ESOP

Environmental Surveillance and Oversight Program

2012 DATA REPORT

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PROMOTE PROTECT PROSPER
South Carolina Department of Health
and Environmental Control

CR-004111 4/14

Introduction

The South Carolina Department of Health and Environmental Control's (SCDHEC) Environmental Surveillance and Oversight Program (ESOP) supports and complements SCDHEC's comprehensive regulatory program at the Savannah River Site (SRS) by focusing on those activities not supported or covered through our normal regulatory framework. The primary function of the ESOP is to evaluate the effectiveness of SRS monitoring activities. To accomplish this function, the ESOP conducts non regulatory monitoring activities on and around the SRS, conducts evaluations of the SRS monitoring program and provides an independent source of information to the public pertaining to levels of contaminants in the environment from historical and current SRS operations.

This report includes a description of the ESOP's multi-media monitoring network and activities along with a summary of the findings of the ESOP from the 2012 calendar year monitoring period.

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Section 1 2012 Air Monitoring

Chapter 1 **Radiological Atmospheric Monitoring**

2012 Radiological Atmospheric Monitoring On and Adjacent to the Savannah River Site

Environmental Surveillance and Oversight Program

97AA007

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January 1, 2012 – December 31, 2012

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1.0 PROJECT SUMMARY

Atmospheric transport has a significant potential to impact the citizens of South Carolina from releases associated with activities at the Savannah River Site (SRS). This project provides independent quantitative monitoring of atmospheric radionuclide releases associated with the SRS. This provides monitoring of atmospheric media on a routine basis to measure radionuclide concentrations in the surrounding environment and to identify trends that may require further investigation. Radiological atmospheric monitoring sites were established to provide spatial coverage of the project area.

The South Carolina Department of Health and Environmental Control (SCDHEC) Environmental Surveillance and Oversight Program (ESOP) air monitoring capabilities in 2012 included eight air-monitoring stations with the capacity for sample collection using glass fiber filters, rain collection pans, silica gel columns, and 19 thermoluminescent dosimeters (TLDs). Five of the air-monitoring stations are on or within two miles of the SRS perimeter; New Ellenton (NEL), Jackson (JAK), Allendale Barricade (ABR), South Carolina Advanced Technology Park in Snelling (SCT), and Dark Horse at the Williston Barricade (DKH); one at the center of the site, Burial Grounds North (BGN); and two are within 25 miles of the site - Aiken (AIK) and Allendale (ALN). Thirteen of the TLDs 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. Only perimeter air monitoring stations and TLDs are used for comparison. Refer to map 1 in Section 4.0 for specific monitoring locations.

The glass fiber filters were used to collect total suspended particulates (TSP). Particulates were screened weekly for gross alpha and gross beta-emitting activity. Precipitation, when present, was sampled and analyzed monthly for tritium. Silica gel distillates of atmospheric moisture were analyzed monthly for tritium. TLDs were collected and analyzed every quarter for ambient beta/gamma levels. SCDHEC emphasizes monitoring for radionuclides in atmospheric media around the SRS at potential public exposure locations.

SCDHEC data substantiated historically reported Department of Energy-Savannah River (DOE-SR) values for radionuclides in the ambient environment at or near the SRS boundary. Average DOE-SR atmospheric radiological monitoring results for gross alpha/beta in air, ambient beta/gamma, and tritium in precipitation at the SRS boundary were within two standard deviations of the SCDHEC reported average values. Variations in atmospheric radiological monitoring results between SCDHEC and DOE-SR are likely a result of differences in monitoring locations, local meteorological conditions, frequency of sampling, and number of locations. Reported differences are at regional background levels and present no difference with regard to the impact on public health.

In summary, no United States Environmental Protection Agency (USEPA) air standards were exceeded at the monitored locations. Sampling results by SCDHEC indicate that SRS activities had a measurable but negligible impact on local air quality.

2.0 RESULTS AND DISCUSSION

Total Suspended Particulates

Gross Alpha

During the 2012 sampling period, gross alpha activity ranged from <LLD (Less than Lower Limit of Detection) to 0.0126 picoCuries per cubic meter (pCi/m^3) at the site perimeter (NEL, JAK, ABR, SCT, and DKH). The maximum gross alpha detection was collected on November 27 at the ABR air station. Values in this range are typically associated with naturally occurring alpha-emitting radionuclides, primarily as decay products of radon, and are considered normal (Kathren 1984). The SCDHEC average gross alpha radionuclide concentration in 2012 was 0.0033 (± 0.0027) pCi/m^3. The DOE-SR gross alpha average of 0.0011 (± 0.0005) pCi/m^3 is within one standard deviation of the SCDHEC gross alpha activity average (SRNS 2012). Section 5.0, Figure 1 shows average gross alpha activity for SRS perimeter locations and illustrates trending of gross alpha values for SCDHEC and DOE-SR.

Gross Beta

During the 2012 sampling period, the site perimeter (NEL, JAK, ABR, SCT, and DKH) gross beta concentrations ranged from 0.0093 to 0.0442 pCi/m^3. The maximum gross beta detection was collected on November 27 at the JAK air station. The average gross beta concentration reported by SCDHEC in 2012 was 0.0229 (±0.0065) pCi/m^3. Section 5.0, Figures 6-11 show SCDHEC trending for 2012 for both gross alpha and gross beta. Values in this range are typically associated with naturally occurring beta-emitting radionuclides, primarily as decay products of radon (Kathren 1984). Small seasonal variations at each monitoring location have been consistent with historically reported SCDHEC values (SCDHEC 2007). The USEPA Office of Radiation and Indoor Air uses gross beta counts as an indicator to determine if additional analyses will be performed. A gamma scan is conducted if the gross beta activity exceeds 1 pCi/m^3 (USEPA 2013). This tiering of definitive analyses is used for all total suspended particulate sampling associated with RadNet. RadNet is comprised of a nationwide network of sampling stations that identify trends in the accumulation of long-lived radionuclides in the environment (USEPA 2005). The DOE-SR gross beta average of 0.0129 (± 0.0040) pCi/m^3 is within two standard deviations of the SCDHEC gross beta activity average (SRNS 2012). Over the past several years, SCDHEC has seen a slight increase in gross beta while DOE-SR results have remained stable. Section 5.0, Figure 2 shows average gross beta activity for the SRS perimeter locations and illustrates trending of gross beta values for SCDHEC and DOE-SR.

Radiochemical Particulate Data

First quarter glass fiber filters were composited and analyzed for plutonium 238 and 239/240. There were no detections of either analyte.

Ambient Beta/Gamma

SCDHEC conducts ambient beta/gamma monitoring through the deployment of TLDs around the perimeter of the SRS. Ambient beta/gamma levels measured with TLDs are provided for all quarters of 2012. It should be noted that 4 millirem (mrem) are subtracted from the reported result for each TLD to account for the transcontinental flight from South Carolina to California and back (Walter 1995). During the 2012 sampling period, total combined quarterly ambient beta/gamma ranged from 58 to 95 mrem, at the site perimeter. The maximum ambient beta/gamma detection was collected at the US 278 at Upper Three Runs Creek location. The SCDHEC average ambient beta/gamma activity for perimeter TLDs in 2012 was 76.69 (±9.72) mrem. The DOE-SR average ambient beta/gamma activity was 83.39 (± 11.34) mrem for 2012 (SRNS 2012). The DOE-SR ambient/beta gamma average was within one standard deviation of the SCDHEC average. During the sampling period, SCDHEC external radiation levels at monitored locations were slightly lower than levels reported by DOE-SR. Over the past six years, there have been no major increases or decreases in the average ambient beta/gamma activity reported by DOE-SR or SCDHEC. Section 5.0, Figure 3 shows trends at the SRS perimeter for averaged ambient beta/gamma values for DOE-SR and SCDHEC.

Tritium

Tritium continues to be the predominant radionuclide detected in the perimeter samples. During 2012, DOE-SR released approximately 16,700 Ci of tritium from SRS (SRNS 2012). Most of the tritium detected in SCDHEC perimeter samples may be attributed to the release of tritium from tritium facilities, separation areas, and from diffuse and fugitive sources (SRNS 2012).

Tritium In Air

Tritium in air values reported by SCDHEC are the result of using the historical means 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 (NCRP 1984). SCDHEC tritium results greater than the LLD are then converted from picocuries per liter (pCi/L) to pCi/m^3 using the formula:

$$\text{pCi/L} = \frac{\text{pCi/ml}(11.5)}{1000} = \text{pCi/m}^3$$

During the 2012 sampling period, tritium in air ranged from <LLD to 8.82 pCi/m^3. The maximum perimeter tritium in air activity was collected at the DKH air station in January. The SCDHEC average measured activity for tritium in air was 4.14 (±1.42) pCi/m^3. The SCDHEC average for tritium activity was well below the USEPA equivalent yearly average standard of 20,000 pCi/m^3 for airborne tritium activity (ANL 2007). The DOE-SR average measured value for tritium activity in air at the SRS perimeter was 12.11(± 4.35) pCi/m^3 (SRNS 2012). DOE-SR average measured values for tritium in atmospheric moisture were higher than SCDHEC average measured values for the SRS perimeter (SRNS 2012). The DOE-SR average measured activity for tritium was within two standard deviations of the SCDHEC measured average. This difference may be attributed to a dilution that occurs when desiccants are used for collecting atmospheric moisture for tritium analysis. Prior to deployment in the field, silica-gel desiccant is dried to remove any moisture. However, a small percentage of water remains in the desiccant. This results in a slight dilution of the collected sample, which is reflected in the distillate. Another factor that may contribute to the lower SCDHEC air tritium values is that only two of the monitoring stations are exactly on the SRS perimeter (property line); while the other three points used for this comparison are located in population centers, approximately two miles from the SRS property line.

Average DOE-SR tritium in air activity was higher than the SCDHEC measured activity but well within the same order-of-magnitude. These variations could be caused by different sampling locations, number of locations, or sample frequency.

Average tritium in air activity at the SRS perimeter reported by SCDHEC for 2012 was lower than reported in 2011 and has fluctuated over the last six years. DOE-SR also reported a slight increase from 2011 to 2012 with fluctuations over the past six years. Section 5.0, Figure 4 illustrates trending of atmospheric tritium activity for SCDHEC and DOE-SR as measured and calculated at the SRS perimeter. Section 5.0, Figures 12-14 show trending for 2012 for SCDHEC.

Tritium In Precipitation

During the 2012 sampling period tritium in precipitation ranged from <LLD to 530.94 pCi/L. The maximum reported value for SCDHEC perimeter locations was collected at the JAK air station in March. The SCDHEC average measured activity for tritium in precipitation was 336.38 (±124.91) pCi/L. The DOE-SR average measured value for tritium activity in precipitation at the SRS perimeter was 522.41 (± 153.38) pCi/L (SRNS 2012). The SCDHEC and DOE-SR averages for tritium activity were well below the USEPA standard of 20,000 pCi/L in drinking water (USEPA 2002). The DOE-SR averages for tritium activity were within two standard deviations of the SCDHEC average. Section 5.0, Figure 5 shows average tritium in precipitation activity for SRS perimeter locations and illustrates trending tritium in precipitation values for SCDHEC and DOE-SR. Section 5.0, Figures 15-17 show trending for 2012 for SCDHEC.

3.0 CONCLUSIONS/RECOMMENDATIONS

All SCDHEC data collected in 2012 confirmed historically 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.

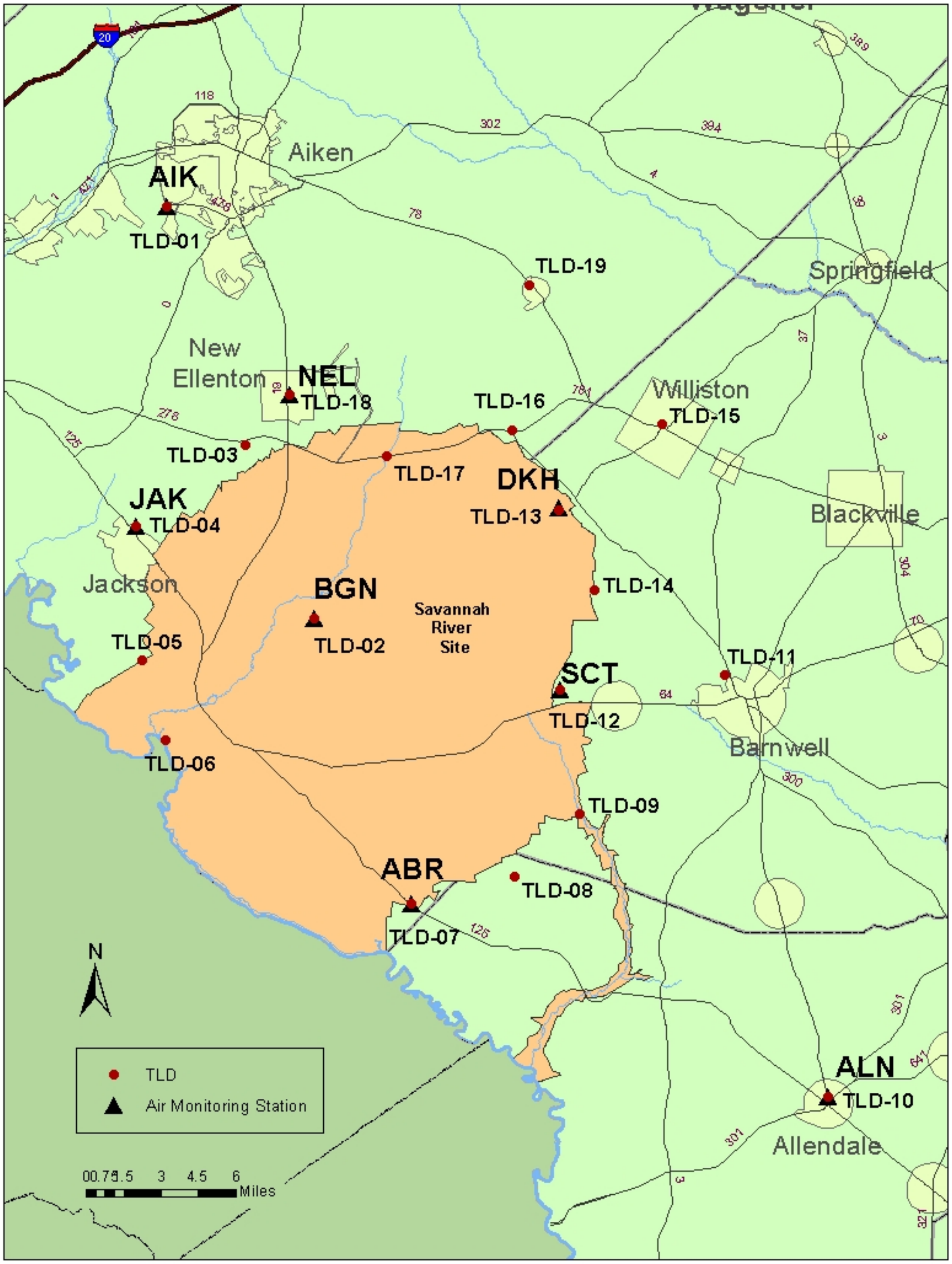
Even with the variability of environmental data and sampling frequencies, DOE-SR gross alpha/beta in air, tritium in precipitation, tritium in air, and ambient beta/gamma averages were within two standard deviations of SCDHEC measured averages.

No USEPA air standards were exceeded at the monitored locations. Sampling results by SCDHEC indicate that SRS activities did have a measurable but negligible impact on local air quality.

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

4.0 MAP

Map 1. 2012 ESOP RADIOLOGICAL ATMOSPHERIC MONITORING LOCATIONS



5.0 TABLES AND FIGURES

2012 Radiological Atmospheric Monitoring On and Adjacent to SRS

Table 1. SCDHEC and DOE-SR Sample Frequency Comparison

Sample Frequency		
	SCDHEC	DOE-SR
Total Suspended Particulates	Weekly	Bi-weekly
Precipitation	Monthly	Bi-weekly
Atmospheric Moisture	Monthly	Monthly
Thermoluminscent Dosimeters	Quarterly	Quarterly

Figure 1. DOE-SR and SCDHEC Comparison of Average Gross Alpha For Total Suspended Particulates at the SRS Perimeter

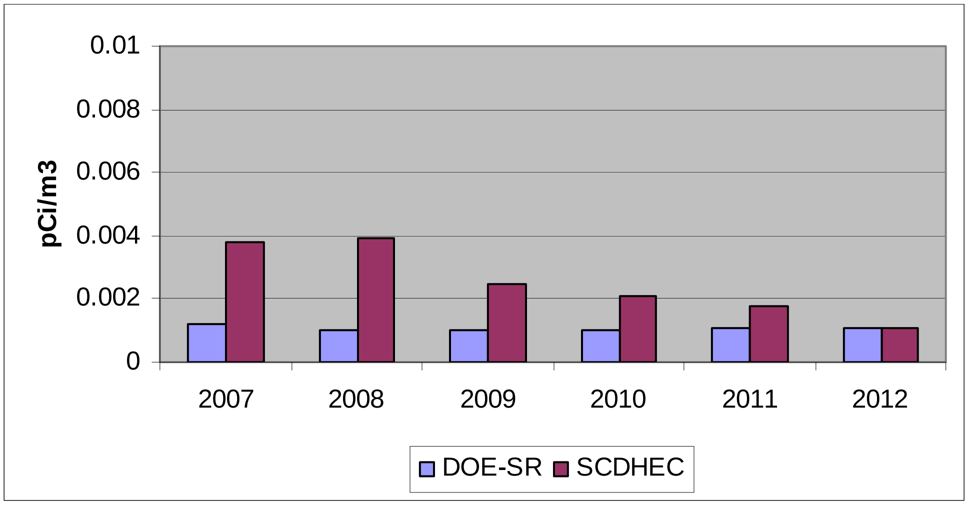


Figure 2. DOE-SR and SCDHEC Comparison of Average Gross Beta For Total Suspended Particulates at the SRS Perimeter

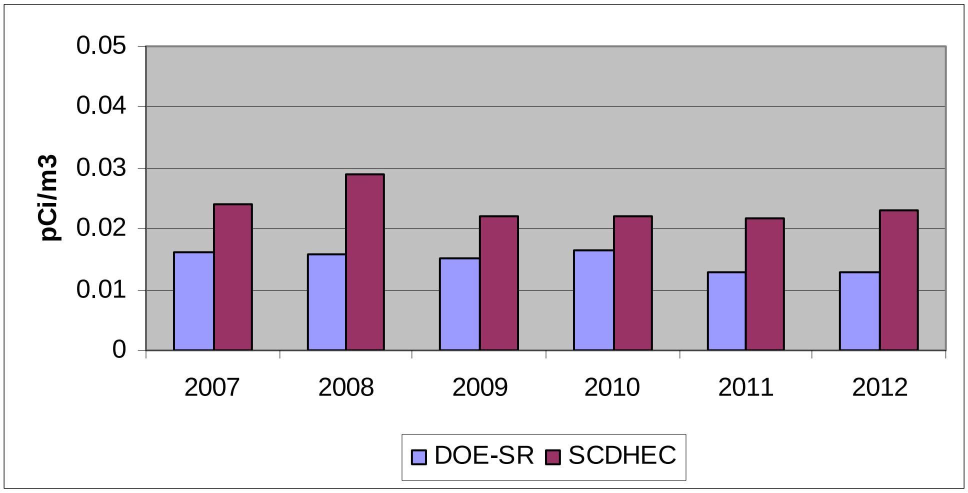


Figure 3. DOE-SR and SCDHEC Comparison of Average Ambient Beta/Gamma at the SRS Perimeter

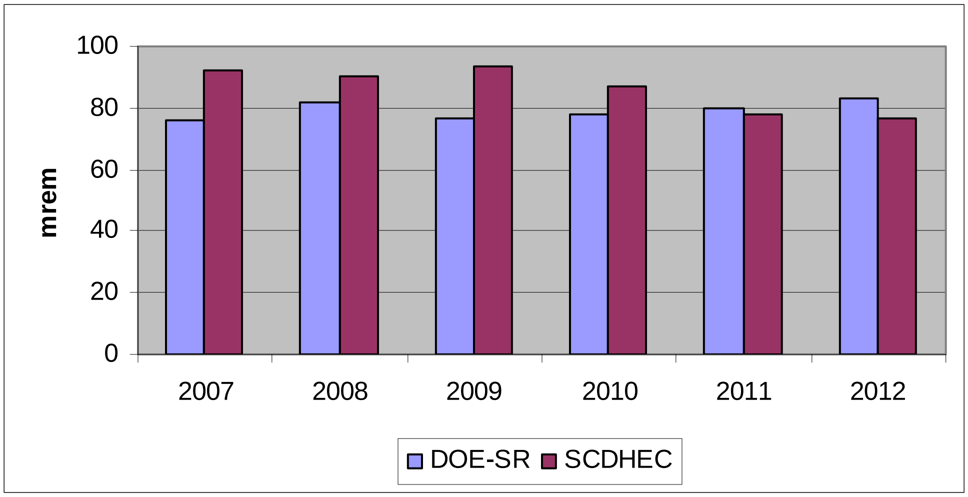


Figure 4. DOE-SR and SCDHEC Comparison of Average Tritium in Air at the SRS Perimeter

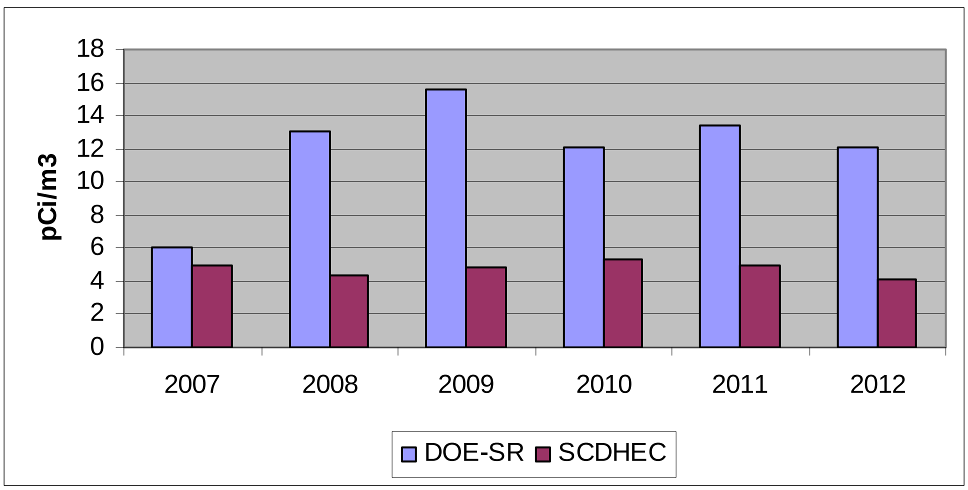


Figure 5. DOE-SR and SCDHEC Comparison of Average Tritium in Precipitation at the SRS Perimeter

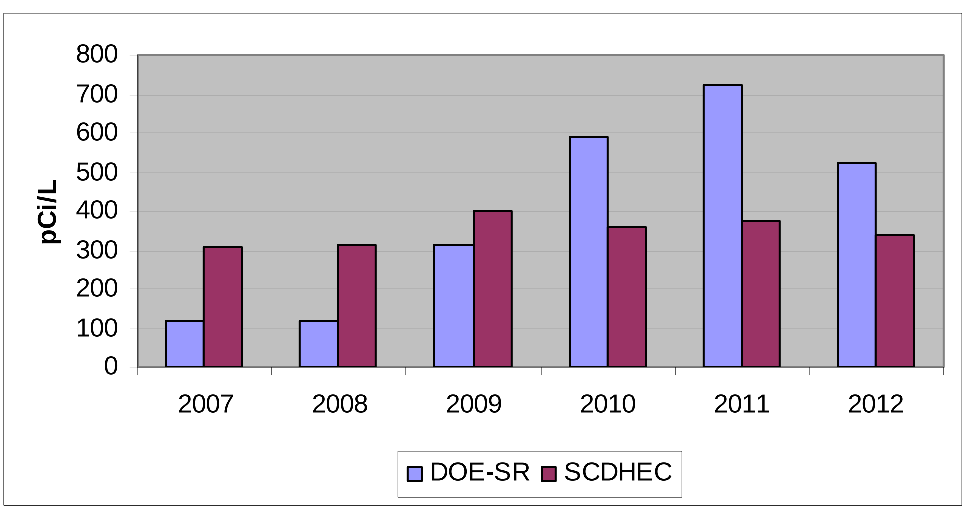


Figure 6. Weekly Gross Alpha in Air (Perimeter Stations)

