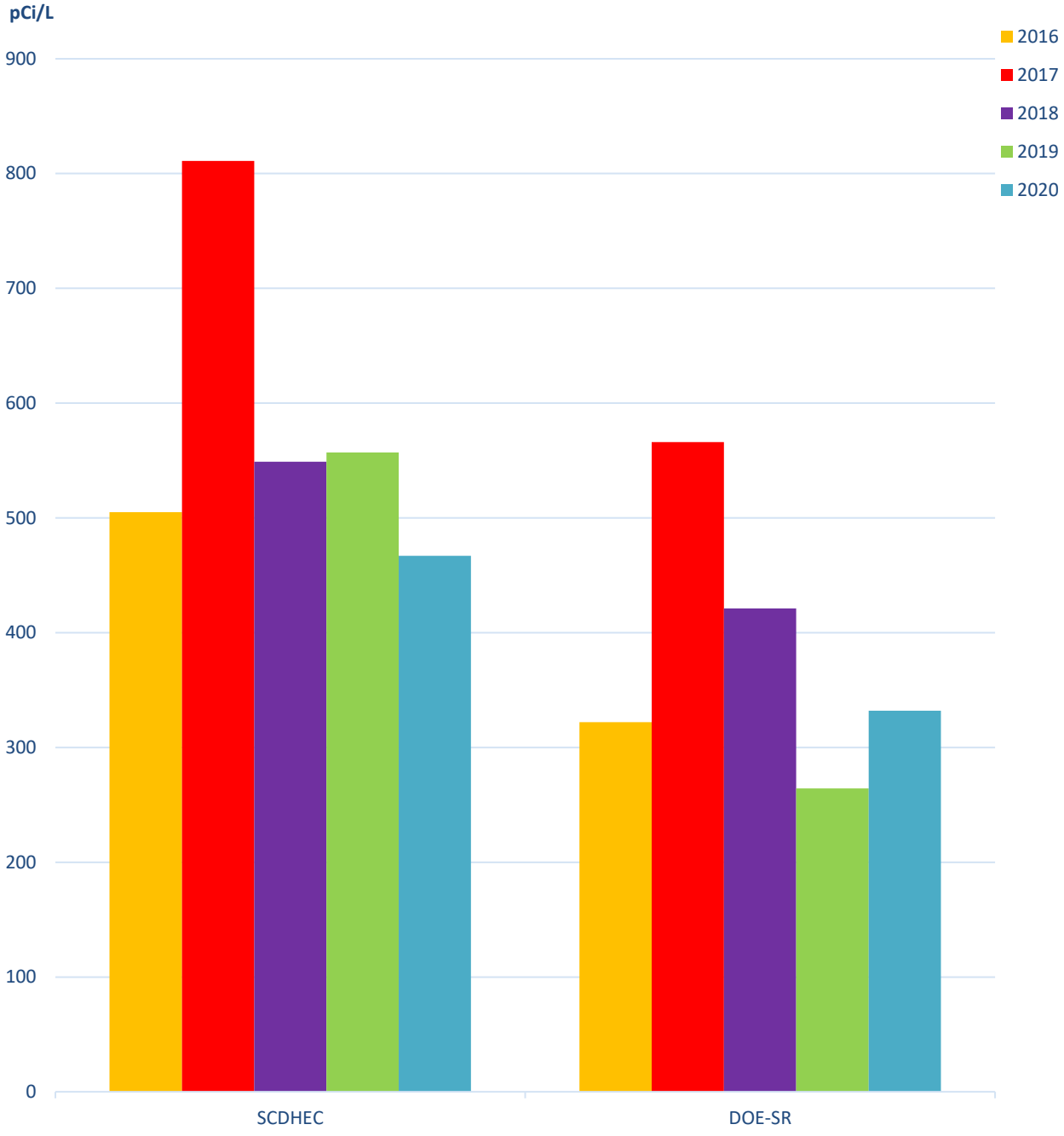
TABLES AND FIGURES

Figure 7. 2016-2020 Average Tritium Data Trends for DHEC and DOE-SR for the Savannah River at US Highway 301 Bridge (SRNS, 2017-2021; DHEC, 2018-2020b)



4.6.0 SUMMARY STATISTICS

2020 DHEC Ambient Monitoring Data-Tritium in pCi/L

Sample Location	Average Concentration	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detections	Number of Samples
Jackson Boat Landing (SV-2010)	312	153	226	205	590	11	31
Tims Branch (SV-324)*	316	58	312	211	460	44	52
Upper Three Runs Creek at SC 125 (SV-325)*	616	210	556	270	1365	52	52
Fourmile Branch (SV-2039)*	21232	4215	21448	9030	27661	52	52
Pen Branch (SV-2047)*	9192	3364	9794	1898	13349	52	52
Steel Creek (SV-327)*	1547	347	1511	958	2544	52	52
Steel Creek Boat Landing (SV-2018)	1205	1242	517	213	5647	42	49
Highway 301 Bridge (SV-118)*	467	404	319	202	1982	37	51
Lower Three Runs Creek at Patterson Mill Rd. (SV-328)	1171	514	1165	351	2075	52	52
L-Lake Spill Way (SV-2052)*	249	42	244	196	373	21	52
Lower Three Runs Creek at Road B (SV-2053)*	241	34	236	193	324	20	52
Upper Three Runs Creek at SRS Road 2-1 (SV-2027)	238	33	232	195	297	12	52
Creek Mouths	**Average Concentration**	**Standard Deviation**	**Median**	**Minimum Detect**	**Maximum Detect**	**Number of Detects**	**Number of Samples**
Upper Three Runs Mouth @ RM 157.4 (SV-2011)	290	31	283	264	325	3	3
Four Mile Creek @ RM 150.6 (SV-2015)	10098	13993	10098	203	19992	2	3
Steel Creek Mouth @ RM 141.5 (SV-2017)	839	682	750	206	1562	3	3
Lower Three Runs Mouth @ RM 129.1 (SV-2020)	325	128	325	235	416	2	3
Little Hell Boat Landing (SV-2019)	256	78	256	201	311	2	3

In 2020, due to flooded rivers and safety concerns a fourth sample was not able to be taken for creek mouths.
* indicates locations that are collocated with DOE-SR sampling sites.

SUMMARY STATISTICS

2020 DHEC Ambient Monitoring Data-Alpha

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median (pCi/L)	Minimum Detect (pCi/L)	Maximum Detect (pCi/L)	Number of Detections	Number of Samples
Jackson Boat Landing (SV-2010)	ND	NA	NA	<LLD	<LLD	0	9
Tims Branch (SV-324)	2.49	1.00	2.31	1.58	3.74	4	12
Upper Three Runs Creek at S.C. 125 (SV-325)	2.61	0.93	2.36	1.84	4.62	7	12
Fourmile Branch (SV-2039)	ND	NA	NA	<LLD	<LLD	0	12
Pen Branch (SV-2047)	NA	NA	NA	1.53	1.53	1	12
Steel Creek (SV-327)	ND	NA	NA	<LLD	<LLD	0	12
Steel Creek Boat Landing (SV-2018)	ND	NA	NA	<LLD	<LLD	0	11
Highway 301 Bridge (SV-118)	ND	NA	NA	<LLD	<LLD	0	12
Lower Three Runs Creek at Road B (SV-2053)	ND	NA	NA	<LLD	<LLD	0	12

2020 DHEC Ambient Monitoring Data-Beta

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median (pCi/L)	Minimum Detect (pCi/L)	Maximum Detect (pCi/L)	Number of Detections	Number of Samples
Jackson Boat Landing (SV-2010)	NA	NA	NA	4.96	4.96	1	9
Tims Branch (SV-324)	ND	NA	NA	<LLD	<LLD	0	12
Upper Three Runs Creek at S.C. 125 (SV-325)	NA	NA	NA	7.66	7.66	1	12
Fourmile Branch (SV-2039)	14.72	8.05	14.10	5.38	32.00	10	12
Pen Branch (SV-2047)	ND	NA	NA	<LLD	<LLD	0	12
Steel Creek (SV-327)	ND	NA	NA	<LLD	<LLD	0	12
Steel Creek Boat Landing (SV-2018)	4.87	0.61	5.08	3.97	5.34	4	11
Highway 301 Bridge (SV-118)	ND	NA	NA	<LLD	<LLD	0	12
Lower Three Runs Creek at Road B (SV-2053)	ND	NA	NA	<LLD	<LLD	0	12

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Chapter 5 Non-radiological Monitoring of Surface Water on SRS

5.1.0 PROJECT SUMMARY

The streams located on SRS receive a wide variety of permitted point source discharges and non-point source run-off from on-site facilities and operations. These discharges specifically include, but are not limited to, industrial storm water, utility water, treated industrial and sanitary wastewater, and run-off from land-disturbing activities.

POINT SOURCE POLLUTION: "Pollution that comes from a specific, identifiable source, such as a pipe or channel"

NONPOINT SOURCE POLLUTION: "Sources that are diffuse, without a single identifiable point of origin, including runoff from agriculture, forestry, and construction sites"

Source: EPA

DHEC assessed the surface water quality for non-radiological parameters in 2020 at SRS by sampling the on-site streams for inorganic and organic constituents. As an indication of possible water quality issues, DHEC data is compared to the freshwater standard guidelines in DHEC's Water Classifications and Standards, Regulation 61-68 (DHEC, 2020c). These guidelines give numeric criteria for specific parameters and narrative criteria that indicate conditions of biological integrity and water quality for aquatic life and human health. The fact that a stream does not meet the specified numeric standards for a particular parameter does not mean the stream is polluted or of poor quality. Natural conditions can cause streams to exceed the standards.

Nine DHEC sample locations were strategically chosen to monitor ambient surface water conditions and detect the non-radiological impact from DOE-SR operations. A map of DHEC sample locations can be found in Section 5.4.0. Six of the DHEC sample locations are collocated with DOE-SR sample locations to provide data comparisons (Section 5.5.0, Table 1). The stream sample locations were selected based on accessibility and their proximity upstream and downstream of DOE-SR operations before flowing into the publicly accessible Savannah River. A list of water quality parameter analyses and sample frequency can be found in Section 5.5.0, Table 2.

Collecting stream water for analysis

5.2.0 RESULTS AND DISCUSSION

Non-radiological Monitoring of Surface Water Summary Statistics can be found in Section 5.6.0 and all Non-radiological Monitoring of Surface Water Data can be found in the 2020 DHEC Data File.

Many chemical and biological processes in surface waters can be affected by pH, a measurement that indicates the alkalinity or acidity of a substance (EPA, 1997). The streams encountered at SRS are typical of southeastern streams characterized as blackwater. A blackwater stream is one that has a deep, slow-moving channel that flows through forested swamps and wetlands. Decaying vegetation in the water results in the leaching

of tannins from the vegetation which results in transparent, acidic water that is darkly stained, resembling tea or coffee. Low pH is typical for blackwater streams such as those sampled at SRS (Hughes et al., 2000).

The pH standard for all South Carolina freshwater streams is between 6.0 and 8.5 standard units (SU) (DHEC, 2020c). All DHEC locations had yearly averages within the standard except for Upper Three Runs at Road A (NWSV-325) with a pH average of 5.92, Upper Three Runs at Road 2-1 (NWSV-2027) with an average pH of 5.40, and Tinker Creek at Road 2-1 (NWSV-2061) with an average pH of 5.88. These streams are blackwater streams, which could contribute to them having a pH lower than 6. See Section 5.5.0, Figure 1 for a comparison of DHEC and DOE-SR data for collocated samples (SRNS, 2021).

Using a Horiba Water Quality Meter to determine field parameters

Oxygen is cycled through the environment and is both produced and consumed in streams. The amount of oxygen in its dissolved form in water is the Dissolved Oxygen (DO). The Biochemical Oxygen Demand (BOD) is the amount of oxygen consumed by microorganisms in stream water. Water quality is diminished when the BOD is high, which depletes the oxygen in the water. Low DO means less oxygen to support higher forms of aquatic life (EPA, 1997). The South Carolina freshwater standard for DO is a daily average of no less than 5.0 milligrams per liter (mg/L) with no individual sample to be below 4.0 mg/L (DHEC, 2020c). All individual samples and yearly averages met the DO standard in 2020. A DO comparison of DHEC and DOE-SR data for collocated samples can be found in Section 5.5.0, Figure 2 (SRNS, 2021). There are no numeric criteria in the South Carolina freshwater standards for a maximum BOD level; however, in 2020, DHEC samples had no detections above the LLD of 2.0 mg/L except for SV-328 which had one sample at 2.60 mg/L, SV-2055 with one sample at 2.80 mg/L, and SV-2061 with one sample at 4.40 mg/L. DOE-SR did not collect BOD samples in 2020, therefore, no comparison can be made for BOD.

Recording field parameters: DO, pH, temperature, conductivity, and total dissolved solids

Temperature can affect biological and chemical processes in a stream. All aquatic organisms can be negatively affected by temperatures that vary from the naturally occurring range (EPA, 1997). The South Carolina freshwater standards state that the temperature of free-flowing freshwater and shall not exceed a maximum of 32.2°C (DHEC, 2020c). DHEC data showed that the stream temperatures during each sampling event were comparable to each other and did not exceed the maximum of 32.2°C.

Water samples to be analyzed by the lab in DHEC's Columbia office

The South Carolina freshwater *E. coli* standard is a daily maximum of 349 Most Probable Number per 100mL (MPN/100mL). All nine streams sampled had individual samples that exceeded 349 MPN/100mL, and all locations had yearly averages above the standard except SV-327, SV-328, and SV-2039 (DHEC, 2020c). DOE-SR did not collect samples for *E. coli* in 2020, therefore, no comparison can be made.

Phosphorous and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. However, in excess they can cause significant water quality problems. Phosphorous and nitrogen cycle through the environment in a variety of forms and can indirectly impact DO and other water quality indicators (EPA, 1997). In 2020, DHEC sampled for total phosphorous and various forms of nitrogen, including nitrate/nitrite, total Kjeldahl nitrogen (TKN), and ammonia. There are no numeric criteria in the South Carolina freshwater standard for total phosphorus, TKN, or ammonia.

DHEC uses the most conservative of the federally established drinking water standards for nitrate/nitrite levels to indicate ambient water quality in freshwater streams for nutrients. The EPA drinking water standards for nitrate/nitrite levels are 10 mg/L and 1 mg/L, respectively, and are designed to protect the public from consumption of high levels of these nutrients (DHEC, 2020c). As a conservative measure, DHEC uses a maximum of 1 mg/L as an indication of possible water quality issues.

Water sample to be analyzed by the lab in DHEC's Aiken office

Overall, the nutrient levels on SRS are comparable to the levels found throughout the Savannah River Basin. DOE-SR did not sample for TKN or ammonia in 2020; therefore, no comparison can be made. A comparison of DHEC and DOE-SR data from collocated samples for total phosphorous and nitrate/nitrite, respectively, can be found in Section 5.5.0, Figures 3 and 4.

Most metals are considered pollutants, including some that are toxic or known carcinogens. In 2020, DHEC personnel collected samples for the following metals: aluminum, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, thallium, and zinc. Due to the potential health

effects of some metals, a yearly average, even if based on a single detection that exceeds the freshwater standards, may indicate a water quality issue. These metals, with the exception of aluminum, calcium, iron, magnesium, and manganese, have numeric criteria for the protection of human health and aquatic life in the South Carolina freshwater quality standards.

The freshwater quality standard for cadmium in South Carolina streams is not to exceed 0.00025 mg/L (DHEC, 2020c). DHEC and DOE-SR samples had no cadmium levels above the standard (SRNS, 2021).

The freshwater quality standards for chromium, copper, and nickel in South Carolina streams are not to exceed 0.011 mg/L, 0.0029 mg/L and 0.016 mg/L, respectively (DHEC, 2020c). DHEC detected nickel in a single sample at SV-324 (0.026 mg/L) but did not detect chromium or nickel in any other sample in 2020. Due to copper's standard of 0.0029 mg/L being lower than the DHEC laboratory's limit of detection of <0.010 mg/L, all samples were found to be <0.010 mg/L and were considered non-detects. DOE-SR detected chromium, copper, and nickel below the standard in their collocated sample locations with the exception of copper at SV-325 (0.0080 mg/L) (SRNS, 2021).

Samples are individually bottled and transported on ice

The freshwater quality standard for lead in South Carolina streams is not to exceed 0.00054 mg/L (DHEC, 2020c). Due to laboratory limitations, DHEC has a lower limit of detection (LLD) higher than the standard. Therefore, any detection of lead would be over the standard. DHEC detected lead in one sample from SV-324 (0.0024 mg/L). Beginning in August 2018, DOE-SR changed their laboratory analysis for lead to achieve a lower detection limit. DOE-SR had no locations with average lead detections above the standard in 2020 in the collocated samples; however, individual samples for Tims Branch, Upper Three Runs, Lower Three Runs, Fourmile Branch, and Pen Branch had detections above the standard (SRNS, 2021).

The freshwater quality standard for mercury in South Carolina streams is not to exceed 0.00005 mg/L (DHEC, 2020c). Mercury was not detected in any of the DHEC or DOE-SR samples in 2020 (SRNS, 2021).

The freshwater quality standard for zinc in South Carolina streams is not to exceed 0.037 mg/L (DHEC, 2020c). DHEC had a sample over the standard at SV-325 (0.069 mg/L), while all other samples were below the standard. DOE-SR had all locations' averages below the zinc standard (SRNS, 2021). A zinc comparison of DHEC and DOE-SR yearly averages for collocated samples can be found in Section 5.5.0, Figure 5.

Samples were also analyzed for beryllium and thallium whose freshwater quality standards are <0.004 mg/L and <0.00024 mg/L, respectively. DHEC and DOE-SR had no detections of thallium and none of the samples had beryllium detects above the standard (SRNS, 2021).

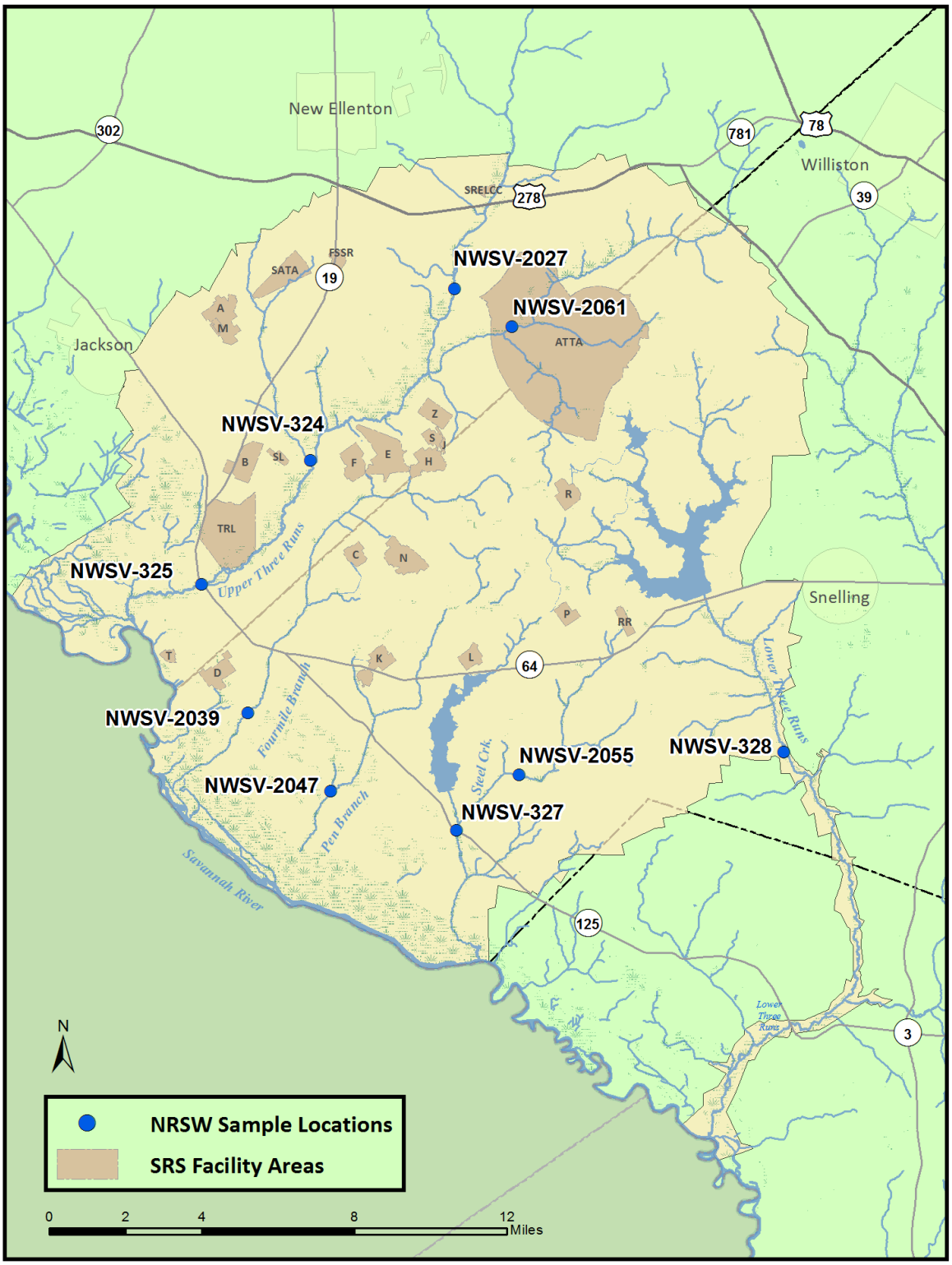
Small discrepancies in data between DOE-SR and DHEC may be attributed to differences in sample collection date and time, sample preservation, and lab analysis. Variances in statistical calculations, such as the yearly averages, may also attribute to dissimilarities. All data less than the LLD were left out of DHEC summary statistics due to lack of numeric information.

5.3.0 CONCLUSIONS AND RECOMMENDATIONS

The current parameters will continue to be monitored to establish trends that may warrant further investigation based on EPA or DHEC standards or recommended levels. Overall, the non-radiological water quality on SRS in 2020 compared favorably with the South Carolina Freshwaters Standard or other recommendations for the parameters and monitored locations. The 2020 DHEC results for most parameters were comparable to the DHEC's Bureau of Water data for the Savannah River watershed (DHEC, 2013b). DHEC will continue to evaluate water quality based on the independent, non-radiological testing and surveillance of SRS surface water. Monitoring is required due to continued land disturbance from clean-up activities, new facility construction, logging, and new missions. The locations, number and frequencies of samples, and monitoring parameters are reviewed annually and modified as needed to maximize available resources and address SRS mission changes.

5.4.0 MAP

Non-radiological Surface Water Sampling Locations



2020 ESOP Non-Radiological Surface Water Monitoring

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5.5.0 TABLES AND FIGURES

Table 1. 2020 DHEC Surface Water Sample Locations

Sample Location	Location Description	Location Rationale
NWSV-2027	Upper Three Runs at Road 2-1	Upstream of most SRS Operations
NWSV-2061	Tinker Creek at Road 2-1	Downstream of ATTA
NWSV-324*	Tims Branch at Road C	Downstream from M- & A-Areas
NWSV-325*	Upper Three Runs at Road A	Downstream from F-Area
NWSV-2055	Meyers Branch at Road 9	Downstream from P-Area
NWSV-2039*	Fourmile Branch at Road 12.2	Downstream from F- and H-Areas
NWSV-2047*	Pen Branch at Road A-13.2	Downstream from K-Area
NWSV-327*	Steel Creek at Road A	Downstream from L-Lake
NWSV-328*	Lower Three Runs at Patterson Mill Road	Downstream from Par Pond

*Collocated with DOE-SR sample locations.