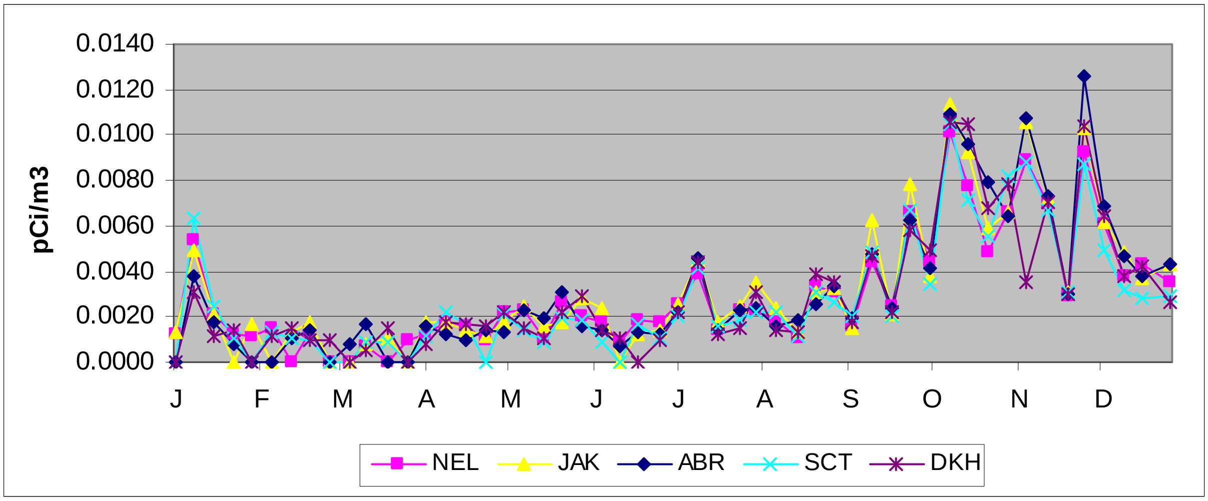


Figure 7. Weekly Gross Alpha in Air (Non-Perimeter Stations)

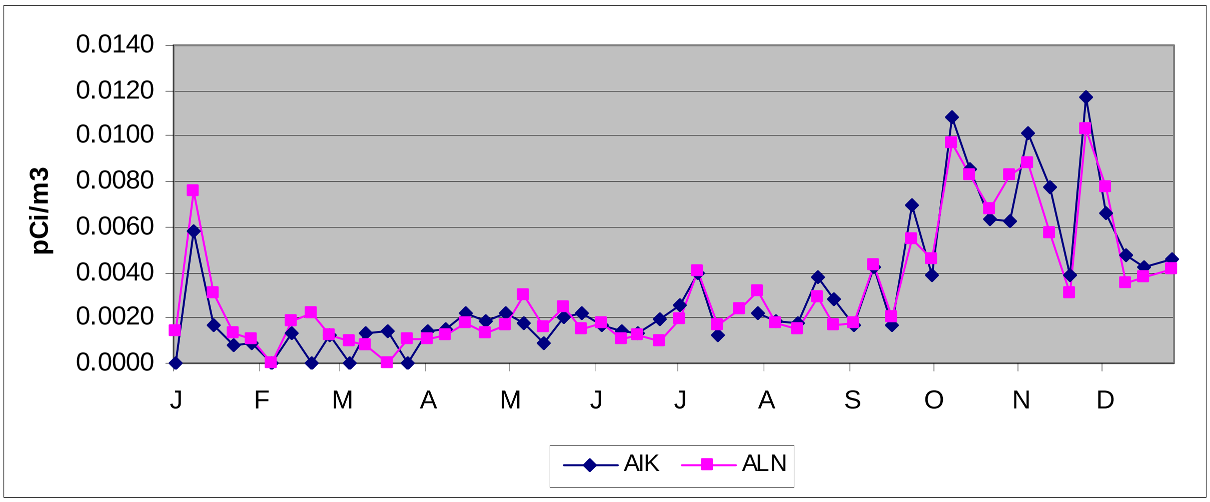
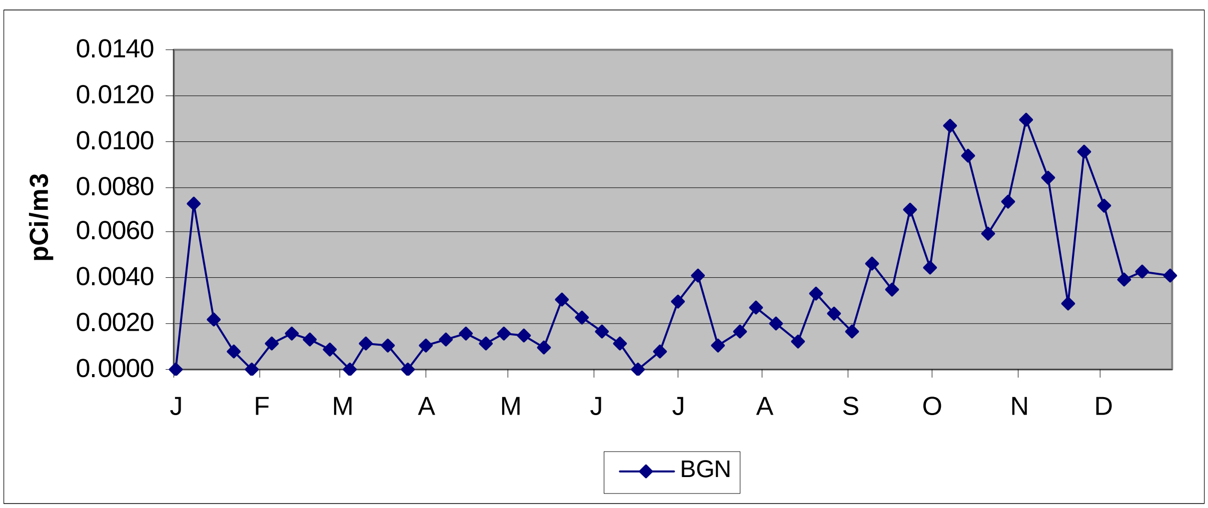


Figure 8. Weekly Gross Alpha in Air (SRS Center Station)



Note: Breaks in data indicate where no sample was available.

Figure 9. Weekly Gross Beta in Air (Perimeter Stations)

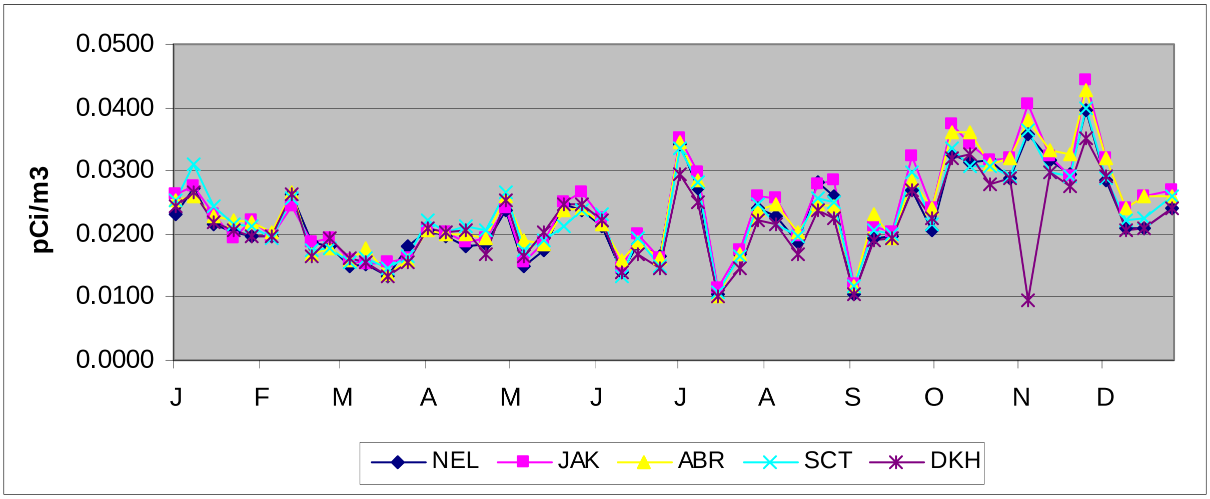


Figure 10. Weekly Gross Beta in Air (Non-Perimeter Stations)

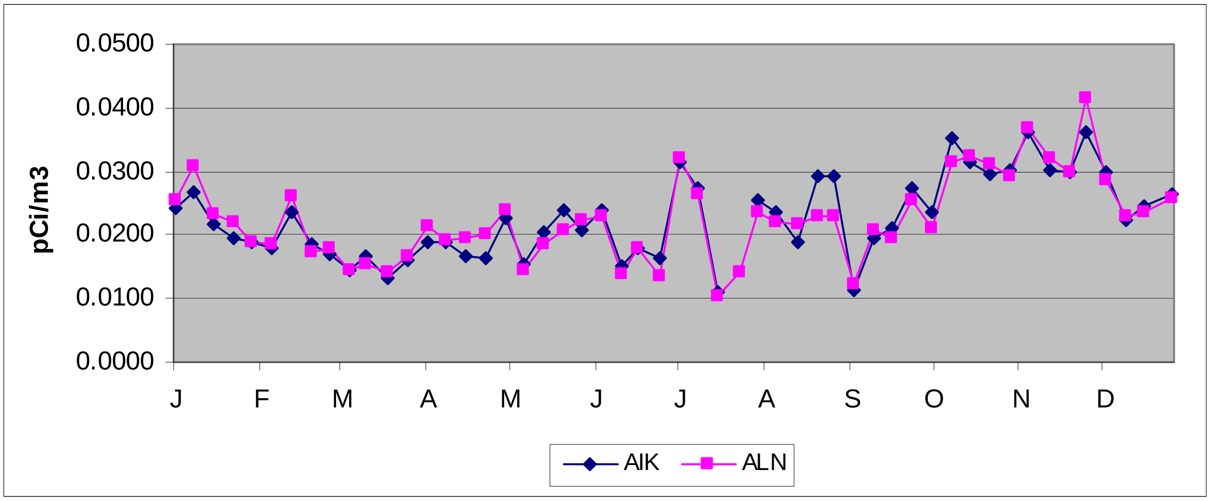
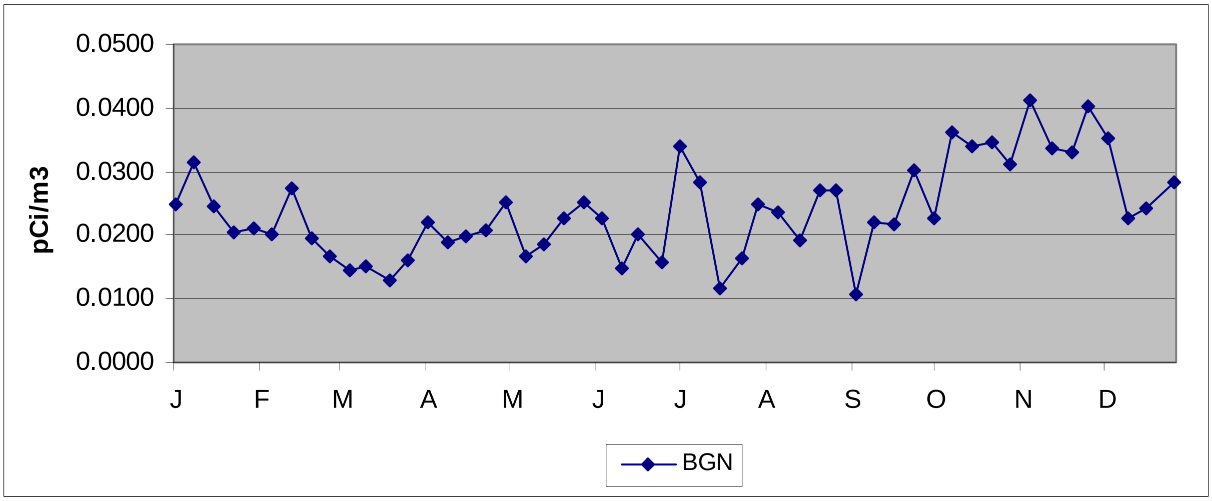


Figure 11. Weekly Gross Beta in Air (SRS Center Station)



Note: Breaks in data indicate where no sample was available.

Figure 12. Tritium in Air (Perimeter Stations)

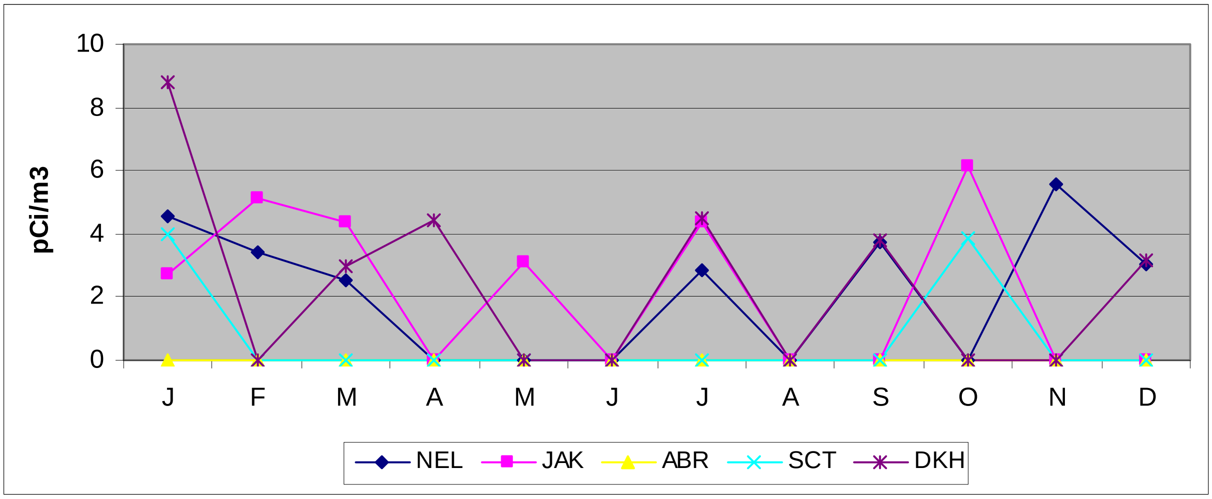


Figure 13. Tritium in Air (Non-Perimeter Stations)

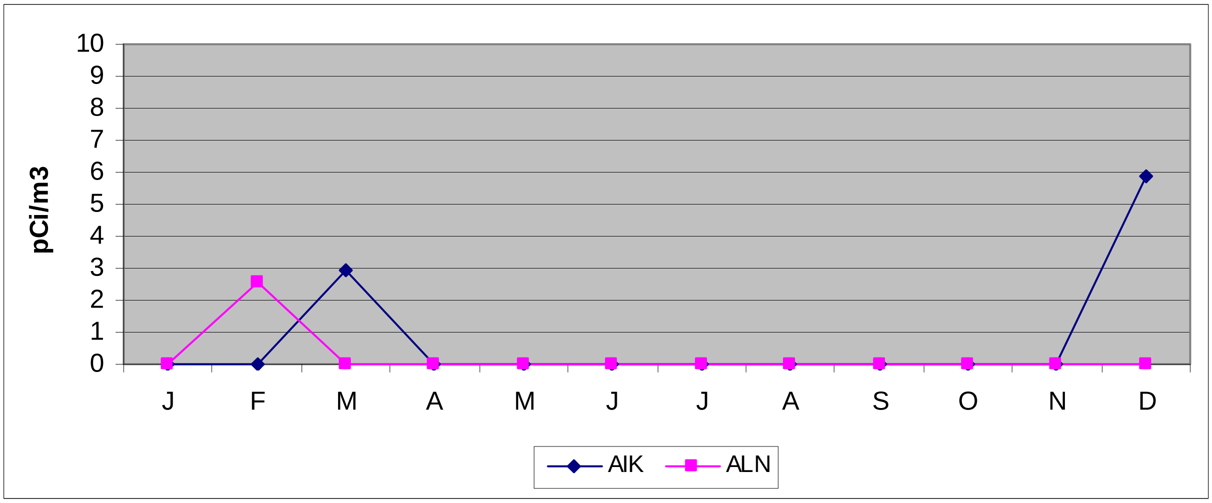
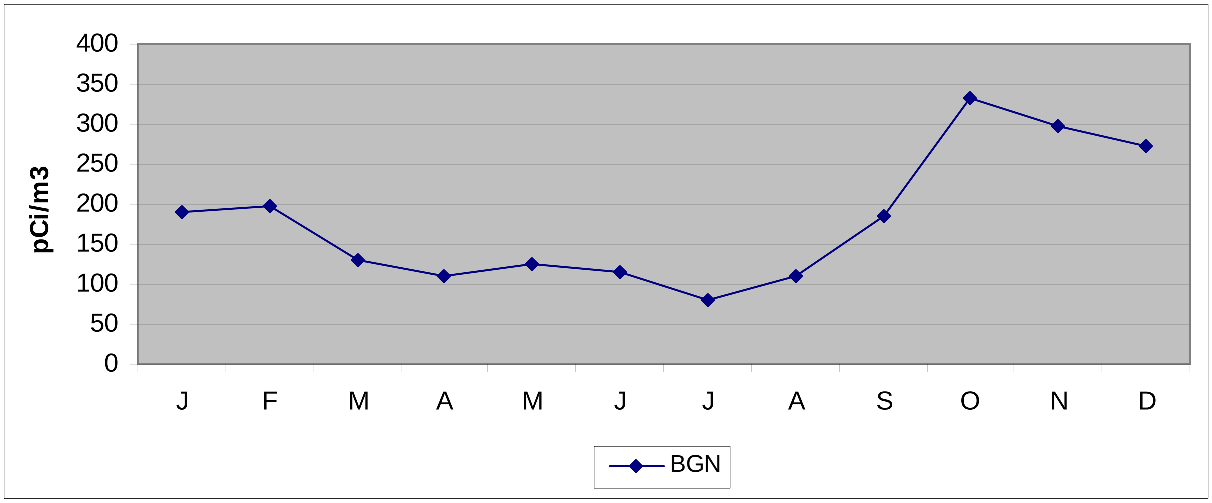


Figure 14. Tritium in Air (SRS Center Station)



Note: Breaks in data indicate where no sample was available.

Figure 15. Tritium in Precipitation (Perimeter Stations)

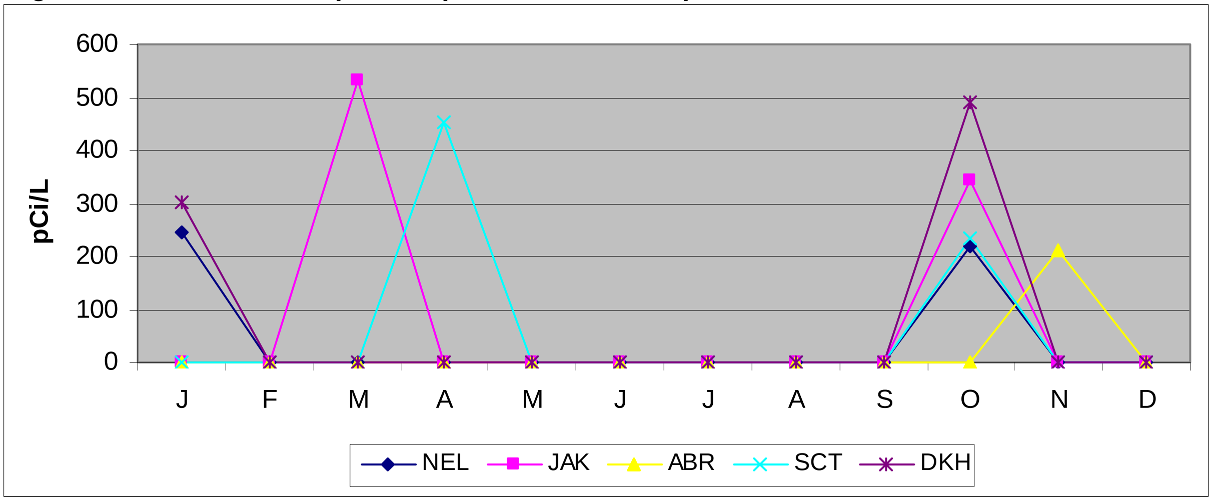


Figure 16. Tritium in Precipitation (Non-Perimeter Stations)

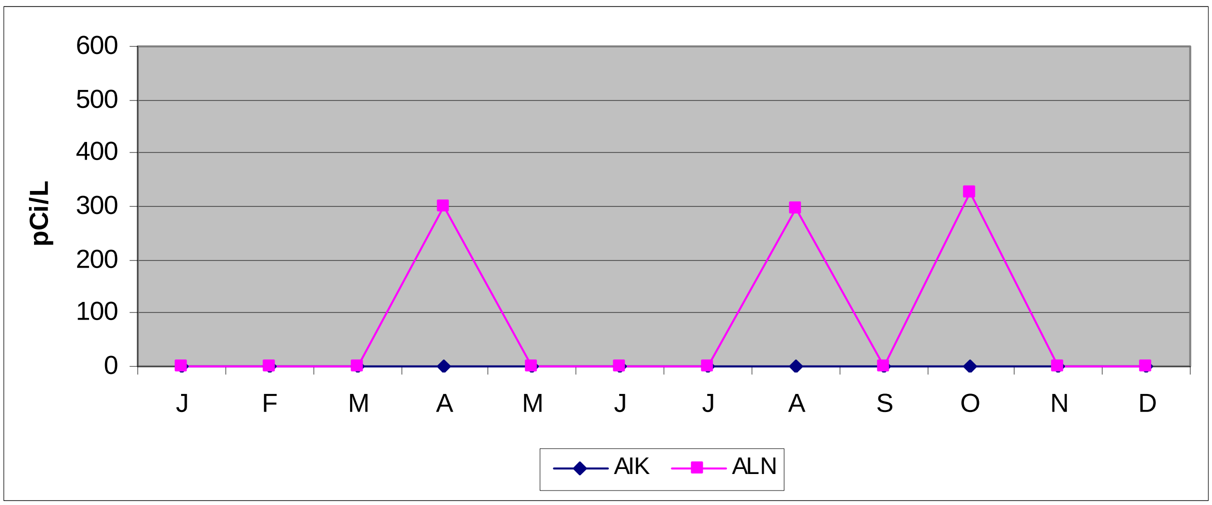
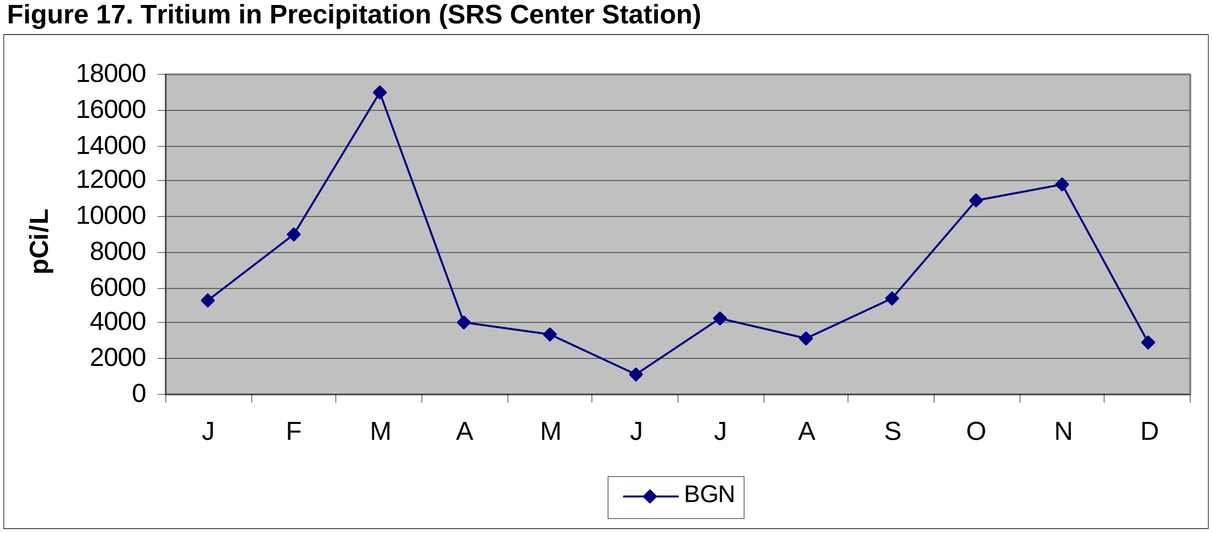


Figure 17. Tritium in Precipitation (SRS Center Station)



Note: Breaks in data indicate where no sample was available.