Table 2. 2020 DHEC Water Quality Parameter Analyses

Laboratory	Frequency	Parameter
Field	Monthly	Temperature, pH, Specific Conductivity, Dissolved Oxygen, and Total Dissolved Solids
DHEC Lab Aiken, S.C.	Monthly	Turbidity, BOD, E. Coli, and TSS
DHEC Lab Columbia, S.C.	Monthly	Alkalinity, Ammonia, Nutrients, Mercury, and Metals, and Total Organic Carbon

TABLES AND FIGURES

Figure 1. pH 2020 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2021)

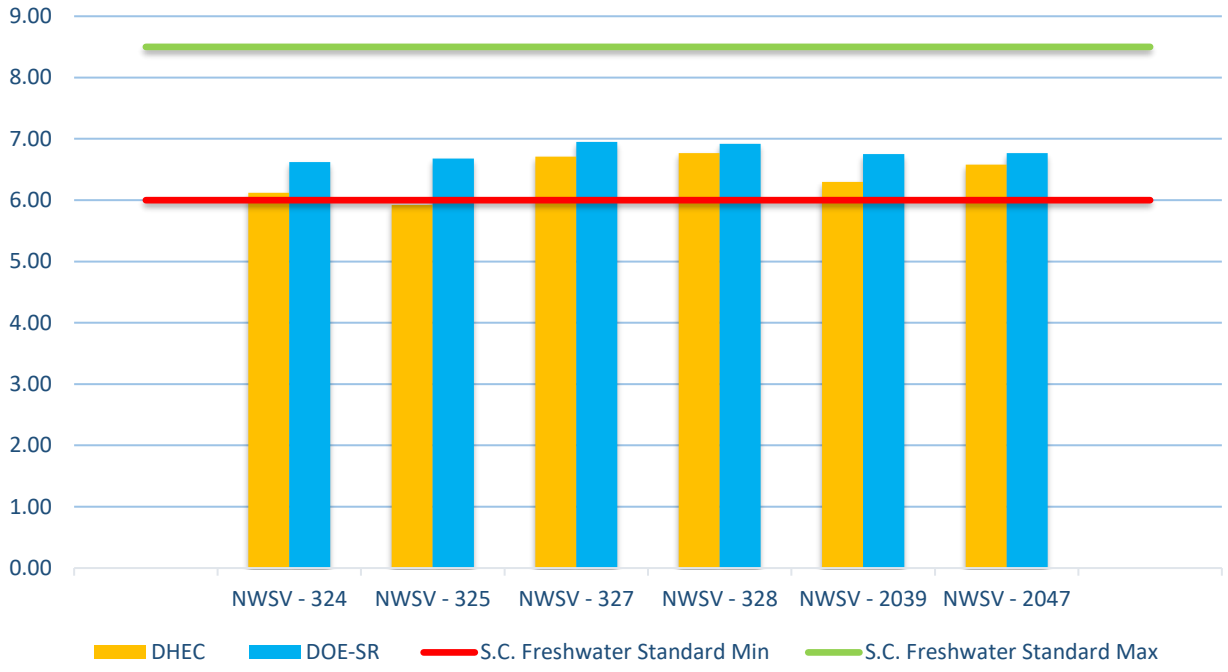
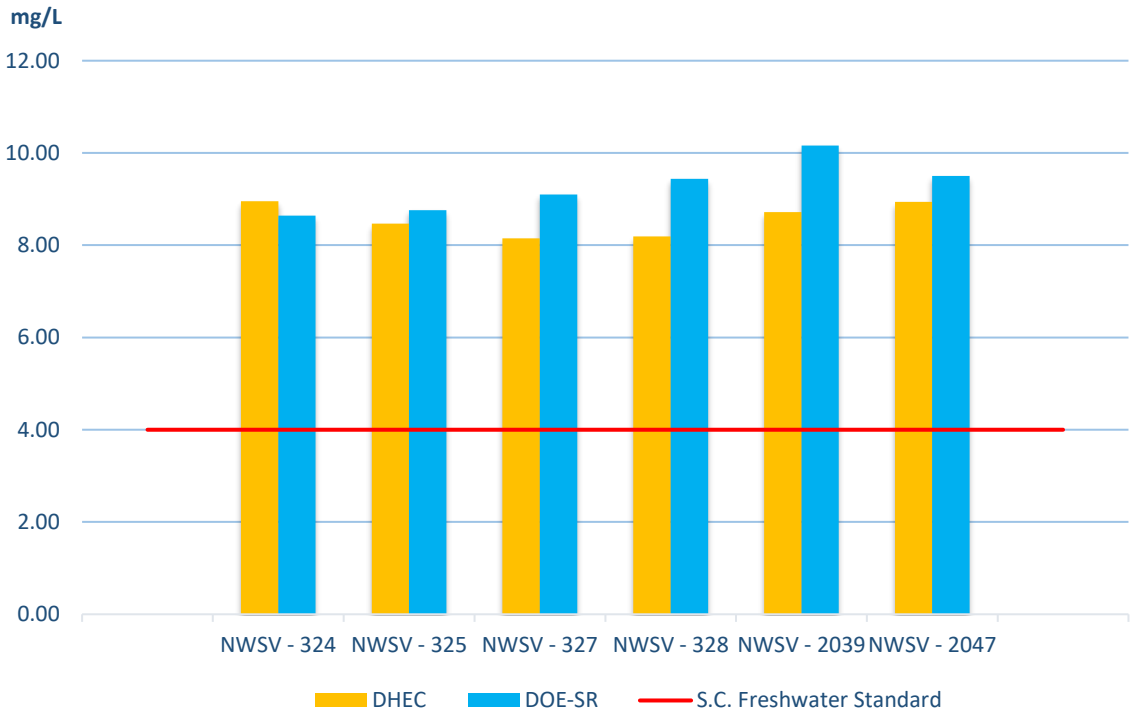
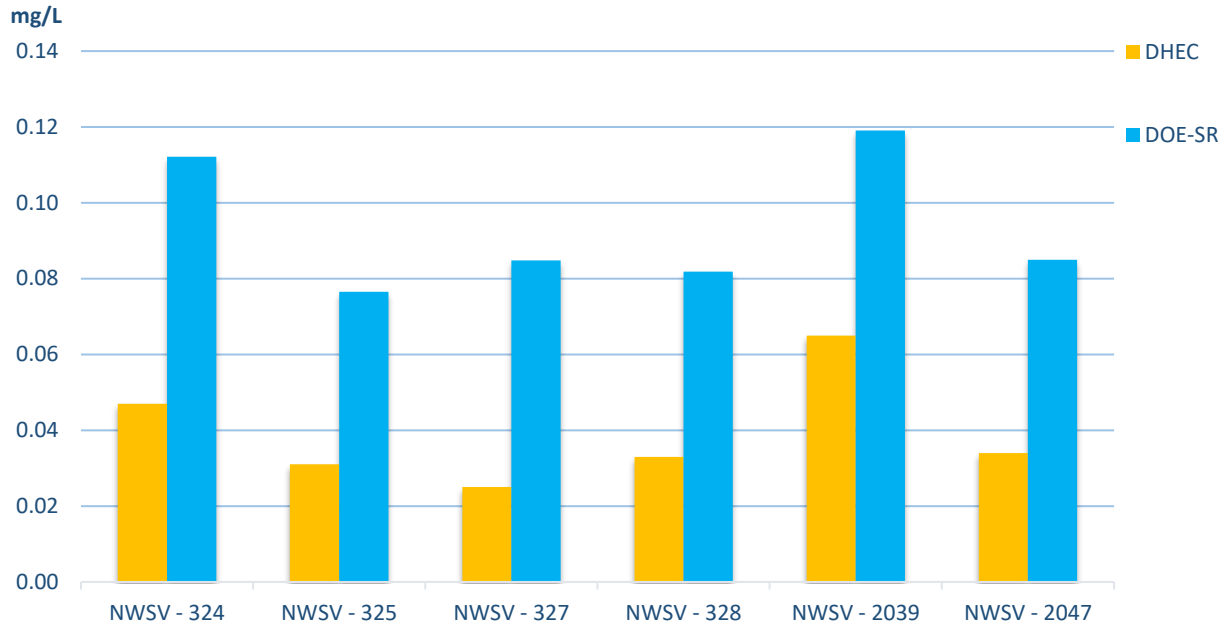


Figure 2. DO 2020 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2021)



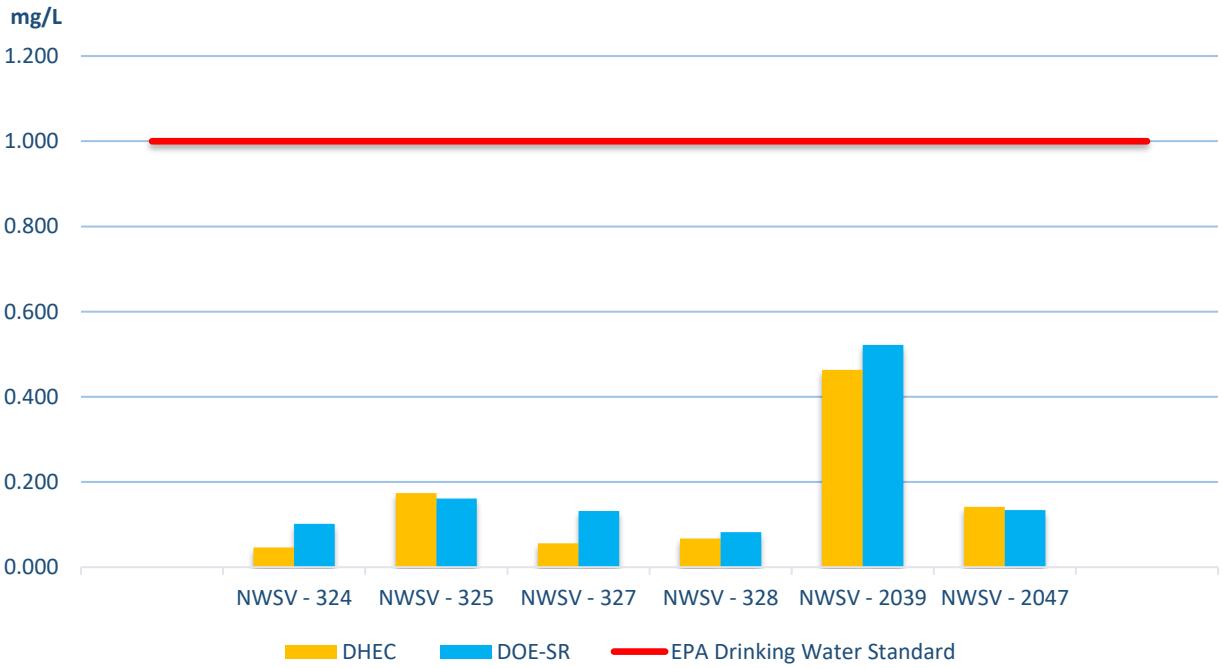
TABLES AND FIGURES

Figure 3. Total Phosphorous 2020 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2021)



DHEC's NWSV-325 only had one sample with a detection, so the number included in the graph is based on a single detect and is not an average.

Figure 4. Nitrate/Nitrite 2020 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2021)



DOE-SR collects nitrate and nitrite as separate parameters. In this graph, DOE-SR's nitrate and nitrite were added together and then an average of the sum was taken to produce one number representing both nitrate and nitrite at each location in order to have comparable data to DHEC.

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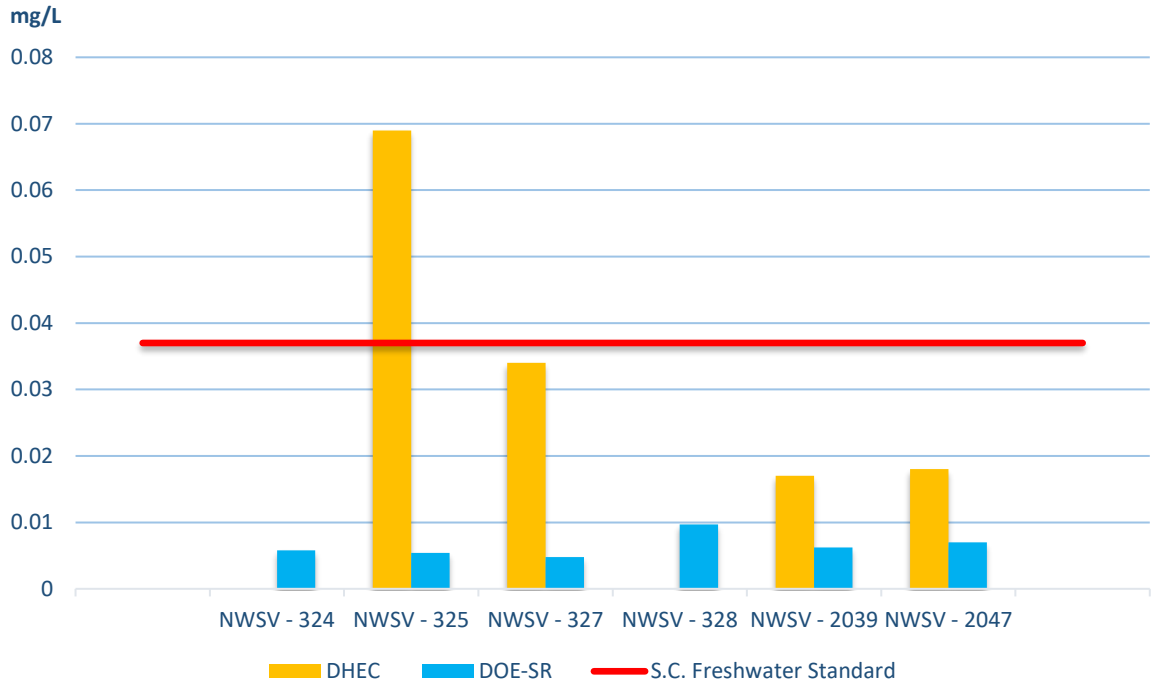
Figure 5. Zinc 2020 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2021)



No bar indicates the no detections. DHEC's NWSV-325, NWSV-327, and NWSV-2047 only had one sample with a detection, so the number included in the graph is based on a single detect and is not an average.

5.6.0 2020 SUMMARY STATISTICS

Notes for the 5.6.0 Summary Statistic Tables on pages 62-66:
NA is Not Applicable.
Cadmium, Chromium, Copper, Mercury, and Thallium were not included in the charts as all locations had averages that were non-detects.

NWSV–324 Tims Branch at Road C

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	6.12	0.36	6.15	5.45	6.7	12
	DO (mg/L)	8.95	0.98	8.81	7.49	10.64	12
	Water Temp (°C)	17.90	4.69	18.75	8.12	24.28	12
	Conductivity (mS/cm)	0.021	0.002	0.022	0.018	0.024	11
Laboratory	Alkalinity (mg/L)	4.3	1.6	4.5	1.8	7.0	10
	Turbidity (NTU)	12.9	17.5	7.1	3.3	65.0	12
	TSS (mg/L)	8.88	7.17	6.00	3.10	25.00	8
	E. Coli (MPN/100mL)	354.34	241.68	307.05	115.30	816.40	10
	TKN (mg/L)	0.53	0.26	0.53	0.23	0.92	9
	Nitrate/Nitrite (mg/L)	0.046	0.020	0.044	0.022	0.077	8
	Total Phosphorus (mg/L)	0.047	0.034	0.037	0.026	0.130	8
	Calcium (mg/L)	1.0	0.3	1.0	0.5	1.7	12
	Iron (mg/L)	3.608	3.2	2.7	1.5	13.0	12
	Lead (mg/L)	NA	NA	NA	0.0024	0.0024	1
	Magnesium (mg/L)	0.41	0.09	0.37	0.31	0.56	12
	Manganese (mg/L)	0.170	0.27	0.08	0.05	0.99	12
	Nickel (mg/L)	NA	NA	NA	0.026	0.026	1
	Hardness (mg/L)	4.2	1.1	4.2	2.6	6.4	12
	Aluminum (mg/L)	0.20	0.09	0.16	0.08	0.36	9
	TOC (mg/L)	5.30	2.09	5.35	2.60	8.90	12

BOD, Ammonia, Zinc, and Beryllium are not included in the graph due to NWSV-324 having no detections in 2020.

NWSV-325 Upper Three Runs at Road A

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	5.92	0.39	6.03	5.38	6.44	11
	DO (mg/L)	8.47	1.57	8.31	6.67	11.82	12
	Water Temp (°C)	18.75	4.55	19.00	9.50	24.99	12
	Conductivity (mS/cm)	0.020	0.003	0.021	0.011	0.023	11
Laboratory	Alkalinity (mg/L)	3.76	1.14	3.60	1.90	6.20	9
	Turbidity (NTU)	4.52	2.01	3.95	2.20	9.10	12
	TSS (mg/L)	5.09	2.31	4.40	2.60	9.10	8
	E. Coli (MPN/100mL)	718.96	748.37	328.15	125.90	2419.60	10
	TKN (mg/L)	0.46	0.19	0.38	0.24	0.77	9
	Nitrate/Nitrite (mg/L)	0.17	0.18	0.13	0.03	0.69	11
	Total Phosphorus (mg/L)	0.031	0.004	0.032	0.024	0.035	6
	Calcium (mg/L)	1.91	0.13	1.95	1.70	2.10	12
	Iron (mg/L)	0.76	0.19	0.79	0.48	1.10	12
	Magnesium (mg/L)	0.40	0.07	0.42	0.29	0.49	12
	Manganese (mg/L)	0.03	0.01	0.02	0.01	0.04	12
	Zinc (mg/L)	NA	NA	NA	<0.010	0.069	1
	Hardness (mg/L)	6.40	0.43	6.25	5.80	7.30	12
	Aluminum (mg/L)	0.22	0.10	0.26	0.11	0.39	9
	TOC (mg/L)	5.61	3.59	3.80	1.90	12.00	12

BOD, Ammonia, Lead, Nickel, and Beryllium are not included in the graph due to NWSV-325 having no detections in 2020.

NWSV-327 Steel Creek at Road A

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	6.71	0.50	6.94	5.68	7.13	12
	DO (mg/L)	8.15	1.37	8.21	6.11	10.97	12
	Water Temp (°C)	20.27	4.97	20.41	12.25	27.75	12
	Conductivity (mS/cm)	0.05	0.01	0.05	0.04	0.07	11
Laboratory	Alkalinity (mg/L)	16.6	4.4	16.5	11.0	24.0	10
	Turbidity (NTU)	4.79	1.98	4.40	2.00	8.50	12
	TSS (mg/L)	8.53	6.04	6.40	1.50	17.00	8
	E. Coli (MPN/100mL)	238.84	193.26	162.40	74.90	613.10	9
	TKN (mg/L)	0.42	0.17	0.44	0.20	0.62	8
	Ammonia (mg/L)	NA	NA	NA	0.10	0.10	1
	Nitrate/Nitrite (mg/L)	0.06	0.02	0.05	0.02	0.09	10
	Total Phosphorus (mg/L)	NA	NA	NA	0.025	0.025	1
	Calcium (mg/L)	5.93	1.17	5.90	3.90	7.90	12
	Iron (mg/L)	0.50	0.19	0.46	0.24	0.81	12
	Magnesium (mg/L)	0.68	0.11	0.67	0.52	0.94	12
	Manganese (mg/L)	0.03	0.01	0.03	0.02	0.06	12
	Zinc (mg/L)	NA	NA	NA	0.034	0.034	1
	Hardness (mg/L)	17.42	2.81	18.00	12.00	22.00	12
	Aluminum (mg/L)	0.19	0.13	0.14	0.05	0.46	9
	TOC (mg/L)	4.85	2.63	3.85	2.20	10.00	12

BOD, Lead, Nickel, and Beryllium are not included in the graph due to NWSV-327 having no detections in 2020.

NWSV-328 Lower Three Runs at Patterson Mill Road

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	6.77	0.53	6.93	5.59	7.30	12
	DO (mg/L)	8.19	1.39	8.17	6.53	10.26	12
	Water Temp (°C)	19.28	4.40	19.80	12.14	26.21	12
	Conductivity (mS/cm)	0.07	0.02	0.08	0.03	0.08	12
Laboratory	Alkalinity (mg/L)	31.70	8.11	34.00	16.00	40.00	10
	Turbidity (NTU)	3.04	1.40	2.70	1.50	6.20	12
	BOD (mg/L)	NA	NA	NA	2.60	2.60	1
	TSS (mg/L)	5.50	4.31	4.20	2.40	15.00	7
	E. Coli (MPN/100mL)	282.62	240.88	172.50	70.30	770.10	9
	TKN (mg/L)	0.41	0.13	0.37	0.25	0.56	7
	Ammonia (mg/L)	NA	NA	NA	0.06	0.06	1
	Nitrate/Nitrite (mg/L)	0.07	0.02	0.07	0.03	0.10	7
	Total Phosphorus (mg/L)	0.03	0.01	0.03	0.03	0.05	6
	Calcium (mg/L)	12.41	3.37	13.50	6.80	16.00	12
	Iron (mg/L)	0.76	0.45	0.66	0.30	1.90	12
	Magnesium (mg/L)	0.51	0.08	0.50	0.41	0.61	10
	Manganese (mg/L)	0.05	0.02	0.04	0.02	0.10	12
	Hardness (mg/L)	34.09	7.89	37.00	19.00	42.00	11
	Aluminum (mg/L)	0.15	0.09	0.13	0.05	0.30	9
	TOC (mg/L)	4.49	2.63	3.60	2.20	11.00	12

Lead, Nickel, Zinc, and Beryllium are not included in the graph due to NWSV-328 having no detections in 2020.

NWSV-2027 Upper Three Runs at Road 2-1

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	5.40	0.41	5.52	4.58	5.98	12
	DO (mg/L)	8.25	1.13	7.96	6.32	9.79	12
	Water Temp (°C)	18.27	3.32	18.56	12.55	22.50	12
	Conductivity (mS/cm)	0.017	0.001	0.016	0.015	0.019	12
Laboratory	Alkalinity (mg/L)	1.77	0.88	1.10	1.00	2.90	7
	Turbidity (NTU)	3.02	1.52	2.55	1.50	6.60	12
	TSS (mg/L)	4.21	1.56	4.10	2.10	7.10	7
	E. Coli (MPN/100mL)	632.92	942.33	204.35	129.60	2419.60	10
	TKN (mg/L)	0.40	0.15	0.47	0.18	0.55	7
	Ammonia (mg/L)	0.08	0.04	0.08	0.05	0.11	2
	Nitrate/Nitrite (mg/L)	0.27	0.07	0.29	0.16	0.35	8
	Total Phosphorus (mg/L)	0.04	0.01	0.04	0.03	0.06	3
	Calcium (mg/L)	0.79	0.30	0.65	0.55	1.50	12
	Iron (mg/L)	0.47	0.14	0.45	0.32	0.78	12
	Magnesium (mg/L)	0.42	0.04	0.43	0.36	0.48	10
	Manganese (mg/L)	0.02	0.00	0.02	0.01	0.02	5
	Hardness (mg/L)	3.48	0.86	3.30	2.70	5.70	11
	Aluminum (mg/L)	0.16	0.09	0.13	0.07	0.36	11
	Beryllium (mg/L)	NA	NA	NA	0.0010	0.0010	1
	TOC (mg/L)	2.99	2.32	2.00	1.10	8.40	12

BOD, Lead, Nickel, and Zinc are not included in the graph due to NWSV-2027 having no detections in 2020.

NWSV-2039 Fourmile Branch at Road 12.2

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	6.30	0.42	6.45	5.29	6.72	12
	DO (mg/L)	8.72	1.22	8.82	6.70	10.87	12
	Water Temp (°C)	18.33	4.78	19.38	8.18	24.39	12
	Conductivity (mS/cm)	0.041	0.006	0.043	0.029	0.048	11
Laboratory	Alkalinity (mg/L)	10.43	2.55	11.00	4.10	13.00	10
	Turbidity (NTU)	5.98	3.88	4.70	3.00	17.00	12
	TSS (mg/L)	7.18	8.25	3.75	2.10	27.00	8
	E. Coli (MPN/100mL)	341.3	371.2	166.3	101.7	1203.3	10
	TKN (mg/L)	0.43	0.21	0.36	0.20	0.80	9
	Nitrate/Nitrite (mg/L)	0.46	0.18	0.48	0.14	0.73	11
	Total Phosphorus (mg/L)	0.07	0.01	0.06	0.05	0.09	8
	Calcium (mg/L)	3.08	0.61	3.15	1.60	3.80	12
	Iron (mg/L)	1.01	0.23	0.97	0.78	1.60	12
	Magnesium (mg/L)	0.52	0.06	0.54	0.40	0.59	12
	Manganese (mg/L)	0.05	0.01	0.04	0.02	0.07	12
	Zinc (mg/L)	0.02	0.01	0.02	0.01	0.02	2
	Hardness (mg/L)	9.83	1.71	10.00	5.60	12.00	12
	Aluminum (mg/L)	0.16	0.09	0.12	0.08	0.34	7
	TOC (mg/L)	4.44	2.11	3.50	2.20	7.80	12

BOD, Ammonia, Lead, Nickel, and Beryllium are not included in the graph due to NWSV-2039 having no detections in 2020.

NWSV-2047 Pen Branch at Road A-13.2

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	6.58	0.79	6.80	5.05	7.74	12
	DO (mg/L)	8.94	1.14	9.30	6.88	10.56	12
	Water Temp (°C)	18.55	4.68	19.42	8.98	24.74	12
	Conductivity (mS/cm)	0.05	0.01	0.05	0.03	0.06	11
Laboratory	Alkalinity (mg/L)	13.89	5.68	15.00	2.60	22.00	10
	Turbidity (NTU)	10.59	17.30	5.65	3.40	65.00	12
	TSS (mg/L)	27.36	53.83	9.30	1.60	160.00	8
	E. Coli (MPN/100mL)	608.61	670.87	355.10	178.90	2419.60	10
	TKN (mg/L)	0.40	0.15	0.38	0.18	0.61	9
	Nitrate/Nitrite (mg/L)	0.14	0.08	0.13	0.04	0.28	11
	Total Phosphorus (mg/L)	0.03	0.01	0.03	0.02	0.06	6
	Calcium (mg/L)	6.23	1.58	6.35	2.80	8.40	12
	Iron (mg/L)	0.97	0.28	0.92	0.66	1.60	12
	Magnesium (mg/L)	0.51	0.08	0.54	0.38	0.63	12
	Manganese (mg/L)	0.05	0.03	0.05	0.02	0.09	12
	Zinc (mg/L)	NA	NA	NA	0.018	0.018	1
	Hardness (mg/L)	17.63	4.15	18.00	8.60	23.00	12
	Aluminum (mg/L)	0.29	0.23	0.24	0.08	0.65	9
	TOC (mg/L)	7.01	4.99	4.55	2.50	16.00	12

BOD, Ammonia, Lead, Nickel, and Beryllium are not included in the graph due to NWSV-2047 having no detections in 2020.