6.0 DATA
2012 Radiological Atmospheric Monitoring on and Adjacent to SRS

2012 Quarterly TLD Beta/Gamma Data **13**

2012 Routine Radiological Atmospheric Monitoring Data **14**

2012 Radiochemical Particulate Data **22**

Notes:
Blank Spaces -- No Sample Available
NA -- Not Applicable
< -- Less Than LLD
LE – Lab Error
MDA – Minimum Detectable Activity

2012 Quarterly TLD Beta/Gamma Data

Sample Location	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Year
	mrem	mrem	mrem	mrem	mrem
Colocated with AIK Air Station	15	14	13	13	55.00
Colocated with BGN Air Station	27	23	25	26	101.00
Green Pond (P)	18	17	18	18	71.00
Colocated with JAK Air Station (P)	17	15	16	17	65.00
Crackerneck Gate (P)	21	18	18	20	77.00
TNX Boat Ramp (P)	21	25	21	24	91.00
Colocated with ABR Air Station (P)	16	16	12	14	58.00
Junction of Millet Road and Round Tree Road (P)	20	18	19	21	78.00
Patterson Mill Road at Lower Three Runs Creek (P)	21	20	20	25	86.00
Colocated with ALN Air Station	18	17	14	18	67.00
Barnwell Airport	22	16	18	19	75.00
Colocated with SCT Air Station (P)	18	19	17	22	76.00
Colocated with DKH Air Station (P)	19	18	16	20	73.00
Seven Pines Road colocated with SRS Air Station (P)	21	22	20	25	88.00
Williston Police Department	20	22	18	20	80.00
Junction of US 278 and SC 781 (P)	18	20	17	18	73.00
US 278 near Upper Three Runs Creek (P)	23	25	22	25	95.00
Colocated with NEL Air Station (P)	18	17	17	22	74.00
Windsor Post Office	18	20	18	16	72.00
Control TLD (Kept in Office)	20	21	21	19	81.00
Lead (Kept in Lead Brick Enclosure)	11	11	8	8	38.00

Note: (P) indicates perimeter TLD

Routine Radiological Atmospheric Monitoring Data

Sample Location:	Aiken Elementary Water Tower (AIK)							
Date	Gross Alpha in Air		Gross Beta in Air		Tritium in Air		Tritium in Rain	
	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/L	+/- 2 sigma
01/03/12	<0.0011	N/A	0.0241	0.0020				
01/10/12	0.0058	0.0012	0.0267	0.0019				
01/17/12	0.0017	0.0007	0.0216	0.0017				
01/24/12	0.0008	0.0005	0.0196	0.0016				
01/31/12	0.0009	0.0006	0.0190	0.0016	<2.41	N/A	<215.24	N/A
02/07/12	<0.0010	N/A	0.0180	0.0016				
02/14/12	0.0013	0.0007	0.0236	0.0017				
02/21/12	<0.0008	N/A	0.0185	0.0016				
02/28/12	0.0012	0.0007	0.0169	0.0016	<2.51	N/A	<216.62	N/A
03/06/12	<0.0008	N/A	0.0144	0.0015				
03/12/12	0.0013	0.0006	0.0167	0.0017				
03/20/12	0.0014	0.0007	0.0131	0.0013				
03/27/12	<0.0009	N/A	0.0161	0.0015	2.93	1.12	<222.40	N/A
04/03/12	0.0014	0.0007	0.0189	0.0017				
04/10/12	0.0015	0.0007	0.0188	0.0016				
04/17/12	0.0022	0.0008	0.0167	0.0015				
04/24/12	0.0019	0.0007	0.0165	0.0015	<2.50	N/A	<206.98	N/A
05/01/12	0.0022	0.0007	0.0225	0.0016				
05/08/12	0.0017	0.0006	0.0155	0.0014				
05/15/12	0.0009	0.0005	0.0204	0.0017				
05/22/12	0.0021	0.0008	0.0240	0.0018				
05/29/12	0.0022	0.0008	0.0208	0.0017	<2.61	N/A	<216.58	N/A
06/05/12	0.0017	0.0007	0.0238	0.0018				
06/12/12	0.0014	0.0007	0.0152	0.0015				
06/18/12	0.0013	0.0008	0.0178	0.0018				
06/26/12	0.0019	0.0007	0.0165	0.0014	<2.55	N/A	<223.29	N/A
07/03/12	0.0025	0.0008	0.0315	0.0021				
07/10/12	0.0040	0.0011	0.0274	0.0019				
07/17/12	0.0012	0.0007	0.0111	0.0013				
07/25/12								
07/31/12	0.0022	0.0009	0.0255	0.0020	<2.65	N/A	<214.04	N/A
08/07/12	0.0019	0.0008	0.0236	0.0018				
08/15/12	0.0018	0.0007	0.0188	0.0015				
08/22/12	0.0038	0.0012	0.0293	0.0020				
08/28/12	0.0028	0.0011	0.0292	0.0021	<2.46	N/A	<214.74	N/A
09/04/12	0.0017	0.0008	0.0114	0.0014				
09/11/12	0.0043	0.0011	0.0194	0.0017				
09/18/12	0.0016	0.0008	0.0212	0.0017				
09/25/12	0.0069	0.0015	0.0275	0.0019	<2.50	N/A	<213.49	N/A
10/02/12	0.0039	0.0012	0.0235	0.0018				
10/09/12	0.0108	0.0017	0.0351	0.0022				
10/16/12	0.0085	0.0015	0.0313	0.0021				
10/23/12	0.0063	0.0014	0.0296	0.0020				
10/30/12	0.0063	0.0014	0.0303	0.0020	<2.49	N/A	<213.49	N/A
11/06/12	0.0101	0.0017	0.0363	0.0022				
11/14/12	0.0078	0.0014	0.0301	0.0019				
11/21/12	0.0039	0.0011	0.0299	0.0020				
11/27/12	0.0117	0.0020	0.0363	0.0025	<2.39	N/A	<209.02	N/A
12/04/12	0.0066	0.0014	0.0298	0.0020				
12/11/12	0.0047	0.0012	0.0222	0.0018				
12/18/12	0.0042	0.0011	0.0245	0.0019				
12/28/12	0.0046	0.0010	0.0264	0.0017	5.85	1.26	<213.24	N/A

Note: Breaks in data indicate where no sample was available.

Routine Radiological Atmospheric Monitoring Data

Sample Location: New Ellenton, SC (NEL)									
Date	Gross Alpha in Air		Gross Beta in Air		Tritium in Air		Tritium in Rain		
	pCi/m3	+/- 2 sigma	pCi/m3	+/- 2 sigma	pCi/m3	+/- 2 sigma	pCi/L	+/- 2 sigma	
01/03/12	0.0012	0.0008	0.0232	0.0020					
01/10/12	0.0054	0.0012	0.0272	0.0019					
01/17/12	0.0021	0.0008	0.0215	0.0017					
01/24/12	0.0012	0.0006	0.0204	0.0017					
01/31/12	0.0012	0.0007	0.0195	0.0016	4.53	1.19	245.95	99.96	
02/07/12	0.0015	0.0008	0.0195	0.0017					
02/14/12	<0.0011	N/A	0.0262	0.0020					
02/21/12	0.0014	0.0007	0.0187	0.0016					
02/28/12	<0.0008	NA	0.0181	0.0016	3.44	1.19	<216.62	N/A	
03/06/12	<0.0008	N/A	0.0149	0.0015					
03/12/12	0.0007	0.0005	0.0152	0.0016					
03/20/12	<0.0008	N/A	0.0133	0.0013					
03/27/12	0.0010	0.0006	0.0181	0.0015	2.54	1.11	<222.40	N/A	
04/03/12	0.0012	0.0006	0.0205	0.0017					
04/10/12	0.0017	0.0007	0.0197	0.0016					
04/17/12	0.0016	0.0007	0.0179	0.0015					
04/24/12	0.0010	0.0006	0.0182	0.0016	<2.50	N/A	<206.98	N/A	
05/01/12	0.0022	0.0008	0.0238	0.0017					
05/08/12	0.0023	0.0007	0.0150	0.0014					
05/15/12	0.0011	0.0005	0.0173	0.0015					
05/22/12	0.0026	0.0009	0.0246	0.0018					
05/29/12	0.0020	0.0008	0.0238	0.0018	<2.61	N/A	<216.58	N/A	
06/05/12	0.0017	0.0007	0.0211	0.0017					
06/12/12	0.0009	0.0006	0.0139	0.0015					
06/18/12	0.0019	0.0008	0.0184	0.0018					
06/26/12	0.0017	0.0007	0.0163	0.0014	<2.55	N/A	<223.29	N/A	
07/03/12	0.0025	0.0008	0.0343	0.0021					
07/10/12	0.0039	0.0010	0.0273	0.0019					
07/17/12	0.0014	0.0007	0.0103	0.0013					
07/25/12	0.0023	0.0008	0.0168	0.0014					
07/31/12	0.0023	0.0009	0.0242	0.0020	2.87	1.22	<214.04	N/A	
08/07/12	0.0018	0.0008	0.0228	0.0017					
08/15/12	0.0010	0.0005	0.0188	0.0015					
08/22/12	0.0033	0.0011	0.0283	0.0020					
08/28/12	0.0031	0.0012	0.0258	0.0020	<2.46	N/A	<214.74	N/A	
09/04/12	0.0016	0.0008	0.0106	0.0013					
09/11/12	0.0044	0.0011	0.0193	0.0017					
09/18/12	0.0025	0.0009	0.0196	0.0016					
09/25/12	0.0066	0.0014	0.0268	0.0019	3.76	1.20	<213.49	N/A	
10/02/12	0.0044	0.0012	0.0205	0.0017					
10/09/12	0.0101	0.0016	0.0327	0.0021					
10/16/12	0.0078	0.0014	0.0314	0.0020					
10/23/12	0.0048	0.0012	0.0318	0.0020					
10/30/12	0.0066	0.0014	0.0289	0.0020	<2.49	N/A	217.24	95.69	
11/06/12	0.0089	0.0015	0.0358	0.0021					
11/14/12	0.0069	0.0014	0.0316	0.0020					
11/21/12	0.0029	0.0010	0.0295	0.0020					
11/27/12	0.0093	0.0018	0.0394	0.0025	5.57	1.22	<209.02	N/A	
12/04/12	0.0061	0.0013	0.0284	0.0020					
12/11/12	0.0038	0.0011	0.0210	0.0017					
12/18/12	0.0044	0.0011	0.0208	0.0017					
12/28/12	0.0035	0.0009	0.0239	0.0016	3.07	1.16	NS	N/A	

Note: Breaks in data indicate where no sample was available.

Routine Radiological Atmospheric Monitoring Data

Sample Location:	**Jackson, SC (JAK)**							
Date	**Gross Alpha in Air**		**Gross Beta in Air**		**Tritium in Air**		**Tritium in Rain**	
	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/L	+/- 2 sigma
01/03/12	0.0013	0.0008	0.0264	0.0021				
01/10/12	0.0049	0.0012	0.0275	0.0019				
01/17/12	0.0021	0.0008	0.0232	0.0018				
01/24/12	<0.0007	N/A	0.0194	0.0017				
01/31/12	0.0016	0.0008	0.0220	0.0017	2.72	1.12	<215.24	N/A
02/07/12	<0.00103	N/A	0.0195	0.0017				
02/14/12	0.0014	0.0007	0.0245	0.0018				
02/21/12	0.0017	0.0008	0.0186	0.0016				
02/28/12	<0.0008	N/A	0.0193	0.0017	5.14	1.25	<216.62	N/A
03/06/12	<0.0008	N/A	0.0159	0.0015				
03/12/12	0.0008	0.0005	0.0152	0.0017				
03/20/12	0.0011	0.0006	0.0156	0.0014				
03/27/12	<0.0009	N/A	0.0161	0.0015	4.36	1.16	530.94	113.15
04/03/12	0.0018	0.0007	0.0206	0.0017				
04/10/12	0.0018	0.0007	0.0201	0.0016				
04/17/12	0.0015	0.0007	0.0187	0.0016				
04/24/12	0.0012	0.0006	0.0193	0.0016	<2.50	N/A	<206.98	N/A
05/01/12	0.0018	0.0007	0.0240	0.0017				
05/08/12	0.0025	0.0007	0.0154	0.0014				
05/15/12	0.0016	0.0007	0.0188	0.0016				
05/22/12	0.0018	0.0008	0.0249	0.0018				
05/29/12	0.0028	0.0009	0.0267	0.0019	3.10	1.23	<216.58	N/A
06/05/12	0.0024	0.0008	0.0226	0.0018				
06/12/12	<0.0007	N/A	0.0144	0.0015				
06/18/12	0.0012	0.0007	0.0198	0.0019				
06/26/12	0.0014	0.0006	0.0162	0.0014	<2.55	N/A	<223.29	N/A
07/03/12	0.0026	0.0008	0.0350	0.0021				
07/10/12	0.0045	0.0011	0.0297	0.0020				
07/17/12	0.0018	0.0008	0.0114	0.0013				
07/25/12	0.0024	0.0008	0.0175	0.0015				
07/31/12	0.0035	0.0011	0.0261	0.0020	4.34	1.28	<214.04	N/A
08/07/12	0.0024	0.0009	0.0256	0.0019				
08/15/12	0.0013	0.0006	0.0196	0.0015				
08/22/12	0.0031	0.0011	0.0279	0.0020				
08/28/12	0.0033	0.0012	0.0284	0.0021	<2.46	N/A	<214.74	N/A
09/04/12	0.0015	0.0007	0.0119	0.0014				
09/11/12	0.0063	0.0013	0.0212	0.0017				
09/18/12	0.0021	0.0008	0.0203	0.0016				
09/25/12	0.0079	0.0015	0.0323	0.0021	<2.50	N/A	<213.49	N/A
10/02/12	0.0038	0.0012	0.0242	0.0018				
10/09/12	0.0114	0.0017	0.0374	0.0023				
10/16/12	0.0093	0.0015	0.0343	0.0022				
10/23/12	0.0059	0.0013	0.0316	0.0021				
10/30/12	0.0066	0.0014	0.0319	0.0021	6.11	1.28	342.02	100.36
11/06/12	0.0106	0.0017	0.0406	0.0023				
11/14/12	0.0072	0.0014	0.0323	0.0020				
11/21/12	0.0031	0.0010	0.0291	0.0020				
11/27/12	0.0103	0.0019	0.0442	0.0027	<2.39	N/A	<209.02	N/A
12/04/12	0.0062	0.0013	0.0319	0.0021				
12/11/12	0.0048	0.0012	0.0242	0.0019				
12/18/12	0.0037	0.0011	0.0260	0.0019				
12/28/12	0.0043	0.0010	0.0269	0.0017	<2.46	N/A	<213.24	N/A

Note: Breaks in data indicate where no sample was available.

Routine Radiological Atmospheric Monitoring Data

Sample Location: Burial Grounds North (BGN)								
Date	Gross Alpha in Air		Gross Beta in Air		Tritium in Air		Tritium in Rain	
	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/L	+/- 2 sigma
01/03/12	<0.0011	N/A	0.0248	0.0020				
01/10/12	0.0073	0.0014	0.0313	0.0021				
01/17/12	0.0022	0.0008	0.0246	0.0018				
01/24/12	0.0008	0.0006	0.0204	0.0017				
01/31/12	<0.0009	N/A	0.0211	0.0017	189.82	4.16	5328.80	215.84
02/07/12	0.0012	0.0007	0.0200	0.0017				
02/14/12	0.0016	0.0008	0.0275	0.0019				
02/21/12	0.0013	0.0007	0.0196	0.0017				
02/28/12	0.0009	0.0006	0.0166	0.0015	196.63	4.28	9024.55	275.72
03/06/12	<0.0007	N/A	0.0146	0.0014				
03/12/12	0.0012	0.0006	0.0151	0.0016				
03/20/12	0.0010	0.0006	0.0129	0.0013				
03/27/12	<0.0009	N/A	0.0159	0.0015	129.84	3.45	16955.61	372.77
04/03/12	0.0011	0.0006	0.0219	0.0018				
04/10/12	0.0014	0.0007	0.0189	0.0016				
04/17/12	0.0016	0.0007	0.0198	0.0016				
04/24/12	0.0011	0.0006	0.0208	0.0017	110.09	3.27	4009.50	192.68
05/01/12	0.0016	0.0007	0.0251	0.0018				
05/08/12	0.0015	0.0007	0.0168	0.0016				
05/15/12	0.0010	0.0005	0.0185	0.0016				
05/22/12	0.0031	0.0009	0.0226	0.0017				
05/29/12	0.0023	0.0008	0.0252	0.0018	125.10	3.52	3430.23	185.75
06/05/12	0.0017	0.0007	0.0227	0.0018				
06/12/12	0.0012	0.0006	0.0149	0.0015				
06/18/12	<0.0009	N/A	0.0201	0.0018				
06/26/12	0.0008	0.0005	0.0158	0.0014	115.67	3.39	1105.04	131.14
07/03/12	0.0030	0.0009	0.0341	0.0021				
07/10/12	0.0041	0.0011	0.0282	0.0019				
07/17/12	0.0011	0.0006	0.0117	0.0013				
07/25/12	0.0017	0.0007	0.0164	0.0014				
07/31/12	0.0027	0.0010	0.0248	0.0020	80.55	2.97	4329.14	203.09
08/07/12	0.0020	0.0008	0.0235	0.0018				
08/15/12	0.0013	0.0006	0.0193	0.0015				
08/22/12	0.0034	0.0011	0.0269	0.0019				
08/28/12	0.0025	0.0011	0.0272	0.0021	110.89	3.28	3137.92	176.63
09/04/12	0.0017	0.0008	0.0107	0.0014				
09/11/12	0.0046	0.0011	0.0219	0.0018				
09/18/12	0.0035	0.0010	0.0218	0.0017				
09/25/12	0.0070	0.0015	0.0301	0.0020	184.15	4.12	5456.08	220.19
10/02/12	0.0045	0.0012	0.0225	0.0018				
10/09/12	0.0107	0.0017	0.0362	0.0022				
10/16/12	0.0094	0.0015	0.0340	0.0021				
10/23/12	0.0060	0.0013	0.0345	0.0021				
10/30/12	0.0074	0.0015	0.0311	0.0020	331.95	5.44	10967.29	309.34
11/06/12	0.0109	0.0017	0.0412	0.0023				
11/14/12	0.0084	0.0015	0.0336	0.0020				
11/21/12	0.0029	0.0010	0.0331	0.0021				
11/27/12	0.0096	0.0018	0.0401	0.0026	298.13	5.13	11854.84	310.20
12/04/12	0.0072	0.0014	0.0351	0.0022				
12/11/12	0.0039	0.0011	0.0226	0.0018				
12/18/12	0.0043	0.0011	0.0242	0.0018				
12/28/12	0.0041	0.0009	0.0283	0.0017	273.26	4.95	2952.54	172.62

Note: Breaks in data indicate where no sample was available.

Routine Radiological Atmospheric Monitoring Data

Sample Location:	Allendale Barricade (ABR)							
Date	Gross Alpha in Air		Gross Beta in Air		Tritium in Air		Tritium in Rain	
	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/L	+/- 2 sigma
01/03/12	<0.0011	N/A	0.0254	0.0021				
01/10/12	0.0038	0.0011	0.0260	0.0019				
01/17/12	0.0017	0.0007	0.0229	0.0018				
01/24/12	0.0008	0.0006	0.0220	0.0018				
01/31/12	<0.0009	N/A	0.0218	0.0017	<2.41	N/A	<215.24	N/A
02/07/12	<0.0010	N/A	0.0202	0.0017				
02/14/12	0.0011	0.0007	0.0266	0.0019				
02/21/12	0.0014	0.0007	0.0169	0.0015				
02/28/12	<0.0008	N/A	0.0177	0.0016	<2.51	N/A	<216.62	N/A
03/06/12	0.0008	0.0006	0.0159	0.0016				
03/12/12	0.0017	0.0007	0.0176	0.0018				
03/20/12	<0.0009	N/A	0.0136	0.0013				
03/27/12	<0.0009	N/A	0.0157	0.0015	<2.41	N/A	<222.40	N/A
04/03/12	0.0016	0.0007	0.0206	0.0017				
04/10/12	0.0012	0.0006	0.0199	0.0016				
04/17/12	0.0010	0.0006	0.0199	0.0016				
04/24/12	0.0015	0.0007	0.0194	0.0017	<2.50	N/A	<206.98	N/A
05/01/12	0.0013	0.0008	0.0260	0.0020				
05/08/12	0.0023	0.0008	0.0191	0.0018				
05/15/12	0.0020	0.0007	0.0185	0.0016				
05/22/12	0.0030	0.0009	0.0237	0.0018				
05/29/12	0.0016	0.0007	0.0239	0.0018	<2.61	N/A	<216.58	N/A
06/05/12	0.0014	0.0007	0.0214	0.0017				
06/12/12	0.0007	0.0005	0.0159	0.0015				
06/18/12	0.0013	0.0008	0.0188	0.0018				
06/26/12	0.0013	0.0006	0.0161	0.0014	<2.55	N/A	<223.29	N/A
07/03/12	0.0022	0.0008	0.0346	0.0022				
07/10/12	0.0045	0.0011	0.0285	0.0020				
07/17/12	0.0014	0.0007	0.0101	0.0012				
07/25/12	0.0023	0.0008	0.0168	0.0015				
07/31/12	0.0024	0.0010	0.0238	0.0020	<2.65	N/A	<214.04	N/A
08/07/12	0.0016	0.0008	0.0247	0.0018				
08/15/12	0.0018	0.0007	0.0201	0.0016				
08/22/12	0.0026	0.0010	0.0246	0.0018				
08/28/12	0.0034	0.0012	0.0243	0.0020	<2.46	N/A	<214.74	N/A
09/04/12	0.0019	0.0008	0.0118	0.0014				
09/11/12	0.0047	0.0012	0.0231	0.0018				
09/18/12	0.0024	0.0009	0.0193	0.0016				
09/25/12	0.0063	0.0014	0.0285	0.0020	<2.50	N/A	<213.49	N/A
10/02/12	0.0041	0.0012	0.0242	0.0018				
10/09/12	0.0109	0.0017	0.0361	0.0022				
10/16/12	0.0096	0.0016	0.0362	0.0022				
10/23/12	0.0079	0.0015	0.0309	0.0021				
10/30/12	0.0065	0.0014	0.0319	0.0021	<2.49	N/A	<203.57	N/A
11/06/12	0.0107	0.0017	0.0380	0.0022				
11/14/12	0.0074	0.0014	0.0331	0.0020				
11/21/12	0.0030	0.0010	0.0327	0.0021				
11/27/12	0.0126	0.0021	0.0428	0.0027	<2.39	N/A	210.25	96.37
12/04/12	0.0068	0.0014	0.0321	0.0021				
12/11/12	0.0047	0.0012	0.0240	0.0019				
12/18/12	0.0038	0.0011	0.0261	0.0019				
12/28/12	0.0043	0.0010	0.0261	0.0016	<2.46	N/A	NS	N/A

Note: Breaks in data indicate where no sample was available.

Routine Radiological Atmospheric Monitoring Data

Sample Location: Allendale, SC (ALN)								
Date	Gross Alpha in Air		Gross Beta in Air		Tritium in Air		Tritium in Rain	
	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/L	+/- 2 sigma
01/03/12	0.0014	0.0008	0.0255	0.0020				
01/10/12	0.0076	0.0014	0.0308	0.0020				
01/17/12	0.0031	0.0009	0.0232	0.0018				
01/24/12	0.0013	0.0007	0.0219	0.0018				
01/31/12	0.0011	0.0007	0.0190	0.0016	<2.41	N/A	<215.24	N/A
02/07/12	<0.0010	N/A	0.0186	0.0016				
02/14/12	0.0018	0.0008	0.0260	0.0018				
02/21/12	0.0022	0.0008	0.0173	0.0016				
02/28/12	0.0012	0.0007	0.0180	0.0016	2.56	1.16	<216.62	N/A
03/06/12	0.0009	0.0006	0.0145	0.0015				
03/12/12	0.0008	0.0005	0.0153	0.0017				
03/20/12	<0.0008	N/A	0.0141	0.0013				
03/27/12	0.0010	0.0007	0.0167	0.0015	<2.41	N/A	<222.40	N/A
04/03/12	0.0011	0.0006	0.0214	0.0018				
04/10/12	0.0012	0.0006	0.0193	0.0016				
04/17/12	0.0018	0.0008	0.0194	0.0016				
04/24/12	0.0014	0.0007	0.0202	0.0017	<2.50	N/A	299.68	109.00
05/01/12	0.0016	0.0007	0.0238	0.0018				
05/08/12	0.0030	0.0009	0.0145	0.0015				
05/15/12	0.0016	0.0006	0.0184	0.0015				
05/22/12	0.0025	0.0008	0.0207	0.0016				
05/29/12	0.0015	0.0007	0.0222	0.0017	<2.61	N/A	<216.58	N/A
06/05/12	0.0018	0.0007	0.0229	0.0018				
06/12/12	0.0011	0.0006	0.0138	0.0015				
06/18/12	0.0012	0.0007	0.0180	0.0018				
06/26/12	0.0010	0.0006	0.0136	0.0013	<2.55	N/A	<223.29	N/A
07/03/12	0.0019	0.0007	0.0321	0.0021				
07/10/12	0.0041	0.0011	0.0265	0.0019				
07/17/12	0.0017	0.0007	0.0105	0.0013				
07/25/12	0.0024	0.0008	0.0141	0.0013				
07/31/12	0.0032	0.0011	0.0237	0.0002	<2.65	N/A	<214.04	N/A
08/07/12	0.0017	0.0008	0.0220	0.0017				
08/15/12	0.0015	0.0006	0.0216	0.0016				
08/22/12	0.0029	0.0011	0.0228	0.0018				
08/28/12	0.0016	0.0010	0.0230	0.0019	<2.46	N/A	297.57	114.62
09/04/12	0.0017	0.0008	0.0123	0.0014				
09/11/12	0.0043	0.0011	0.0208	0.0017				
09/18/12	0.0020	0.0008	0.0194	0.0016				
09/25/12	0.0055	0.0013	0.0255	0.0019	<2.50	N/A	<213.49	N/A
10/02/12	0.0046	0.0012	0.0210	0.0017				
10/09/12	0.0097	0.0016	0.0314	0.0021				
10/16/12	0.0083	0.0014	0.0325	0.0021				
10/23/12	0.0068	0.0014	0.0311	0.0020				
10/30/12	0.0082	0.0015	0.0292	0.0020	<2.49	N/A	327.84	108.39
11/06/12	0.0088	0.0015	0.0368	0.0022				
11/14/12	0.0057	0.0013	0.0322	0.0020				
11/21/12	0.0031	0.0011	0.0299	0.0020				
11/27/12	0.0103	0.0019	0.0414	0.0026	<2.39	N/A	<209.02	N/A
12/04/12	0.0077	0.0015	0.0287	0.0020				
12/11/12	0.0035	0.0011	0.0229	0.0018				
12/18/12	0.0038	0.0011	0.0237	0.0018				
12/28/12	0.0041	0.0010	0.0257	0.0016	<2.46	N/A	<213.24	N/A

Note: Breaks in data indicate where no sample was available.

Routine Radiological Atmospheric Monitoring Data

Sample Location: Snelling, SC South Carolina Advanced Technology Park (SCT)								
Date	Gross Alpha in Air		Gross Beta in Air		Tritium in Air		Tritium in Rain	
	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/L	+/- 2 sigma
01/03/12	<0.0011	N/A	0.0254	0.0021				
01/10/12	0.0064	0.0013	0.0310	0.0021				
01/17/12	0.0025	0.0008	0.0244	0.0018				
01/24/12	0.0010	0.0006	0.0214	0.0018				
01/31/12	<0.0009	N/A	0.0211	0.0018	3.98	1.17	<215.24	N/A
02/07/12	0.0013	0.0008	0.0192	0.0017				
02/14/12	0.0011	0.0007	0.0257	0.0019				
02/21/12	0.0009	0.0006	0.0173	0.0016				
02/28/12	<0.0008	N/A	0.0177	0.0016	<2.51	N/A	<216.62	N/A
03/06/12	<0.0008	N/A	0.0156	0.0015				
03/12/12	0.0009	0.0005	0.0160	0.0017				
03/20/12	0.0009	0.0006	0.0147	0.0014				
03/27/12	<0.0009	N/A	0.0166	0.0015	<2.41	N/A	<222.40	N/A
04/03/12	0.0011	0.0006	0.0223	0.0018				
04/10/12	0.0022	0.0008	0.0204	0.0017				
04/17/12	0.0016	0.0008	0.0213	0.0017				
04/24/12	<0.0008	N/A	0.0206	0.0017	<2.50	N/A	451.66	103.67
05/01/12	0.0021	0.0008	0.0266	0.0020				
05/08/12	0.0014	0.0007	0.0174	0.0017				
05/15/12	0.0009	0.0006	0.0190	0.0018				
05/22/12	0.0020	0.0008	0.0213	0.0017				
05/29/12	0.0018	0.0008	0.0236	0.0017	<2.61	N/A	<216.58	N/A
06/05/12	0.0009	0.0006	0.0231	0.0018				
06/12/12	<0.0006	N/A	0.0134	0.0014				
06/18/12	0.0016	0.0009	0.0194	0.0020				
06/26/12	0.0010	0.0006	0.0149	0.0013	<2.55	N/A	<223.29	N/A
07/03/12	0.0020	0.0007	0.0337	0.0021				
07/10/12	0.0042	0.0011	0.0281	0.0020				
07/17/12	0.0016	0.0007	0.0109	0.0013				
07/25/12	0.0019	0.0007	0.0166	0.0014				
07/31/12	0.0022	0.0009	0.0246	0.0020	<2.65	N/A	<214.04	N/A
08/07/12	0.0022	0.0008	0.0216	0.0017				
08/15/12	0.0011	0.0006	0.0195	0.0015				
08/22/12	0.0030	0.0011	0.0255	0.0019				
08/28/12	0.0026	0.0011	0.0251	0.0020	<2.46	N/A	<214.74	N/A
09/04/12	0.0021	0.0008	0.0117	0.0014				
09/11/12	0.0048	0.0012	0.0207	0.0017				
09/18/12	0.0020	0.0009	0.0200	0.0017				
09/25/12	0.0067	0.0014	0.0297	0.0020	<2.50	N/A	<213.49	N/A
10/02/12	0.0035	0.0011	0.0214	0.0017				
10/09/12	0.0105	0.0016	0.0335	0.0021				
10/16/12	0.0072	0.0014	0.0307	0.0020				
10/23/12	0.0055	0.0013	0.0307	0.0020				
10/30/12	0.0082	0.0015	0.0292	0.0020	3.86	1.20	234.82	96.70
11/06/12	0.0088	0.0016	0.0365	0.0022				
11/14/12	0.0067	0.0013	0.0297	0.0019				
11/21/12	0.0031	0.0011	0.0292	0.0020				
11/27/12	0.0087	0.0018	0.0398	0.0026	<2.39	N/A	<209.02	N/A
12/04/12	0.0049	0.0012	0.0288	0.0020				
12/11/12	0.0031	0.0010	0.0222	0.0018				
12/18/12	0.0028	0.0009	0.0226	0.0018				
12/28/12	0.0029	0.0008	0.0258	0.0016	<2.46	N/A	<213.24	N/A

Note: Breaks in data indicate where no sample was available.

Routine Radiological Atmospheric Monitoring Data

Sample Location: Williston Barricade (DKH)								
Date	Gross Alpha in Air		Gross Beta in Air		Tritium in Air		Tritium in Rain	
	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/m^3	+/- 2 sigma	pCi/L	+/- 2 sigma
01/03/12	<0.0011	N/A	0.0243	0.0020				
01/10/12	0.0031	0.0010	0.0266	0.0019				
01/17/12	0.0012	0.0006	0.0219	0.0017				
01/24/12	0.0014	0.0007	0.0205	0.0017				
01/31/12	<0.0009	N/A	0.0195	0.0016	8.82	1.34	303.39	102.43
02/07/12	0.0012	0.0007	0.0196	0.0017				
02/14/12	0.0015	0.0008	0.0264	0.0019				
02/21/12	0.0010	0.0006	0.0165	0.0153				
02/28/12	0.0010	0.0006	0.0192	0.0017	<2.51	N/A	<216.62	N/A
03/06/12	<0.0008	N/A	0.0161	0.0016				
03/12/12	0.0006	0.0005	0.0154	0.0017				
03/20/12	0.0015	0.0007	0.0132	0.0013				
03/27/12	<0.0009	N/A	0.0155	0.0015	2.95	1.13	<222.40	N/A
04/03/12	0.0008	0.0005	0.0208	0.0017				
04/10/12	0.0018	0.0007	0.0202	0.0017				
04/17/12	0.0017	0.0007	0.0207	0.0017				
04/24/12	0.0016	0.0007	0.0169	0.0015	4.40	1.22	<206.98	N/A
05/01/12	0.0022	0.0009	0.0252	0.0020				
05/08/12	0.0015	0.0007	0.0166	0.0017				
05/15/12	0.0011	0.0006	0.0203	0.0019				
05/22/12	0.0022	0.0009	0.0248	0.0020				
05/29/12	0.0029	0.0010	0.0246	0.0020	<2.61	N/A	<216.58	NA
06/05/12	0.0014	0.0008	0.0220	0.0020				
06/12/12	0.0010	0.0006	0.0138	0.0015				
06/18/12	<0.0010	N/A	0.0169	0.0018				
06/26/12	0.0010	0.0006	0.0145	0.0013	<2.55	N/A	<223.29	N/A
07/03/12	0.0022	0.0008	0.0295	0.0020				
07/10/12	0.0044	0.0011	0.0250	0.0019				
07/17/12	0.0012	0.0007	0.0101	0.0012				
07/25/12	0.0015	0.0007	0.0145	0.0013				
07/31/12	0.0031	0.0010	0.0221	0.0019	4.50	1.27	<214.04	N/A
08/07/12	0.0014	0.0007	0.0215	0.0017				
08/15/12	0.0014	0.0006	0.0169	0.0014				
08/22/12	0.0039	0.0011	0.0238	0.0018				
08/28/12	0.0035	0.0012	0.0224	0.0019	<2.46	N/A	<214.74	N/A
09/04/12	0.0018	0.0008	0.0104	0.0133				
09/11/12	0.0047	0.0011	0.0190	0.0016				
09/18/12	0.0022	0.0009	0.0194	0.0016				
09/25/12	0.0058	0.0014	0.0269	0.0019	3.80	1.20	<213.49	N/A
10/02/12	0.0050	0.0013	0.0224	0.0018				
10/09/12	0.0106	0.0016	0.0319	0.0021				
10/16/12	0.0105	0.0016	0.0326	0.0021				
10/23/12	0.0068	0.0014	0.0279	0.0019				
10/30/12	0.0079	0.0015	0.0288	0.0020	<2.49	N/A	491.19	105.89
11/06/12	0.0036	0.0011	0.0093	0.0012				
11/14/12	0.0071	0.0013	0.0297	0.0019				
11/21/12	0.0030	0.0010	0.0275	0.0019				
11/27/12	0.0104	0.0019	0.0351	0.0025	<2.39	N/A	<209.02	N/A
12/04/12	0.0065	0.0014	0.0290	0.0020				
12/11/12	0.0038	0.0011	0.0207	0.0017				
12/18/12	0.0042	0.0011	0.0210	0.0017				
12/28/12	0.0027	0.0008	0.0242	0.0016	3.19	1.16	<213.24	N/A

Note: Breaks in data indicate where no sample was available.

RADIOCHEMICAL PATICULATE DATA

2012 First Quarter Radiochemical Particulate Data Summary

Sample Location: **Aiken (AIK)**

Sample Batch:		1st Quarter 2012	+/- 2 sigma	MDA
Radionuclides pCi/m3	Pu-238	<MDA	N/A	2.42E-05
	Pu-239/240	<MDA	N/A	2.41E-05

Sample Location: **New Ellenton (NEL)**

Sample Batch:		1st Quarter 2012	+/- 2 sigma	MDA
Radionuclides pCi/m3	Pu-238	<MDA	N/A	2.37E-05
	Pu-239/240	<MDA	N/A	2.97E-05

Sample Location: **Jackson (JAK)**

Sample Batch:		1st Quarter 2012	+/- 2 sigma	MDA
Radionuclides pCi/m3	Pu-238	<MDA	N/A	3.08E-05
	Pu-239/240	<MDA	N/A	2.89E-05

Sample Location: **Burial Grounds North (BGN)**

Sample Batch:		1st Quarter 2012	+/- 2 sigma	MDA
Radionuclides pCi/m3	Pu-238	<MDA	N/A	1.89E-05
	Pu-239/240	<MDA	N/A	2.70E-05

Sample Location: **Allendale Barricade (ABR)**

Sample Batch:		1st Quarter 2012	+/- 2 sigma	MDA
Radionuclides pCi/m3	Pu-238	<MDA	N/A	2.57E-05
	Pu-239/240	<MDA	N/A	2.81E-05

Sample Location: **Allendale (ALN)**

Sample Batch:		1st Quarter 2012	+/- 2 sigma	MDA
Radionuclides pCi/m3	Pu-238	<MDA	N/A	9.73E-06
	Pu-239/240	<MDA	N/A	9.71E-06

Sample Location: **Snelling (SCT)**

Sample Batch:		1st Quarter 2012	+/- 2 sigma	MDA
Radionuclides pCi/m3	Pu-238	LE	N/A	N/A
	Pu-239/240	LE	N/A	N/A

Sample Location: **Williston Barricade (DKH)**

Sample Batch:		1st Quarter 2012	+/- 2 sigma	MDA
Radionuclides pCi/m3	Pu-238	<MDA	N/A	1.62E-05
	Pu-239/240	<MDA	N/A	1.85E-05

Note: No SCT results due to lab error.

7.0 SUMMARY STATISTICS

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Note:
Avg—Average
Std Dev—Standard Deviation
Min—Minimum
Max—Maximum
N—Number of Samples
( )—Number of Detections

2012 Statistical Review of Ambient TLD Beta/Gamma Data

Sample Location	Quarterly Avg	Std Dev	Min	Max	Median
	mrem	mrem	mrem	mrem	mrem
Colocated with AIK Air Station	13.75	0.96	13.00	15.00	13.50
Colocated with BGN Air Station	25.25	1.71	23.00	27.00	25.50
Green Pond (P)	17.75	0.50	17.00	18.00	18.00
Colocated with JAK Air Station (P)	16.25	0.96	15.00	17.00	16.50
Crackerneck Gate (P)	19.25	1.50	18.00	21.00	19.00
TNX Boat Ramp (P)	22.75	2.06	21.00	25.00	22.50
Colocated with ABR Air Station (P)	14.50	1.91	12.00	16.00	15.00
Junction of Millet Road and Round Tree Road (P)	19.50	1.29	18.00	21.00	19.50
Patterson Mill Road at Lower Three Runs Creek (P)	21.50	2.38	20.00	25.00	20.50
Colocated with ALN Air Station	16.75	1.89	14.00	18.00	17.50
Barnwell Airport	18.75	2.50	16.00	22.00	18.50
Colocated with SCT Air Station (P)	19.00	2.16	17.00	22.00	18.50
Colocated with DKH Air Station (P)	18.25	1.71	16.00	20.00	18.50
Seven Pines Road colocated with SRS Air Station (P)	22.00	2.16	20.00	25.00	21.50
Williston Police Department	20.00	1.63	18.00	22.00	20.00
Junction of US 278 and SC 781 (P)	18.25	1.26	17.00	20.00	18.00
US 278 near Upper Three Runs Creek (P)	23.75	1.50	22.00	25.00	24.00
Colocated with NEL Air Station (P)	18.50	2.38	17.00	22.00	17.50
Windsor Post Office	18.00	1.63	16.00	20.00	18.00
Control TLD (Kept in Office)	20.25	0.96	19.00	21.00	20.50
Lead (Kept in Lead Brick Enclosure)	9.50	1.73	8.00	11.00	9.50

Note: (P) indicates perimeter TLD

2012 Summary Statistics

Statistical Review Of Radiological Monitoring at Aiken Elementary Water Tower (AIK)				
Analyte	Gross Alpha in Air	Gross Beta in Air	Tritium in Air	Tritium in Rain
Units	pCi/m^3	pCi/m^3	pCi/m^3	pCi/L
N	51 (46)	51 (51)	12 (2)	12 (0)
Mean	0.0035	0.0227	4.39	No Detections
Std Dev	0.0028	0.0064	2.06	N/A
Median	0.0022	0.0222	4.39	N/A
Min	0.0008	0.0111	2.93	N/A
Max	0.0117	0.0363	5.85	N/A

Statistical Review Of Radiological Monitoring at New Ellenton, SC (NEL)				
Analyte	Gross Alpha in Air	Gross Beta in Air	Tritium in Air	Tritium in Rain
Units	pCi/m^3	pCi/m^3	pCi/m^3	pCi/L
N	52 (48)	52 (52)	12 (7)	11 (2)
Mean	0.0032	0.0224	3.68	231.59
Std Dev	0.0024	0.0064	1.05	20.31
Median	0.0023	0.0209	3.44	231.59
Min	0.0007	0.0103	2.54	217.24
Max	0.0101	0.0394	5.57	245.95

Statistical Review Of Radiological Monitoring at Jackson, SC (JAK)				
Analyte	Gross Alpha in Air	Gross Beta in Air	Tritium in Air	Tritium in Rain
Units	pCi/m^3	pCi/m^3	pCi/m^3	pCi/L
N	52 (48)	52 (52)	12 (6)	12 (2)
Mean	0.0036	0.0240	4.30	436.48
Std Dev	0.0028	0.0072	1.26	133.59
Median	0.0025	0.0236	4.35	436.48
Min	0.0008	0.0114	2.72	342.02
Max	0.0114	0.0442	6.11	530.94

Statistical Review Of Radiological Monitoring at Burial Grounds North, SRS (BGN)				
Analyte	Gross Alpha in Air	Gross Beta in Air	Tritium in Air	Tritium in Rain
Units	pCi/m^3	pCi/m^3	pCi/m^3	pCi/L
N	52 (47)	52 (52)	12 (12)	12 (12)
Mean	0.0035	0.0239	178.84	6545.96
Std Dev	0.0029	0.0073	82.76	4671.89
Median	0.0023	0.0226	157.00	4828.97
Min	0.0008	0.0107	80.55	1105.04
Max	0.0109	0.0412	331.95	16955.61

2012 Summary Statistics

Statistical Review Of Radiological Monitoring at Allendale Barricade (ABR)				
Analyte	Gross Alpha in Air	Gross Beta in Air	Tritium in Air	Tritium in Rain
Units	pCi/m^3	pCi/m^3	pCi/m^3	pCi/L
N	52 (46)	52 (52)	12 (0)	11 (1)
Mean	0.0035	0.0237	No Detections	One Detect of 210.25
Std Dev	0.0030	0.0070	N/A	N/A
Median	0.0023	0.0234	N/A	N/A
Min	0.0007	0.0101	N/A	N/A
Max	0.0126	0.0428	N/A	N/A

Statistical Review Of Radiological Monitoring at Allendale, SC (ALN)				
Analyte	Gross Alpha in Air	Gross Beta in Air	Tritium in Air	Tritium in Rain
Units	pCi/m^3	pCi/m^3	pCi/m^3	pCi/L
N	52 (50)	52 (52)	12 (1)	12 (3)
Mean	0.0032	0.0225	One Detect of 2.56	308.36
Std Dev	0.0026	0.0065	N/A	16.90
Median	0.0020	0.0220	N/A	299.68
Min	0.0008	0.0105	N/A	297.57
Max	0.0103	0.0414	N/A	327.84

Statistical Review Of Radiological Monitoring at Snelling, SC (SCT)				
Analyte	Gross Alpha in Air	Gross Beta in Air	Tritium in Air	Tritium in Rain
Units	pCi/m^3	pCi/m^3	pCi/m^3	pCi/L
N	52 (45)	52 (52)	12 (2)	12 (2)
Mean	0.0032	0.0230	3.92	343.24
Std Dev	0.0025	0.0063	0.09	153.33
Median	0.0022	0.0219	3.92	343.24
Min	0.0009	0.0109	3.86	234.82
Max	0.0105	0.0398	3.98	451.66

Statistical Review Of Radiological Monitoring at Dark Horse (DKH)				
Analyte	Gross Alpha in Air	Gross Beta in Air	Tritium in Air	Tritium in Rain
Units	pCi/m^3	pCi/m^3	pCi/m^3	pCi/L
N	52 (47)	52 (52)	12 (6)	12 (2)
Mean	0.0032	0.0214	4.61	397.29
Std Dev	0.0026	0.0059	2.15	132.80
Median	0.0022	0.0209	4.10	397.29
Min	0.0006	0.0093	2.95	303.39
Max	0.0106	0.0351	8.82	491.19

LIST OF ACRONYMS

ABR	Allendale Barricade
AIK	Aiken
ALN	Allendale
BGN	Burial Grounds North
DKH	Dark Horse at the Williston Barricade
DOE-SR	Department of Energy-Savannah River
ESOP	Environmental Surveillance and Oversight Program
JAK	Jackson
LLD	Lower Limit of Detection
MDA	Minimum Detectable Activity
NEL	New Ellenton
SCDHEC	South Carolina Department of Health and Environmental Control
SCT	South Carolina Advanced Technology Park
SRS	Savannah River Site
TLD	Thermoluminescent Dosimeter
TSP	Total Suspended Particulates
USEPA	United States Environmental Protection Agency

Units of Measure

Ci	Curie
mrem	millirem
pCi/L	picoCuries per liter
pCi/m^3	picoCuries per cubic meter
+-	Plus or minus. Refers to one standard deviation unless otherwise stated

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Section 2 2012 Water Monitoring

Chapter 2	**Ambient Groundwater Monitoring Adjacent to SRS**
Chapter 3	**Drinking Water Quality Monitoring**
Chapter 4	**Radiological Monitoring of Surface Water on and Adjacent to the SRS**
Chapter 5	**Nonradiological Monitoring of Surface Water**
Chapter 6	**Radiological and Nonradiological Monitoring of Sediments**

2012 Ambient Groundwater Monitoring Adjacent to the Savannah River Site

Environmental Surveillance and Oversight Program

96GW003
Michael D. May, Jr. Project Manager
January 01, 2012 - December 31, 2012

Midlands EQC Region - Aiken
206 Beaufort Street N.E.
Aiken, SC 29801

PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

The Environmental Surveillance and Oversight Program (ESOP) of the South Carolina Department of Health and Environmental Control (SCDHEC) samples an ambient groundwater monitoring network adjacent to the Savannah River Site (SRS) to characterize groundwater quality in the area. This annual evaluation is conducted to determine possible offsite groundwater impacts due to operations conducted at the SRS. ESOP provides this project report annually as an independent source of information concerning Department of Energy-Savannah River (DOE-SR) activities and the potential impacts of those activities to public health and the environment.

SCDHEC currently utilizes a regional groundwater monitoring well network consisting of cluster wells (C-wells) and network wells (consisting of private wells and public water systems). This groundwater well network consists of approximately 75 wells that are routinely sampled by SCDHEC. The C-wells are owned and maintained by the South Carolina Department of Natural Resources (SCDNR). These cluster wells are screened from shallow surficial aquifers to depths exceeding 1,400 feet below ground surface. The C-well clusters are situated throughout the perimeter of the SRS.

The following items outline the objectives of the project, as well as the importance of sampling for radionuclides throughout the groundwater well network:

- Evaluate groundwater quality adjacent to SRS;
- Compare results with historical data;
- Determine any SRS contaminant migration offsite;
- Expand current ambient water quality databases;
- Provide the public with independently generated, region specific, groundwater quality information.

The study area is composed of a 10-mile perimeter extending from the SRS boundary, as well as random background locations found throughout the state of South Carolina. The 10-mile sampling perimeter was selected based on groundwater well availability and overall proximity to the SRS. As part of the ongoing ambient groundwater study, sampling of random background (B locations) will continue throughout the state of South Carolina. These sample locations are selected at random using a designated quadrant system that extends throughout the state of South Carolina. These samples are collected from either private or municipal groundwater wells. Map 1 in Section 4.0 depicts the network groundwater well locations, the extent of the study area, and the wells sampled during the 2012 sampling event. ESOP evaluates five aquifer zones (Upper Three Runs, Gordon, Crouch Branch, McQueen Branch, and Piedmont Aquifer) from the water table to confined aquifers more than 1,400 feet deep (Section 5.0, Table 2).

The SCDHEC analytical laboratory data from the 2012 groundwater sampling event revealed limited contaminants present in the groundwater wells sampled. These groundwater wells, along with the extent of contaminants, will be detailed in Section 2.0 of this report. Due to the low concentrations and limited extent of the contaminants identified in these groundwater wells, it is likely the sources of these contaminants are a result of naturally occurring processes in the subsurface.

2.0 RESULTS AND DISCUSSION

The 2012 groundwater sampling event was scheduled for 12 wells. Nine of these wells are designated as network wells (Section 4.0, Map 1), and the remaining three wells are classified as background wells. Based on a review of the wet chemistry, metals, tritium, gross alpha, non-volatile beta, and gamma-emitting radioisotope analytical data provided by the SCDHEC analytical and radiological laboratories, various contaminants were detected in the 12 groundwater wells sampled.

Alpha activity was detected at three of the groundwater well locations sampled during the 2012 sampling event (GWI03002, GWG03115, GWB41), none of which exceeded the maximum contaminant level (MCL) of 15 picocuries per liter (pCi/L). Neither non-volatile beta or tritium activity was detected at any of the well locations sampled during the 2012 event.

The 2012 groundwater sampling event revealed additional contamination in several groundwater well locations. One or more of the following contaminants: nitrate/nitrite, barium, copper, cadmium, lead, and antimony were detected in 6 well locations. None of these contaminants exceeded the United States Environmental Protection Agency (USEPA) MCL primary drinking water standard.

The 2012 groundwater analytical data suggests the extent of the contaminants are isolated and likely the result of dissolved metals and radionuclides from naturally occurring geologic formations.

Contaminants commonly found in the SRS groundwater include: volatile organic compounds, metals, and tritium. In the event known contaminants (commonly found in SRS groundwater) are found in wells located within the SCDHEC sampling network, the affected wells would be investigated further to help determine the source. Due to the extensive groundwater contamination on the SRS, SCDHEC will continue to monitor groundwater quality to identify any future SRS offsite contaminant migration.

Radiological Parameter Results

The presence of naturally occurring radionuclides has been well documented in the groundwater regime across the state of South Carolina. Groundwater investigations performed by state and federal agencies such as SCDHEC, SCDNR and the USGS have confirmed the presence of these radionuclides.

Gross alpha was detected at three of the 12 groundwater wells sampled during the 2012 event. These three locations (2 network and 1 background) are identified as GWI03002, GWG03115, and GWB41 and yielded activities of 2.09 pCi/L, 10.50 pCi/L, and 3.22 pCi/L respectively. None of these locations exceeded the USEPA drinking water limit of 15 pCi/L.

Non-volatile beta was not detected in any of the 12 groundwater wells sampled. Historically, the presence of naturally occurring radionuclides has been well documented in the groundwater regime across the state of South Carolina. As a result, continued sampling for non-volatile beta activity in the future will continue.

Tritium was not detected in any of the 12 groundwater wells sampled in 2012. However, due to the known tritium groundwater contamination on the SRS and the overall concern from local stakeholders such as the Aiken Citizens Advisory Board, tritium sampling will continue and be addressed in all future project reports.

Gamma analysis was conducted on all groundwater samples for the 2012 sampling event. However, gamma activity was below the detection level for all samples collected.

Nonradiological Parameter Results

The presence of metals and other nonradiological contaminants in the environment can be attributed to man-made processes such as industrial manufacturing and/or the natural decay of deposits. However, a review of the following metal and nonradiological contaminants detected indicates their limited presence and concentration is most likely due to the erosion of natural deposits. Additionally, the position of these wells, as related to the SRS's centrally located process areas suggests the theory of natural occurrence. All analytical results can be found in Section 6.0.

During the 2012 groundwater sampling event, no volatile organic compounds (VOCs) were detected at any of the sampling locations.

Antimony was detected at one groundwater well location (GWG06126) with a concentration of 0.0034 mg/L. The USEPA has established an MCL for antimony of 0.006 mg/L. Although the antimony concentration found in this groundwater well is detectable, this concentration is below the USEPA established MCL.

Barium was detected at one groundwater well location (GWG03121) with a concentration of 0.130 mg/L. Although the concentration of barium in this well is detectable, it does not exceed the 2.00 mg/L MCL established by the USEPA. As a result, this concentration is not considered a known human health risk.