NWSV-2055 Meyers Branch at Road 9

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	6.57	0.58	6.72	5.24	7.29	12
	DO (mg/L)	8.57	1.26	8.46	6.88	10.73	12
	Water Temp (°C)	18.10	4.46	18.36	10.42	24.80	12
	Conductivity (mS/cm)	0.04	0.01	0.04	0.03	0.05	12
Laboratory	Alkalinity (mg/L)	13.64	3.66	15.50	5.30	16.00	10
	Turbidity (NTU)	5.13	4.95	3.60	2.00	20.00	12
	BOD (mg/L)	NA	NA	NA	2.80	2.80	1
	TSS (mg/L)	12.07	14.63	6.60	4.60	45.00	7
	E. Coli (MPN/100mL)	539.78	764.33	218.35	121.10	2419.60	10
	TKN (mg/L)	0.47	0.17	0.42	0.33	0.78	6
	Ammonia (mg/L)	NA	NA	NA	0.05	0.05	1
	Nitrate/Nitrite (mg/L)	0.10	0.03	0.12	0.04	0.13	7
	Total Phosphorus (mg/L)	0.07	0.07	0.04	0.03	0.19	5
	Calcium (mg/L)	5.53	1.46	6.10	3.00	7.10	12
	Iron (mg/L)	0.68	0.44	0.52	0.30	1.90	12
	Magnesium (mg/L)	0.44	0.09	0.42	0.34	0.64	10
	Manganese (mg/L)	0.05	0.03	0.03	0.02	0.11	12
	Hardness (mg/L)	16.27	2.80	17.00	12.00	19.00	11
	Aluminum (mg/L)	0.32	0.31	0.24	0.08	1.10	11
	Beryllium (mg/L)	NA	NA	NA	0.0011	0.0011	1
	TOC (mg/L)	5.76	4.42	4.00	1.90	15.00	12

Lead, Nickel, and Zinc are not included in the graph due to NWSV-2055 having no detections in 2020.

NWSV-2061 Upper Three Runs at Road 2-1

Parameters		Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects
Field	pH (SU)	5.88	0.50	6.03	4.61	6.46	12
	DO (mg/L)	8.38	1.72	8.08	6.39	11.12	12
	Water Temp (°C)	18.67	4.84	18.64	10.37	25.63	12
	Conductivity (mS/cm)	0.024	0.002	0.024	0.021	0.028	12
Laboratory	Alkalinity (mg/L)	6.20	1.89	5.60	4.90	11.00	9
	Turbidity (NTU)	3.32	0.87	3.15	2.40	5.50	12
	BOD (mg/L)	NA	NA	NA	4.40	4.40	1
	TSS (mg/L)	5.79	1.91	5.40	4.10	9.50	7
	E. Coli (MPN/100mL)	495.37	692.50	277.30	114.50	2419.60	10
	TKN (mg/L)	0.39	0.09	0.37	0.26	0.55	7
	Ammonia (mg/L)	0.09	0.05	0.09	0.05	0.12	2
	Nitrate/Nitrite (mg/L)	0.07	0.07	0.04	0.02	0.23	7
	Total Phosphorus (mg/L)	0.06	0.02	0.07	0.04	0.10	8
	Calcium (mg/L)	2.80	0.27	2.80	2.40	3.40	12
	Iron (mg/L)	0.56	0.12	0.56	0.40	0.79	12
	Magnesium (mg/L)	0.36	0.04	0.36	0.30	0.43	10
	Manganese (mg/L)	0.02	0.01	0.02	0.01	0.04	12
	Hardness (mg/L)	8.45	0.74	8.60	7.40	10.00	11
	Aluminum (mg/L)	0.20	0.08	0.18	0.10	0.36	12
	TOC (mg/L)	5.45	3.10	4.30	3.00	13.00	12

Lead, Nickel, Zinc, and Beryllium are not included in the graph due to NWSV-2061 having no detections in 2020.

Chapter 6 Monitoring of Sediments on and Adjacent to SRS

6.1.0 PROJECT SUMMARY

The accumulation of radiological and non-radiological contaminants in sediment can directly affect aquatic organisms which can lead to human exposure. Impacts to water bodies come through direct discharge, atmospheric fallout, and runoff. These accumulated contaminants may re-suspend in streams and rivers or disperse downstream, potentially affecting drinking water supplies and fish consumed by the public. The transportation of sediments is a dynamic process. Stream flow changes can redistribute contaminants or bury them as part of the natural sedimentation process. Patterns of sediment contamination are strongly affected by hydrologic factors and the physical and chemical characterization of the sediment (EPA, 1987).

Collecting sediment samples from the riverbank

SRS streams receive surface water runoff and water from permitted discharges (DOE, 1995). SRS is within the Savannah River watershed, with five major streams feeding into the Savannah River. Dispersal of any contaminants from these streams has the potential to impact the Savannah River.

Homogenizing the sample and removing rocks/sticks

DHEC personnel evaluate sediment samples for radionuclide and non-radionuclide contaminant concentrations in SRS streams, SRS storm-water basins, creek mouths along the boundary of SRS, the Savannah River, and publicly accessible boat landings in the SRS vicinity. Radionuclide detections in sediment are typically the result of accumulation over many years and do not represent yearly depositions. Sediment samples on SRS are routinely split with DOE-SR to compare results.

A complete list of all radiological and non-radiological analytes can be found in List of Analytes, Table 1 and Table 2 on page ix. DHEC sediment sampling locations are illustrated in Section 6.4.0, Map. DHEC and DOE-SR split samples were collected from six stream locations on SRS, three SRS storm-water basins, five SRS creek mouths, and two publicly accessible boat landings. A complete list of sample locations is listed in Section 6.5.0, Table 1.

6.2.0 RESULTS AND DISCUSSION

DHEC sediment monitoring summary statistics can be found in Section 6.6.0 and sediment monitoring data can be found in the 2020 DHEC Data File.

6.2.1 Radiological Results

Cesium-137 releases from Z-Area have the potential to contaminate tributaries of McQueen Branch, which flows into Upper Three Runs. The impact for possible contamination warrants long-term monitoring by DHEC along SRS streams and the publicly accessible Savannah River.

Sediment is collected and then dried before radiological analysis

The creek mouths of SRS are a conduit for the dispersal of radionuclides into publicly accessible water. Cesium-137 activity was found by DHEC in the sediment within several creek mouths at the Savannah River. Actinium-228, beryllium-7, potassium-40, lead-212, lead-214, radium-226, and thorium-234 are NORM decay products that account for the remaining gamma detections. All other gamma-emitting radionuclides had no detections above their respective MDA in 2020.

DHEC had sporadic gross alpha and gross non-volatile beta activity detections in 2020. The summary statistics can be found in Section 6.6.0.

Cesium-137 is the most abundant anthropogenic radionuclide found in the sediment samples. Cesium-137 levels in 2020 data from samples collected outside SRS boundaries are all within the expected range and consistent with previous DHEC background data. Cs-137 in sediment may be attributed, in part, to fallout from past nuclear events in the 1950s and 1960s. The highest level of Cs-137 from all 2020 DHEC and DOE-SR collocated sediment samples occurred at Steel Creek Mouth (5.34 pCi/g for DHEC and 4.95 pCi/g for DOE-SR) and Four Mile Creek (2.92 pCi/g for DHEC and 2.96 pCi/g for DOE-SR) (SRNS, 2021). Cesium-137 contamination in Steel Creek Mouth is well documented and not unexpected. All sample results were well below the Preliminary Remediation Goal (PRG) of 28 pCi/g for Cs-137 (Section 6.5.0, Table 2) (EPA, 2014).

Sediment samples after being placed in drying oven

Figure 1 in Section 6.5.0 illustrates the average Cs-137 activity in sediment samples from all the DHEC locations. DHEC Cs-137 data from the SRS creek mouths were trended for 2016-2020 (Section 6.5.0, Figure 2) and were compared to DOE-SR data (Section 6.5.0, Figure 3).

6.2.2 Non-radiological Results

Metals in sediment can be naturally occurring or a result of man-made processes such as those used in SRS operations, which have released elevated amounts into streams on SRS. Re-distribution of sediment from flooding can carry contaminants to downstream locations. Geological factors in the Savannah River basin contribute to the levels of metals through erosion and sedimentation. All 2020 DHEC and DOE-SR samples had averages below the Ecological Screening Values (ESVs) for beryllium (for which DOE-SR does not test), copper, lead, nickel, mercury, and zinc (EPA, 2018a). DHEC had no chemicals with detection concentrations above the ESV for the background location in 2020 except for Barium.

Comparisons were made to the ESVs for sediment, which do not represent remediation goals or cleanup levels but are used to identify constituents of potential concern (EPA, 2018a).

Barium was detected above the ESV of 20 mg/kg by DHEC in all creek mouths and storm-water basins, in four on-site streams (SMSV-2048, SMSV-2049, SMSV-327, and SMSV-2073), in five of the boat landings (SMSVC20, SMJBL20, SMBFL20, SMRVP20, and SMSC20), and in the background location. DOE-SR detected barium above the ESV in all creek mouths and storm-water basins and in four on-site streams (FMC @ Rd A, McQB at MO, U3R-3, and SC-4).

Sediment is measured out to be tested for non-radiological parameters

Beryllium does not have an established ESV for sediment, so in lieu of a sediment value, the ESV for soil was used. DHEC had no detects above the ESV of 2.5 mg/kg. DOE-SR did not analyze for beryllium in 2020.

Cadmium was detected above the ESV of 1 mg/kg by DHEC in one of the creek mouths (SMSV-2017), two of the storm-water basins (SME-001 and SME-003), none of the on-site streams, and one of the public boat landings (SMBFL20). DOE-SR did not detect cadmium above the ESV in any location in 2020.

Chromium was detected above the ESV of 43.4 mg/kg in two DHEC stormwater basins (SME-001 and SME-003) and in none of DOE-SR's samples.

DHEC and DOE-SR did not detect copper above the ESV of 31.6 mg/kg in any samples.

DHEC detected manganese above the ESV of 460 mg/kg in all creek mouths and at three boat landings (SMBFL20, SMJBL20, and SMSC20). DOE-SR had four creek mouths (BDC RM, RM 129, RM 150.2, and RM 157.2) with results above the ESV.

Mercury was not detected by DHEC, while DOE-SR had no samples with mercury detections not exceeding the ESV.

DHEC non-radiological sediment data can be found in the 2020 DHEC Data File and non-radiological summary statistics can be found in Section 6.6.0.

6.3.0 CONCLUSIONS AND RECOMMENDATIONS

SRS sediments should continue to be monitored due to current releases of contaminants and the potential for future discharges from SRS operations, legacy wastes, and clean-up activities. Year-to-year data comparisons are difficult to interpret due to the nature of sediment accumulation. Differences among samples may be due to the fraction of clays that most effectively retain radionuclides. There is also difficulty in replicating the exact sampling point due to erosion and sedimentation. Monitoring of on-site sediments is of great importance since over-land precipitation and streams transport contaminated sediment with radionuclides outside the SRS boundary.

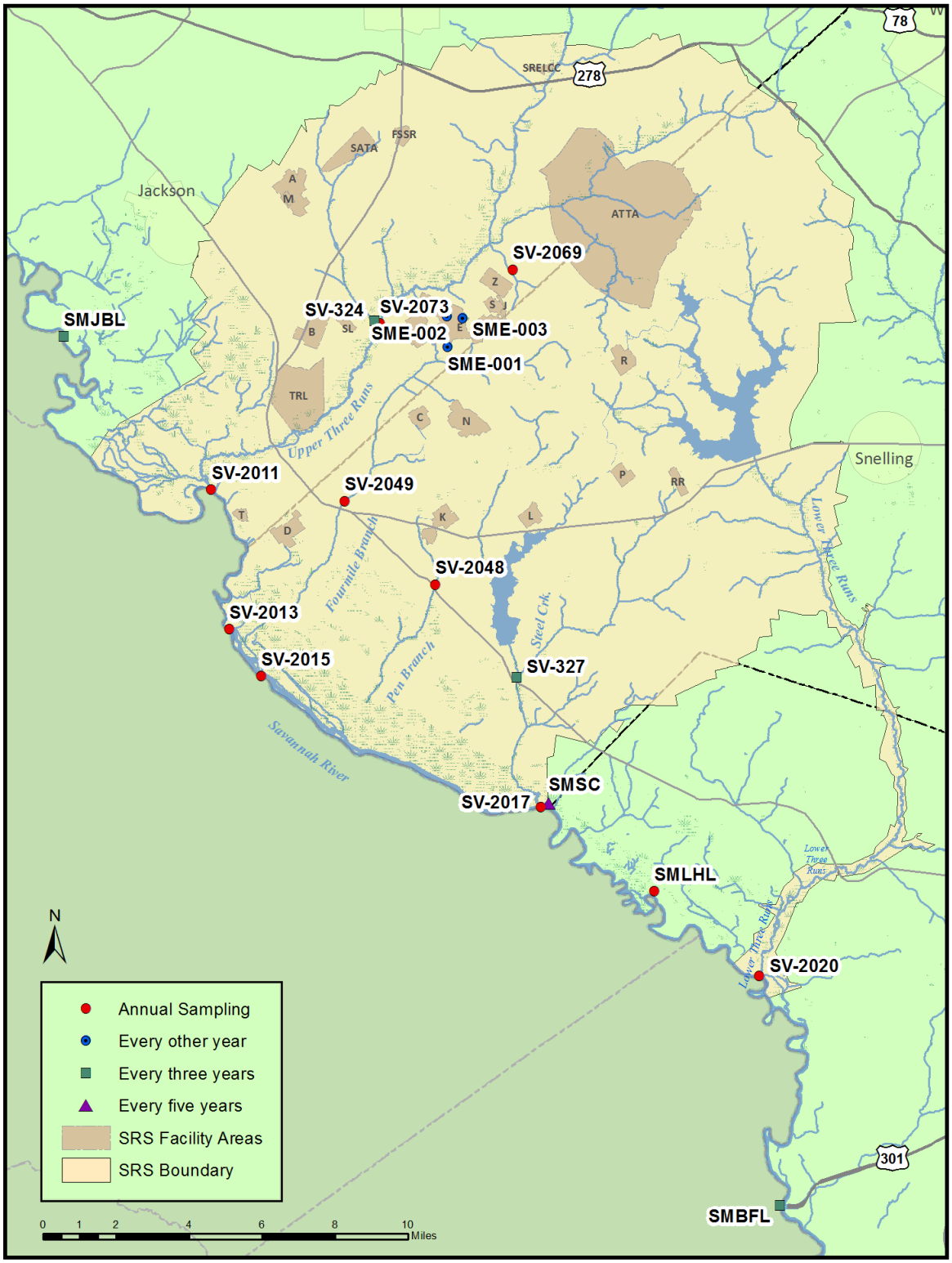
Dried samples are pulverized before being sent to the Columbia lab to be analyzed for radionuclides

DHEC will continue independent monitoring of sediment on SRS and in the Savannah River to improve our understanding of the presence of radionuclide and non-radionuclide concentrations. DHEC will also periodically evaluate and modify the sampling methodology to better accomplish project goals and objectives.

Trending of data over multiple years demonstrates whether radionuclide concentrations in the SRS area are declining through radioactive decay or possibly increasing due to disturbances on SRS. By comparing data throughout the years, DOE-SR can evaluate its results as well as show the differences between its data and results from samples collected through monitoring by DHEC. Cooperation between DOE-SR and DHEC provides credibility and confidence in the information being provided to the public.

6.4.0 MAP

SRS Sediment Sampling Locations



2020 ESOP Sediment Monitoring Map www.scdhec.gov/srs

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6.5.0 TABLES AND FIGURES

Table 1. 2020 DHEC Sediment Sample Locations

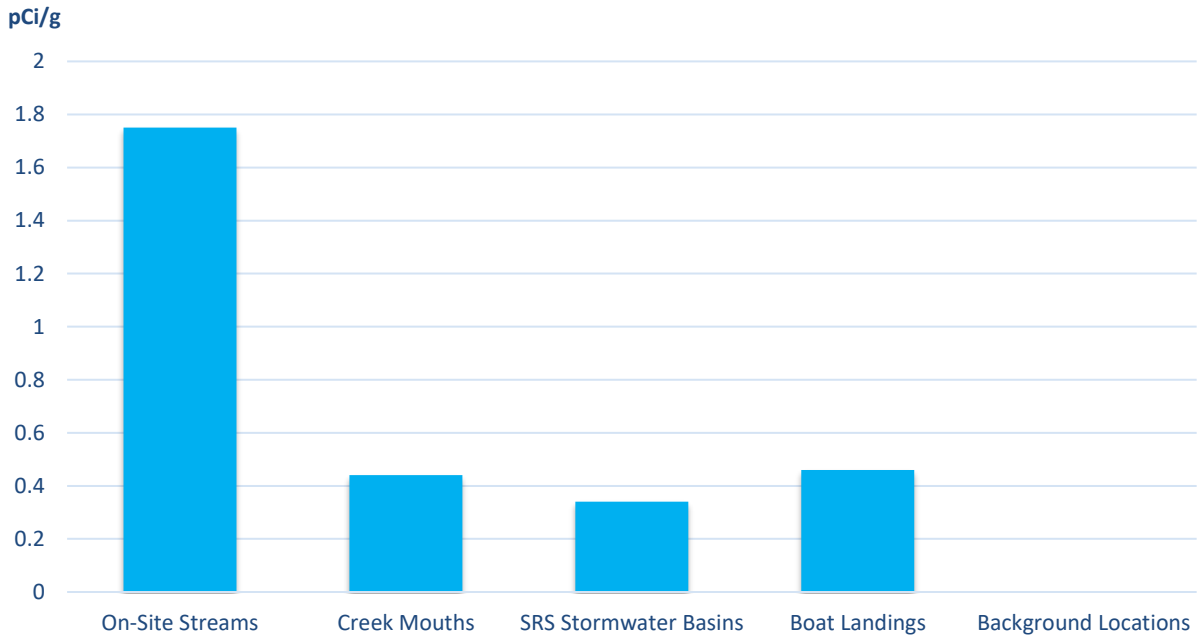
DHEC Sample Location ID	DOE Sample Location ID	Location Description
Storm-water Basins		
SME-001	E-001	E-001 E Area Storm-water Basin
SME-002	E-002	E-002 E Area Storm-water Basin
SME-003	E-003	E-003 E Area Storm-water Basin
Creek Mouths		
SMSV-2011	RM 157.2	Upper Three Runs Mouth @ RM 157.4
SMSV-2013	BDC RM	Beaver Dam Creek Mouth @ RM 152.3
SMSV-2015	RM 150.2	Fourmile Branch Creek Mouth @RM 150.6
SMSV-2017	SC RM	Steel Creek Mouth @ RM 141.5
SMSV-2020	RM 129	Lower Three Runs Mouth @RM 129.1
On-site Streams		
SMSV-2073	U3R-3	Upper Three Runs @ Rd C
SMSV-2069	McQB at MO	McQueen Branch @ Monroe Owens Rd
SMSV-327	SC-4	Steel Creek at Road A
SMSV-324	TB-5 @ Rd C	Tims Branch Near Road C
SMSV-2048	PB @ Rd A	Pen Branch @ Rd 125
SMSV-2049	FMC @ Rd A	Four Mile Creek @ Rd 125
Upstream of SRS		
SMRVP20	NA	North Augusta Riverview Park Boat Landing
SMSVC20	NA	Steven’s Creek Boat Landing
SMJBL20	RM 170.5	Jackson Boat Landing
Downstream of SRS		
SMSC20	NA	Steel Creek Boat Landing
SMLHL20	NA	Little Hell Boat Landing
SMBFL20	RM 118.7	Burton's Ferry Boat Landing

DHEC Sample Location ID	DOE Sample Location ID	Location Description
SMPKY20	NA	Pinckney Island National Wildlife Refuge

Table 2. Soil Ingestion Preliminary Remediation Goals of Select Anthropogenic Radionuclides (EPA, 2014)

Radionuclide	PRG (pCi/g)
Americium-241	4.9
Cesium-137	28
Cobalt – 60	83
Iodine-131	6000
Plutonium-238	4.4
Plutonium-239/240	3.9

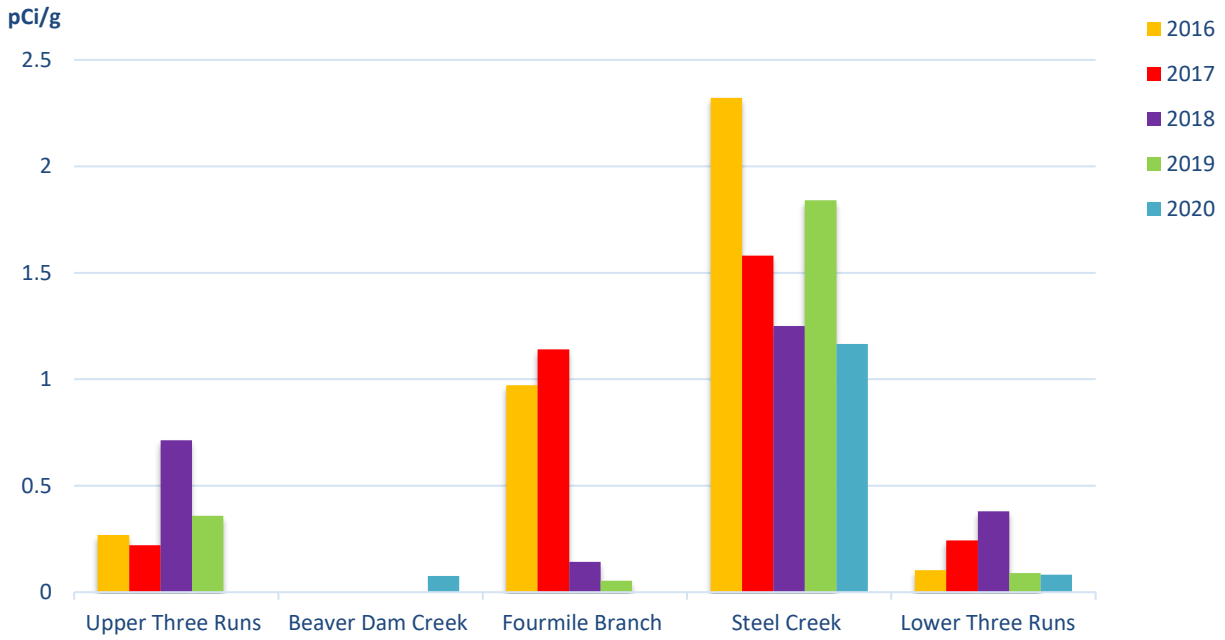
Figure 1. 2020 Comparisons of Cs-137 Average Activity Among Sample Location Type



No bar denotes no detection.

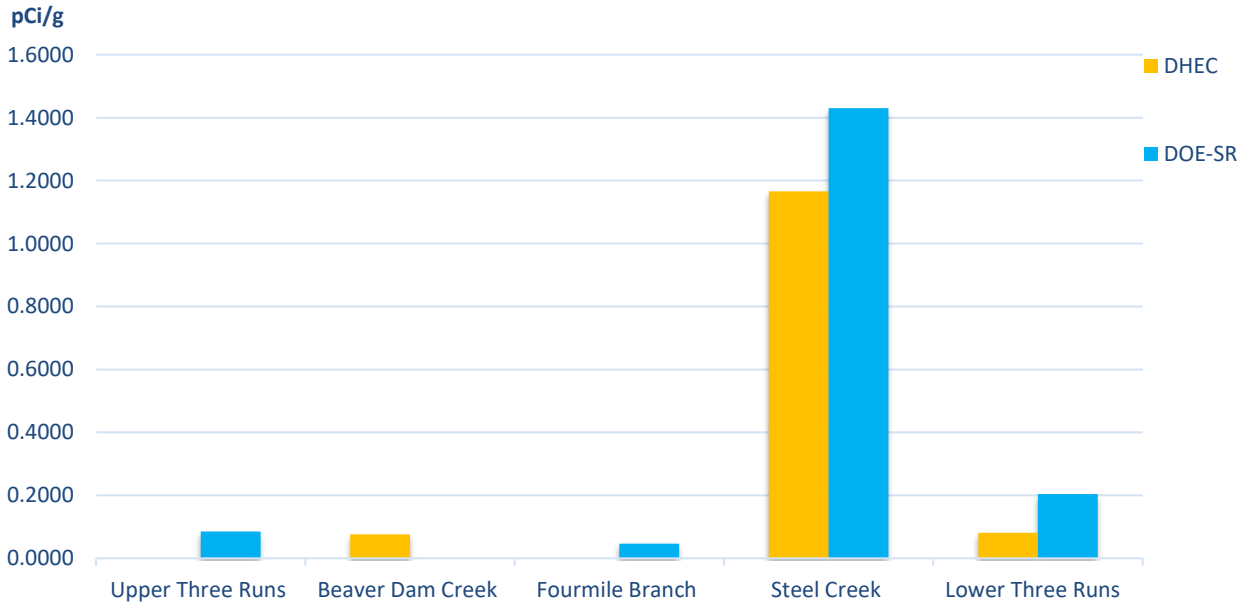
TABLES AND FIGURES

Figure 2. 2016-2020 Trending Data for Cs-137 in SRS Creek Mouth Samples (DHEC, 2018-2020b)



No bar denotes no detection for that year.