Cadmium was detected in two groundwater wells (GWG03112, GWG06126) with concentrations of 0.00021 mg/L and 0.00015 mg/L respectively. Although the concentrations of cadmium in these wells are detectable, they are well below the 0.005 mg/L MCL established by the USEPA.

Copper was detected at three groundwater well locations (GWD03010, GWG03112, and GWG06126) with concentrations of 0.011 mg/L, 0.013 mg/L, and 0.021 mg/L respectively. The USEPA has established an MCL for copper of 1.3 mg/L. Although the copper concentrations found in these groundwater wells is detectable, these concentrations are well below the USEPA established MCL.

Lead was detected in three groundwater wells (GWD03010, GWG03112, and GWG06126) yielding concentrations of 0.0028 mg/L, 0.0058 mg/L, and 0.0082 mg/L respectively. The USEPA has established an MCL for lead of 0.015 mg/L. Although the lead concentrations found in these wells are detectable, the concentrations are below the MCL and are not considered to be a known human health risk.

Nitrate/Nitrite was detected at concentrations well below the 10 mg/L MCL in five groundwater wells (GWD03010, GWG03103, GWG06151, GWGI03002, and GWG03115) yielding concentrations of 4.60 mg/L, 0.023 mg/L, 1.60 mg/L, 3.70 mg/L, and 0.52 mg/L respectively. Calculation revealed a nitrate/nitrite average of 2.09 mg/L in these five groundwater well locations. The presence of nitrate/nitrite is most likely due to the erosion of natural deposits and/or runoff from fertilizer use. Once in the soil, nitrate is mobile due to its water solubility characteristic, and therefore moves easily through the soil matrix at a speed comparable to groundwater flow velocity.

ESOP and DOE-SR Data Comparison

Due to the fact DOE-SR collects groundwater samples from a separate onsite monitoring well network, direct SCDHEC offsite groundwater comparisons could not be made to their findings in the latest SRS Environmental Report for 2012. However, the 2012 SRS report identifies numerous areas of groundwater contamination throughout the SRS property. These areas of impacted groundwater include A-Area, C-Area, D-Area, E-Area, F-Area, H-Area, K-Area, L-Area, M-Area, P-Area, R-Area, Sanitary Landfill, TNX, and Chemicals Metals Pesticides (CMP) pits. The extent of the contamination varies and some of the contaminants include: chlorinated volatile organics, tritium, gross alpha, beta radionuclides, and strontium 90 (SRNS 2013). SCDHEC groundwater contaminates detected in the 2012 sample event include tritium, gross alpha, and various metals. Due to the presence of the aforementioned contaminants in the groundwater on the SRS, the ESOP groundwater project will continue sampling for these contaminants in future sampling events.

Summary Statistics

During the 2012 groundwater sampling event, 12 wells were sampled. Of these 12 wells, three of the wells are classified as random background wells. The remaining nine wells are classified as network wells. These network wells are located on private property (private residence, public water system, or church) and situated around the perimeter of the SRS.

Laboratory analytical data revealed no detections for tritium, non-volatile beta, or gamma.

Summary statistics from the network groundwater wells sampled revealed a gross alpha average of 6.30 (± 5.95) pCi/L (based on two detections). The calculated average is slightly higher than the single background detection of 3.22 pCi/L. None of the gross alpha detections exceeded the 15 pCi/L safe drinking water limits established by the USEPA.

3.0 CONCLUSIONS AND RECOMMENDATIONS

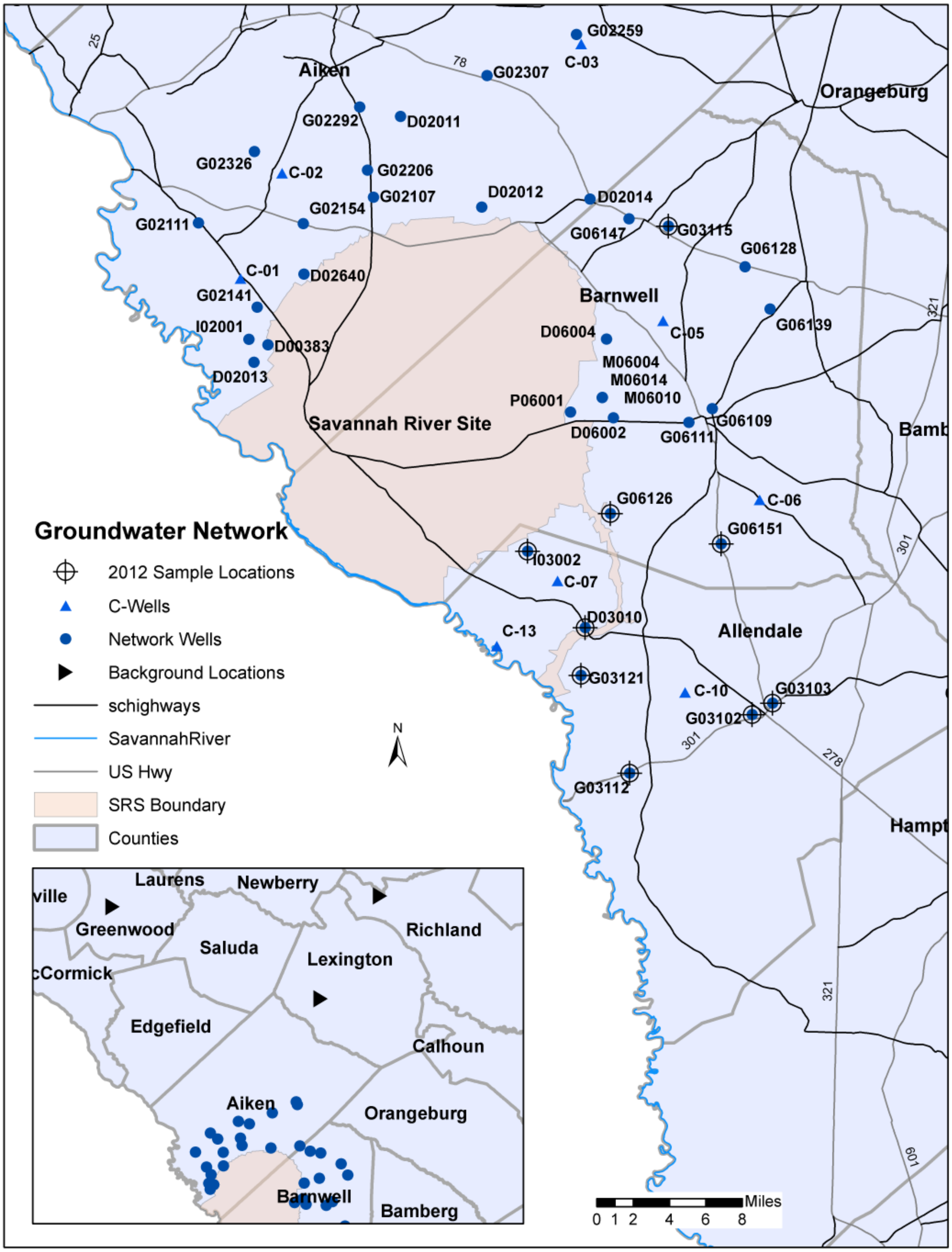
A review of the 2012 analytical data revealed various but limited nonradiological and/or radiological constituents in the majority of the 12 groundwater wells sampled. Although several of the wells sampled during this event revealed detectable concentrations, the data suggests the extent of the contaminants are isolated and likely the result of dissolved metals and radionuclides from naturally occurring geologic formations.

The Ambient Groundwater Quality Monitoring Project (AGQMP) attempted to determine if constituents, other than naturally occurring, have impacted groundwater within the monitoring network. The results of the 2012 groundwater sampling event indicate several nonradiological constituents and naturally occurring radionuclides are impacting groundwater quality in isolated regions throughout the groundwater monitoring well network as well as background locations. Independent monitoring of basic water quality parameters, metals, VOCs, tritium, gross alpha, non-volatile beta, and gamma-emitting radionuclides will continue throughout future annual groundwater investigations. In addition, statistical analysis of background data along with evaluating DOE-SR groundwater monitoring data, will be performed. Continued groundwater monitoring will provide a better understanding of actual groundwater quality parameters, their extent, and trends. As a result, comparisons with historical data can be made. In addition, ESOP will provide SCDHEC's Bureau of Water with groundwater data to assist in their evaluation of the extent of naturally occurring radionuclides in the region.

During future DOE-SR ambient groundwater sampling events (using the SRS P-wells), SCDHEC will request the opportunity to conduct split QA/QC (Quality Assurance/Quality Control) sampling. The term P-Wells is used to describe the groundwater monitoring well network used to sample groundwater within the SRS site boundary. Split sampling at random well locations throughout the SRS groundwater well network will help provide SCDHEC further annual confirmation.

4.0 Ambient Groundwater Monitoring

Map 1 Ambient Groundwater Quality Monitoring Well Network



5.0 Tables and Figures
Ambient Groundwater Monitoring

Table 1 ESOP Groundwater Monitoring Well Data, 2012

Well No.	Well Name	Sample Year	Top of Casing Elevation (ft amsl)	Total Depth (ft bgs)	Aquifer
G02292	Hunter's Glen	2010	unknown	210	SP
G02206	Oak Hill Subdivision	2010	445	240	SP
G02107	New Ellenton	2010	421	425	CB
G02259	Aiken State Park	2010	262	*	SP
G02154	Talatha Water District	2010	250	185	CB
G02141	Jackson	2010	225	105	SP
G02111	Beech Island Water District	2010	380	360	CB
G02326	ORA Site	2010	300	397	MB
D02014	Messer Well	2010	unknown	144	SP
G02307	Oakwood School	2010	428	404	CB
D02013	Cowden Plantation, Well 2	2010	124	*	SP
I02001	Cowden Plantation, Well 1	2010	132	*	CB
D02011	Mettlen Well	2010	400	180	SP
D02012	Windsome Plantation, House Well	2010	260	*	SP
G06109	Barnwell, Hwy. 3	2011	230	146	UTR
G06111	Barnwell, Rose St.	2011	220	166	UTR
G06128	Edisto Station	2011	322	360	GOR
G06147	Williston, Halford St.	2011	352	530	CB
G06139	Barnwell State Park	2011	248	163	UTR
D06002	Moore Well	2011	240	*	UTR
P06001	Allied General Nuclear, Well 1	2011	250	*	MB
D06004	J. Williams Well	2011	245	76.15	UTR
M06004	Chem Nuclear WO0061	2011	254.52	401	CB
M06014	Chem Nuclear WO0071	2011	255.33	250	GOR
M06010	Chem Nuclear WO0069	2011	254.28	145	UTR
D03010	**Martin Post Office**	**2012**	**108**	**105**	**UTR**
I03002	**Ingrim Residence**	**2012**	*****	*****	**UTR**
G03102	**Allendale, Water St.**	**2012**	**201**	**343**	**UTR**
G03103	**Allendale, Googe St.**	**2012**	**180**	**347**	**UTR**
G03112	**Allendale Welcome Center**	**2012**	**143**	**100**	**UTR**
G06151	**Chappels Labor Camp**	**2012**	**250**	**260**	**UTR**
G03121	**Clariant**	**2012**	**180**	**812**	**CB**
G03115	**Martin District Fire Department**	**2012**	*****	*****	*****
G06126	**Starmet (Carolina Metals)**	**2012**	**200**	**323**	**GOR**

Table 1 (continued) ESOP Groundwater Monitoring Well Data, 2012

Well No.	Well Name	Sample Year	Top of Casing Elevation (ft amsl)	Total Depth (ft bgs)	Aquifer
M02101	SCDNR Cluster C-01, AIK-2378	2013	220.3	185	CB
M02102	SCDNR Cluster C-01, AIK-2379	2013	224.2	266	CB
M02103	SCDNR Cluster C-01, AIK-2380	2013	228.9	385	MB
M02104	SCDNR Cluster C-01, AIK-902	2013	231.9	511	MB
M02202	SCDNR Cluster C-02, AIK-825	2013	418.8	231	CB
M02203	SCDNR Cluster C-02, AIK-824	2013	418.6	365	CB
M02204	SCDNR Cluster C-02, AIK-818	2013	418.3	425	MB
M02205	SCDNR Cluster C-02, AIK-817	2013	418.9	535	MB
M02301	SCDNR Cluster C-03, AIK-849	2013	301.6	97	SP
M02302	SCDNR Cluster C-03, AIK-848	2013	299.7	131	CB
M02303	SCDNR Cluster C-03, AIK-847	2013	299	193	CB
M02304	SCDNR Cluster C-03, AIK-846	2013	297.8	255	CB
M02305	SCDNR Cluster C-03, AIK-845	2013	296.9	356	MB
M02306	SCDNR Cluster C-03, AIK-826	2013	294.9	500	MB
M06501	SCDNR Cluster C-05, BRN-360	2013	264.3	140	UTR
M06502	SCDNR Cluster C-05, BRN-359	2013	265.5	214	GOR
M06503	SCDNR Cluster C-05, BRN-367	2013	263.8	285	GOR
M06504	SCDNR Cluster C-05, BRN-368	2013	265.1	443	CB
M06505	SCDNR Cluster C-05, BRN-365	2013	263.5	539	CB
M06506	SCDNR Cluster C-05, BRN-366	2013	266.7	715	MB
M06507	SCDNR Cluster C-05, BRN-358	2013	265.6	847	MB
M06601	SCDNR Cluster C-06, BRN-351	2014	207.3	95	UTR
M06602	SCDNR Cluster C-06, BRN-350	2014	207.4	170	UTR
M06603	SCDNR Cluster C-06, BRN-352	2014	207.1	293	GOR
M06604	SCDNR Cluster C-06, BRN-354	2014	207.6	411	GOR
M06605	SCDNR Cluster C-06, BRN-353	2014	207.7	588	CB
M06608	SCDNR Cluster C-06, BRN-349	2014	208.6	1045	MB
M03706	SCDNR Cluster C-07, ALL-368	2014	246.6	691	CB
M03707	SCDNR Cluster C-07, ALL-369	2014	242.1	800	CB
M03708	SCDNR Cluster C-07, ALL-370	2014	245.1	975	MB
M03709	SCDNR Cluster C-07, ALL-358	2014	243.1	1123	MB
M03702	SCDNR Cluster C-07, ALL-364	2014	245.2	225	UTR
M03703	SCDNR Cluster C-07, ALL-365	2014	244.3	333	GOR
M03704	SCDNR Cluster C-07, ALL-366	2014	243.5	400	GOR
M03705	SCDNR Cluster C-07, ALL-367	2014	245.7	566	CB

Table 1 (continued) ESOP Groundwater Monitoring Well Data, 2012

Well No.	Well Name	Sample Year	Top of Casing Elevation (ft amsl)	Total Depth (ft bgs)	Aquifer
M03101	SCDNR Cluster C-10, ALL-347	2014	281.6	1423	MB
M03104	SCDNR Cluster C-10, ALL-374	2014	280.9	580	GOR
M03131	SCDNR Cluster C-13, Artesian	2014	80	*	GOR
M03132	SCDNR Cluster C-13, ALL-378	2014	90	1060	MB
D02640	Green Pond Road	2014	*	222	*
D00383	Brown Road	2014	*	*	*

Notes:
1. * - Total depth/top of casing information unknown, Aquifer assigned based on owner information.
2. ft amsl – feet above mean sea level
3. ft bgs – feet below ground surface
4. UTR – Upper Three Runs, CB – Crouch Branch, SP – Steeds Pond, GOR – Gordon, MB- McQueen Branch

Tables and Figures

Ambient Groundwater Monitoring

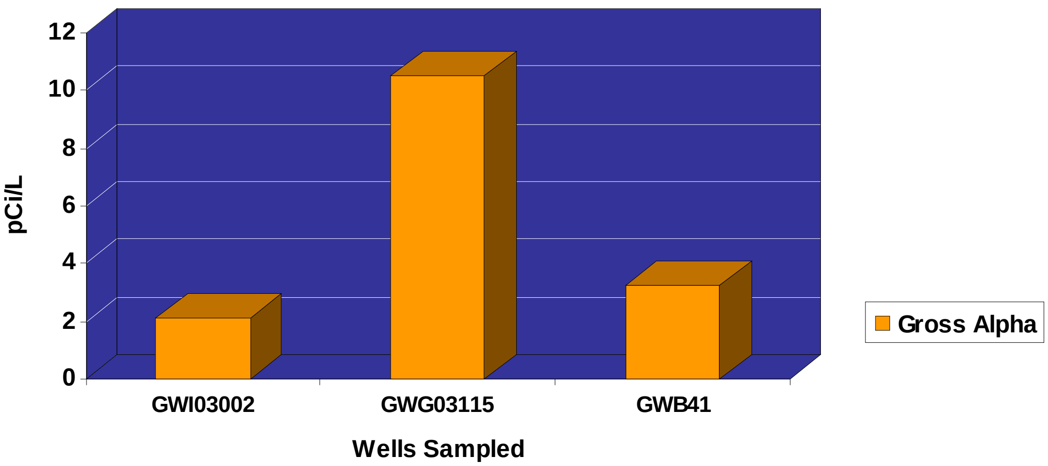
Table 2 Summary of the Stratigraphy and Hydrostratigraphy of the Study Area

PERIOD/EPOCH	GROUP	FORMATION	HYDROLOGIC UNIT	
Middle Miocene	Cooper	Upland Unit	Unsaturated Zone	
Tertiary / Eocene	Barnwell	Tobacco Road	Steed Pond Aquifer	Upper Three Runs Aquifer (UTR)
		Dry Branch/Clinchfield		
	Orangeburg	Tinker/Santee		
				Gordon Confining Unit
		Warley Hill		
		Congaree		Gordon Aquifer (GOR)
	Black Mingo	Fourmile		
Tertiary / Paleocene		Snapp	Crouch Branch Confining Unit	
		Lang Syne/Sawdust Landing		
Late Cretacious	Lumbee	Steel Creek	Crouch Branch Aquifer	
		Black Creek	McQueen Branch Confining Unit	
			McQueen Branch Aquifer	
		Middendorf		
Paleozoic or Precambrian		Cape Fear	Appleton Confining System	
		Crystalline Basement	Piedmont Hydrogeologic Province	

Tables and Figures

Ambient Groundwater Monitoring

Figure 1. 2012 Gross Alpha Activity



6.0 Data

Ambient Groundwater Monitoring

2012 Radiological Data **13**

2012 Nonradiological Data **17**

Notes:
1. Bold numbers with dark shaded boxes denotes a detection
2. LLD = Lower Limit of Detection
3. MDA = Minimum Detectable Activity
4. NA = Not Applicable
5. **C** = temperature in Celsius
6. mg/L **=** milligrams per liter
7. mS/cm **=** milliSiemens per centimeter
8. ntu **=** nephelometric turbidity units

2012 Radiological Data (Gamma)

Location Description	GWG03102	GWD03010	GWG03103	GWG03112	GWG03121
Collection Date	3/27/2012	3/27/2012	3/27/2012	4/3/2012	4/3/2012
Be-7 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Be-7 Confidence Interval	NA	NA	NA	NA	NA
Be-7 MDA	27.19	25.68	26.56	23.63	26.30
Na-22 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Na-22 Confidence Interval	NA	NA	NA	NA	NA
Na-22 MDA	2.00	2.00	1.90	1.86	1.81
K-40 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
K-40 Confidence Interval	NA	NA	NA	NA	NA
K-40 MDA	17.83	40.31	39.67	39.75	17.83
Mn-54 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Mn-54 Confidence Interval	NA	NA	NA	NA	NA
Mn-54 MDA	1.90	1.96	1.95	2.03	2.04
Co-58 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Co-58 Confidence Interval	NA	NA	NA	NA	NA
Co-58 MDA	2.58	2.57	2.36	2.27	2.53
Co-60 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Co-60 Confidence Interval	NA	NA	NA	NA	NA
Co-60 MDA	2.09	2.02	1.61	1.85	1.89
Zn-65 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Zn-65 Confidence Interval	NA	NA	NA	NA	NA
Zn-65 MDA	4.22	3.83	4.35	3.58	4.56
Y-88 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Y-88 Confidence Interval	NA	NA	NA	NA	NA
Y-88 MDA	2.03	2.31	2.42	2.06	2.01
Zr-95 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Zr-95 Confidence Interval	NA	NA	NA	NA	NA
Zr-95 MDA	5.05	4.64	4.79	4.18	4.58
Ru-103 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Ru-103 Confidence Interval	NA	NA	NA	NA	NA
Ru-103 MDA	3.85	3.50	3.85	3.37	3.05
Sb-125 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Sb-125 Confidence Interval	NA	NA	NA	NA	NA
Sb-125 MDA	6.34	6.75	6.22	6.47	5.95
I-131 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
I-131 Confidence Interval	NA	NA	NA	NA	NA
I-131 MDA	41.16	31.93	43.34	24.26	25.35
Cs-134 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Cs-134 Confidence Interval	NA	NA	NA	NA	NA
Cs-134 MDA	1.95	1.93	2.04	1.90	1.98
Cs-137 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Cs-137 Confidence Interval	NA	NA	NA	NA	NA
Cs-137 MDA	1.96	2.27	2.15	2.08	2.08
Ce-144 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Ce-144 Confidence Interval	NA	NA	NA	NA	NA
Ce-144 MDA	22.45	22.95	21.90	22.80	22.14
Eu-152 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Eu-152 Confidence Interval	NA	NA	NA	NA	NA
Eu-152 MDA	7.06	6.60	6.84	6.88	6.91
Eu-154 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Eu-154 Confidence Interval	NA	NA	NA	NA	NA
Eu-154 MDA	5.57	5.53	5.24	5.15	4.99
Eu-155 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Eu-155 Confidence Interval	NA	NA	NA	NA	NA
Eu-155 MDA	10.91	10.72	10.86	11.20	10.64
Pb-212 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Pb-212 Confidence Interval	NA	NA	NA	NA	NA
Pb-212 MDA	5.26	5.33	5.14	5.35	5.30
Pb-214 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Pb-214 Confidence Interval	NA	NA	NA	NA	NA
Pb-214 MDA	5.14	5.24	4.96	5.06	5.16
Ra-226 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Ra-226 Confidence Interval	NA	NA	NA	NA	NA
Ra-226 MDA	57.28	53.97	65.97	69.72	68.37
Ac-228 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Ac-228 Confidence Interval	NA	NA	NA	NA	NA
Ac-228 MDA	9.07	8.99	9.36	8.90	9.36
U/Th-238 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
U/Th-238 Confidence Interval	NA	NA	NA	NA	NA
U/Th-238 MDA	66.99	68.86	67.71	68.83	70.56
Am-241 Activity	<MDA	<MDA	<MDA	<MDA	<MDA
Am-241 Confidence Interval	NA	NA	NA	NA	NA
Am-241 MDA	21.81	20.77	20.31	21.32	20.41

2012 Radiological Data (Gamma)

Location Description	GWG06151	GWI03002	GWG06126	GWG03115
Collection Date	4/4/2012	4/11/2012	5/30/2012	5/30/2012
Be-7 Activity	<MDA	<MDA	<MDA	<MDA
Be-7 Confidence Interval	NA	NA	NA	NA
Be-7 MDA	25.55	22.36	46.70	46.80
Na-22 Activity	<MDA	<MDA	<MDA	<MDA
Na-22 Confidence Interval	NA	NA	NA	NA
Na-22 MDA	1.59	1.92	2.59	3.05
K-40 Activity	<MDA	<MDA	<MDA	<MDA
K-40 Confidence Interval	NA	NA	NA	NA
K-40 MDA	43.74	40.58	74.80	70.80
Mn-54 Activity	<MDA	<MDA	<MDA	<MDA
Mn-54 Confidence Interval	NA	NA	NA	NA
Mn-54 MDA	2.02	1.94	3.13	3.25
Co-58 Activity	<MDA	<MDA	<MDA	<MDA
Co-58 Confidence Interval	NA	NA	NA	NA
Co-58 MDA	2.37	2.14	3.67	4.18
Co-60 Activity	<MDA	<MDA	<MDA	<MDA
Co-60 Confidence Interval	NA	NA	NA	NA
Co-60 MDA	1.84	1.85	2.79	2.88
Zn-65 Activity	<MDA	<MDA	<MDA	<MDA
Zn-65 Confidence Interval	NA	NA	NA	NA
Zn-65 MDA	4.44	3.95	7.83	7.60
Y-88 Activity	<MDA	<MDA	<MDA	<MDA
Y-88 Confidence Interval	NA	NA	NA	NA
Y-88 MDA	2.32	2.26	3.75	3.54
Zr-95 Activity	<MDA	<MDA	<MDA	<MDA
Zr-95 Confidence Interval	NA	NA	NA	NA
Zr-95 MDA	4.25	4.00	7.80	9.35
Ru-103 Activity	<MDA	<MDA	<MDA	<MDA
Ru-103 Confidence Interval	NA	NA	NA	NA
Ru-103 MDA	3.41	2.76	6.82	6.32
Sb-125 Activity	<MDA	<MDA	<MDA	<MDA
Sb-125 Confidence Interval	NA	NA	NA	NA
Sb-125 MDA	5.73	6.12	9.52	9.00
I-131 Activity	<MDA	<MDA	<MDA	<MDA
I-131 Confidence Interval	NA	NA	NA	NA
I-131 MDA	22.83	14.81	104.00	116.00
Cs-134 Activity	<MDA	<MDA	<MDA	<MDA
Cs-134 Confidence Interval	NA	NA	NA	NA
Cs-134 MDA	1.92	1.89	3.20	3.21
Cs-137 Activity	<MDA	<MDA	<MDA	<MDA
Cs-137 Confidence Interval	NA	NA	NA	NA
Cs-137 MDA	2.25	2.13	3.74	3.35
Ce-144 Activity	<MDA	<MDA	<MDA	<MDA
Ce-144 Confidence Interval	NA	NA	NA	NA
Ce-144 MDA	22.32	22.63	35.90	34.30
Eu-152 Activity	<MDA	<MDA	<MDA	<MDA
Eu-152 Confidence Interval	NA	NA	NA	NA
Eu-152 MDA	6.90	6.70	10.60	10.50
Eu-154 Activity	<MDA	<MDA	<MDA	<MDA
Eu-154 Confidence Interval	NA	NA	NA	NA
Eu-154 MDA	4.41	5.31	7.17	8.45
Eu-155 Activity	<MDA	<MDA	<MDA	<MDA
Eu-155 Confidence Interval	NA	NA	NA	NA
Eu-155 MDA	10.90	10.88	20.80	19.70
Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
Pb-212 Confidence Interval	NA	NA	NA	NA
Pb-212 MDA	5.43	5.32	7.48	7.87
Pb-214 Activity	<MDA	<MDA	<MDA	<MDA
Pb-214 Confidence Interval	NA	NA	NA	NA
Pb-214 MDA	4.98	5.68	8.20	8.33
Ra-226 Activity	<MDA	<MDA	<MDA	<MDA
Ra-226 Confidence Interval	NA	NA	NA	NA
Ra-226 MDA	66.87	58.22	96.40	99.10
Ac-228 Activity	<MDA	<MDA	<MDA	<MDA
Ac-228 Confidence Interval	NA	NA	NA	NA
Ac-228 MDA	9.20	9.29	15.40	14.40
U/Th-238 Activity	<MDA	<MDA	<MDA	<MDA
U/Th-238 Confidence Interval	NA	NA	NA	NA
U/Th-238 MDA	65.95	69.01	121.00	122.00
Am-241 Activity	<MDA	<MDA	<MDA	<MDA
Am-241 Confidence Interval	NA	NA	NA	NA
Am-241 MDA	22.85	22.12	69.00	62.50

2012 Radiological Data (Gross Alpha, Beta)

Location Description	GWD03010	GWG03102	GWG03103	GWG03112
Collection Date	3/27/2012	3/27/2012	3/27/2012	4/3/2012
Alpha Activity	<LLD	<LLD	<LLD	<LLD
Alpha Confidence Interval	N/A	N/A	N/A	N/A
Alpha LLD	1.95	3.28	3.28	3.24
Beta Activity	<LLD	<LLD	<LLD	<LLD
Beta Confidence Interval	N/A	N/A	N/A	N/A
Beta LLD	2.72	2.86	2.86	2.85

Location Description	GWG03121	GWG06151	GWI03002	GWG06126
Collection Date	4/3/2012	4/4/2012	4/11/2012	5/30/2012
Alpha Activity	<LLD	<LLD	**2.09**	<LLD
Alpha Confidence Interval	N/A	N/A	1.64	N/A
Alpha LLD	2.26	1.81	1.98	4.08
Beta Activity	<LLD	<LLD	<LLD	<LLD
Beta Confidence Interval	N/A	N/A	N/A	N/A
Beta LLD	2.75	2.70	2.72	2.65

Location Description	GWG03115
Collection Date	5/30/2012
Alpha Activity	**10.50**
Alpha Confidence Interval	4.00
Alpha LLD	4.12
Beta Activity	<LLD
Beta Confidence Interval	N/A
Beta LLD	2.66

Network Wells

Location Description	GWB33	GWB14	GWB41
Collection Date	12/18/2012	12/19/2012	12/19/2012
Alpha Activity	<LLD	<LLD	**3.22**
Alpha Confidence Interval	N/A	N/A	2.31
Alpha LLD	4.31	4.08	3.13
Beta Activity	<LLD	<LLD	<LLD
Beta Confidence Interval	N/A	N/A	N/A
Beta LLD	2.57	2.57	2.69

Background Wells

2012 Radiological Data (Tritium)

Location Description	GWD03010	GWG03102	GWG03103	GWG03112	GWG03121
Collection Date	3/27/2012	3/27/2012	3/27/2012	4/3/2012	4/3/2012
Tritium Activity	<LLD	<LLD	<LLD	<LLD	<LLD
Tritium Confidence Interval	N/A	N/A	N/A	N/A	N/A
Tritium LLD	222	222	222	222	222

Location Description	GWG06151	GWI03002	GWG06126	GWG03115
Collection Date	4/4/2012	4/11/2012	5/30/2012	5/30/2012
Tritium Activity	<LLD	<LLD	<LLD	<LLD
Tritium Confidence Interval	N/A	N/A	N/A	N/A
Tritium LLD	222	222	222	222

Network Wells

Location Description	GWB33	GWB14	GWB41
Collection Date	12/18/2012	12/19/2012	12/19/2012
Tritium Activity	<LLD	<LLD	<LLD
Tritium Confidence Interval	N/A	N/A	N/A
Tritium LLD	208	208	208

Background Wells

2012 Nonradiological Data

Location Description	GWD03010	GWG03103	GWG03102	GWG03112	GWG03121
Collection Date	3/27/2012	3/27/2012	3/27/2012	4/3/2012	4/3/2012
Field Water Quality Data					
pH	5.78	6.02	5.88	6.02	6.42
Conductivity (mS/cm)	0.168	0.140	0.126	0.264	0.416
Turbidity (NTU)	0.00	0.00	0.00	0.00	0.00
Dissolved Oxygen (mg/L)	7.62	7.12	6.84	6.14	5.68
Temperature ©	20.60	20.40	20.92	19.68	19.06
Analyte					
Nitrate/Nitrite (mg/L)	**4.60**	**0.023**	<0.020	<0.020	<0.020
Barium (mg/L)	<0.050	<0.050	<0.050	<0.050	**0.130**
Beryllium (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Copper (mg/L)	**0.011**	<0.010	<0.010	**0.013**	<0.010
Mercury (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Arsenic (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cadmium (mg/L)	<0.00010	<0.00010	<0.00010	**0.00021**	<0.00010
Lead (mg/L)	**0.0028**	<0.0020	<0.0020	**0.0058**	<0.0050
Antimony (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Selenium (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Thallium (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Vinyl Chloride (mg/L)	Lab Error	Lab Error	Lab Error	<0.00500	<0.00500
Trichloroethene (mg/L)	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500
Tetrachloroethene (mg/L)	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500

Location Description	GWG06151	GWGI03002	GWG06126	GWG03115
Collection Date	4/4/2012	4/11/2012	5/30/2012	5/30/2012
Field Water Quality Data				
pH	6.18	6.84	7.53	N/A
Conductivity (mS/cm)	0.368	0.512	0.277	N/A
Turbidity (NTU)	0.00	0.00	37.60	N/A
Dissolved Oxygen (mg/L)	5.26	4.18	6.17	N/A
Temperature ©	20.08	20.62	21.59	N/A
Analyte				
Nitrate/Nitrite (mg/L)	**1.60**	**3.70**	<0.020	**0.52**
Barium (mg/L)	<0.050	<0.050	<0.050	<0.050
Beryllium (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
Copper (mg/L)	<0.010	<0.010	**0.021**	<0.010
Mercury (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020
Arsenic (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050
Cadmium (mg/L)	<0.00010	<0.00010	**0.00015**	<0.00010
Lead (mg/L)	<0.0050	<0.0020	**0.0082**	<0.0050
Antimony (mg/L)	<0.0030	<0.0030	**0.0034**	<0.0030
Selenium (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020
Thallium (mg/L)	<0.00050	<0.00050	<0.0010	<0.00050
Vinyl Chloride (mg/L)	<0.00500	<0.00500	<0.00500	<0.00500
Trichloroethene (mg/L)	<0.00500	<0.00500	<0.00500	<0.00500
Tetrachloroethene (mg/L)	<0.00500	<0.00500	<0.00500	<0.00500

7.0 Summary Statistics

Ambient Groundwater Monitoring

2012 Radiological Summary Statistics 19

Notes:

1. N/A = Not Applicable
2. LLD = Lower Limit of Detection

2012 Ambient Groundwater Monitoring Summary Statistics

Location Description	Well Designation	Alpha (pCi/L)
GWI03002	Network Well	2.09
GWG03115	Network Well	10.50
GWB41	Background Well	3.22

Network Wells						
	Mean	Std Dev	Median	Max	Min	Number
Alpha (pCi/L)	6.30	5.95	6.30	10.50	2.09	2

Background Wells						
	Mean	Std Dev	Median	Max	Min	Number
Alpha (pCi/L)	3.22	N/A	3.22	3.22	3.22	1

LIST OF ACRONYMS

AGQMP	Ambient Groundwater Quality Monitoring Project
CMP	Chemicals Metals Pesticides
DOE-SR	Department of Energy - Savannah River
ESOP	Environmental Surveillance and Oversight Program
GW	Groundwater
LLD	Lower Limit of Detection
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
QA/QC	Quality Assurance/Quality Control
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
STD DEV	Standard Deviation
SRS	Savannah River Site
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

UNITS OF MEASURE

pCi/L	Picocuries per liter
±	Plus or minus. Refers to one standard deviation unless otherwise stated

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Savannah River Nuclear Solutions, LLC (SRNS). 2013. Savannah River Site Environmental Report for 2012. Savannah River Site Aiken, SC. SRNS-STI-2013-00024.

South Carolina Department of Health and Environmental Control (SCDHEC) 1999. Determination of Ambient Groundwater Quality Adjacent to the Savannah River Site, Annual Report, 1997, SCDHEC Environmental Surveillance and Oversight Program.

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APPENDIX A

Regional Geology

The study area, including SRS, is located in west-central South Carolina. The regional geology is characterized as the Aiken Plateau of the Coastal Plain physiographic province. SRS is located approximately 20 miles southeast of the fall line of the Piedmont physiographic province. A thickening wedge of Cenozoic and Cretaceous sediment, which overlies Paleozoic crystalline basement rock and Triassic sedimentary rocks, underlies the area south of the fall line (Aadland et al 1995). The sediment, consisting of alternating sands and clays with Tertiary carbonates, thickens toward the southeast from zero at the fall line to more than 1,800 feet at the Allendale-Hampton County line. The sediment is about 1,100 feet thick beneath the central portion of SRS and dips toward the southeast at about 35 feet per mile. Table 2 in Section 5.0 summarizes the stratigraphy and hydrostratigraphy of the study area. For a more detailed review of regional geology and hydrogeology, refer to the 1997 Annual Report (SCDHEC 1999).

Radiological Analytes Table

Radioisotope	Abbreviation
Actinium-228	Ac-228
Americium-241	Am-241
Berylium-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
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

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2012 Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site

Environmental Surveillance and Oversight Program

97DW006
Michael D. May, Jr. Project Manager
January 01, 2012 - December 31, 2012

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PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

The Environmental Surveillance and Oversight Program (ESOP) Drinking Water Monitoring Project, as part of South Carolina Department of Health and Environmental Control (SCDHEC), evaluates drinking water quality in communities that could potentially be impacted by Savannah River Site (SRS) operations. ESOP monitoring provides information to the public regarding the extent that radiological constituents may or may not have impacted community drinking water systems adjacent and downstream to the SRS. Additionally, ESOP provides analytical data from this project for comparison to published Department of Energy-Savannah River (DOE-SR) data. The project objectives are to collect monthly composite surface water samples from one location upstream from the SRS (North Augusta) as well as three locations downstream from the SRS (Purrysburg, Chelsea Beaufort/Jasper (B/J), and Savannah, GA). Additionally, semi-annual grab samples are collected from selected public drinking water systems within 30 miles from the center point of the SRS. SCDHEC analyzes all samples for gross alpha, non-volatile beta, gamma-emitting radionuclides, and tritium.

The study area was established as a 30-mile radius circle centered in the SRS. The 30-mile sampling perimeter was selected based on drinking water system availability and overall proximity to the SRS. Using SCDHEC geographical information system, 19 primarily groundwater fed and four surface water fed public drinking water systems were selected (Section 4.0, Map 1). These sample locations were selected specifically to help ensure complete sample coverage around the perimeter of the SRS. These water systems serve approximately 281,000 customers with approximately 105,000 receiving their water from groundwater sources (Section 5.0, Table 1). None of the drinking water samples collected originated from the SRS drinking water system.

As part of the drinking water project, sampling of random background (B locations) will continue throughout the state of South Carolina. These sample locations are selected at random using a designated quadrant system that extends throughout the state of South Carolina. These samples are collected from public drinking water systems.

During 2012, DOE-SR collected surface water samples from four locations (North Augusta, Purrysburg, Chelsea B/J, and Savannah) that are colocated with the ESOP surface water fed drinking water systems. Currently, DOE-SR does not conduct drinking water sampling from groundwater fed wells off-site.

Historically, tritium has been the primary environmental release due to operations at the SRS. Tritium was produced as a nuclear weapon enhancement component. The majority of tritium releases came from the production reactors and the separation areas (Till et al 2001). In addition to SRS activities, tritium can be attributed to releases from other nuclear facilities within close proximity of the study area.

Man-made gamma-emitting radionuclides, such as iodine-131, cesium-137, and cobalt-60, were products of SRS activities. These radionuclides were produced by fission in reactor fuels and were primarily released in surface streams in the 1960s or into the atmosphere in the separation areas (WSRC 1998).

2.0 RESULTS AND DISCUSSION

Surface Water System Network Results

Tritium

Tritium is naturally present in surface waters at 10 to 30 picocuries per liter (pCi/L) (ANL 2007). The maximum contaminant level (MCL) developed by the United States Environmental Protection Agency (USEPA) for tritium in drinking water supplies is 20,000 pCi/L. Tritium continues to be the most abundant radionuclide detected in public drinking water in the study area (Section 6). Detected in both groundwater and surface water systems, the ESOP tritium detectable average was 253 pCi/L (based on a single detection) for groundwater systems and 417.72 (± 94.36) pCi/L for surface water systems. The DOE-SR detectable average for surface water systems was 381.00 (± 19.95) pCi/L (SRNS 2013). These tritium activities, however, were quite low when compared to the USEPA drinking water MCL of 20,000 pCi/L (USEPA 2002).

Historically, the primary tritium releases originated from processes associated with the reactors (R, P, K, L, and C), separation facilities (F-area and H-area), the heavy water facility (D-area), and tritium recovery in the tritium facilities. The main types of tritium releases originate from site facilities, migration from seepage basins in F-area and H-area, the burial ground, and the K-area containment basin. In the early operational years, nearly 100% of the releases to streams were related to direct releases. After the cessation of operational activities, most releases were a result of migration from the seepage basins. Since the mid 1970s, migration and outcropping to streams have accounted for most of the SRS tritium released to surface water (Till et al. 2001).

Based on a review of the surface water data from the Savannah River, tritium was detected above the lower limit of detection (LLD) in approximately 77% of surface water composite samples. The LLD range for tritium in 2012 was 197 pCi/L to 221 pCi/L. Detectable tritium activity in these samples yielded an average of 417.72 (± 94.36) pCi/L and ranged from 230 to 975 pCi/L. These tritium activities are measurable but not significant when compared to the 20,000 pCi/L USEPA MCL (USEPA 2002). Of the 12 upstream North Augusta surface water composites, there were three detections above the LLD. Tritium activity in the North Augusta samples ranged from 246 to 333 pCi/L and averaged 277.66 (± 48.09) pCi/L. Of the 36 composite samples collected downstream from the SRS, 34 samples had a tritium activity slightly above the minimum detectable activity (MDA). The tritium activity in these three downstream intakes (Chelsea B/J, Purrysburg Plant, and City of Savannah) had a range of 230 to 975 and averaged 464.40 (± 16.74) pCi/L. Figure 1 of Section 5.0 illustrates the trending data for surface water fed systems over the past five years.

Three background samples were also collected during the 2012 sampling event. Laboratory results revealed a single tritium detection of 329 pCi/L at DWB03. This activity is well below the 20,000 pCi/L USEPA drinking water standard and also below the calculated average for surface water (417.72 pCi/L).

Additional radiological samples (Plutonium and Uranium) were collected from three background and three perimeter locations during the 2012 drinking water sampling event. These samples were collected in an effort to help ESOP develop a baseline before the SRS MOX (Mixed Oxide) fuel fabrication facility becomes operational. Of the six sample locations, there was one detection for Pu-239/240 (DWE30), four detections for U-234 (DWB01, DWB03, DWE29, and DWE30), and two detections for U-238 (DWE28 and DWE30) (Section 6.0). These activities were all slightly above the detection limit and well below the USEPA established MCL. The source of these contaminants can likely be attributable to the naturally occurring radiological decay series commonly found in the subsurface and atmospheric deposition.

Gamma-emitting Radionuclides

Gamma-emitting radionuclides of concern (Section 5.0, Table 2) were not detected above the MDA and have not been detected for any of the surface water samples collected by ESOP or DOE-SR since 2002.

Gross Alpha and Non-volatile Beta

Gross alpha-emitting radionuclides were released to liquid effluent from the reactor materials area (M-area), separations areas (F-area and H-area), and the reactor areas. The primary stream affected by the M-area releases was Tims Branch, which ultimately flows into Upper Three Runs. Fourmile Creek is the stream most affected by releases coming from the separation areas. Releases from the reactor areas affected all streams with the exception of Upper Three Runs (Till et al 2001). Gross beta-emitting radionuclides were released to liquid effluent from the separations areas (F-area and H-area). The aforementioned streams ultimately flow directly or indirectly into the Savannah River.

Gross alpha was detected at Chelsea B/J and Purrysburg with an average activity of 5.80 (± 0.90) pCi/L and ranged from 0.35 to 13.50 pCi/L. Non-volatile beta was detected at three locations (North Augusta, Chelsea B/J, and City of Savannah). These three locations revealed non-volatile beta detections that averaged 3.02 (± 0.19) pCi/L and ranged from 2.74 to 3.35 pCi/L. Speciation is not conducted for gross alpha or non-volatile beta unless there is detection above the USEPA MCL of 15 pCi/L or 8 pCi/L, respectively (USEPA 2002). Alpha and beta activity is likely attributable to naturally occurring radionuclides.

Section 5.0 (Figures 2 and 3) illustrates the trends in gross alpha and non-volatile beta activities since the year 2008. Although there are several detections identified during the 2012 sampling event, none of these analytes have exceeded the USEPA established MCL for each of these contaminants. As a result, these concentrations are not considered to be known human health risks.

Groundwater System Network Results

Tritium

Based on a review of the analytical data, only one of the 19 groundwater fed systems sampled had tritium activities above the LLD. This tritium detection, located at the Talatha public water system, yielded an activity of 253 pCi/L. This tritium activity is measurable but not significant when compared to the 20,000 pCi/L USEPA MCL (USEPA 2002) and the background activity of 329 pCi/L. Figure 1 in Section 5.0 shows trending data from the past five years for the samples from groundwater fed systems that showed detections.

Gamma-emitting Radionuclides

Gamma-emitting radionuclides of concern were not detected above the MDA in any groundwater samples tested in ten years of testing by ESOP. As a result of the history of non-detections for gamma-emitting radionuclides, no summary statistics were calculated (Section 6.0).

Gross Alpha and Non-volatile Beta

Gross alpha was detected in six of the 19 primarily groundwater fed systems (Montmorenci, Jackson, Beech Island, Breezy Hill, SCAT Park, and College Acres) tested in 2012. The range for gross alpha activity was 2.18 to 6.52 pCi/L with an average activity of 3.78 (± 1.20) pCi/L. All gross alpha samples were below the USEPA MCL of 15 pCi/L (USEPA 2002). Speciation is not conducted for gross alpha unless there is a detection above the USEPA MCL of 15 pCi/L. Summary statistics for groundwater fed systems are located in Section 7.

Non-volatile beta was detected in one of the 19 groundwater systems (SCAT Park) tested in 2012. The sample collected at this location yielded an activity of 2.85 pCi/L. All 19 non-volatile beta samples collected were below the USEPA MCL of 8 pCi/L (USEPA 2002). Speciation is not conducted for non-volatile beta unless there is a detection above the USEPA MCL of 8 pCi/L.

Background Sample Results

During the 2012 drinking water sampling event, three background samples were collected at random throughout the state of South Carolina (DWB01, DWB02, DWB03). Each of these samples were tested for gross alpha, non-volatile beta, gamma, and tritium. Laboratory results revealed a single detection for tritium of 329 pCi/L at DWB03. Although this activity is detectable, it is well below the USEPA established 20,000 pCi/L drinking water limit.

ESOP and DOE-SR Data Comparison

DOE-SR conducts monthly composite sampling at the four water treatment plants (North Augusta, Purrysburg, Chelsea B/J and Savannah) that use Savannah River surface water to supply drinking water for the local population.

Based on the DOE-SR 2012 annual report (SRNS 2013), tritium in the three downstream water intakes averaged 456.00 (± 20.06) pCi/L ranging from 424.00 to 482.00 pCi/L while ESOP downstream detections averaged 464.40 (± 185.64) pCi/L ranging from 445.08 to 474.42 pCi/L. Figure 4 and Figure 5 illustrate DOE-SR finished water tritium detection averages over a five year time period. DOE-SR had an overall detected tritium average of 381.00 (± 19.95) pCi/L for all surface water samples collected in 2012. This was lower than the ESOP detected tritium average of 417.72 (± 94.36) pCi/L for the same period. The ESOP calculated average tritium activity for North Augusta is 277.66 (± 48.09) pCi/L. This average is lower than the averages for the other downstream locations due to the fact North Augusta is located upstream from the SRS (Section 5.0, Table 3). All samples were within two standard deviations as well as being lower than the USEPA MCL of 20,000 pCi/L (USEPA 2002). Tritium activity in 2012 is within two standard deviations of the running 5-year average. These activity levels are well below the USEPA MCL. Naturally occurring radionuclides may account for variability in tritium activities. Tritium continues to be the most abundant radionuclide in the Savannah River.

Gamma-emitting radionuclides were not detected in DOE-SR or ESOP samples in 2012. DOE-SR and ESOP detected non-volatile beta in surface water samples. The DOE-SR non-volatile beta average (for all four locations) of 2.30 (± 0.12) pCi/L was slightly less than the ESOP non-volatile beta average (for North Augusta, City of Savannah, and Chelsea B/J) of 3.02 (± 0.19) pCi/L. DOE-SR reported an average gross alpha activity (for all four locations) of 0.17 (± 0.06) pCi/L. ESOP had surface water gross alpha detections at the Chelsea B/J and Purrysburg plants with an average of 5.80 (± 0.90) pCi/L. All detections were less than the established USEPA MCL for gross alpha and non-volatile beta in drinking water (USEPA 2002).

Alphas (or betas) are not directly comparable due to the unknown nature (species) of the contributing alphas (or betas) in any two compared samples.

3.0 CONCLUSIONS AND RECOMMENDATIONS

Tritium continues to be the most abundant radionuclide detected in public drinking water supplies potentially impacted by the SRS. Tritium was detected in both groundwater and surface water systems. However, these tritium activities are low considering the USEPA 20,000 pCi/L MCL for drinking water. Detections of gross alpha and non-volatile beta radionuclides of concern were all below their respective MCLs. Comparative analysis with DOE-SR for groundwater systems cannot be performed because DOE-SR does not sample groundwater systems off the Savannah River Site. Due to this fact, it is of great importance that SCDHEC continues to monitor these off-site public water systems in the event these wells are impacted by contaminated groundwater from the SRS (SRNS 2013).