Figure 3. 2020 Cesium-137 in Savannah River Creek Mouths–DHEC Comparison to DOE-SR Data (SRNS, 2021)



Beaver Dam Creek is a man-made stream that was used for past operations at D-Area

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6.6.0 SUMMARY STATISTICS

2020 DHEC Radiological Data

On-Site Streams

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum Detect (pCi/g)	Maximum Detect (pCi/g)	Number of Detections	Number of Samples
Gross Alpha	15.39	11.22	9.91	7.10	34.60	5	6
Gross Beta	17.42	7.31	15.50	11.30	29.80	5	6
Cs-137	1.75	2.34	0.29	0.05	5.34	5	6

Creek Mouths

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum Detect (pCi/g)	Maximum Detect (pCi/g)	Number of Detections	Number of Samples
Gross Alpha	10.89	6.46	9.99	5.82	21.90	5	5
Gross Beta	23.48	5.43	24.50	17.80	29.30	5	5
Cs-137	0.44	0.63	0.08	0.08	1.17	3	5

Storm-water Basins

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum Detect (pCi/g)	Maximum Detect (pCi/g)	Number of Detections	Number of Samples
Gross Alpha	12.83	3.04	11.60	10.60	16.30	3	3
Gross Beta	22.63	6.67	22.00	16.30	29.60	3	3
Cs-137	0.34	0.25	0.34	0.17	0.51	2	3

Boat Landings

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum Detect (pCi/g)	Maximum Detect (pCi/g)	Number of Detections	Number of Samples
Gross Alpha	13.65	0.21	13.65	13.50	13.80	2	6
Gross Beta	18.18	6.49	18.60	10.30	25.40	5	6
Cs-137	0.46	0.54	0.26	0.05	1.08	3	6

Background Samples

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum Detect (pCi/g)	Maximum Detect (pCi/g)	Number of Detections	Number of Samples
Gross Alpha	ND	ND	ND	ND	ND	0	1
Gross Beta	6.83	NA	6.83	6.83	6.83	1	1
Cs-137	ND	ND	ND	ND	ND	0	1

ND is Not Detected, NA is Not Applicable

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SUMMARY STATISTICS

2020 DHEC Non-radiological (Metals) Data

On-Site Streams

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	38.17	25.30	36.50	13.00	85.00	6	6	20
Beryllium	0.57	0.36	0.44	0.32	1.10	4	6	2.5*
Cadmium	ND	ND	ND	ND	ND	0	6	1
Chromium	9.67	2.77	9.90	5.40	13.00	6	6	43.4
Copper	2.80	0.84	2.95	1.50	3.70	6	6	31.6
Lead	5.45	0.07	5.45	5.40	5.50	2	6	35.8
Manganese	118.33	70.73	98.50	56.00	240.00	6	6	460
Mercury	ND	ND	ND	ND	ND	0	6	0.18
Nickel	5.80	2.00	6.40	3.40	8.40	5	6	22.7
Zinc	19.67	8.12	17.50	10.00	30.00	6	6	121

Creek Mouth Locations

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	95.40	24.20	100.00	57.00	120.00	5	5	20
Beryllium	0.41	0.01	0.41	0.40	0.42	2	5	2.5*
Cadmium	NA	NA	NA	1.30	1.30	1	5	1
Chromium	16.40	7.27	19.00	7.00	25.00	5	5	43.4
Copper	6.58	4.11	7.40	1.60	12.00	5	5	31.6
Lead	7.77	1.84	7.30	6.20	9.80	3	5	35.8
Manganese	944.00	243.58	880.00	690.00	1200.00	5	5	460
Mercury	ND	ND	ND	ND	ND	0	5	0.18
Nickel	7.10	3.00	8.50	3.00	10.00	5	5	22.7
Zinc	33.40	14.14	40.00	15.00	48.00	5	5	121

Storm-water Basins

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	71.33	21.50	66.00	53.00	95.00	3	3	20
Beryllium	0.97	0.23	1.10	0.70	1.10	3	3	*2.5
Cadmium	1.70	0.42	1.70	1.40	2.00	2	3	1
Chromium	46.33	9.87	51.00	35.00	53.00	3	3	43.4
Copper	13.00	1.00	13.00	12.00	14.00	3	3	31.6
Lead	13.00	2.65	14.00	10.00	15.00	3	3	35.8
Manganese	143.67	83.55	100.00	91.00	240.00	3	3	460
Mercury	ND	ND	ND	ND	ND	0	3	0.18
Nickel	17.33	3.51	17.00	14.00	21.00	3	3	22.7
Zinc	91.67	18.01	91.00	74.00	110.00	3	3	121

Boat Landings

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	81.85	67.80	65.50	8.10	170.00	6	6	20
Beryllium	NA	NA	NA	0.52	0.52	1	6	2.5*
Cadmium	NA	NA	NA	1.50	1.50	1	6	1
Chromium	15.33	11.74	15.00	1.90	30.00	6	6	43.4
Copper	9.82	6.88	8.20	3.00	18.00	5	6	31.6
Lead	20.63	11.77	21.50	7.50	32.00	4	6	35.8
Manganese	891.00	760.96	815.00	36.00	1700.00	6	6	460
Mercury	ND	ND	ND	ND	ND	0	6	0.18
Nickel	7.38	5.14	7.40	2.10	13.00	5	6	22.7
Zinc	37.57	22.37	34.00	5.40	69.00	6	6	121

Background Sample

Analyte	Concentration (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	50.0	1	1	20
Beryllium	NA	0	1	2.5*
Cadmium	NA	0	1	1
Chromium	22.0	1	1	43.4
Copper	NA	0	1	31.6
Lead	6.1	1	1	35.8
Manganese	19.0	1	1	460
Mercury	NA	0	1	0.18
Nickel	3.4	1	1	22.7
Zinc	8.6	1	1	121

ND is Not Detected
NA is Not Applicable
ESVs come from EPA, 2018a
There is not an ESV established for beryllium in sediment, so the ESV for beryllium in soil is used in lieu of the sediment value. This is denoted by an *.

Chapter 7 Surface Soil Monitoring Adjacent to SRS

7.1.0 PROJECT SUMMARY

DHEC independently evaluates surface soil adjacent to SRS from ground surface to a 12-inch depth for gross alpha, gross non-volatile beta, and select gamma-emitting radionuclides, as well as specific metals of concern. Soil samples are collected to determine if SRS activities have had an impact on areas outside the site boundary. Radionuclide detections in soil are the result of accumulation over many years.

A 50-mile area from the center of SRS was chosen for the comparison of DHEC and DOE-SR SRS perimeter radiological data averages. DOE-SR does not collect metals for surface soil; therefore, no direct data comparisons can be made.

DHEC collected samples from eight SRS perimeter locations and one background location in 2020 (Section 7.5.0, Table 1). SRS perimeter sampling locations are depicted on the Map in Section 7.4.0.

7.2.0 RESULTS AND DISCUSSION

Soil Monitoring Summary Statistics for radionuclides and metals can be found in Section 7.6.0, and all Soil Monitoring Data can be found in the 2020 DHEC Data File.

7.2.1 Radiological Parameter Results

Collecting soil samples which will be analyzed for radiological material and metals

Most samples had detectable amounts of Cs-137, an anthropogenic radionuclide that may be present due to a legacy of releases by SRS and atmospheric fallout from past nuclear weapons testing (SRNS, 2021). Cs-137 activity in 2020 is comparable to levels detected by DHEC in the past. There were no surface soil samples collected in 2020 that were above the EPA Preliminary Remediation Goals (PRGs), which can be found in Section 7.5.0, Table 2 (EPA, 2014).

Cesium-137 was the only gamma-emitting radionuclide that DHEC and DOE-SR shared in analytical results. Both DHEC and DOE-SR resulted in similar findings. DHEC had a perimeter average Cs-137 concentration of 0.12 pCi/g, which was slightly lower than DOE-SR's findings of 0.23 pCi/g. The PRG for C-137 is 28 pCi/g and all sample results were well below that level. Trending data for Cs-137 in SRS perimeter samples is in Section 7.5.0, Figures 1 and 2.

The results found by both DHEC and DOE-SR are influenced by the number of samples used to determine the average and by collecting samples from different locations. The average level of Cs-137 in surface soil can vary due to the highly variable nature

of soils. Radiocesium bioavailability in soil is influenced by soil properties such as clay content, pH, organic matter, and soil microflora (Absalom et al., 2001).

The only other gamma-emitting radionuclides detected in DHEC surface soil samples were potassium-40, lead-212, lead-214, radium-226, actinium-228, and thallium-234. These are NORM decay products (**2020** DHEC Data File).

7.2.2 Non-radiological Parameter Results

DOE-SR did not analyze for metals; therefore, no comparisons could be made. DHEC saw no exceedances of the EPA Regional Screening Levels (RSLs) in any of the surface soil samples in 2020 (EPA, 2018b). A complete list of all DHEC non-radiological analytes and RSLs can be found in Section 7.5.0, Table 3.

Clearing away debris to expose soil

Barium has been a constituent of the H-Area Hazardous Waste Management Facility (WSRC, 1993). Barium was detected in all SRS perimeter and background samples.

Beryllium is a strong, lightweight metal used in nuclear weapons work as a shield for radiation and as a neutron source (Till et al., 2001). Beryllium was not detected in the SRS perimeter or background samples in 2020.

Cadmium enters the atmosphere through fuel and coal combustion (Till et al. 2001). None of the perimeter or background surface soil samples yielded detections.

Chromium solutions were used at SRS as corrosive inhibitors. Chromium was a part of wastewater solutions resulting from dissolving stainless steel. It was also used in cleaning solutions in the separations areas (Till et al., 2001). The legal disposal of fly ash on land as a result of burning coal is a contributor of both chromium and nickel to soils. Chromium was detected in all eight of the SRS perimeter samples and in the background location.

D-Area and the other coal combustion powerhouses emitted copper and other heavy metals (Till et al., 2001). These mechanisms are possible sources of elevated copper levels in surface soils. Copper was detected in six of the SRS perimeter samples and in the background location.

Atmospheric emissions of lead from SRS occurred through coal and fuel combustion (Till et al., 2001). Lead can deposit in soil and due to its immobility can have a long residence time when compared to other pollutants. Lead can accumulate in soils where its bioavailability can persist long-term (Alloway, 1995). Lead was detected in two of the SRS perimeter samples and in the background location.

Manganese has been released in the separations areas' processes and discharged to liquid waste tanks (Till et al., 2001). It is also a byproduct of coal burning. Manganese was detected in all nine of the SRS perimeter samples and in the background location.

The largest anthropogenic source of nickel globally is the burning of fuels and coal combustion (Alloway, 1995). At SRS, nickel was directly released through M-Area effluent from the plating rinse tanks and through site use of diesel generators (Till et al., 2001). Nickel was detected in one SRS perimeter sample and the background location.

Samples being prepped for the oven

Zinc was released in relatively small amounts to the separations areas' seepage basins as well as the M-Area seepage basin (Till et al., 2001). Zinc was detected in eight SRS perimeter samples and in the background location.

SRS facilities, such as F- and H- Area, tritium facilities, waste tanks, and the coal-fired power plants have emitted mercury to the atmosphere (Till et al., 2001). Atmospheric fallout contributes to mercury findings in surface soil. There were no mercury detections in surface soil samples collected in 2020.

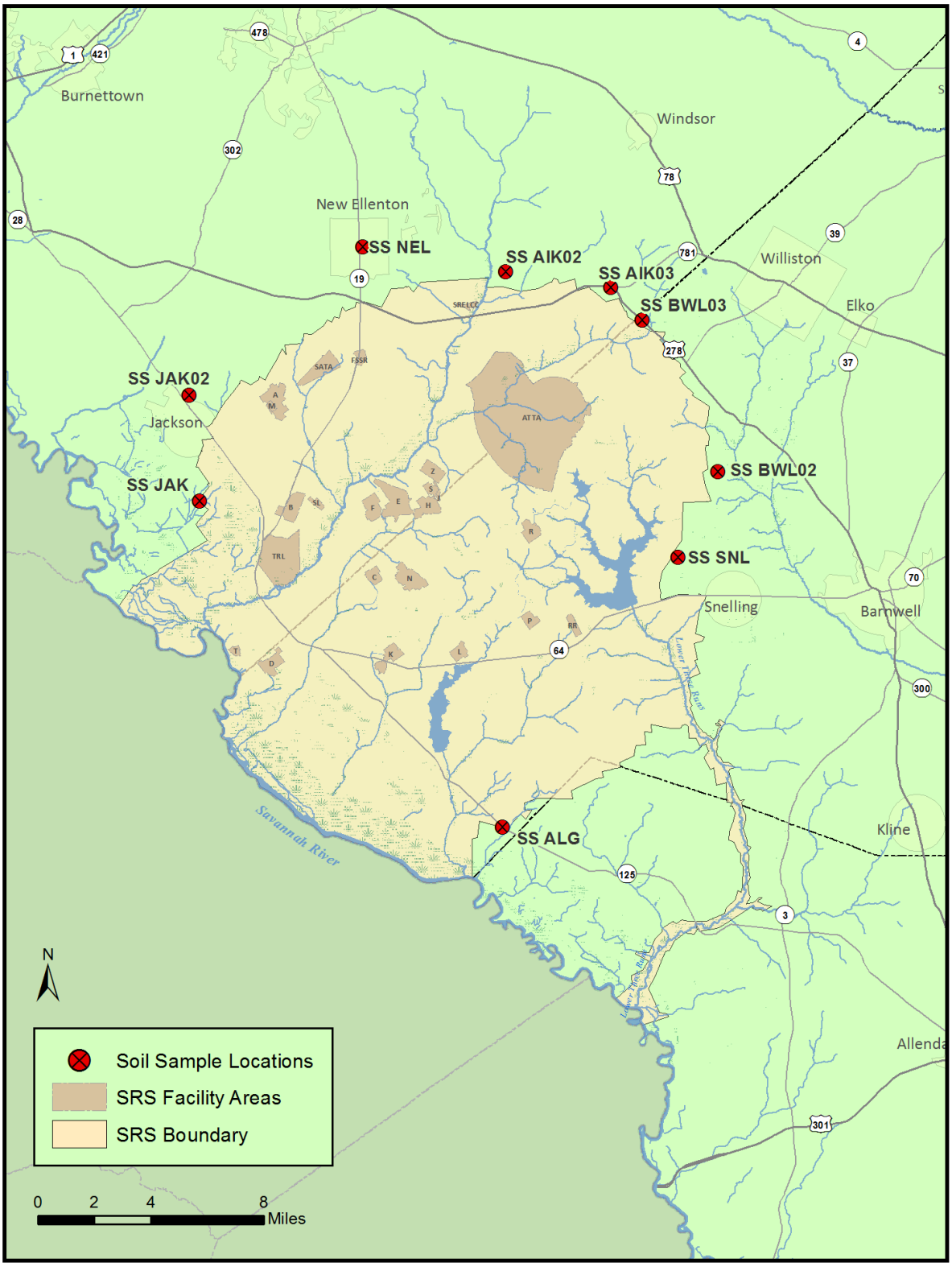
7.3.0 CONCLUSIONS AND RECOMMENDATIONS

Soil samples from DHEC and DOE-SR programs varied by location and in number. When interpreting data, it should be taken into consideration that samples were collected from a variety of soil types and locations.

DHEC will continue to monitor independently the SRS perimeter surface soil and will periodically evaluate modification of the monitoring activities to better accomplish project goals and objectives. Monitoring will continue as long as there are activities at SRS that create the potential for contamination to enter the environment. Continued monitoring will provide an improved understanding of radionuclide and non-radionuclide activity in SRS perimeter surface soils and the surrounding areas. Additional monitoring will impart valuable information to human health exposure pathways. Trending of data over multiple years will give a more definitive answer as to whether radionuclide concentrations in the SRS area are declining due to radioactive decay or possibly increasing due to flooding, soil disturbances and prescribed burns on SRS. The comparison of data allows for independent data verification of DOE-SR monitoring activities. Cooperation between DOE-SR and DHEC provides credibility and confidence in the information being provided to the public.

7.4.0 MAP

SRS Perimeter Surface Soil Monitoring



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7.5.0 TABLES AND FIGURES

Table 1. Soil Sample Locations for in 2020

Perimeter Soil Samples		
Sample ID	**Location**	**County**
SS AIK 20	Aiken Elementary	Aiken
SS AIK02 20	Boggy Gut Rd	Aiken
SS AIK03 20	Dunlap Circle, across 278 from Jaywood Rd	Aiken
SS BWL02 20	Seven Pines Rd	Allendale
SS BWL03 20	Hwy 278 and Grandy's Mill Rd	Allendale
SS BWL05 20	Lake Edgar Brown Boat Ramp	Barnwell
SS DKH 20	Darkhorse	Barnwell
SS SNL 20	Technology Rd in Snelling	Barnwell
Background Soil Samples		
Sample ID	**Location**	**County**
SS PKY 20	Pinckney Island National Refuge	Beaufort

Table 2. Soil Ingestion Preliminary Remediation Goals of Select Anthropogenic Radionuclides (EPA, 2014)

Radionuclide	PRG (pCi/g)
Americium-241	4.9
Cesium-137	28
Cobalt – 60	83
Iodine-131	6000
Plutonium-238	4.4
Plutonium-239/240	3.9

Table 3. Regional Screening Levels of Metals (EPA, 2018b)

Analyte	RSL (mg/kg)
Barium	15,000
Beryllium	160
Cadmium	70
Total Chromium	23**
Copper	3,100
Lead	400
Manganese	1,800
Mercury	11
Nickel	1,500
Zinc	23,000

**The DHEC lab analyzes soil samples for total chromium; however, a RSL is not established for total chromium. The value provided in the table above is the ecological screening value for total chromium in soil.

TABLES AND FIGURES

Figure 1. 2016-2020 DHEC and DOE-SR Trending Averages for Cesium-137 (SRNS, 2017-2021; DHEC, 2018-2020b)

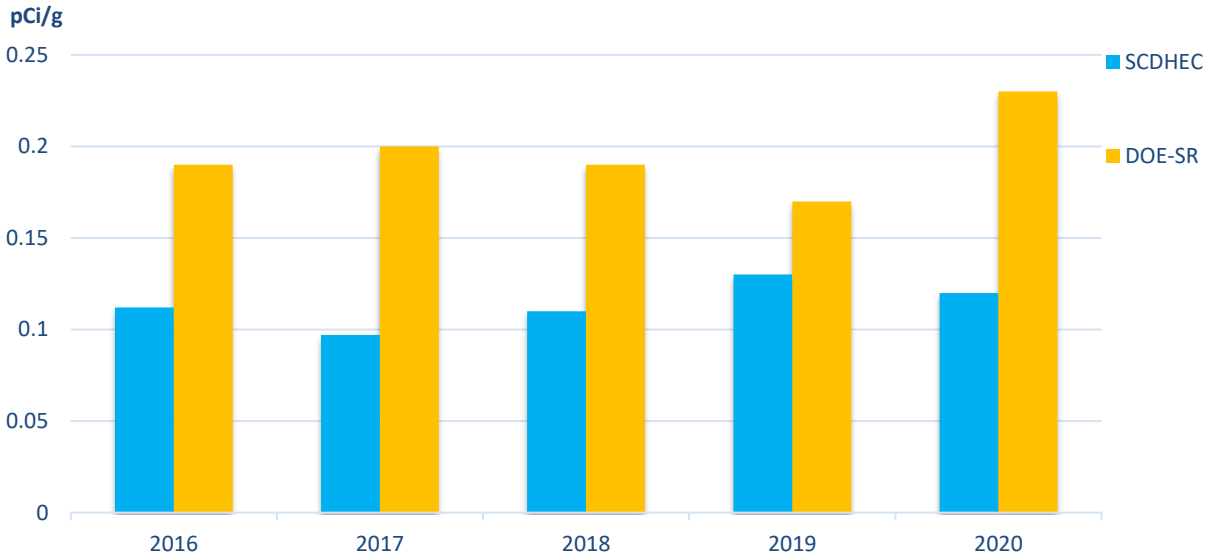
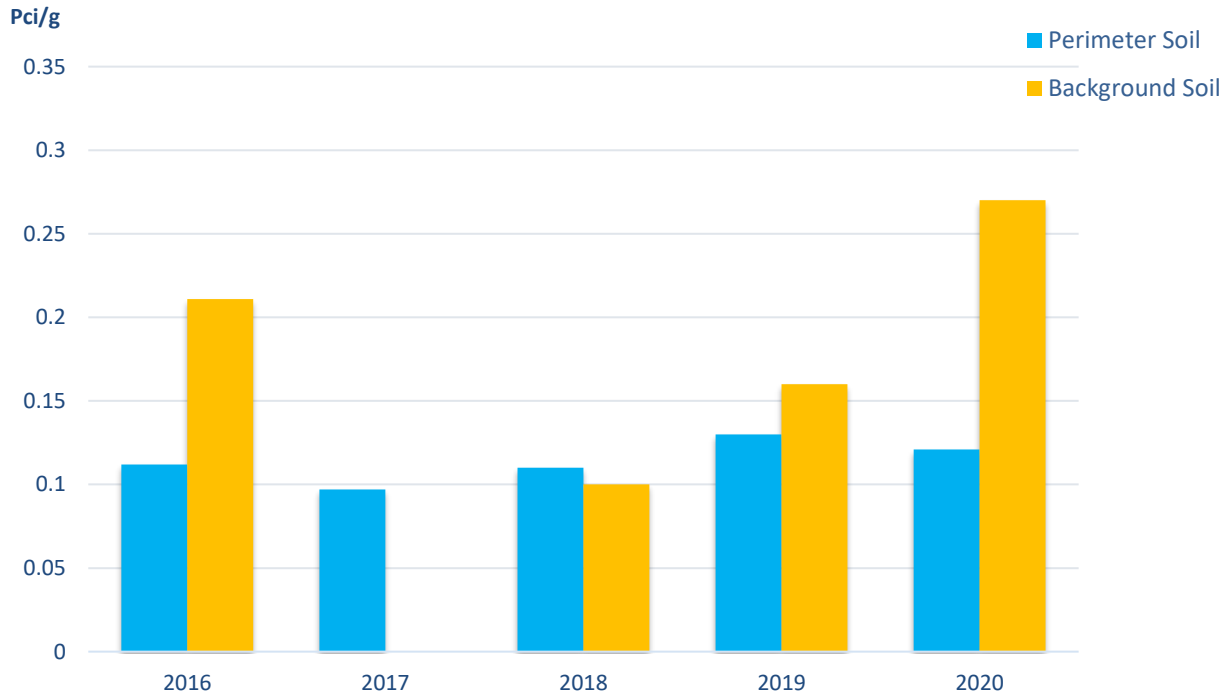


Figure 2. 2016-2020 Perimeter and Background Trending Averages for Cesium-137 (DHEC 2018 – 2020b)



Background samples were not collected in 2017.

7.6.0 SUMMARY STATISTICS

2020 DHEC Radiological Statistics -- SRS Perimeter Samples

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum Detect (pCi/g)	Maximum Detect (pCi/g)	Number of Detections	Number of Samples
Gross Alpha	ND	ND	ND	ND	ND	0	8
Gross Beta	8	2	8.100	7.030	9.170	2	8
Cs-137	0.121	0.041	0.125	0.066	0.169	6	8

2020 DHEC Radiological Statistics -- Background Sample

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum Detect (pCi/g)	Maximum Detect (pCi/g)	Number of Detections	Number of Samples
Gross Alpha	ND	ND	ND	ND	ND	0	1
Gross Beta	NA	NA	NA	5.87	5.87	1	1
Cs-137	NA	NA	NA	0.27	0.27	1	1

2020 DHEC Non-radiological (Metals) Statistics -- SRS Perimeter Samples

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Number of Detections	Number of Samples
Barium	11.6	3.5	10.0	7.8	17.0	8	8
Chromium	3.7	1.2	3.9	1.8	5.3	8	8
Copper	2.1	1.5	1.5	1.1	5.0	6	8
Lead	11.7	4.7	11.7	8.3	15.0	2	8
Manganese	36.2	16.5	39.0	8.2	58.0	8	8
Nickel	NA	NA	NA	2.4	2.4	1	8
Zinc	8.2	3.6	8.5	3.4	14.0	8	8

2020 DHEC Non-radiological (Metals) Statistics -- Background Sample

Analyte	Concentration (mg/kg)	Number of Detections	Number of Samples
Barium	21.0	1	1
Chromium	4.6	1	1
Copper	2.5	1	1
Lead	13.0	1	1
Manganese	120.0	1	1
Nickel	2.20	1	1
Zinc	38.0	1	1

NA is Not Applicable and ND is Not Detected
All samples were analyzed for Beryllium, Cadmium, and Mercury; however, there were no detects for both the perimeter and background locations, so these chemicals were not included in the charts.

Chapter 8 Radiological Monitoring of Terrestrial Vegetation Adjacent to SRS

8.1.0 PROJECT SUMMARY

DOE-SR contracts for the collection and analysis of terrestrial vegetation, primarily Bermuda grass, to determine concentrations of radionuclides (SRNS, 2021). In 2019, DHEC began sampling Bermuda grass (*cynodon dactylon*) to align with DOE's methodology and no longer collects leaves from broad-leafed evergreen trees and shrubs. DHEC and DOE-SR locations are collocated with samples being obtained from 10 locations at the SRS perimeter, and one on-site location at the burial grounds. DHEC also has a background location at Pinckney Island National Wildlife Refuge. DHEC and DOE-SR perimeter stations sampled in 2020 are shown in Section 8.4.0, Map.

Preparing grass samples for lab analysis

8.2.0 RESULTS AND DISCUSSION

Terrestrial Vegetation Data

Terrestrial Vegetation Monitoring Data can be found in the 2020 DHEC Data File.

In 2020, DHEC detected tritium only at its center location (Burial Ground North – 10,047.6 pCi/L) (Section 8.5.0). DOE-SR had tritium detects in two perimeter locations (Darkhorse - 184.8 pCi/L and East Talatha – 1138.1 pCi/L) and at the center location (Burial Ground North at 40,429.6 pCi/L) (SRNS, 2021).

Tritium analysis results from DHEC and DOE-SR sampling are presented in Section 8.5.0, Table 1. Differences between the two programs in sampling dates and analysis methods should be considered during comparison. Provided there were detections, a data comparison of associated locations from the two programs was conducted by converting from pCi/g to pCi/L.

Weighing grass samples

Gamma

In 2020, DHEC detected actinium-228, beryllium-7, potassium-40, and lead-214. These isotopes are NORM; therefore, the results will not be discussed further but are presented in the 2020 DHEC Data File. A list of radionuclides in the gamma spectroscopy analysis are in List of Analytes, Table 1, page ix.

Gamma analysis results for Cs-137 from DHEC and DOE-SR sampling in 2020 are presented in Section 8.5.0, Table 2. The man-made isotopes Co-60 and Am-241 were not detected in the DHEC 2020 samples.

8.3.0 CONCLUSIONS AND RECOMMENDATIONS

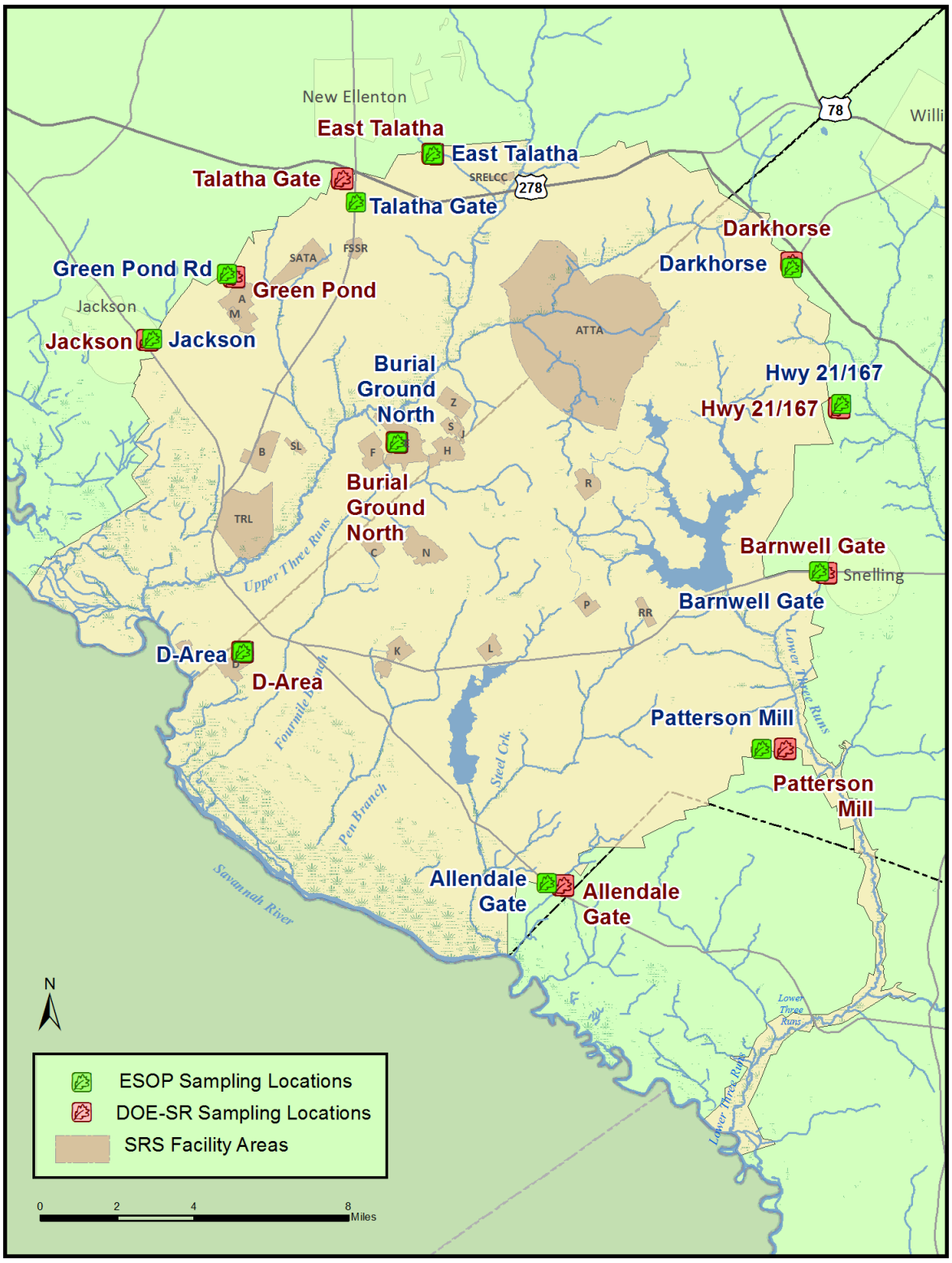
In 2020, DHEC discontinued sampling at the three 25-mile radius locations (Hwy 301 Welcome Center, Augusta Loc and Dam, and the Aiken Airport). Two of these locations are in found in Georgia, whereas DHEC's background sample is collected from Pinckney Island National Wildlife Refuge in Beaufort County, SC.

DHEC's revision of beginning to sample Bermuda grass on an annual basis in 2019 allows for a more direct comparison with the data collected by DOE-SR. By having parallel sampling techniques with DOE-SR, DHEC will potentially observe less differences in the data.

Collection bags for Bermuda grass

8.4.0 MAP

Terrestrial Vegetation Sampling Locations



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8.5.0 TABLES AND FIGURES

Table 1. 2020 Tritium Data Comparison for DHEC and DOE-SR Sampling Locations (SRNS, 2021)

Stations	DHEC Result (pCi/L)	DOE-SR Result (pCi/L)
Burial Ground North	10,047.62	40,428.57
Sample Perimeter Locations		
Talatha Gate	ND	ND
Green Pond Rd	ND	ND
Jackson	ND	ND
East Talatha	ND	1,138.10
Darkhorse	ND	183.81
Hwy 21/167	ND	ND
Barnwell Gate	ND	ND
Patterson Mill Rd	ND	ND
Allendale Gate	ND	ND
D-Area	ND	ND
Background Locations	**DHEC Result (pCi/L)**	**DOE-SR Result (pCi/L)**
Background – Pinckney	ND	NS

NS is No Sample
ND is Not Detected
No summary statistics were shown due to the limited detections; however, DOE-SR had a perimeter location average of 660.95 pCi/L for tritium in 2020.

8.5.0 TABLES AND FIGURES

Table 2. 2020 Cesium-137 Data Comparison for DHEC and DOE-SR Sampling Locations (SRNS, 2021)

Stations	DHEC Result (pCi/g)	DOE-SR Result (pCi/g)
Burial Ground North	ND	ND
Sample Perimeter Locations		
Talatha Gate	ND	0.07
Green Pond Rd	0.030	0.05
Jackson	ND	ND
East Talatha	ND	0.19
Darkhorse	0.128	0.12
Hwy 21/167	0.071	0.21
Barnwell Gate	0.047	0.06
Patterson Mill Rd	ND	0.08
Allendale Gate	0.187	0.26
D-Area	0.039	0.14
Perimeter Locations' Summary Statistics – Cs-137		
Average	**0.08**	**0.13**
Standard Deviation	**0.06**	**0.08**
Median	**0.06**	**0.12**

NS is No Sample
ND is Not Detected

Chapter 9 Radiological Monitoring of Edible Vegetation Adjacent to SRS

9.1.0 PROJECT SUMMARY

The Radiological Monitoring of Edible Vegetation Project is a component of the DHEC's ESOP that monitors edible vegetation from SRS perimeter and background locations.

DHEC defined a study area comprised of grids radiating out to 25 miles from the SRS center point, 25 miles to 50 miles, and background locations greater than 50 miles from the SRS center point (Map in Section 9.4.0). DOE-SR, as compared to DHEC, has five defined quadrants where samples are collected annually: four quadrants are within 10 miles of SRS in each direction (NE, NW, SE, SW), along with one quadrant located within 25 miles SE. Direct comparisons between DOE-SR and DHEC could not be made due to variation in sampling and analysis methodologies.

Collecting peaches from a local farm

Edible vegetation is collected based solely on availability and is directly dependent upon the growing season. Certain farmers, gardeners, and/or businesses surrounding the perimeter of SRS contribute domestically grown crops. Wild, edible vegetation, such as muscadines and plums, are also collected. References to vegetation in this section pertain to the edible parts of plants.

DHEC background sampling helps to separate atomic test fallout contamination levels and other sources (e.g. ongoing permitted releases at other nuclear facilities) from SRS source potential contamination. However, fallout dispersion patterns and concentrations are weather related and not uniform, and no assignment of a specific source can be made.

9.2.0 RESULTS AND DISCUSSION

Peaches from a local farm

Edible Vegetation Monitoring Data can be found in the 2020 DHEC Data File.

The U.S. Food and Drug Administration (FDA) has guidance levels for specific radionuclides called Derived Intervention Levels (DILs). The FDA adopted DILs to help determine whether domestic food in interstate commerce or food offered for import into the United States presents a safety concern (FDA, 2005).

DHEC detected tritium in one sample of fruit from the NE-1 quadrant at 0.22 pCi/g in 2020, while DOE-SR detected tritium in one of the seventeen samples (in soybeans in the NW Quadrant 0-10 miles at 0.009 pCi/g) (SRNS, 2021).

Preparing corn to be blended for analysis

In 2020, DOE-SR edible vegetation exhibited radiological detections of gross beta, americium-241, plutonium-239, strontium-89/90, technetium-99, uranium-234, uranium-235, and uranium-238 (SRNS, 2021). Potassium-40 was the only gamma analyte detected in 2020 in DHEC samples. All the detected gamma radionuclides, except Cs-137, are NORM and are the source of most detections in edible vegetation; therefore, they are not discussed further.

The FDA-derived Guidance Level for Cs-137 is 32.4 pCi/g (FDA, 2005). DHEC detected Cs-137 in one sample of fungi from S-1 Quadrant at 0.35 pCi/g. DOE-SR had detections of Cs-137 in two of the seventeen samples collected in 2020 at an average of 0.02 pCi/g (the highest detection being in greens in the SE Quadrant 25 miles at 0.02 pCi/g) (SRNS, 2021).

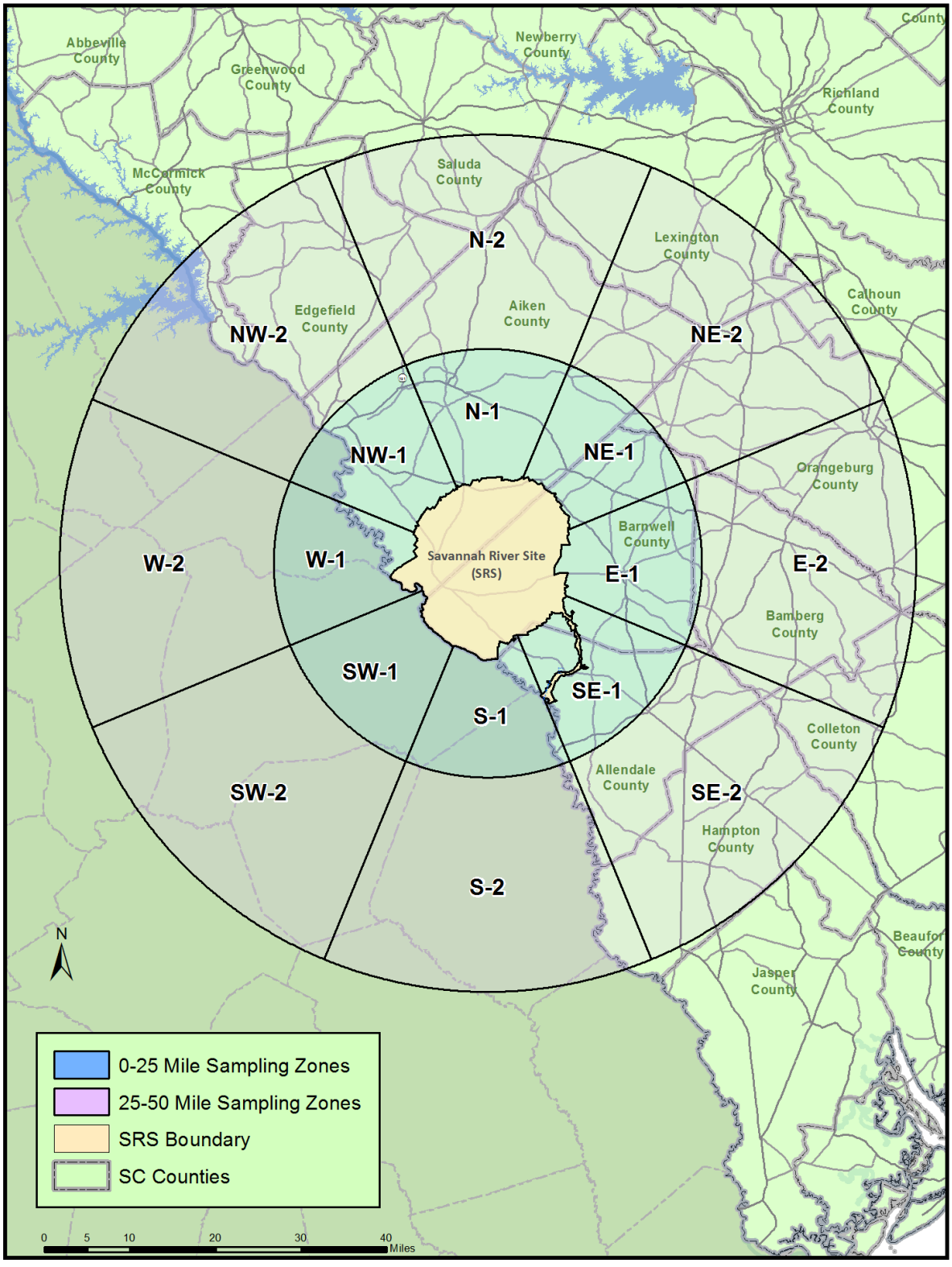
9.3.0 CONCLUSIONS AND RECOMMENDATIONS

DHEC and DOE-SR have different edible vegetation sampling schemes. DOE-SR samples primarily domestic plants collected from annual contributors in quadrants at zero to 10 miles from the perimeter of the SRS border and one quadrant at 25 miles. DHEC accepts domestic plants as donations from citizens and collects perennial, wild, edible vegetation and fungi found within 50 miles of the SRS center point and background locations (Section 9.4.0).

In the future, DHEC will explore opportunities to split samples with DOE-SR and attempt to establish collocated sampling locations for better comparisons between the two. In addition, DHEC will continue to collect wild fungi due to its inherent ability to bioconcentrate Cs-137.

9.4.0 MAP

DHEC Edible Vegetation Monitoring



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Chapter 10 Radiological Monitoring of Dairy Milk

10.1.0 PROJECT SUMMARY

Operations at SRS have resulted in the potential for radiological constituents to be released to the surrounding environment (Till et al., 2001). Consumption of milk products containing radioactive materials can be a human exposure pathway. When an atmospheric release occurs, radionuclides can be deposited on pastures and ingested by grazing dairy animals. The animals may release a portion of the radionuclides into their milk that could be consumed by humans (CDC, 2001). Radionuclides could also enter milk through the irrigation of a pasture using groundwater containing radioactive materials and through uptake by plants from soil containing radioactive materials.

In 2020, DHEC collected milk from four dairies within South Carolina (Section 10.4.0, Map). One of the dairies, MK-01 closed halfway through 2020 and will no longer be sampled in future years. All four of these locations are within a 50-mile radius to the center of SRS. This project provides analytical data for trending and comparison to published DOE-SR data.

DHEC personnel collected unpasteurized milk samples on a quarterly basis in 2020. All milk samples from each quarter were analyzed for tritium, Sr-89/90, and gamma-emitting radionuclides. While a select group of gamma-emitting radionuclides (iodine-131 (I-131), Cs-137, and cobalt-60 (Co-60)) are analytes of concern in dairy milk for this project, all other detections such as Potassium-40 (K-40) are considered NORM. Naturally occurring radionuclides are the source of most public exposure; however, they are not discussed in this report unless detections are significantly greater than those of the background location detections. In 2020, DHEC did not sample any background dairy locations. DHEC analyzes samples for total strontium (Sr-89/90) instead of only Sr-90. This is done to provide a more conservative result, and it is assumed the total strontium detected is in the form of Sr-90.

10.2.0 RESULTS AND DISCUSSION

None of the 14 DHEC milk samples collected in 2020 exhibited tritium activity above the LLD (2020 DHEC Data File). DOE-SR did not detect tritium in any of the samples collected in 2020 from the South Carolina dairies (SRNS, 2021).

DHEC analyzed for gamma-emitting radionuclides (K-40, I-131, Cs-137, and Co-60) in 14 milk samples collected in 2020. All analytical results for these radionuclides were below the sample MDA except for naturally occurring K-40. These results can be found in the 2020 DHEC Data File. These results are consistent with past gamma results and no summary statistics were calculated for these radionuclides due to a lack of numerical data. Out of 16 samples from South Carolina, DOE-SR detected Cs-137 in cow milk in two samples with an average activity of 10.4 pCi/L (SRNS, 2021).

Six of the 14 DHEC milk samples collected in 2020 exhibited strontium activity above the MDA. Section 10.5.0, Figure 1 shows the trend for DHEC strontium detections for the last five years. All strontium averages have been below the EPA established MCL of 8 pCi/L for Sr-90 in drinking water since testing initiated in 1998 (EPA, 2020). DOE-SR detected Sr-89/90 in five of the 16 samples collected in 2020 in South Carolina, with an average activity level of 1.72 pCi/L in cow milk (SRNS, 2021).

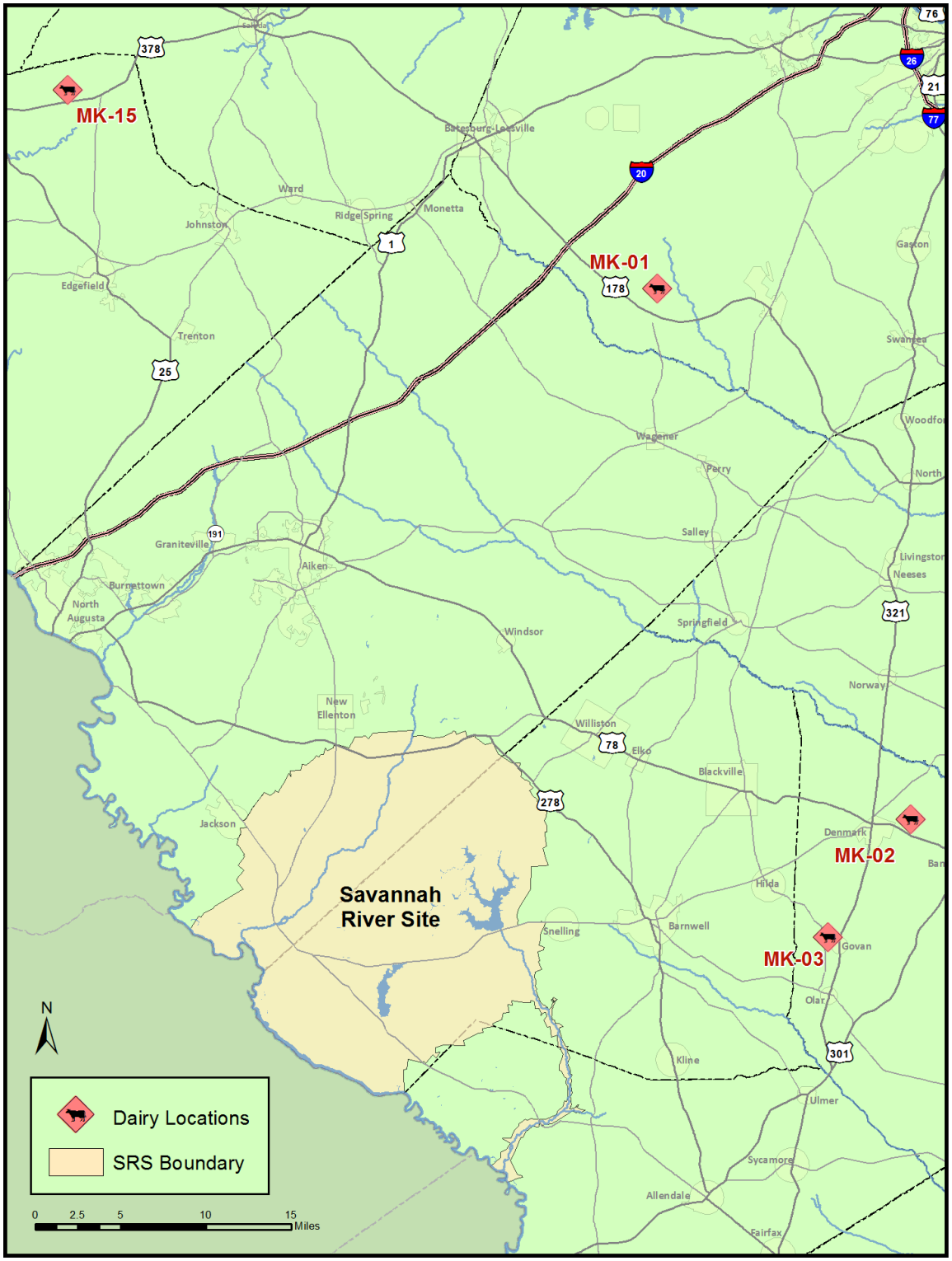
10.3.0 CONCLUSIONS AND RECOMMENDATIONS

A large portion of the radiological activity observed in milk samples can be attributed to fallout from past nuclear testing (Kathren, 1984). Also, radionuclides within soil and plants can potentially be redistributed because of farming practices and fires. Due to strontium's ability to be stored in bones and cesium building up in muscles, DHEC will continue to monitor tritium, gamma-emitting radionuclides, and strontium in milk to ensure the safety of milk consumption by the public.

The remaining dairies in DHEC's study area appear to be stable with no indication of closing in the foreseeable future. DHEC will continue to seek opportunities to add additional dairies to the sampling program for better coverage of the study area.

10.4.0 MAP

Radiological Dairy Milk Monitoring Sampling Locations



2020 ESOP Dairy Milk Monitoring Map www.scdhec.gov

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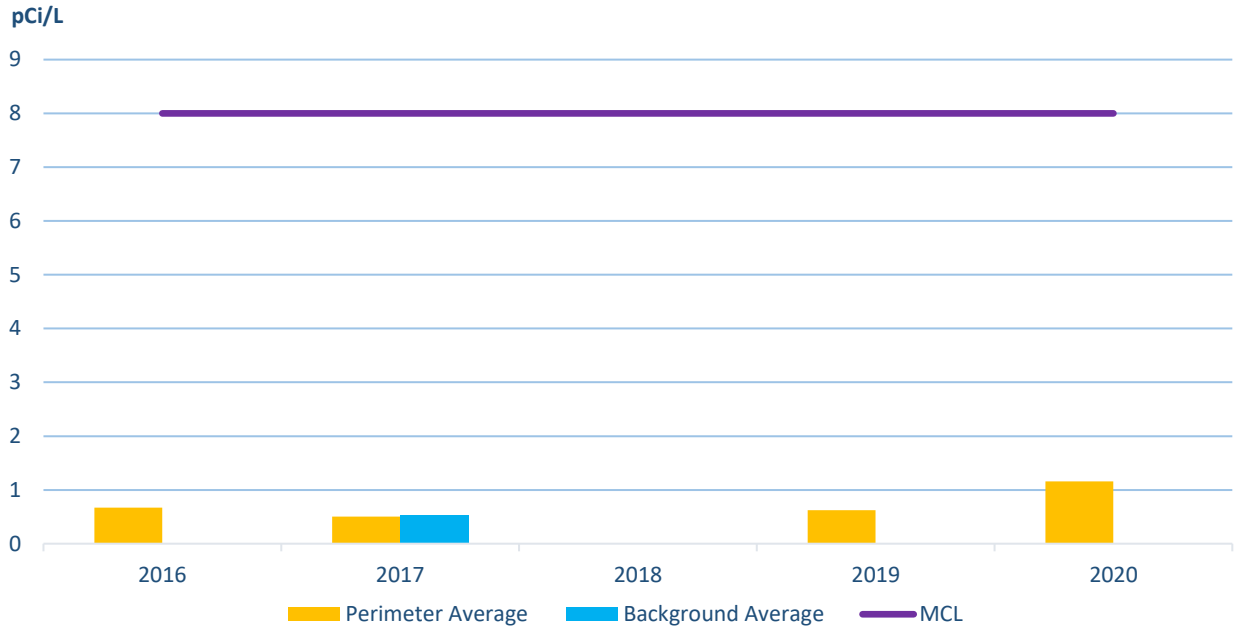
10.5.0 TABLES AND FIGURES

Figure 1. DHEC Average Strontium-89/90 Data Trends for 2016-2021 (DHEC, 2018-2020b)



No bar indicates <MDA
No background location was collected in 2018, 2019, and 2020

10.6.0 SUMMARY STATISTICS

2020 Strontium-89/90 All Sample Detections

Sample Location	Average (pCi/L)	Standard Deviation	Median (pCi/L)	Minimum Detect (pCi/L)	Maximum Detect (pCi/L)	Number of Detections	Number of Samples
MK-01	ND	ND	ND	ND	ND	0	2
MK-02	1.295	0.581	1.295	0.884	1.705	2	4
MK-03	0.970	0.426	0.970	0.668	1.271	2	4
MK-15	1.218	0.115	1.218	1.137	1.299	2	4

NA is Not Applicable
No background sample was taken

Chapter 11 Fish Monitoring Associated with SRS

11.1.0 PROJECT SUMMARY

DHEC ESOP conducts non-regulatory, independent monitoring and surveillance of fish to determine the magnitude, extent, and trend levels for radionuclides and selected metals.