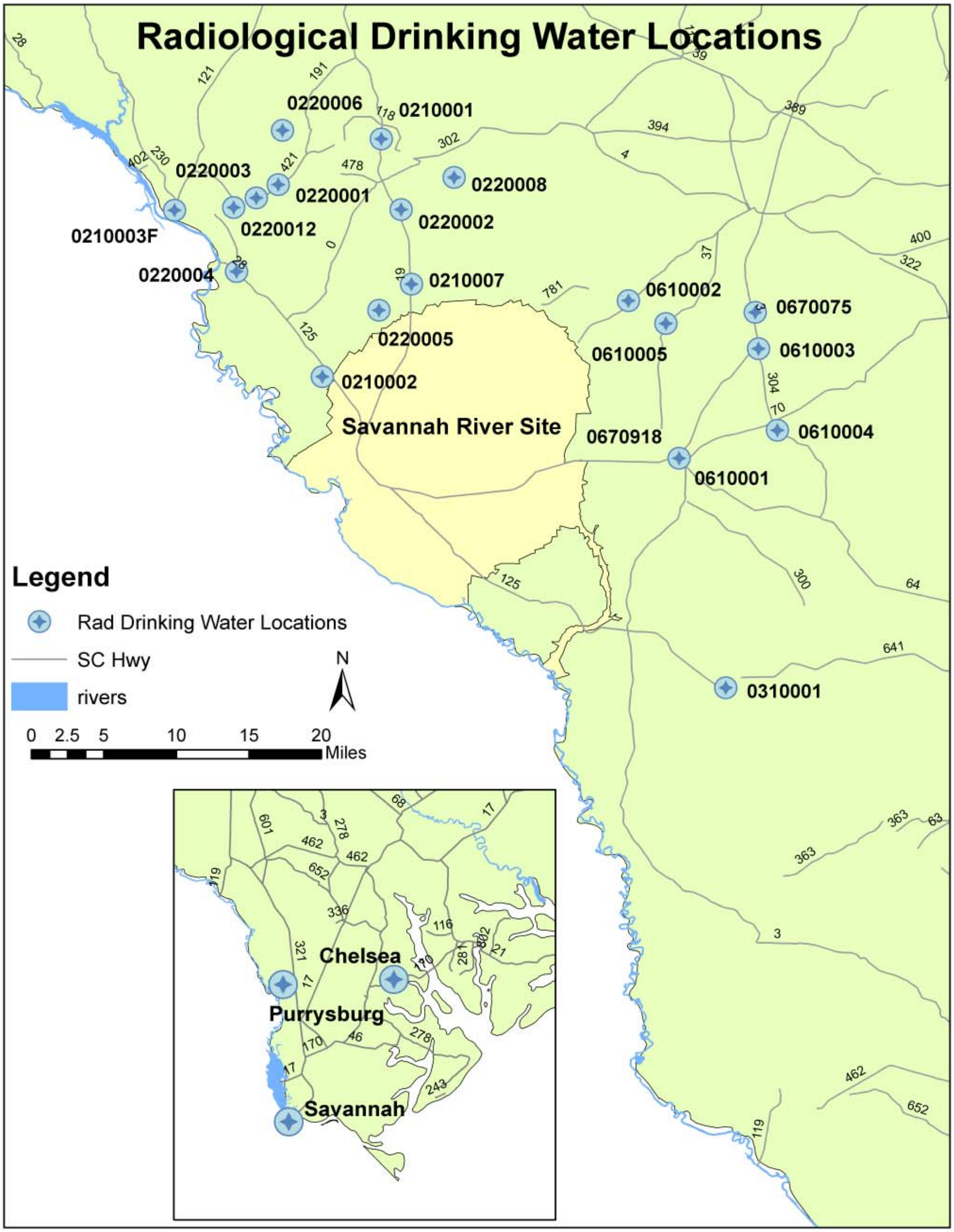
The SCDHEC Drinking Water Monitoring Project continues to be an important source of essential data for assessing human health exposure pathways. Due to the extent of the surface water contamination on the SRS and its potential to migrate south/southwest and discharge to the Savannah River, SCDHEC will continue to monitor surface water quality to identify any future contaminant migration that could potentially impact drinking water systems downstream from the SRS. SCDHEC will continue sampling to provide the public with an independent source of radiological data for drinking water systems within the SRS study area.

SCDHEC will continue collecting background samples that will provide a better idea of what ambient radioactivity levels are present in South Carolina. The data from these samples will be used in statistical analyses with the routine samples.

Currently, additional drinking water systems in the area around the SRS are being considered for routine sampling. If these locations prove to be beneficial to the drinking water project, they will be added to the project and included in all future sampling events.

4.0 Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site

Map 1. SCDHEC ESOP Drinking Water Network



5.0 Tables and Figures

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site

Table 1. Drinking Water Systems Sampled by ESOP

System Number	System Name	Number of Taps	Population
0210001	Aiken	18,443	42,374
0210002	Jackson	1,309	3,602
0210007	New Ellenton	2,231	5,303
0220001	Langley Water District	367	838
0220002	College Acres Public Water District	529	1,350
0220003	Bath Water District	314	1,064
0220004	Beech Island	3,094	7,436
0220005	Talatha Water District	571	1,553
0220006	Breezy Hill Water District	5,080	12,495
0220008	Montmorenci Water District	1,396	3,428
0220012	Valley Public Service Authority	3,409	7,803
0310001	Allendale	1,521	4,052
0610001	Barnwell	2,494	6,727
0610002	Williston	1,650	3,307
0610003	Blackville	1,141	2,973
0610004	Hilda	131	466
0610005	Elko	150	462
0670075	Healing Springs	1	6*
0670918	SCAT Park	6	125
0210003F	North Augusta Surface Water	12,022	31,506
0720003F	Chelsea B/J Plant	44,227	133,353
0720004F	Purrysburg B/J Plant		
SAVF	City of Savannah (Industrial)	35	10,619
	TOTAL	100,121	280,842
	Approximate Groundwater	43,837	105,364
	Approximate Surface Water	56,284	175,478

***** This information is likely higher due to public access to the natural spring.
Note: Data was obtained from SCDHEC Environmental Facility Information System database.

Tables and Figures
Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site

Table 2. Gamma Analyte Table

Radioisotope	Abbreviation
Actinium-228	Ac-228
Americium-241	Am-241
Berylium-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
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

Tables and Figures
Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site

Table 3. DOE-SR and ESOP Data Comparisons

	ESOP Tritium	DOE-SR Tritium	ESOP Gross Alpha	DOE-SR Gross Alpha	ESOP NV Beta	DOE-SR NV Beta
North Augusta	277.66	156.00	N/A	0.08	3.19	1.90
Chelsea B/J	474.42	462.00	5.16	0.21	3.05	2.70
Purrysburg	445.08	482.00	6.43	0.14	N/A	2.17
Savannah	473.70	424.00	N/A	0.25	2.81	2.42
Average	**417.72**	**381.00**	**5.80**	**0.17**	**3.02**	**2.30**

Tables and Figures
Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site

Figure 1. ESOP Yearly Tritium Averages in Drinking Water Systems

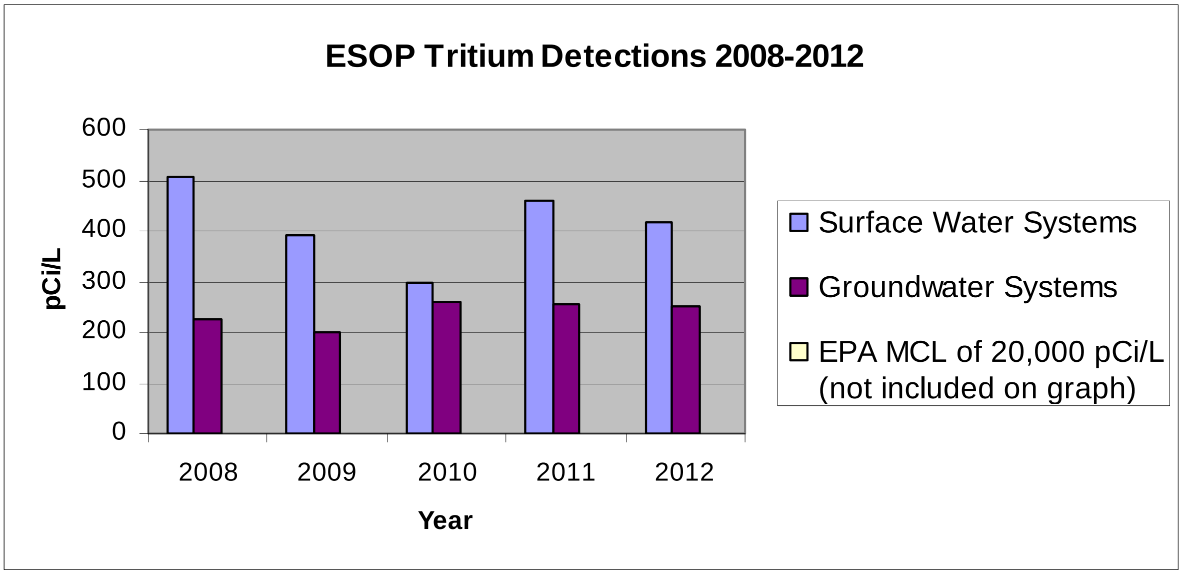


Figure 2. ESOP Yearly Gross Alpha Averages in Drinking Water Systems

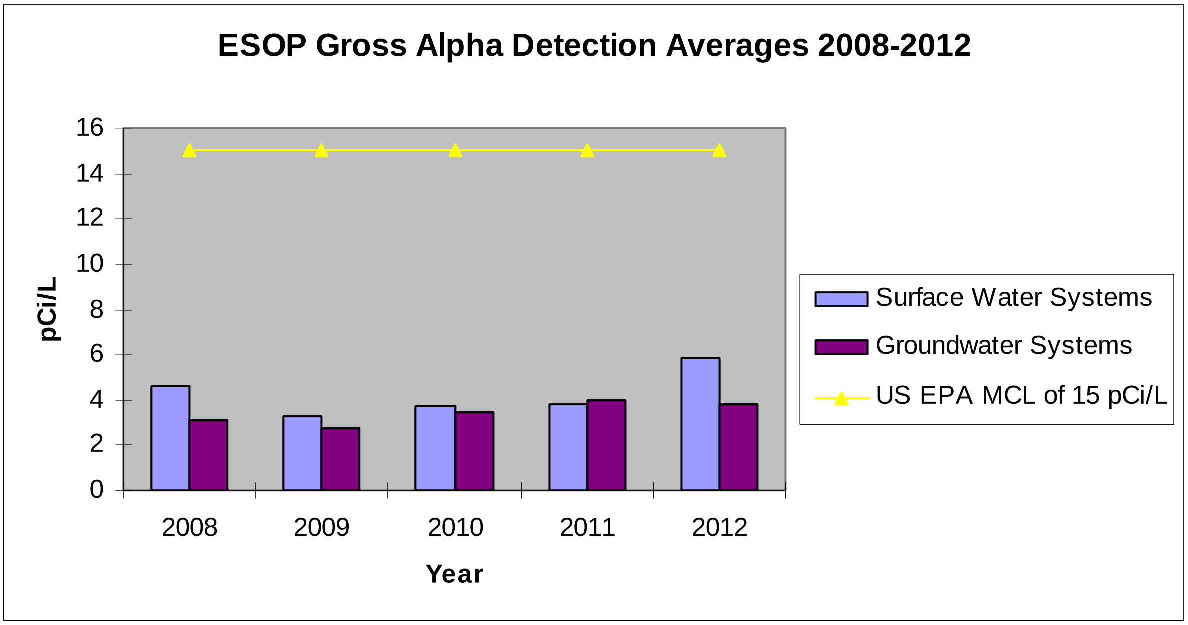
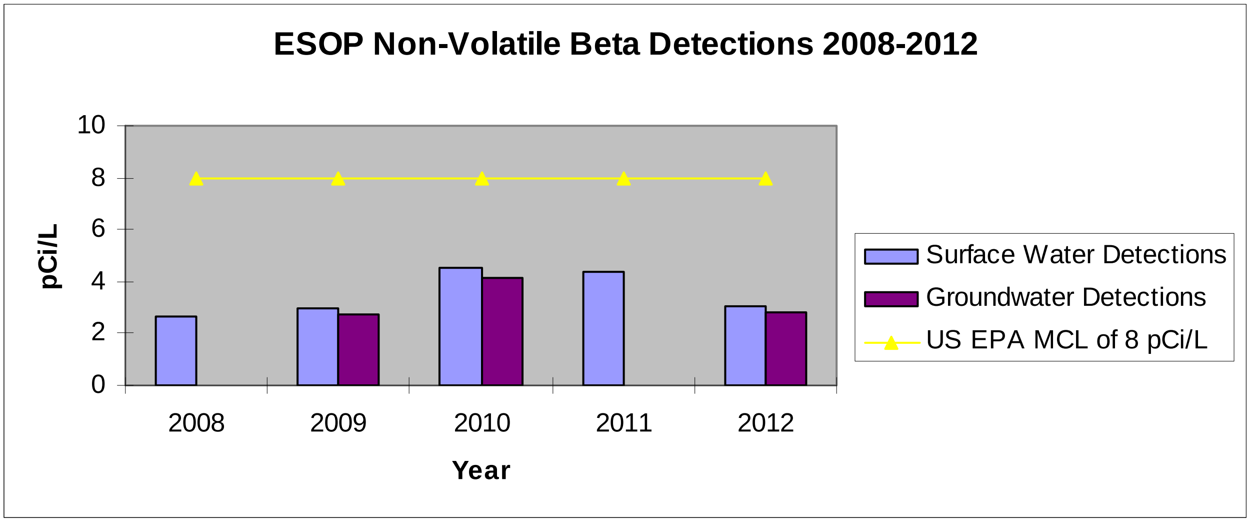


Figure 3. ESOP Yearly Non-Volatile Beta Averages in Drinking Water Systems



Note: Missing bar for 2008 and 2011 indicates no groundwater detections were found for those years.

Figure 4. DOE-SR Yearly Tritium Averages in Drinking Water Systems

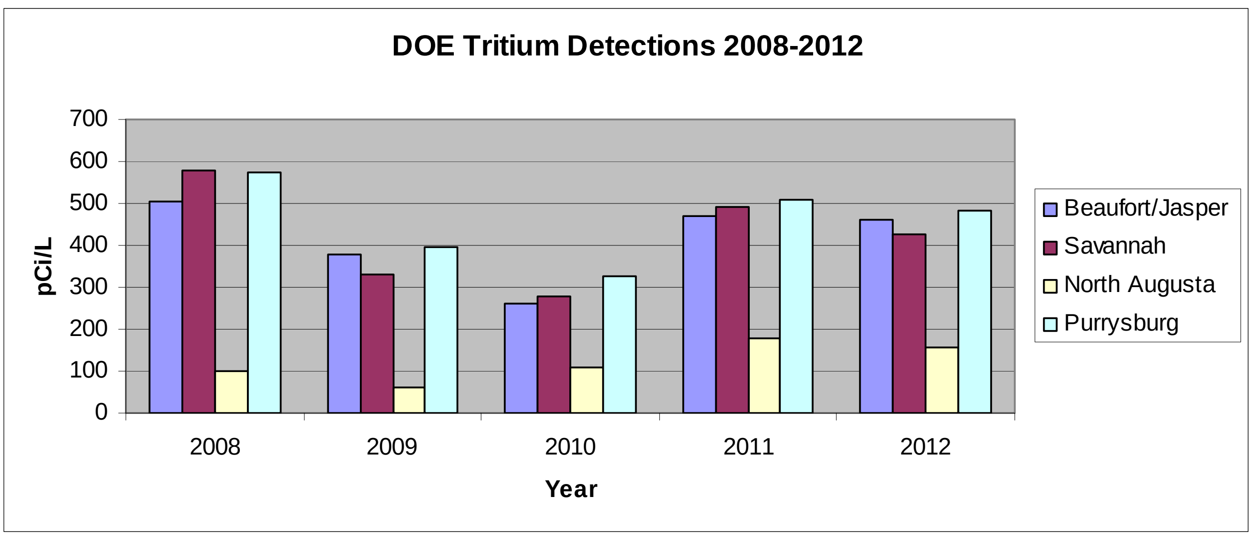
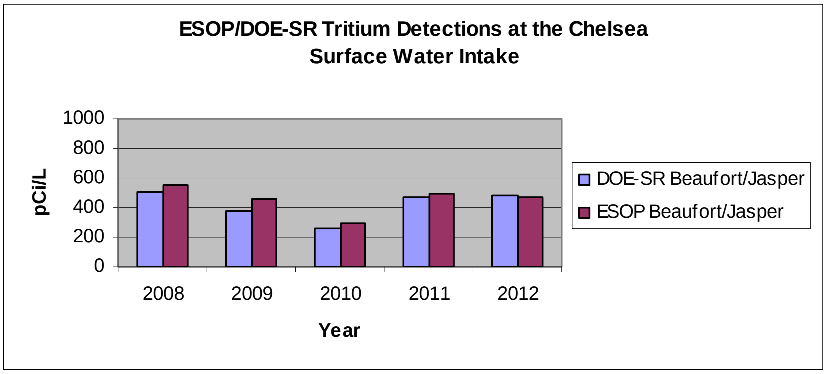
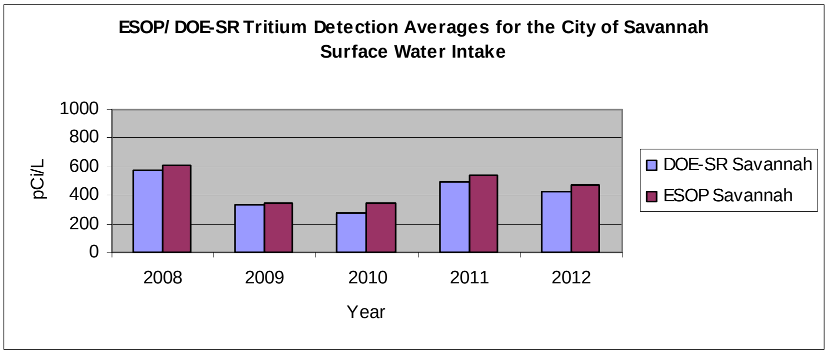
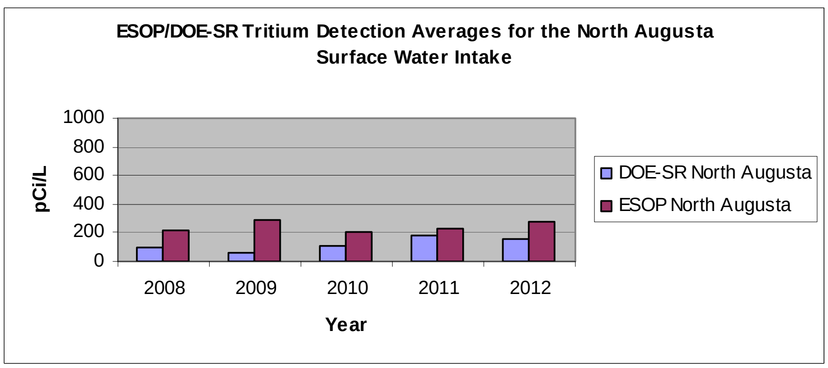
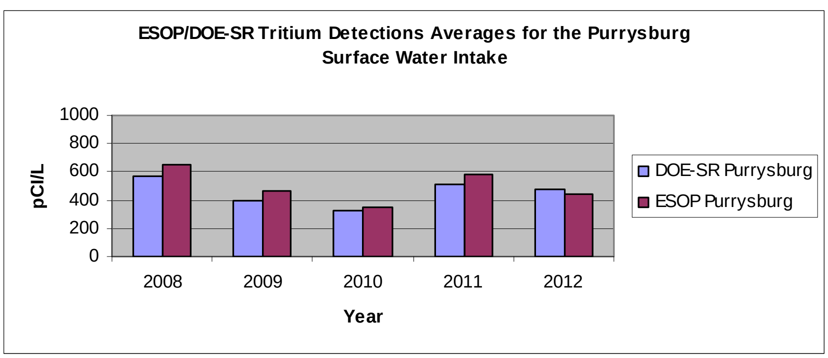


Figure 5. ESOP/DOE-SR Comparison of 2011 Averages of Tritium in Drinking Water Systems









6.0 Data

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site

2012 RADIOLOGICAL DATA FOR SURFACE WATER SYSTEMS..14

2012 RADIOLOGICAL DATA FOR GROUNDWATER SYSTEMS..15

2012 RADIOLOGICAL DATA FOR BACKGROUND SAMPLE LOCATIONS..17

Notes:

1. Bold numbers denote detection.
2. N/A = Not Applicable
3. LLD = Lower Limit of Detection
4. MDA = Minimum Detectable Activity
5. NV = Non-volatile

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site Data
Radiological Data for Surface Water Systems

Sample Number:		DW0210003F											
Sample Name:		North Augusta Surface Water											
Date:		Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
Gross Alpha	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	2.95	2.91	2.27	2.29	2.50	2.50	3.02	3.62	3.64	3.59	3.31	3.28
N-V Beta	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**3.19**	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.62	N/A	N/A	N/A	N/A
	(LLD)	1.99	3.08	3.13	3.13	2.80	2.80	2.69	2.24	2.57	2.57	2.79	2.79
Tritium	(pCi/L)	<LLD	**333**	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**246**	**254**
±2	(sigma)	N/A	102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	93	94
	(LLD)	213	213	216	216	215	215	215	215	221	221	203	203
Cesium-137	(pCi/L)	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(MDA)	2.574	2.803	3.284	3.389	3.139	3.552	2.880	2.375	3.292	2.999	2.838	2.585

Sample Number:		DW0720003F											
Sample Name:		Chelsea B/J Surface Water Canal Intake											
Date:		Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
Gross Alpha	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**5.16**	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.92	N/A	N/A	N/A	N/A
	(LLD)	3.68	3.22	2.60	2.58	2.83	2.79	3.66	0.00	4.11	4.17	3.75	3.88
N-V Beta	(pCi/L)	<LLD	**2.74**	<LLD	<LLD	<LLD	<LLD	<LLD	**3.35**	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	1.56	N/A	N/A	N/A	N/A	N/A	1.86	N/A	N/A	N/A	N/A
	(LLD)	2.13	2.18	3.17	3.17	2.83	2.83	2.50	2.65	2.57	2.57	2.80	2.80
Tritium	(pCi/L)	**314**	**295**	**286**	**328**	**534**	**570**	**413**	**310**	**513**	**975**	**544**	**611**
±2	(sigma)	104	102	102	104	109	111	104	102	111	126	104	106
	(LLD)	213	213	216	216	215	215	215	215	221	221	203	203
Cesium-137	(pCi/L)	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(MDA)	2.643	2.848	3.406	3.246	3.425	3.556	2.180	2.993	3.382	3.738	2.791	3.308

Sample Number:		DWSAVF											
Sample Name:		City of Savannah Surface Water (Industrial)											
Date:		Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
Gross Alpha	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	3.23	2.69	2.57	2.57	2.77	3.24	3.77	3.14	4.13	4.07	4.47	4.49
N-V Beta	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**2.81**	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.76	N/A	N/A	N/A
	(LLD)	2.01	2.29	3.17	3.17	2.83	2.52	2.48	2.57	2.57	2.57	2.96	2.96
Tritium	(pCi/L)	<LLD	<LLD	**302**	**328**	**254**	**570**	**383**	**373**	**788**	**455**	**586**	**698**
±2	(sigma)	N/A	N/A	103	104	99	113	105	104	120	109	107	110
	(LLD)	213	213	216	216	215	215	215	215	221	221	197	197
Cesium-137	(pCi/L)	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(MDA)	2.643	2.516	3.205	3.170	3.538	2.729	1.878	2.310	3.702	3.389	4.756	4.090

Sample Number:		DW0720004F											
Sample Name:		Purrysburg B/J Plant Surface Water SR Intake											
Date:		Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
Gross Alpha	(pCi/L)	<LLD	<LLD	<LLD	<LLD	**5.44**	<LLD	**0.35**	**13.50**	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	2.50	N/A	0.49	3.65	N/A	N/A	N/A	N/A
	(LLD)	2.49	3.14	2.53	2.54	2.72	3.38	0.00	3.52	3.98	3.98	3.61	3.71
N-V Beta	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	3.13	3.17	3.16	3.16	2.82	2.88	2.64	2.05	2.57	2.57	2.79	2.80
Tritium	(pCi/L)	**266**	**273**	**402**	**326**	**541**	**415**	**492**	**485**	**230**	**783**	**373**	**755**
±2	(sigma)	101	101	106	103	110	105	108	108	100	120	98	112
	(LLD)	213	213	216	216	215	215	215	215	221	221	203	203
Cesium-137	(pCi/L)	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(MDA)	2.596	2.712	3.701	3.285	3.314	3.327	2.335	1.947	3.657	3.507	3.150	3.186

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site Data
Radiological Data for Groundwater Systems

System Number:		0210001		0210002		0670075		0210007		0220001	
System Name:		Aiken		Jackson		Healing Springs		New Ellenton		Langley Water	
Date:		Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12
Gross Alpha	(pCi/L)	<LLD	<LLD	**6.52**	**4.84**	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	2.32	2.43	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	2.31	3.18	2.18	3.02	3.65	3.45	2.91	3.16	3.38	3.24
N-V Beta	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	3.12	3.01	2.51	3.01	2.83	2.75	2.44	3.01	2.95	3.01
Tritium	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	207	209	207	209	217	219	207	209	207	209
Cesium-137	(pCi/L)	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(MDA)	3.466	2.576	3.757	2.837	3.370	1.928	3.437	1.302	3.170	2.952

System Number:		0220005		0220006		0220008		0220012		0310001	
System Name:		Talatha Water		Breezy Hill		Montmorenci		Valley PSA		Allendale	
Date:		Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12
Gross Alpha	(pCi/L)	<LLD	<LLD	**2.18**	<LLD	**3.13**	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	1.50	N/A	2.21	N/A	N/A	N/A	N/A	N/A
	(LLD)	3.81	3.56	1.62	3.17	2.87	3.24	3.89	3.82	4.83	4.55
N-V Beta	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	2.23	2.75	2.38	3.01	2.19	3.01	2.20	3.02	2.61	3.03
Tritium	(pCi/L)	**253**	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	97	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	207	219	207	209	207	209	207	209	207	209
Cesium-137	(pCi/L)	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(MDA)	3.519	1.760	2.813	2.789	3.035	0.902	3.749	2.329	3.286	1.504

System Number:		0610004		0610001		0220003		0220002		0610002	
System Name:		Hilda		Barnwell		Bath Water Dist.		College Acres		Williston	
Date:		Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12
Gross Alpha	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**4.26**	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.53	N/A	N/A
	(LLD)	3.38	3.40	5.00	3.55	3.32	3.53	2.75	3.28	3.43	3.36
N-V Beta	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	2.68	3.01	2.61	3.01	2.21	3.01	2.53	3.01	2.56	3.01
Tritium	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	217	209	207	209	207	209	207	209	207	209
Cesium-137	(pCi/L)	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(MDA)	3.397	2.551	3.127	1.123	3.324	1.946	3.162	1.155	3.580	2.131

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site Data
Radiological Data for Groundwater Systems