Electroshocking boat on the Savannah River

In 2020, DHEC collected largemouth bass (*Micropterus salmoides)*, channel catfish (*Ictalurus punctatus*), and flathead catfish (*Pylodictis olivaris*) from four stations where creeks from SRS meet the Savannah River: Upper Three Runs Creek (SV-2011), Fourmile Branch (SV-2015), Steel Creek (SV-2017), and Lower Three Runs Creek (SV-2020). Samples of largemouth bass and channel catfish were also collected from the background station on the Combahee river between Beaufort and Colleton counties (MD-119), one Savannah River station upstream of SRS (New Savannah Bluff Lock and Dam (NSBLD SV-2028)), and two stations downstream of SRS (Highway 301 (SV-118) and Highway 17 saltwater (SV-2091 – the only area where striped mullet (*Mugil cephalus*) and red drum (*Sciaenopsocellatus*) are caught)). Flathead catfish were also collected at SV-118 and SV-2028. Stations sampled in 2020 are shown in Section 11.4.0, Map. These stations are accessible to the public.

A total of five largemouth bass and five channel catfish were collected from all Savannah River stations and the Combahee River background site. Five red drums and five striped mullets were collected from the saltwater station (SV-2091). Non-edible portions (bone) were tested for Sr-89/90. Edible portions (muscle tissue) were analyzed for mercury and other selected metals and gamma-emitting isotopes. Five flathead catfish were composited and tested for gamma-emitting radionuclides in muscle tissue and strontium in bone tissue. Recently, tritium was found to contribute to “less than 1% of the estimated total fisherman dose” (SRNS, 2016b). This is due to tritium’s ability to reach concentration equilibrium (the ability of a chemical to balance out) in both water and fish flesh resulting in no bioaccumulation (build up) in fish muscle (SRNS, 2016b). With this discovery, DOE-SR and DHEC have at this time discontinued its testing of tritium in fish flesh.

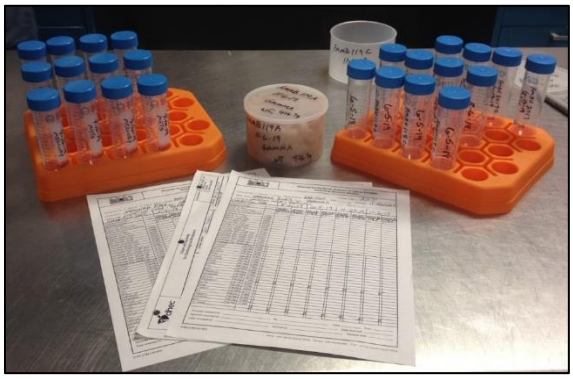
Catching a largemouth bass

11.2.0 RESULTS AND DISCUSSION

Fish Monitoring Summary Statistics can be found in Section 11.6.0 and all Fish Monitoring Data can be found in the 2020 DHEC Data File.

11.2.1 Radiological Data Comparison

DHEC bass and catfish data collected in 2020 were compared to DOE-SR data (Section 11.5.0) (SRNS, 2021). One difference between the two programs is that DHEC analyzes one composite from each species for each station, whereas the DOE-SR program analyzes three composites per station for Cs-137. Therefore, a single composite for a DHEC station was compared to the average of the three DOE-SR composites reported. For Sr-89/90, DOE-SR reports individual sample results. To compare Sr-89/90 data, the average of these individual DOE-SR samples for each location are compared to the one composite sample of DHEC.



Prepared fish samples ready for laboratory analysis

Trending graphs for 2020 activity levels of Cs-137 and Sr-89/90 are reported in Section 11.5.0, Figures 1 and 2.

Channel Catfish (left) and Largemouth Bass (right) being weighed and length being measured

11.2.2 Non-radiological Data Comparison

DHEC and DOE-SR analyzed fish for antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, and zinc. DHEC did have detections of copper, manganese, mercury, and zinc in some of its edible fish samples. Due to differences in sampling methodology, direct comparisons were not made between DHEC and DOE-SR for these non-radiological constituents; however, since mercury tends to be a public health focus with fish consumption, a comparison was made for bass and both catfish species (Section 11.5.0, Table 7, 8, and 9). Mercury trends for 2020 are reported in Section 11.5.0, Figure 3.

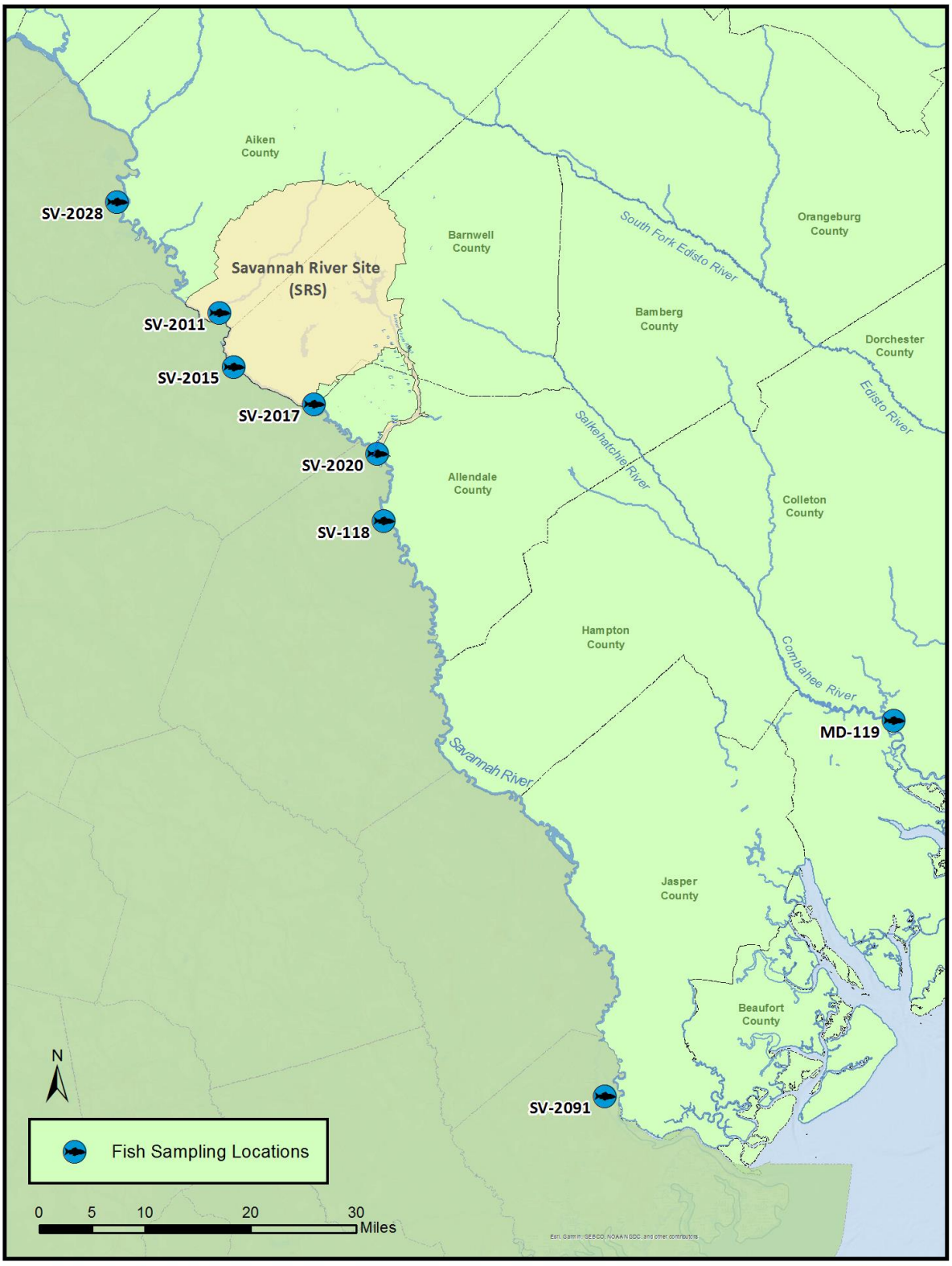
11.3.0 CONCLUSIONS AND RECOMMENDATIONS

Higher levels of radionuclides are found in Savannah River fish collected adjacent to and downstream of SRS compared to upstream. Therefore, independent monitoring of radionuclide levels in Savannah River fish will continue along with evaluating the DOE-SR Radiological Fish Monitoring Program. Continued monitoring will provide a better understanding of actual radionuclides, their extent, and trends. This data will allow DHEC to advise and inform the public. Data comparison will also be part of the further evaluation of the DOE-SR program. This independent evaluation will provide credibility and confidence in the DOE-SR data and its uses.

Future analyses of the target species will continue to include mercury and selected metals. This will augment the existing data on Savannah River fish, provide information for human health assessment, and provide another basis for comparison of results with DOE-SR data.

11.4.0 MAP

Fish Monitoring Sampling Locations



2020 ESOP Fish Monitoring Map www.scdhec.gov

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11.5.0 TABLES AND FIGURES

2020 DHEC and DOE-SR Data Comparison (SRNS, 2021)

Table 1. Cesium-137 in Edible Channel Catfish

Location	Agency	Number of Detects	Result (pCi/g)
NSBLD	DHEC	0	ND
	DOE-SR	2	0.02
Upper Three Runs	DHEC	0	ND
	DOE-SR	2	0.02
Fourmile Branch	DHEC	1	0.04
	DOE-SR	3	0.11
Steel Creek	DHEC	1	0.08
	DOE-SR	2	0.08
Lower Three Runs	DHEC	0	ND
	DOE-SR	3	0.16
Hwy. 301	DHEC	0	ND
	DOE-SR	3	0.03

Table 2. Cesium-137 in Edible Flathead Catfish

Location	Agency	Number of Detects	Result (pCi/g)
NSBLD	DHEC	0	ND
	DOE-SR	NS	NS
Upper Three Runs	DHEC	0	ND
	DOE-SR	3	0.04
Fourmile Branch	DHEC	1	0.15
	DOE-SR	2	0.04
Steel Creek	DHEC	1	0.07
	DOE-SR	3	0.11
Lower Three Runs	DHEC	1	0.03
	DOE-SR	3	0.18
Hwy. 301	DHEC	0	ND
	DOE-SR	3	0.02

Table 3. Cesium-137 in Edible Bass

Location	Agency	Number of Detects	Result (pCi/g)
NSBLD	DHEC	0	ND
	DOE-SR	2	0.03
Upper Three Runs	DHEC	1	0.12
	DOE-SR	1	0.07
Fourmile Branch	DHEC	1	0.49
	DOE-SR	3	0.07
Steel Creek	DHEC	1	0.23
	DOE-SR	3	0.45
Lower Three Runs	DHEC	0	ND
	DOE-SR	2	0.05
Hwy. 301	DHEC	0	ND
	DOE-SR	3	0.02

ND is Not Detected
NS is Not Sampled
DOE-SR data are averages
DHEC submits one composite sample for each location, whereas DOE-SR submits three composite samples for Cs-137, six composite samples for Sr-89/90, and seven composite samples for Mercury at each location

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TABLES AND FIGURES

2020 DHEC and DOE-SR Data Comparison (SRNS, 2021)

Table 4. Strontium-89/90 in Non-Edible Channel Catfish

Location	Agency	Number of Detects	Result (pCi/g)
NSBLD	DHEC	1	0.01
	DOE-SR	3	0.57
Upper Three Runs	DHEC	1	0.01
	DOE-SR	3	0.68
Fourmile Branch	DHEC	1	0.01
	DOE-SR	3	1.13
Steel Creek	DHEC	1	0.01
	DOE-SR	3	0.76
Lower Three Runs	DHEC	1	0.01
	DOE-SR	3	0.80
Hwy. 301	DHEC	1	0.02
	DOE-SR	3	0.55

Table 5. Strontium-89/90 in Non-Edible Flathead Catfish

Location	Agency	Number of Detects	Result (mg/kg)
NSBLD	DHEC	1	0.01
	DOE-SR	NS	NS
Upper Three Runs	DHEC	1	ND
	DOE-SR	3	0.62
Fourmile Branch	DHEC	1	0.02
	DOE-SR	3	0.78
Steel Creek	DHEC	1	0.01
	DOE-SR	3	0.65
Lower Three Runs	DHEC	1	0.01
	DOE-SR	3	0.55
Hwy. 301	DHEC	1	0.01
	DOE-SR	3	0.59

Table 6. Strontium-89/90 in Non-Edible Bass

Location	Agency	Number of Detects	Result (mg/kg)
NSBLD	DHEC	1	0.03
	DOE-SR	3	0.53
Upper Three Runs	DHEC	1	0.03
	DOE-SR	3	0.72
Fourmile Branch	DHEC	1	0.02
	DOE-SR	3	1.04
Steel Creek	DHEC	1	0.02
	DOE-SR	3	1.10
Lower Three Runs	DHEC	1	0.03
	DOE-SR	3	0.67
Hwy. 301	DHEC	1	0.02
	DOE-SR	3	0.72

TABLES AND FIGURES

2020 DHEC and DOE-SR Data Comparison (SRNS, 2021)

Table 7. Mercury in Edible Channel Catfish

Location	Agency	Number of Detects	Result (pCi/g)
NSBLD	DHEC	0	ND
	DOE-SR	7	0.15
Upper Three Runs	DHEC	1	0.14
	DOE-SR	7	0.25
Fourmile Branch	DHEC	1	0.11
	DOE-SR	7	0.24
Steel Creek	DHEC	1	0.18
	DOE-SR	7	0.26
Lower Three Runs	DHEC	1	0.11
	DOE-SR	7	0.32
Hwy. 301	DHEC	1	0.11
	DOE-SR	7	0.47

Table 8. Mercury in Edible Flathead Catfish

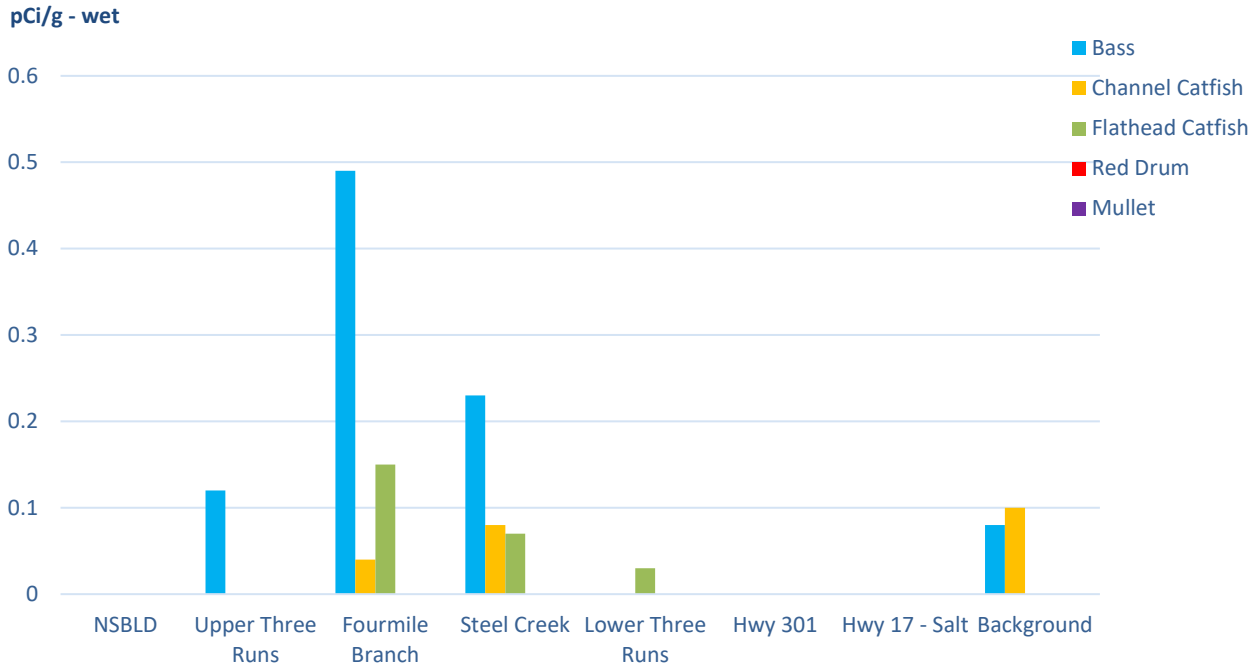
Location	Agency	Number of Detects	Result (mg/kg)
NSBLD	DHEC	1	0.10
	DOE-SR	NS	NS
Upper Three Runs	DHEC	1	0.15
	DOE-SR	7	0.21
Fourmile Branch	DHEC	1	0.18
	DOE-SR	7	0.15
Steel Creek	DHEC	1	0.18
	DOE-SR	7	0.27
Lower Three Runs	DHEC	1	0.15
	DOE-SR	7	0.28
Hwy. 301	DHEC	1	0.22
	DOE-SR	7	0.18

Table 9. Mercury in Edible Bass

Location	Agency	Number of Detects	Result (mg/kg)
NSBLD	DHEC	1	0.35
	DOE-SR	7	0.38
Upper Three Runs	DHEC	1	0.45
	DOE-SR	7	0.33
Fourmile Branch	DHEC	1	0.34
	DOE-SR	7	0.41
Steel Creek	DHEC	1	0.35
	DOE-SR	7	0.51
Lower Three Runs	DHEC	1	0.45
	DOE-SR	7	0.59
Hwy. 301	DHEC	1	0.47
	DOE-SR	7	0.69

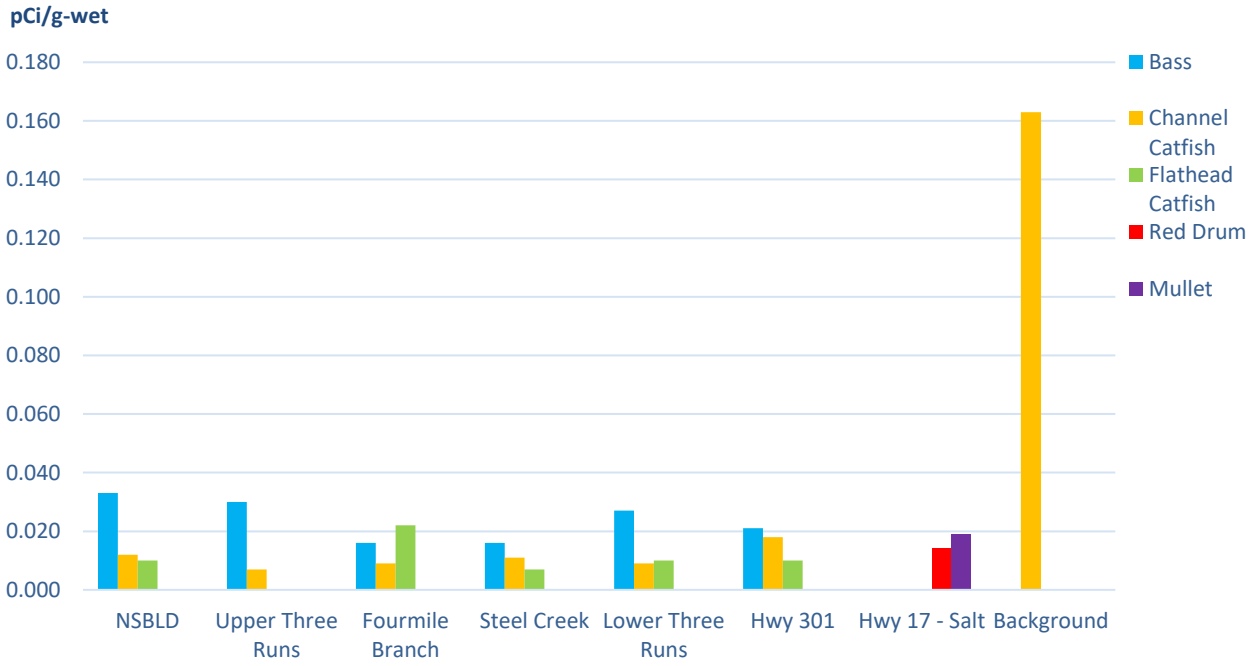
TABLES AND FIGURES

Figure 1. 2020 DHEC Cesium-137 in Fish Composites



Missing bars indicate <MDA. No background sample was collected for flathead catfish in 2020.

Figure 2. 2020 DHEC Strontium-89/90 in Fish Bone Composites



Missing bars indicate <MDA. No background sample was collected for flathead catfish in 2020.

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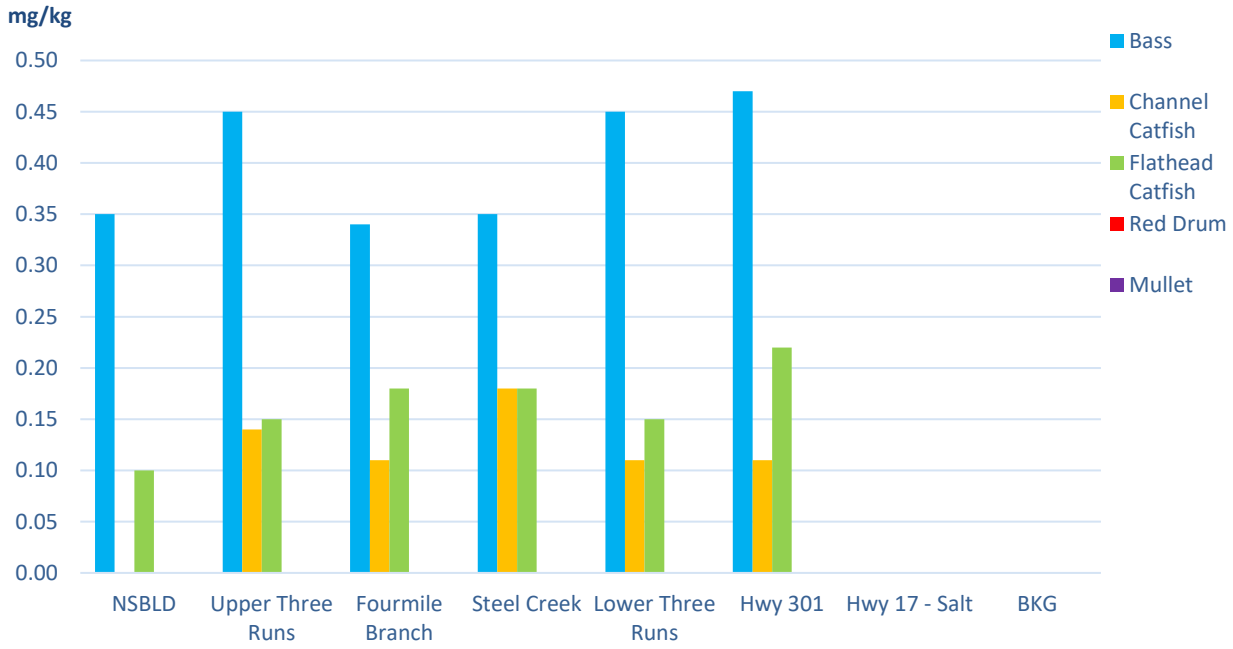
TABLES AND FIGURES

Figure 3. 2020 DHEC Mercury in Fish



Missing bars indicate <LLD. DHEC did not sample for the Hwy 17-Salt and background locations for mercury in 2020.

11.6.0 SUMMARY STATISTICS

2020 DHEC Cesium-137 Levels in Savannah River Fish (pCi/g–wet)

Edible	Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects	Number of Samples
Bass	0.279	0.191	0.228	0.119	0.491	3	6
Channel Catfish	0.059	0.031	0.059	0.037	0.080	2	6
Flathead Catfish	0.084	0.059	0.072	0.031	0.148	3	6

2020 DHEC Strontium-89/90 Levels in Savannah River Fish (pCi/g–wet)

Non-Edible	Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects	Number of Samples
Bass	0.024	0.007	0.024	0.016	0.033	6	6
Channel Catfish	0.011	0.004	0.010	0.007	0.018	6	6
Flathead Catfish	0.012	0.006	0.010	0.007	0.022	5	6

2020 DHEC Mercury Levels in Savannah River Fish (mg/kg)

Edible	Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detects	Number of Samples
Bass	0.402	0.061	0.400	0.340	0.470	6	6
Channel Catfish	0.130	0.031	0.110	0.110	0.180	5	6
Flathead Catfish	0.163	0.040	0.165	0.100	0.220	6	6

Cs-137 and mercury results represent the activity level in fish tissue
Sr-89/90 results represent the activity level in an aliquot of fish bone

Chapter 12 Game Animal Monitoring Adjacent to SRS

12.1.0 PROJECT SUMMARY

DHEC conducts game animal monitoring activities around SRS due to white-tailed deer and feral hogs having the highest potential of mammalian species for human exposure pathway from Cs-137 (Haselow, 1991). The game animal project addresses concerns of potentially contaminated white-tailed deer and feral hogs migrating off SRS. It also provides valuable information concerning potential exposure to Cs-137 from consuming game animals harvested around SRS.

White-tailed deer and feral hogs have access to several contaminated areas on and off SRS which allows them to be a vector for the redistribution of contaminants (primarily Cs-137). A five-mile study area was established based on a typical white-tailed deer upper limit home range to ensure that potentially contaminated deer residing at or near the SRS boundary would be included in the sample set.

Cesium-137 is the isotope of focus for game due to its ability to accumulate in an animal's skeletal muscles (Brisbin & Smith, 1975). When contaminated game is eaten by hunters, Cs-137 is readily incorporated into the human body because of its similarity to K-40 in physiological processes (Davis, 1963).

12.2.0 RESULTS AND DISCUSSION

Game Monitoring Summary Statistics can be found in Section 12.6.0 and all Game Monitoring Data can be found in the 2020 DHEC Data File.

DHEC analyzed muscle tissue collected in 2020 for Cs-137 from 26 deer and one hog collected from area hunters via hunting clubs, plantations, and Crackerneck Wildlife Management Area within a five-mile study area adjacent to SRS (Section 12.4.0, Map). Additionally, five deer tissue samples were collected and analyzed from a background location at Pinckney Island National Refuge. Sample size, location, and collection dates were dependent on the participating hunters.

Cesium-137 and the naturally occurring K-40, Pb-212, and Pb-214 were the only isotopes detected in game samples collected in 2020. Naturally occurring isotopes will not be discussed in this report. Cesium-137 concentrations from deer and hogs collected in the SRS perimeter study area are shown in Section 12.5.0, Figure 1.

DOE-SR does not collect game animal samples within the DHEC study area, and off-site hunter doses are based on DOE-SR models.

12.3.0 CONCLUSIONS AND RECOMMENDATIONS

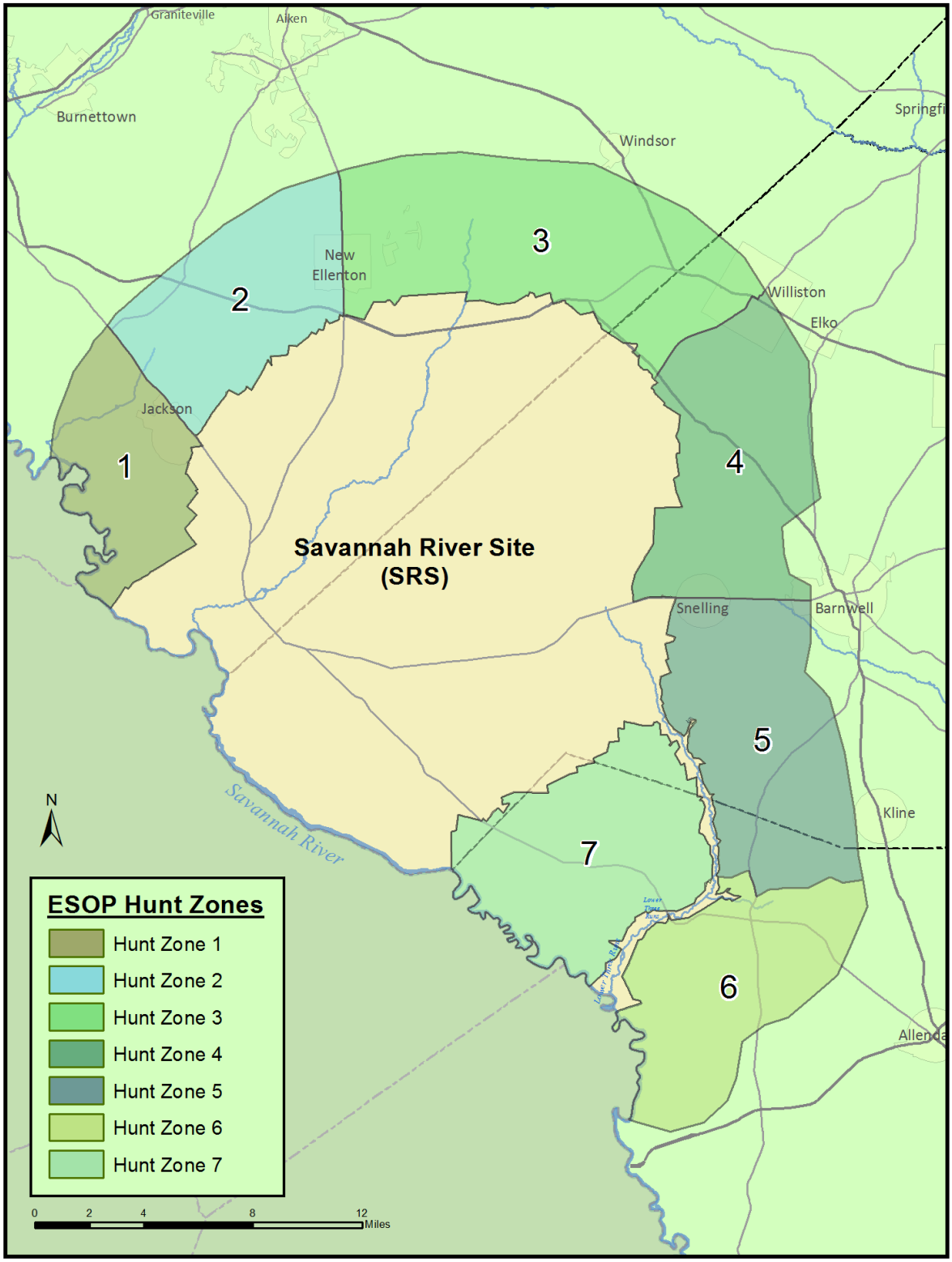
Historic SRS operations released known Cs-137 contamination to Steel Creek, Par Pond, Lower Three Runs, their floodplains, and the Savannah River swamp (Till et al., 2001), all of which impact hunt zones four, five, six, and seven (Section 12.4.0, Map). Although a portion of Cs-137 was deposited on SRS from site operations, levels found in the study area and background location are likely results of above ground nuclear weapons testing (Haselow, 1991).

Age, sex, body weight, soil type, diet, and collection location may affect the Cs-137 activities found in white-tailed deer and hogs (Haselow, 1991). A hunter consuming deer from SRS, the study area, or background locations would most likely ingest a portion of the activity associated with these animals. Refer to the 2020 DHEC Critical Pathway Dose section of this report for a better understanding of the contamination found in game versus other food sources.

DHEC will continue to monitor Cs-137 levels in deer and hogs within the established study area and background locations to assess trends. DHEC will continue to pursue new hunters within the five-mile study area to ensure adequate sample numbers can be achieved each year. DHEC will also put additional efforts into trapping wild hogs within the study area.

12.4.0 MAP

Game Monitoring Sampling Locations



2020 ESOP Game Animal Monitoring

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12.5.0 TABLES AND FIGURES

Figure 1. 2020 DHEC Hunt Zone Average Cs-137 Concentration in Game

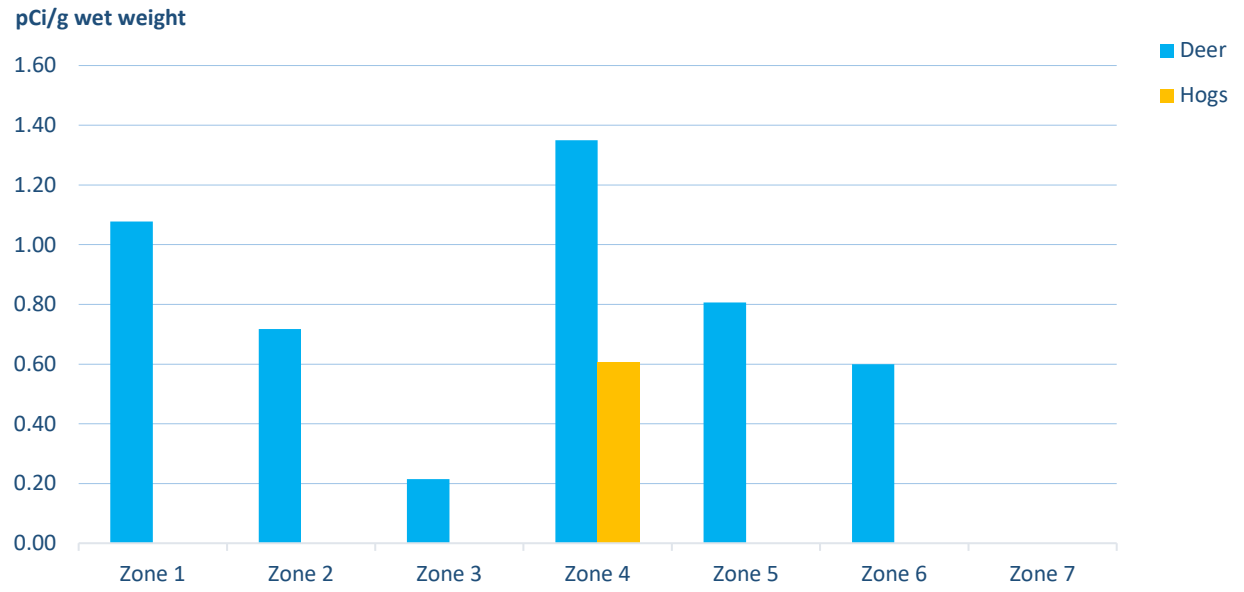
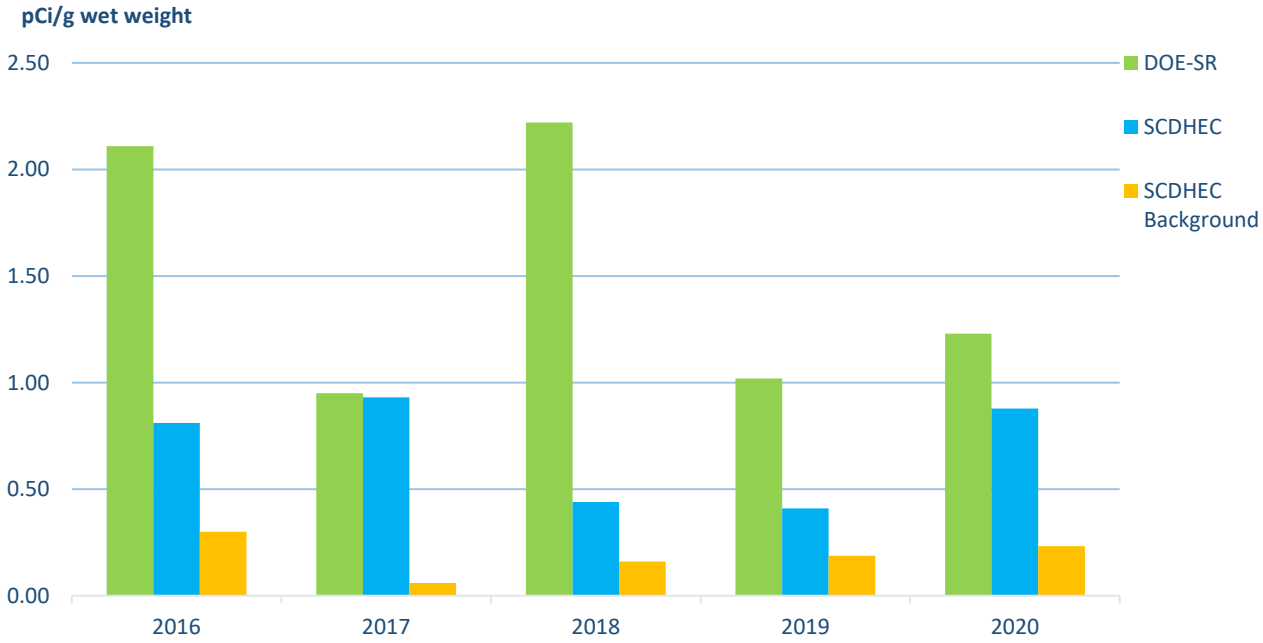


Figure 2. 2016-2020 Average Cs-137 Concentration in Deer (SRNS, 2017-2021; DHEC, 2018-2020b)



2016-2020 background location was Pinckney Island National Wildlife Refuge.
SRS data is from on-site deer only and DHEC data is from SRS 5-mile perimeter only.
DOE-SR data is the gross average concentration of Cs-137 calculated from field averages, which is used in an algorithm to provide a comparable dose to DHEC. DOE-SR lab's average Cs-137 concentration was 0.955 pCi/g.

12.6.0 SUMMARY STATISTICS

2020 Cs-137 Concentration (pCi/g wet weight) in Deer

	Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detections	Number of Samples
Study Area Deer	0.878	0.669	0.972	0.053	1.969	20	26
Background Deer	0.232	0.116	0.216	0.136	0.424	5	5

2020 Cs-137 Concentration (pCi/g wet weight) in Deer DHEC Hunt Zones

Hunt Zone	Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detections	Number of Samples
Zone 1 Deer	1.077	0.481	0.972	0.613	1.753	4	4
Zone 2 Deer	0.717	0.650	0.717	0.258	1.177	2	3
Zone 3 Deer	0.215	0.272	0.063	0.053	0.529	3	5
Zone 4 Deer	1.349	0.596	1.378	0.364	1.891	5	5
Zone 5 Deer	0.806	0.926	0.598	0.058	1.969	4	5
Zone 6 Deer	0.600	0.654	0.600	0.138	1.062	2	2
Zone 7 Deer	ND	NA	NA	<MDA	<MDA	0	2

2020 Cs-137 Concentration (pCi/g wet weight) in Hogs DHEC Hunt Zones

Hunt Zone	Average	Standard Deviation	Median	Minimum Detect	Maximum Detect	Number of Detections	Number of Samples
Zone 4 Hogs	NA	NA	NA	0.607	0.607	1	1

Zones 1, 2, 3, 5, 6, 7 and the background did not have hog samples in 2020

Chapter 13 Critical Pathway and Dose

13.1.0 PROJECT SUMMARY

DHEC implements a Radionuclide Critical Pathway/Dose Calculation Project to calculate the potential exposure or dose to the public within 50 miles of a SRS center point. This study area was chosen for comparison to the DOE-SR 80-km (50-mile) radius dose results. Individual project managers chose differing sample locations/schemes within this study area to establish trends in media radionuclide concentrations.

DHEC and DOE-SR programs were evaluated based on media potential exposure in mrem (Section 13.2.4). The figures in Section 13.4.0 illustrate the trends and central tendencies in the critical pathway potential dose exposures. The annual dose is calculated on average exposed individual (AEI) and maximum exposed individual (MEI) bases which are summarized in Section 13.4.0, Table 1.

13.2.0 RESULTS AND DISCUSSION

All 2020 Dose Data can be found in Section 13.5.0.

The DHEC MEI is a hypothetical subsistence and survivalist type of individual who resides downriver in the area below all SRS contributions to the Savannah River, visits the entire 50-mile perimeter study area, and receives the MEI dose based on the single highest detection per radionuclide per media detected in the environment. The 2020 data and dose results are discussed under the following headings in this section: 2020 AEI and MEI Dose, Critical Pathways 2020 Summary, and DOE-SR and DHEC 2020 Comparisons. Total AEI Dose covers the 2011-2020 period, whereas other headings discuss only 2020 data. Not all media were collected for all years during this summary period (2011-2020).

The critical pathways were analyzed both on a millirem (mrem) basis and percentage of dose basis (Section 13.4.0, Table 4). Percentages denote relative importance, whereas mrem denotes potential exposure levels. The dose critique attempts to point out the limits of this dose estimate and why any DOE-SR and DHEC estimates may or may not be similar.

13.2.1 2020 AEI and MEI Dose

The basis for dose calculations is not limited to a particular pathway of dose exposure based on lifestyle or media encountered but is simply a tabulation of all detected dose found in all media sampled regardless of applicability to an individual. Only the highest dose from the Savannah River-derived drinking water or the groundwater-derived drinking water was used in the AEI and MEI totals beginning in 2020 . The use of the highest contributor also applies to the dose from fish by the species of fish. Table 1 in Section 13.4.0 summarizes all DHEC detections by media on an AEI and MEI detection basis. Except for wild game, background sample results are not subtracted before dose calculations are performed.

The AEI dose is a conservative estimate based on consumption rates, represented by the consumption rate column in the data tables, average dose per media (Section 13.5.0), and is based on sample results only with no modeling. In 2020, the calculated AEI dose was 1.550 mrem (Section 13.4.0, Table 1), with 1.541 mrem from food dose. If wild game is not consumed,

the AEI dose falls to 0.126 mrem. The AEI dose skews high, as only detections are used in the dose calculations. For a typical person in the study area, the dose they receive should be lower than the AEI dose.

In 2020, the total calculated MEI dose was 4.189 mrem, of which 4.140 mrem was attributable to food consumption. If wild game is not consumed, the MEI dose falls to 0.820 mrem. The MEI basis column uses the single highest detection for a media radionuclide and calculates dose as if the high dose occurrence was somehow stored and the exposure continued throughout the year. If the individual did not store the media at the location, date, and time of DHEC sample collection and achieve a full year's exposure to that media, then the MEI estimate represents a sizable overestimate.

Only speciated doses for specific radionuclides were included in the estimated doses for 2020. The use of detections only in determining AEI dose per radionuclide per media, the calculation of dose based on the MEI detection for each radionuclide/media, and conservative consumption references provided a protective dose estimate. Each media radionuclide dose, excluding Naturally Occurring Radioactive Material (NORM), was considered as part of a critical pathway with contributions through the inhalation, ingestion, and direct exposure routes.

The MEI dose can be received by only one individual since that individual had to consume the specific dose basis animals. Two elevated dose bases (AEI and MEI) were used because they were measured and protective without the inclusion of screening value assumptions for alpha and beta. The assumption of all alpha as plutonium-239 (Pu-239) and all beta as strontium-90 (Sr-90) may double the calculated dose without evidence for that assumption in speciated data. Therefore, unspeciated dose assignments were discontinued in 2011 and replaced by calculating a MEI dose potential from the single highest detection per radionuclide per media.

13.2.2 Critical Pathways 2020 Summary

Atmospheric Pathway 2020 Summary

The DHEC 2020 atmospheric pathway contributed dose to the individual through the inhalation of tritium (H-3) in air, the consumption of food, predominantly from wild game but also including milk, edible vegetation, and fungi, as well as direct exposure from soil and the incidental consumption of soil with edible vegetation. Section 13.4.0, Table 2 illustrates the dominance of the atmospheric pathway, which accounted for 1.490 mrem, at 96.13 percent, of dose to the AEI and 3.553 mrem, at 84.82 percent, of dose to the MEI. The primary contributor to the atmospheric pathway was Cs-137 in wild game.

Liquid Pathway 2020 Summary

The DHEC 2020 liquid pathway estimated AEI dose to the individual was from the consumption of fish and drinking water from the Savannah River (Section 13.4.0, Table 2). The liquid pathway contributions to dose exposure were secondary to those contributed by the atmospheric pathway. In 2020, the liquid pathway contribution to the AEI was 0.060 mrem, accounting for 3.87 percent of dose. The contribution to the MEI dose was 0.636 mrem, at 15.18 percent. The primary contributor to dose in the liquid pathway was Cs-137 in fish.

Food Sub-pathway 2020 Summary

The food sub-pathway was covered under the atmospheric and liquid pathways except for these additional observations. The annual 2020 DHEC AEI food sub-pathway dose order, highest to lowest for averages, was wild game (deer; 1.205 mrem), wild game (hog; 0.219 mrem), fungi (0.063 mrem), fish (0.052 mrem), vegetation (0.001 mrem), and milk (0.001 mrem). Incidental soil ingestion did not contribute any quantifiable dose.

The 2020 MEI food pathway order was wild game (deer; 3.150 mrem), fish (0.590 mrem), wild game (hog; 0.219 mrem), fungi (0.173 mrem), milk (0.005 mrem), and vegetation (0.003 mrem). Incidental soil ingestion did not contribute any quantifiable dose. Cs-137 was the predominant dose contributor to food through the consumption of deer for the AEI and the MEI. It should be noted that deer and hog consumption rates are based on the edible portions of the relevant harvested animals and they vary from year to year. In 2020, only one hog was harvested, and the dose is based on a single animal. Cs-137 also contributed to dose from fish and Sr-89/90 contributed to dose from milk.

Isotopic Contribution Summary

Most of the AEI dose exposure in 2020 was due to Cs-137: 1.539 mrem (99.29 percent) of the 1.550 mrem total. The primary contributor to the Cs-137 AEI dose was wild game (deer). Tritium was the second highest dose contributor in 2020 at 0.010 mrem. Cesium-137, H-3, and Sr-89/90 were each detected in the atmospheric and the liquid pathways.

Cs-137 was also the primary contributor to the MEI, at 4.133 mrem (98.66 percent) of the 4.189 mrem total, with H-3 second, at 0.051 mrem. Cs-137 in wild game (deer) was the single largest dose contributor to the MEI.

13.2.3 2011-2020 Total AEI Dose

Section 13.4.0, Table 4 summarizes dose associated with all media on an AEI basis from 2011-2020. The critical pathway basis of comparison for DHEC detected dose comes from releases of radionuclides that were deposited outside of SRS during 2011-2020 and within 50 miles of the SRS center point although animals that are harvested off-site may have migrated from on-site.

Table 4 illustrates the dominance of the atmospheric pathway accumulated dose which accounted for 93.04 percent, over the liquid pathway, at 6.96 percent. The food sub-pathway was the dominant route, accounting for 99.45 percent of accumulated exposure. The AEI received a 2.991 mrem average dose per year during the 2011-2020 period. If doing comparisons with the average dose for the 2010-2019 year period, please note that there is a misplaced decimal point in last year's publication. The yearly average AEI dose for that period was 3.119 mrem.

Section 13.4.0, Figures 1-3, and Table 4 illustrate the various pathways of dose exposure. The AEI basis critical pathway dose for 2020, 1.550 mrem, is less than the 7.00 mrem dose an individual typically receives from living in a brick house for one year (Wahl, 2011). Section 13.4.0, Figures 1-3 illustrate the media exposure trends via line graphs.

The predominant source of AEI exposure from 2011-2020 was wild game (deer and hog). The total dose for wild game over the past ten years was 22.727 mrem, which amounts to 75.98 percent of the total accumulated AEI exposure (29.911 mrem) during that time period. Following wild game were fungi (3.838 mrem; 12.83 percent), fish (1.946 mrem; 6.51 percent), and edible vegetation (1.019 mrem; 3.41 percent). Furthermore, wild game accounted for 81.67 percent of the accumulated dose from the atmospheric pathway and 76.41 percent of the food sub-pathway.

The predominant route of accumulated exposure from 2011-2020 for water sources was public system water from the Savannah River (0.100 mrem). Groundwater-derived drinking water accounted for 0.030 mrem. However, groundwater is no longer added into the total (only the highest source of drinking water is used). The primary routes for minor sources of accumulated dose were incidental ingestion from swimming (0.026 mrem) and from the inhalation of tritium in air (0.020 mrem).

13.2.4 DOE-SR and DHEC 2020 Comparisons

DOE-SR calculates potential doses to members of the public from atmospheric and liquid releases, as well as from special-case exposure scenarios, on an annual basis (SRNS, 2021). These include liquid pathway and air pathway doses, an all-pathway dose, a sportsman dose, on-site and off-site hunter doses, and an off-site fisherman dose. The DOE-SR dose estimates are analogous to DHEC dose estimates as follows, although it must be noted that there are differences between DOE-SR and DHEC sampling and dose estimation protocols:

1. The DOE-SR all-pathway dose and the sum of the DHEC fish, wading, swimming, public system drinking water from the Savannah River, vegetation, milk, and inhalation doses, serve as a means of comparison of the dose a member of the public in the study area (an individual who doesn't consume wild game or gather edible mushrooms) could receive from SRS activities during a given year.

2. The DOE-SR off-site hog consumption, off-site deer consumption, and swamp fisherman doses and the DHEC hog dose, deer dose, and fish dose at the mouth of Steel Creek serve as a means of comparison of the dose a survivalist type of individual who consumes fish from the Savannah River and wild game could receive in a given year.

3. The DOE-SR creek mouth fisherman dose being derived from fish caught at the mouth of Steel Creek: DHEC uses only that location to calculate a comparable creek fisherman dose. In 2020 the highest DOE-SR fish dose applicable to the public was from the Steel Creek location. Therefore, the DHEC Swamp Fisherman, which includes the fish results only, and Creek Mouth Fisherman doses are the same for 2020.

The DOE-SR all-pathways representative person dose and the DHEC all-pathway approximation were the most relevant dose estimates that represent the potential dose exposure for the public in 2020. The DOE-SR all-pathways representative person dose for 2020 was 0.36 mrem (Section 13.4.0, Table 3). The sum of the DHEC fish, wading, swimming, public system drinking water from the Savannah River, vegetation, milk, and inhalation doses was 0.33 mrem in 2020. The DHEC all-pathway approximation for 2020 is 0.33 percent of the DOE all-pathway dose standard of 100 mrem/year (SRNS, 2021).

In 2020, the DOE-SR creek mouth fisherman dose (0.531 mrem), which used bass caught from the mouth of Steel Creek, was higher than DHEC's estimate from the same location (0.274 mrem). The DOE-SR off-site deer hunter dose estimate of 2.97 mrem was lower than DHEC's 3.15 mrem estimate while the off-site hog hunter estimate of 5.01 mrem was higher than DHEC's 0.219 mrem estimate (Section 13.4.0, Table 3) (SRNS, 2021).

13.2.5 Dose Critique

In 2020, most sampling resulted in less than minimum detectable activity (MDA) determinations and was not included in the DHEC summary statistics, which used detections only. The use of detections only in calculations was protective and biases the measures of central tendency higher (Gilbert, 1987).

The NORM averages and maximums were not included in the dose estimates as this dose was considered part of the background dose for the study area. The yearly dose averages were inflated since most sample results were less than MDA. The justification for using detections only was to allow for undetected radionuclides and media. The justification for selecting higher source consumption levels was due to the conceptualization of the DHEC MEI as a survivalist type who consumed natural media at a greater than typical use rate. The basis for both considerations was to be protective of the public and environment.

The inclusion of alpha and beta assumed dose in the past provided an excessively high dose estimate and was not supported by media radionuclide species detections. The inclusion of calculations based on a single highest maximum detection for each radionuclide/media was a more definable basis for establishing an upper bound rather than the dose assumption of unknown alpha as Pu-239 and unknown beta as Sr-90. This upper bound is not practically achievable by the MEI due to the unlikely probability of exposure to all maximums at a constant rate throughout the year (via storage of media). However, since most of the dose was due to wild-type food (whether animal or plant) consumption containing Cs-137, then a single individual who ate all of the highest dose deer, hog, and edible plant and mushrooms could approach the MEI dose if these media were stored and consumed over the entire year.

DHEC used dose instead of risk so that direct comparisons of dose could be made with similar media data published in DOE-SR's Annual Site Environmental Reports. DOE-SR-modeled radionuclide releases for a particular year were not directly comparable to DHEC's yearly detected dose in some media due to bioaccumulation.

13.3.0 CONCLUSIONS AND RECOMMENDATIONS

The 2020 results indicated that monitoring of the primary inhalation, ingestion, and direct exposure routes from the atmospheric and liquid pathways should continue. Groundwater, surface water, sediments, plants, and animals should be monitored for signs of contaminants that are associated with past and present SRS operations. Early detection is paramount to protecting the public and the environment if a release to off-site streams or atmosphere occurs. DHEC will continue to monitor SRS and adjacent areas for the primary radionuclide contributors to dose.

13.4.0 TABLES AND FIGURES

Table 1. DHEC Dose Estimates (mrem) for all Media: AEI and MEI

Pathway	Route	Source of Exposure	AEI	MEI
Atmospheric	Inhalation	Surface Soil Resuspension	0.000	0.000
Atmospheric	Inhalation	Inhalation of H-3 in Air	0.001	0.002
Air Inhalation Total			**0.001**	**0.002**
Liquid	Ingestion	Fish	0.052	0.590
Atmospheric	Ingestion	Cow Milk	0.001	0.005
Atmospheric	Ingestion	Wild Game (Deer)	1.205	3.150
Atmospheric	Ingestion	Wild Game (Hog)	0.219	0.219
Atmospheric	Ingestion	Vegetation (Fruit and Vegetables)	0.001	0.003
Atmospheric	Ingestion	Fungi	0.063	0.173
Atmospheric	Ingestion	Soil Ingestion with Food	0.000	0.000
Food Ingestion Total			**1.541**	**4.140**
Liquid	Ingestion	Public System Drinking Water - Savannah River	0.008	0.043
Liquid	Ingestion	Drinking Water - Groundwater	0.005	0.014
Liquid	Ingestion	Ingestion from Swimming	0.000	0.003
Drinking Water Total			**0.008**	**0.046**
Liquid	Direct	Direct Exposure from Swimming	0.000	0.000
Liquid	Direct	Direct Exposure from Wading	0.000	0.000
Atmospheric	Direct	Direct Exposure from Farm Soil	0.000	0.001
Direct Exposure Total			**0.000**	**0.001**
Overall Total Dose			**1.550**	**4.189**

ND is No Detections
Drinking Water - Groundwater includes both public and private wells.
Drinking Water Total is the sum of the Savannah River/Groundwater dose, whichever is higher, and the Ingestion from Swimming dose.
The Wild Game (Hog) dose for 2020 is based on one animal. Therefore, the AEI and the MEI are the same.

Table 2. DHEC Dose Estimates (mrem) for the Atmospheric and Liquid Pathways: AEI and MEI

Critical Pathway Summary	AEI	MEI
The Atmospheric Pathway Totals	1.490	3.553
The Liquid Pathway Totals	0.060	0.636
Combined Dose	**1.550**	**4.189**

TABLES AND FIGURES

Table 3. DHEC/DOE-SR Dose Comparisons

Pathway	Comparison Basis	DOE-SR[1]	DHEC[2]
All-Pathway	DHEC All-Pathway Approximation[3]	0.36	0.33
Sportsman	On-site Hunter	10.6	NS
	On-site Turkey	NS[6]	NS
	Swamp Fisherman (fish only)[4]	0.531	0.274
	Creek Mouth Fisherman[5]	0.531	0.274
	Off-site Hunter Deer	2.97	3.15
	Off-site Hunter Hog	5.01	0.219
	Edible Fungi	NS	0.173

1. DOE-SR data from Table 6-5a and Table 6-6 (SRNS, 2021).
2. Based on DHEC maximums or single highest detection basis for all media per route of exposure unless otherwise specified (Table 1).
3. Sum of DHEC highest Steel Creek fish, wading exposure, swimming ingestion, Savannah River-derived drinking water (treated only), vegetation, milk, and atmospheric inhalation.
4. Compares DOE-SR and DHEC bass results from the mouth of Steel Creek (DHEC location SV-2017).
5. Compares DOE-SR and DHEC bass results from the mouth of Steel Creek. (DHEC location SV-2017). As Steel Creek accounted for the highest DOE-SR fish detection in 2020, the Swamp Fisherman and Creek Mouth Fisherman sample results are the same when soil is excluded.
6. There were no turkey hunts in 2020.

TABLES AND FIGURES

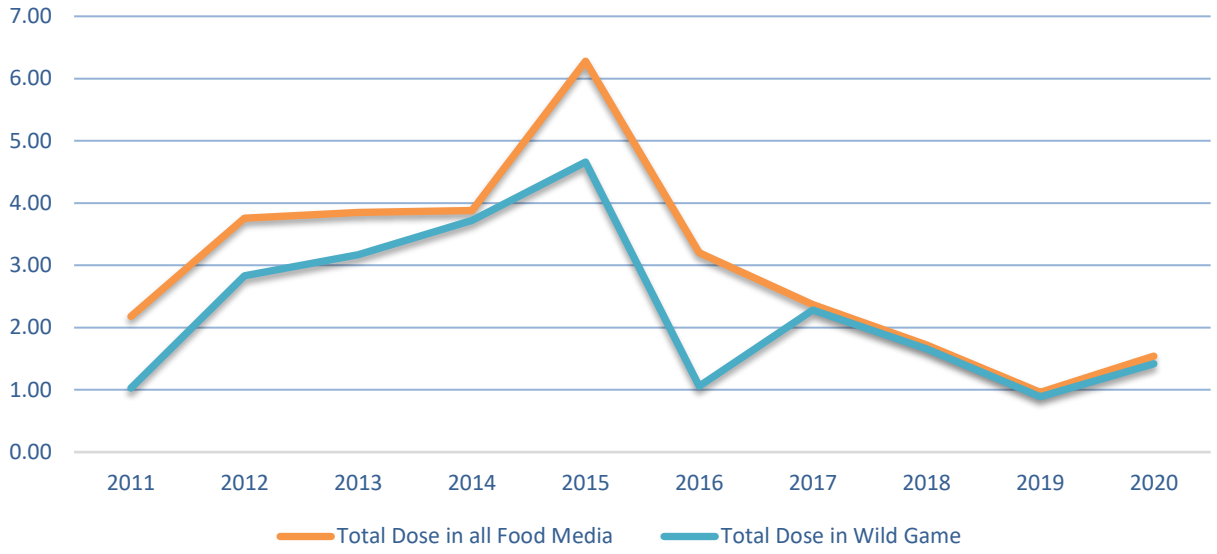
Table 4. 2011-2020 AEI Exposure: Total AEI Dose (mrem) and Percentage

Pathway	AEI Media Categories	2020[1]	2011-2020[2]	2011-2020 % AEI[3]
Atmospheric	Surface Soil Resuspension Inhalation	0.000	0.009	0.03
Atmospheric	H-3 Inhalation	0.001	0.020	0.07
Liquid	Fish	0.052	1.946	6.51
Atmospheric	Cow Milk	0.001	0.215	0.72
Atmospheric	Wild Game (Deer and Hog)	1.424	22.727	75.98
Atmospheric	Vegetation (Leafy, Fruit, and Nuts)	0.001	1.019	3.41
Atmospheric	Fungi	0.063	3.838	12.83
Atmospheric	Soil Ingestion with Food	0.000	0.000	0.00
Liquid	Drinking Water from the Savannah River	0.008	0.100	0.33
Liquid	Drinking Water from Groundwater[4]	0.005	0.030	NA
Liquid	Ingestion from Swimming	0.000	0.026	0.09
Liquid	Direct Exposure from Swimming	0.000	0.000	0.00
Liquid	Direct Exposure from Wading	0.000	0.010	0.03
Atmospheric	Direct Exposure from Farm Soil	0.000	0.001	0.00
Totals		1.550	29.911	100%

1. The 2020 column is average dose in mrem during 2020.
2. The 2011-2020 column is total dose in mrem over the 2011-2020 ten-year period.
3. The AEI % basis column is the percentage of the 2011-2020 total dose due to a given media.
4. Only the highest drinking water source is used for the ten-year total and percentages.
5. If doing comparisons with the average dose for the 2010-2019 year period, please note that there is a misplaced decimal point in last year's publication. The yearly average AEI dose for that period was 3.119 mrem.

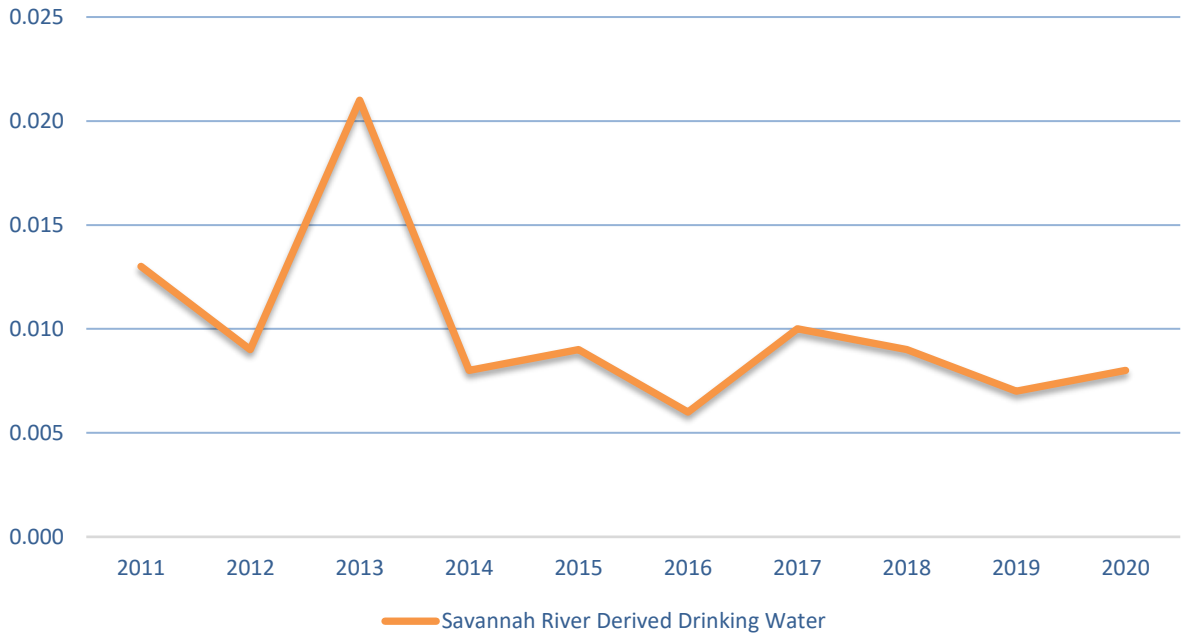
TABLES AND FIGURES

Figure 1. 2011-2020 DHEC AEI Food Dose



This graph shows the total food AEI dose trend and the trend for the primary contributor to that dose in mrem.

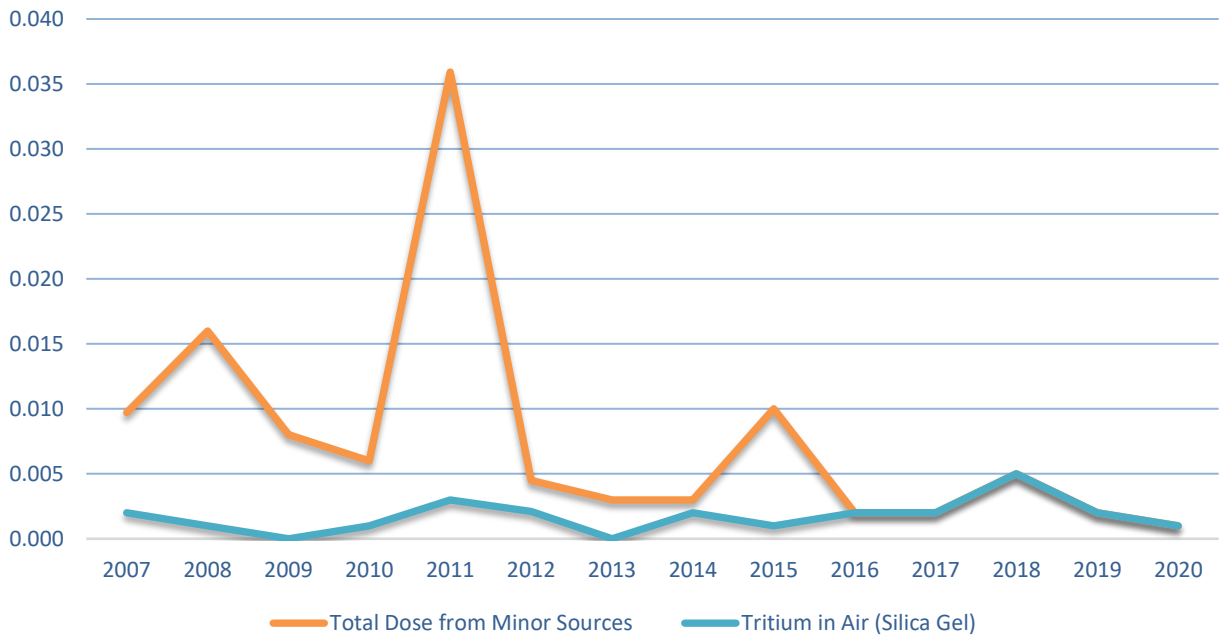
Figure 2. 2011-2020 DHEC AEI Water Dose



This graph shows the water AEI dose trend for drinking water obtained from the Savannah River in mrem. Only groundwater-derived or Savannah River-derived drinking water is used, whichever is higher.

TABLES AND FIGURES

Figure 3. 2011-2020 DHEC AEI Dose from Minor Sources



This graph shows the total minor sources AEI dose trend and the trend for the primary contributor to that dose in mrem.

13.5.0 2020 DOSE DATA

AEI Fish Dose

Dose from Fish Ingestion (AEI)				
Media	**Radionuclide**	**Activity (pCi/g)**	**Consumption Rate (kg/yr)**	**Dose (mrem)**
Bass	Cs-137	0.279	3.7	0.052
Bass	Sr-89/90	0.024	3.7	0.000
Channel Catfish	Cs-137	0.059	3.7	0.000
Channel Catfish	Sr-89/90	0.011	3.7	0.000
Flathead Catfish	Cs-137	0.084	3.7	0.016
Flathead Catfish	Sr-89/90	0.022	3.7	0.000
Drum	Cs-137	ND	3.7	ND
Drum	Sr-89/90	0.014	3.7	0.000
Mullet	Cs-137	ND	3.7	ND
Mullet	Sr-89/90	0.019	3.7	0.000
Fish Total			**0.052**	

MEI Fish Dose

Dose from Fish Ingestion (MEI)				
Media	**Radionuclide**	**Activity (pCi/g)**	**Consumption Rate (kg/yr)**	**Dose (mrem)**
Bass	Cs-137	0.491	24.0	0.590
Bass	Sr-89/90	0.033	24.0	0.000
Channel Catfish	Cs-137	0.080	24.0	0.096
Channel Catfish	Sr-89/90	0.018	24.0	0.000
Flathead Catfish	Cs-137	0.148	24.0	0.178
Flathead Catfish	Sr-89/90	0.022	24.0	0.000
Drum	Cs-137	ND	24.0	ND
Drum	Sr-89/90	0.014	24.0	0.000
Mullet	Cs-137	ND	24.0	ND
Mullet	Sr-89/90	0.019	24.0	0.000
Fish Total			**0.590**	

ND is No Detects
All consumption rates are from Aranceta et al., 2006; Botsch et al., 2000; EPA, 2011; and SRNS, 2021.

2020 DOSE DATA

AEI Milk Dose

Dose from Milk (AEI)				
Media	**Radionuclide**	**Activity (pCi/L)**	**Consumption Rate (kg/yr)**	**Dose (mrem)**
Milk	H-3	ND	69.0	ND
Milk	Cs-137	ND	69.0	ND
Milk	Sr-89/90	1.16	69.0	0.001
Milk	I-131	ND	69.0	ND
Milk Total			**0.001**	

MEI Milk Dose

Dose from Milk (MEI)				
Media	Radionuclide	**Activity (pCi/L)**	**Consumption Rate (kg/yr)**	**Dose (mrem)**
Milk	H-3	ND	260.0	ND
Milk	Cs-137	ND	260.0	ND
Milk	Sr-89/90	1.71	260.0	0.005
Milk	I-131	ND	260.0	ND
Milk Total			**0.005**	

AEI Wild Game Dose

Dose from Wild Game (AEI)		
Media	**Radionuclide**	**Dose**
Deer	Cs-137	1.205
Hog	Cs-137	0.219
Game Total		**1.424**

Deer AEI is based on an edible portion of 56 lbs.; Hog AEI is based on an edible portion of 90 lbs.

MEI Wild Game Dose

Dose from Wild Game (MEI)		
Media	**Radionuclide**	**Dose**
Deer	Cs-137	3.150
Hog	Cs-137	0.219
Game Total		**3.369**

Deer MEI is based on an edible portion of 83 lbs.; Hog MEI is based on an edible portion of 90 lbs.

2020 DOSE DATA

AEI Edible Vegetation Dose

Dose in Edible Vegetation (AEI)				
Media	**Radionuclide**	**Activity (pCi/g)**	**Consumption Rate (kg/yr)**	**Dose (mrem)**
Fruit and Vegetables	H-3	0.220	92	0.001
	Cs-137	ND	92	ND
Fruit and Vegetable Total				**0.001**
Nuts	H-3	NS	NA	NA
	Cs-137	NS	NA	NA
Nuts Total				**NA**
Fungi	H-3	ND	3.65	ND
	Cs-137	0.345	3.65	0.063
Fungi Total				**0.063**
Combined Vegetation Total				**0.064**

2020 MEI Edible Vegetation Dose

Dose in Edible Vegetation (MEI)				
Media	**Radionuclide**	**Activity (pCi/g)**	**Consumption Rate (kg/yr)**	**Dose (mrem)**
Fruit and Vegetables	H-3	0.220	248	0.003
	Cs-137	ND	248	ND
Fruit and Vegetable Total				**0.003**
Nuts	H-3	NS	NA	NA
	Cs-137	NS	NA	NA
Nuts Total				**NA**
Fungi	H-3	ND	10	ND
	Cs-137	0.345	10	0.173
Fungi Total				**0.173**
Combined Vegetation Total				**0.176**

ND is No Detects
NA is Not Applicable
NS is Not Sampled

2020 DOSE DATA

2020 AEI Ingestion from Surface Water and Wells Dose

Ingestion from Surface Water and Wells (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Savannah River Sourced Drinking Water		pCi/L	L/yr	mrem
Surface Water	**H-3**	**391**	**300**	**0.008**
Groundwater Sourced Drinking Water		pCi/L	L/yr	mrem
Groundwater	**H-3**	**248**	**300**	**0.005**
Ingestion from Surface Water and Wells Total				**0.008**

2020 MEI Ingestion from Surface Water and Wells Dose

Ingestion from Surface Water and Wells (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Savannah River Sourced Drinking Water		pCi/L	L/yr	mrem
Surface Water	**H-3**	**837**	**800**	**0.043**
Groundwater Sourced Drinking Water		pCi/L	L/yr	Mrem
Groundwater	**H-3**	**273**	**800**	**0.014**
Ingestion from Surface Water and Wells Total				**0.043**

Groundwater aquifers that are known to be used for drinking water were used and samples were collected as part of the groundwater project. Individual groundwater-sourced drinking water taps were not sampled.

Only the highest dose is used for the total.

2020 DOSE DATA

AEI Incidental Water Ingestion and Direct Exposure from Water Dose

Incidental Water Ingestion and Direct Exposure from Water (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Swimming at Savannah River Creek Mouths				
Surface Water Swimming	H-3	pCi/L	L/yr	mrem
Ingestion		**1780**	**0.189**	**0.000**
Surface Water Swimming	H-3	pCi/L	hrs/yr	mrem
Surface Water Immersion		**1780**	**9**	**0.000**
Savannah River Creek Mouth Total				**0.000**

MEI Incidental Water Ingestion and Direct Exposure from Water Dose

Incidental Water Ingestion and Direct Exposure from Water (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Swimming at Savannah River Creek Mouths				
Surface Water Swimming	H-3	pCi/L	L/yr	mrem
Ingestion		**19992**	**2.57**	**0.003**
Surface Water Swimming	H-3	pCi/L	hrs/yr	mrem
Surface Water Immersion		**19992**	**36**	**0.000**
Savannah River Creek Mouth Total				**0.003**

AEI Sediment at Creek Mouths and Boat Landings Dose

Sediment at Creek Mouths and Boat Landings (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Sediment Dose		pCi/g	hrs/yr	mrem
Creek Mouths	Cs-137	0.441	9	0.000
Boat Landings	Cs-137	0.460	9	0.000
Sediment Total				**0.000**

MEI Sediment at Creek Mouths and Boat Landings Dose

Sediment at Creek Mouths and Boat Landings (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Sediment Dose		pCi/g	hrs/yr	mrem
Creek Mouths	Cs-137	1.12	36	0.000
Boat Landings	Cs-137	1.08	36	0.000
Sediment Total				**0.000**

2020 DOSE DATA

AEI Surface Soil Ingestion Dose

Surface Soil Ingestion (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil		pCi/g	Mg/day	mrem
Ingestion	Cs-137	0.121	20	0.000
Soil Ingestion Total				**0.000**

This represents soil inadvertently consumed with plants.

MEI Surface Soil Ingestion Dose

Surface Soil Ingestion (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil		pCi/g	Mg/day	mrem
Ingestion	Cs-137	0.169	20	0.000
Soil Ingestion Total				**0.000**

This represents soil inadvertently consumed with plants.

AEI Soil Direct Dose

Soil Direct (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil		pCi/g	hrs/yr	mrem
External Direct	Cs-137	0.121	2602	0.000
Direct Soil Total				**0.000**

The consumption rate is from Edwards et al., 2012.

2020 MEI Soil Direct Dose

Soil Direct (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil		pCi/g	hrs/yr	mrem
External Direct	Cs-137	0.169	2602	0.001
Direct Soil Total				**0.001**

The consumption rate is from Edwards et al., 2012.

2020 DOSE DATA

AEI Atmospheric Inhalation Dose

Atmospheric Inhalation (AEI)				
Surface Soil Resuspension and Air Inhalation				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil Resuspension		**pCi/g**	**m3/yr**	**mrem**
Inhalation	Cs-137	0.121	5000	0.000
Surface Soil Resuspension Total				**0.000**
Air Inhalation (Silica Gel)		**pCi/m^3**	**m3/yr**	**mrem**
Inhalation	H-3	3.64	5000	0.001
Atmospheric Inhalation Total				**0.001**

MEI Atmospheric Inhalation Dose

Atmospheric Inhalation (MEI)				
Surface Soil Resuspension and Air Inhalation				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil Resuspension		**pCi/g**	**m3/yr**	**mrem**
Inhalation	Cs-137	0.169	6400	0.000
Surface Soil Resuspension Total				**0.000**
Air Inhalation (Silica Gel)		**pCi/m^3**	**m3/yr**	**Mrem**
Inhalation	H-3	4.66	6400	0.002
Atmospheric Inhalation Total				**0.002**

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