System Number:		0610005		0610003		0220004		0670918	
System Name:		Elko		Blackville		Beech Island		SCAT Park	
Date:		Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12	Mar-12	Oct-12
Gross Alpha	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	**3.24**	**4.16**	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	2.34	2.12	N/A
	(LLD)	2.17	3.71	7.53	4.87	2.61	3.14	2.50	3.60
N-V Beta	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**2.85**	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	1.61	N/A
	(LLD)	2.44	3.02	3.11	2.77	2.37	3.01	2.20	3.02
Tritium	(pCi/L)	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(LLD)	207	209	217	219	207	209	207	209
Cesium-137	(pCi/L)	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
±2	(sigma)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	(MDA)	3.313	2.692	3.426	0.943	3.346	1.700	3.689	2.551

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site Data
Radiological Data for Background Sample Locations

Location Description	DWB01	DWB02	DWB03
Collection Date	5/16/2012	5/17/2012	5/18/2012
Tritium Activity	<LLD	<LLD	**329**
Tritium Confidence Interval	N/A	N/A	104
Tritium LLD	216	216	216
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	N/A	N/A	N/A
Alpha LLD	2.09	2.37	2.21
Beta Activity	<LLD	<LLD	<LLD
Beta Confidence Interval	N/A	N/A	N/A
Beta LLD	3.11	3.14	3.12
Cs-137 Activity	<MDA	<MDA	<MDA
Cs-137 Confidence Interval	N/A	N/A	N/A
Cs-137 MDA	3.341	3.508	3.538

Location Description	DWB01	DWB02	DWB03
Collection Date	5/16/2012	5/17/2012	5/18/2012
Pu-238	0.00348	0.02460	0.02130
Pu-238 Confidence Interval	0.01450	0.01880	0.01970
Pu-238 MDA	0.02760	0.02670	0.03000
Pu-239/240	0.00189	0.00000	0.00637
Pu-239/240 Confidence Interval	0.01230	0.00742	0.01100
Pu-239/240 MDA	0.02480	0.01760	0.02780
U-234	**0.01550**	0.00869	**0.01610**
U-234 Confidence Interval	0.00978	0.01130	0.00852
U-234 MDA	0.01270	0.01870	0.00642
U-235	0.00478	0.00857	0.00132
U-235 Confidence Interval	0.00575	0.00943	0.00685
U-235 MDA	0.00879	0.01290	0.01420
U-238	0.00385	0.00519	0.00746
U-238 Confidence Interval	0.00802	0.01130	0.00630
U-238 MDA	0.01450	0.02080	0.00784

Location Description	DWE28	DWE29	DWE30
Collection Date	2/7/2012	2/8/2012	2/10/2012
Pu-238	0.0051	0.0055	0.0105
Pu-238 Confidence Interval	0.0130	0.0172	0.0162
Pu-238 MDA	0.0241	0.0319	0.0282
Pu-239/240	0.0034	0.0128	**0.0366**
Pu-239/240 Confidence Interval	0.0095	0.0108	0.0200
Pu-239/240 MDA	0.0184	0.0135	0.0157
U-234	0.0469	**0.0127**	**0.0260**
U-234 Confidence Interval	0.0163	0.0092	0.0117
U-234 MDA	0.0099	0.0104	0.0091
U-235	0.0066	0.0000	0.0031
U-235 Confidence Interval	0.0073	0.0048	0.0060
U-235 MDA	0.0099	0.0105	0.0112
U-238	**0.0401**	0.0070	**0.0173**
U-238 Confidence Interval	0.0150	0.0068	0.0094
U-238 MDA	0.0098	0.0085	0.0074

7.0 Summary Statistics

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site

2012 SURFACE WATER FED SUMMARY STATISTICS 19

2012 GROUNDWATER FED SUMMARY STATISTICS 20

Notes:

1. N/A = Not Applicable
2. Min. = Minimum
3. Max. = Maximum
4. Num = Number of Detections
5. NV = Non-volatile
6. Avg. = Average
7. St. Dev. = Standard Deviation

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site
Surface Water Fed Summary Statistics

Radionuclide:	Gross Alpha (pCi/L)	Statistical Analysis					
System Name:	System Number:	Median	Avg.	St. Dev.	Max	Min	Num
Chelsea B/J	0720003	5.16	5.16	N/A	5.16	5.16	1
Purrysburg	0720004	5.44	6.43	6.63	13.5	0.35	3
Yearly Average of Detectable gross alpha			5.80				
Standard Deviation			0.90				

Radionuclide:	Gross NV Beta (pCi/L)	Statistical Analysis					
System Name:	System Number:	Median	Avg.	St. Dev.	Max	Min	Num
North Augusta	0210003	3.19	3.19	N/A	3.19	3.19	1
Chelsea B/J	0720003	3.05	3.05	0.43	3.35	2.74	2
City of Savannah	SAV	2.81	2.81	N/A	2.81	2.81	1
Yearly Average of Detectable non-volatile (NV) beta			3.02				
Standard Deviation			0.19				

Radionuclide:	Tritium (pCi/L)	Statistical Analysis					
System Name:	System Number:	Median	Avg.	St. Dev.	Max	Min	Num
North Augusta	0210003	254	277.66	48.09	333	246	3
Chelsea B/J	0720003	463	474.42	198.61	975	286	12
City of Savannah	SAV	419	473.70	179.09	788	254	10
Purrysburg	0720004	408.50	445.08	179.22	783	230	12
Yearly Average of Detectable Tritium			417.72				
Standard Deviation			94.36				

Radiological Monitoring of Drinking Water Adjacent to the Savannah River Site
Groundwater Fed Summary Statistics

Radionuclide:	Gross Alpha (pCi/L)	Statistical Analysis					
System Name:	**System Number:**	**Median**	**Avg.**	**St. Dev.**	**Max**	**Min**	**Num**
Montmorenci	**0220008**	3.13	3.13	N/A	3.13	3.13	1
Jackson	**0210002**	5.68	5.68	1.19	6.52	4.84	2
Beech Island	**0220004**	3.24	3.24	N/A	3.24	3.24	1
Breezy Hill	**0220006**	2.18	2.18	N/A	2.18	2.18	1
SCAT Park	**0670918**	4.16	4.16	N/A	4.16	4.16	1
College Acres	**0220002**	4.26	4.26	N/A	4.26	4.26	1
Yearly Average of Detectable Gross Alpha			**3.78**				
Standard Deviation			**1.20**				

Radionuclide:	NV Beta (pCi/L)	Statistical Analysis					
System Name:	**System Number:**	**Median**	**Avg.**	**St. Dev.**	**Max**	**Min**	**Num**
SCAT Park	**0670918**	2.85	2.85	N/A	2.85	2.85	1
Yearly Average of Detectable NV Beta			**2.85**				
Standard Deviation			**N/A**				

Radionuclide:	Tritium (pCi/L)	Statistical Analysis					
System Name:	**System Number:**	**Median**	**Avg.**	**St. Dev.**	**Max**	**Min**	**Num**
Talatha Water	**220005**	253	253	N/A	253	253	1
Yearly Average of Detectable Tritium			**253.00**				
Standard Deviation			**N/A**				

LIST OF ACRONYMS

DOE-SR	Department of Energy - Savannah River
ESOP	Environmental Surveillance and Oversight Program
LLD	Lower Limit of Detection
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
SCAT	South Carolina Advanced Technology
SCDHEC	South Carolina Department of Health and Environmental Control
SRS	Savannah River Site
USEPA	United States Environmental Protection Agency

UNITS OF MEASURE

pCi/L	Picocuries per liter
±	Plus or minus. Refers to one standard deviation unless otherwise stated
±2	Plus or minus 2 standard deviations.

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2012 Radiological Monitoring of Surface Water on and Adjacent to the Savannah River Site

Environmental Surveillance and Oversight Program

97RW002
Beth Cameron, Project Manager
January 01, 2012 - December 31, 2012

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D H E C
PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

The U.S. Atomic Energy Commission established the Savannah River Site (SRS) in 1950 to produce plutonium, tritium, and other materials for national defense and civilian purposes (Till et al. 2001). Due to the large number of materials 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 released radionuclides to the offsite public. In 1992, CDC hired Radiological Assessments Corporation (known as Risk Assessment Corporation as of 1998) to perform screening procedures to determine the key radionuclides released to the environment. These screening methods indicated that the main radionuclides released to surface water were tritium (H3) and cesium-137 (Cs-137). Other radionuclides of interest are strontium-90 (Sr-90), cobalt-60 (Co-60), americium-241 (Am-241), and uranium (U). The five production reactors (R, K, P, L, and C) were the primary sources for these radionuclide releases directly to onsite streams. Additionally, effluent from the separation areas (F-Area and H-Area) was discharged into storage tanks and seepage basins, but not directly into streams. However, some releases from these areas occurred due to leaks in cooling coils, that contained water pumped from deep wells. The fuel fabrication area (M-Area), heavy water reprocessing facility (D-Area), and the administration area (A-Area) also contributed radionuclides to liquid discharge. Onsite streams affected by these releases were Upper Three Runs Creek, Beaver Dam Creek, Fourmile Branch, Pen Branch, Tims Branch, Steel Creek, and Lower Three Runs Creek. All of these SRS streams are tributaries to the Savannah River (Till et al. 2001).

Tritium was one of the principle nuclear materials produced at SRS to multiply the firepower of plutonium in nuclear weapons (Till et al. 2001). The primary tritium releases originated from processes associated with the reactors, separation areas, D-Area, and tritium recovery in the tritium facilities. The two main types of tritium releases came from direct site facility releases and migration from seepage basins in the separation areas, the burial ground, and the K-Area containment basin. In the early operational years, almost 100% of the releases to streams were related to direct releases. After the cessation of active reactor activities, most releases were a result of migration from the seepage basins. Since the mid 1970s, migration and outcropping to streams have accounted for most of the SRS tritium released to surface water (Zeigler et al. 1985, Murphy et al. 1991, Murphy and Carlton 1991). After 1988, the Effluent Treatment Facility (ETF) went into operation and the F-Area and H-Area basins were not used (CDC 2006). The primary purpose of ETF was to process low level radioactive wastewater from the separation areas (SRS 2008). Periodically, ETF has controlled tritium releases to Upper Three Runs Creek. Additionally, tritium occurs naturally from the interaction of cosmic radiation with atmospheric gases (USEPA 2008a) and also as a result of past nuclear testing (Till et al. 2001).

Most of the Cs-137 at SRS was formed as a byproduct of the nuclear fuel and targets during operation of the five production reactors. Cesium-137 is an important radionuclide to monitor due to its 30-year half-life. Additionally, the biological behavior of Cs-137 is similar to potassium, which is essential to the function of living cells (USEPA 2008b). Therefore, the potential for Cs-137 uptake into humans is important considering the potential health effects. The streams that were largely affected by Cs-137 are Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs Creek, with Steel Creek historically showing the highest activity (Till et al. 2001).

Alpha-emitting radionuclides were released to liquid effluent from M-Area, separation areas, and the reactor areas. The primary stream affected by the M-area releases was Tims Branch, which ultimately flows into Upper Three Runs Creek. Fourmile Branch is the stream most affected by releases coming from the separation areas. Releases from the reactor areas affected all streams with the exception of Upper Three Runs Creek (Till et al. 2001).

Beta-emitting radionuclides were released to liquid effluent from separation areas and the reactors. Fourmile Branch is the stream primarily affected by releases from the separations areas. Steel Creek, Pen Branch, and Lower Three Runs Creek were mainly affected by releases from the reactors. Strontium-90 is a main contributor of beta activity and came primarily from the reactors (Till et al. 2001).

The previously mentioned SRS surface water bodies, as well as the Savannah River, continue to be the focus for monitoring and surveillance activities of the Radiological Monitoring of Surface Water (RSW) project that is part of the South Carolina Department of Health and Environmental Control (SCDHEC) Environmental Surveillance and Oversight Program (ESOP). Since the Savannah River is the primary drinking water source for downstream communities, it is important to ensure radionuclide concentrations in the river are well below limits considered safe for human consumption. Surface water samples are collected and analyzed for radionuclides, and the results are compared to Department of Energy-Savannah River (DOE-SR) data. DOE-SR conducts surveillance and monitoring activities for the following purposes: determining 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. ESOP supports DOE-SR's objectives to ensure the primary goal of drinking water safety is established and met. Data trends for radionuclides are given (Section 5.0, Tables and Figures; Section 6.0, Data Tables; and Section 7.0, Summary Statistics). These activities will allow the RSW project to generate independent data to compare with DOE-SR data, and is shared with the public.

The RSW Project continues to collect surface water samples from 13 specific locations within and outside of the SRS boundary as part of an ambient sampling network (Section 4.0, Map 1.). Section 5.0, Table 1 identifies sample ID, location, rationale, and frequency. Seven of these locations use ISCO™ automatic water samplers to collect aliquots every 30 minutes to produce a composite. Grab samples are collected from the remaining six locations. Samples are collected three days per week (Monday, Wednesday, Friday) from the locations that have the automatic water samplers. The composite sampler is utilized to collect composite samples over a 48-hour period (Monday through Wednesday and Wednesday through Friday) or a 72-hour period (Friday through Monday). An 80-milliliter (ml) bottle is separated for same day tritium analysis. Seven hundred milliliters is poured into a secondary bottle from the composited on Monday Wednesday, and Friday. This composite sample is then composited in a tertiary container to be analyzed monthly for gross alpha, gross beta, and gamma (Table 1.). Some locations were chosen because they are considered to be public access locations. The public access locations are downstream of SRS, with the exception of the background location of Jackson Boat Landing (SV-2010), providing a potential means for exposure to radionuclides.

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, Beaver Dam Creek, Fourmile

Branch, Steel Creek, and Lower Three Runs Creek). Pen Branch is not sampled because the Savannah River Swamp interrupts the flow for this creek and there is no creek mouth access.

An enhanced surface water monitoring program is implemented to provide downstream drinking water customers with advance notice of the potential for increased tritium levels in the Savannah River due to an SRS release. This early detection facet is possible because of the continuous monitoring of the six SRS streams that flow to the Savannah River. Samples for tritium analysis are collected from the seven locations with automatic water samplers. Additionally, a grab sample is collected from Johnson's Boat Landing (SV-2080) and US Highway 301 at the Savannah River (SV-118). Sampling devices at SV-118 consist of an ISCO™ composite sampler and a 24 bottle carousel sampler. The carousel sampler provides hourly samples collected for the same respective time frame as the composite sampler. This gives ESOP a more accurate method for detecting potential tritium concentrations. Samples are analyzed at the Midlands EQC Region-Aiken Environmental Quality Control (EQC) tritium laboratory on the day of collection and results from the tritium analysis are used to project tritium activity in the Savannah River. Results from the enhanced program are considered to be unofficial results and are used only for notification purposes.

An additional component of the RSW Project is the Supplemental Surface Water Monitoring Program implemented in 2005. The purpose of this sampling program is to monitor any potential releases of radionuclides. Sample locations are located along McQueen Branch, Upper Three Runs, Fourmile Branch, and Steel Creek. This monitoring was established for early detection of unplanned releases from SRS source term areas. Samples are collected on Monday, prepped the same day, and analyzed for gamma emitting radiolnuclides the next day as part of a quick scan early detection procedure. These samples are collected as unofficial results for notification purposes only.

In August of 2007, ESOP began collecting ambient grab samples from a location at SC Highway 125 and Lower Three Runs Creek. This sampling was conducted in response to elevated tritium levels detected in groundwater samples near the Energy Solutions (formerly Chem-Nuclear) facility in Snelling, SC. The purpose of adding this location was to determine any potential tritium contributions to Lower Three Runs from Energy Solutions. This sampling location was moved to a location (Lower Three Runs Creek and Patterson Mill Road, SV-328) closer to the source during November of 2007.

Quarterly sampling for iodine-129 (I-129) and technetium-99 (Tc-99) was conducted at the ambient location on Fourmile Branch due to concerns that these are possible constituents related to effluent from the burial grounds.

The automatic water samplers located at SV-118 are powered by alternating current. This power source can be interrupted at times due to power outages most often associated with seasonal thunderstorms. Although this interruption of power typically is not frequent, only a partial sample may be collected in the composite sampler. Additionally, the sampling program in the carousel sampler may be halted, resulting in missed samples during a sampling event. All other automatic water samplers are powered by marine batteries and can also run low causing the sampler to not collect a full sample. Any missed composite samples are collected as grab samples. Solar panels are being purchased, as they fit in the budget, to alleviate this situation in the future.

2.0 RESULTS AND DISCUSSION

SCDHEC Surface Water Data

All monitoring data are in Section 6.0 and summary statistics are in Section 7.0. All established sampling locations are in Section 5.0, Table 1.

<u>Tritium</u>

In 2012, tritium activity was detected at all ambient locations where weekly samples were collected (Section 7.0, Summary Statistics). Average tritium activities at Jackson Boat Landing (SV-2010), TNX Boat Landing (SV-2012), and Upper Three Runs Creek at United States Forestry Service (USFS) Rd E-2 (SV-2027), were lower than average tritium activities at the other ambient sample locations. All of these locations are upstream from SRS impacts and are therefore considered background locations. The average detected tritium for these locations was 251 (±28) picocuries per liter (pCi/L) for SV-2010, 292 (±57) pCi/L for SV-2012, and 236 (±40) pCi/L for SV-2027. Fourmile Branch at USFS Rd. 13.2 (SV-2039) and Pen Branch at USFS Rd. 13.2 (SV-2047) continue to yield the highest levels of tritium activity. SV-2039 had an average tritium activity of 44,039 (±6,157) pCi/L and SV-2047 had an average tritium activity of 31,950 (±9,438) pCi/L. Detected tritium activity at all locations ranged from 159 pCi/L at SV-2027 to 54,691 pCi/L at SV-2039**.** Section 5.0, Figure 1 shows trending for 2008-2012 tritium averages.

Tritium activity in the Savannah River at the creek mouths of the five SRS streams was monitored on a quarterly basis in 2012 (Section 7.0, Summary Statistics). Three samples were collected each quarter at Fourmile Branch (SV-2015): one from the creek mouth, one from 30 feet downstream of the creek mouth, and one from 150 feet downstream of the creek mouth. Samples were taken at these three intervals to show the effect of the mixing zone created by the Savannah River flow. Samples collected directly at the creek mouth of Fourmile Branch (SV-2015a) had the highest average tritium activity (20,587 (±14,339) pCi/L) of all creek mouth locations**.**

<u>Gamma</u>

As part of a gamma spectroscopy analysis, samples were analyzed for gamma-emitting radionuclides (Section 5.0, Table 2) at the Radiological Environmental Monitoring Division (REMD) Laboratory in Columbia, SC. Cesium-137 has been historically detected in samples collected from Fourmile Branch and Lower Three Runs Creek. These streams were affected by releases from reactor activities, so periodic Cs-137 detections are likely in samples collected from these locations. In 2008, Co-60 and Am-241 results were incorporated in the RSW project report for comparison purposes with SRS data. All Cs-137, C0-60, and Am-241 results from the gamma analysis in 2012 were below their respective Minimum Detectable Activities (MDA).

Alpha

In 2012, alpha-emitting radionuclides were detected at three locations where monthly composite samples were collected (Section 7.0, Summary Statistics). Average detected activity over all locations ranged from 3.39 (± 0.68) pCi/L at SV-327 to 8.20 (± 4.38) pCi/L at SV-325. SV-325 had detections in six of the 12 samples collected. Pen Branch had two detections averaging 5.57 (±3.10) pCi/L. In 2012, average alpha detections were lower than in 2011. There were only three locations in 2012 that had any alpha detections compared to five locations in 2011. The average alpha detected at SV-325 decreased from 11.95 (±5.76) pCi/L in 2011 to 8.20 (±4.38) pCi/L in 2012 (SCDHEC 2012).

Historically, SV-325 yields detections for alpha activity (SCDHEC 2000-2012). Isotopic analysis performed by DOE-SR revealed the source to be natural uranium (SRNS 2011). This may contribute to the common occurrence of alpha detections at this location. The 2012 average alpha activity at SV-325 was below the United States Environmental Protection Agency (USEPA) Maximum Contaminant Level (MCL) for drinking water of 15 pCi/L (USEPA 2002). Beginning in 2009, samples collected at this location exhibited particles of sediment and detritus usually associated with rain events. 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 attenuated by salts and solids dried onto a planchet (USEPA 2010). Furthermore, samples submitted to the REMD underwent a shorter turnaround for analysis during this period. This could have resulted in the detection of short lived radionuclides that had not decayed sufficiently. This sampling location is monitored for turbidity to ensure it is not a concern in collected samples. Ambient monitoring average annual alpha trends for 2008-2012 are shown in Section 5.0, Figure 2. All 2012 averages were below the USEPA MCL of 15 pCi/L for gross alpha-emitting particles in drinking water (USEPA 2002).

Beta

Beta-emitting radionuclide activity was detected in four of nine locations where monthly composite samples were collected (Section 7.0, Summary Statistics). The activity ranged from a single detection of 2.75 (±1.79) pCi/L at SV-327 to a single detection of 4.94 (±2.43) pCi/L at SV-118**.** Four Mile Creek was primarily affected by releases from the separations areas, so gross beta detections can be expected at this location. In 2012, Fourmile creek had an average detection of 4.47 (±1.56) pCi/L. Ambient monitoring average annual beta trends for 2008-2012 are shown in Section 5.0, Figure 3. USEPA has established a MCL of 4 millirem per year for beta particle and photon radioactivity from man-made radionuclides in drinking water. The USEPA screening MCL for gross beta-emitting particles for drinking water systems is 50 pCi/L minus natural K-40 (USEPA 2002)**,** and all averages were below this limit.

Iodine-129 and Technetium-99

Iodine-129 and Technetium-99 sampling of the ambient location on Fourmile Branch was monitored on a quarterly basis in 2012. There were no I-129 detections above the MDA in the four quarterly samples. There were Tc-99 detections in two of the four quarterly samples averaging 4.92 (±2.64) pCi/L (Section 6.0).

USEPA has established a MCL of 4 millirem per year for beta particle and photon radioactivity from man-made radionuclides in drinking water. Technetium-99 would be covered under this MCL. The average concentration of Tc-99, which is assumed to yield 4 millirem per year, is 900 pCi/L. 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 Tc-99 and I-129, the sum of the annual dose from all the radionuclides shall not exceed 4 millirem/year (USEPA 2002).

SCDHEC/DOE-SR DATA COMPARISON

Data from 2012 reported in this project were compared to DOE-SR reported results (Section 5.0, Tables 3, 4, 5). The SCDHEC and DOE-SR colocated sampling sites were Upper Three Runs Creek at SC Highway 125, Fourmile Branch at USFS Road 12.2, Pen Branch and USFS Road 13.2, Steel Creek at SC Highway 125, Lower Three Runs Creek at SRS Road B, and the Savannah River at US Highway 301 Bridge. DOE-SR sampled at several other locations along these streams, however the data comparisons are only for the colocated sample sites.

Tritium

DOE-SR reports all values, including values that are negative and ones that are below detection. Therefore, DOE-SR reports an average for all locations derived from detections and non-detection values. For the purpose of this report, the average, median, and standard deviation for all DOE-SR data was recalculated using detections only for a more accurate comparison. SCDHEC and DOE-SR had detections for tritium at all colocated sample locations (Section 5.0, Table 3). DOE-SR average tritium activities for all colocated sites were within one standard deviation (SD) of SCDHEC average tritium activities. SCDHEC and DOE-SR samples indicate that Fourmile Branch (44,039 (±6,157) pCi/L and 43,558 (±8,364) pCi/L, respectively) and Pen Branch (31,950 (±9,438) pCi/L and 28,448 (±7,267) pCi/L, respectively) have the highest tritium activity of all SRS streams**.** The 2012 SCDHEC and DOE-SR tritium results appear to be consistent with historically reported data values (Section 5.0, Figures 4-9: SCDHEC 2003-2012, WSRC 2003-2008, SRNS 2009-2013).

Gamma

DOE-SR reported a single detection of Am-241 (0.08 (±0.01) ± 2SD) (SRNS 2013) at the colocated sample site Upper Three Runs at Road A. SCDHEC had no gamma detected above the MDA in 2012.

Alpha

DOE-SR detected gross alpha activity at all of the colocated sampling locations in 2012. SCDHEC detected gross alpha activity at only three of the colocated sample locations with DOE-SR (Section 5.0, Table 4). DOE-SR average gross alpha activities were within one SD of SCDHEC at Upper Three Runs colocated sample site. DOE-SR average gross alpha activities were within two SD of SCDHEC at the Pen Branch and were over three SD at the Steel Creek colocated sample site. SCDHEC and DOE-SR samples collected from Upper Three Runs Creek at SC Highway 125 exhibited the highest gross alpha average concentration (8.20 (±4.38) pCi/L and 8.91 (±8.75) pCi/L (SRNS 2013), respectively).

Beta

SCDHEC detected gross beta activity at three of the six colocated sampling locations while DOE-SR detected activity at all six colocated locations (Section 5.0, Table 5). SCDHEC did not detect gross beta activity at Upper Three Runs, Pen Branch, or Lower Three Runs. DOE-SR average gross beta activities were within two SD of SCDHEC average gross beta activities at Fourmile Branch and over three SD difference at Steel Creek and on Savannah River at the Hwy 301 Bridge. DOE-SR samples collected from Fourmile Branch exhibited the highest gross beta average activities at 6.06 (±0.96) pCi/L (SRNS 2013). SCDHEC samples collected from Highway 301 had the highest average beta activity with a single detection of 4.94 pCi/L.

Iodine-129 and Technetium-99

Iodine-129 and Technitium-99 were not compared for SCDHEC and DOE-SR because there was no colocated site analyzed.

3.0 CONCLUSIONS AND RECOMMENDATIONS

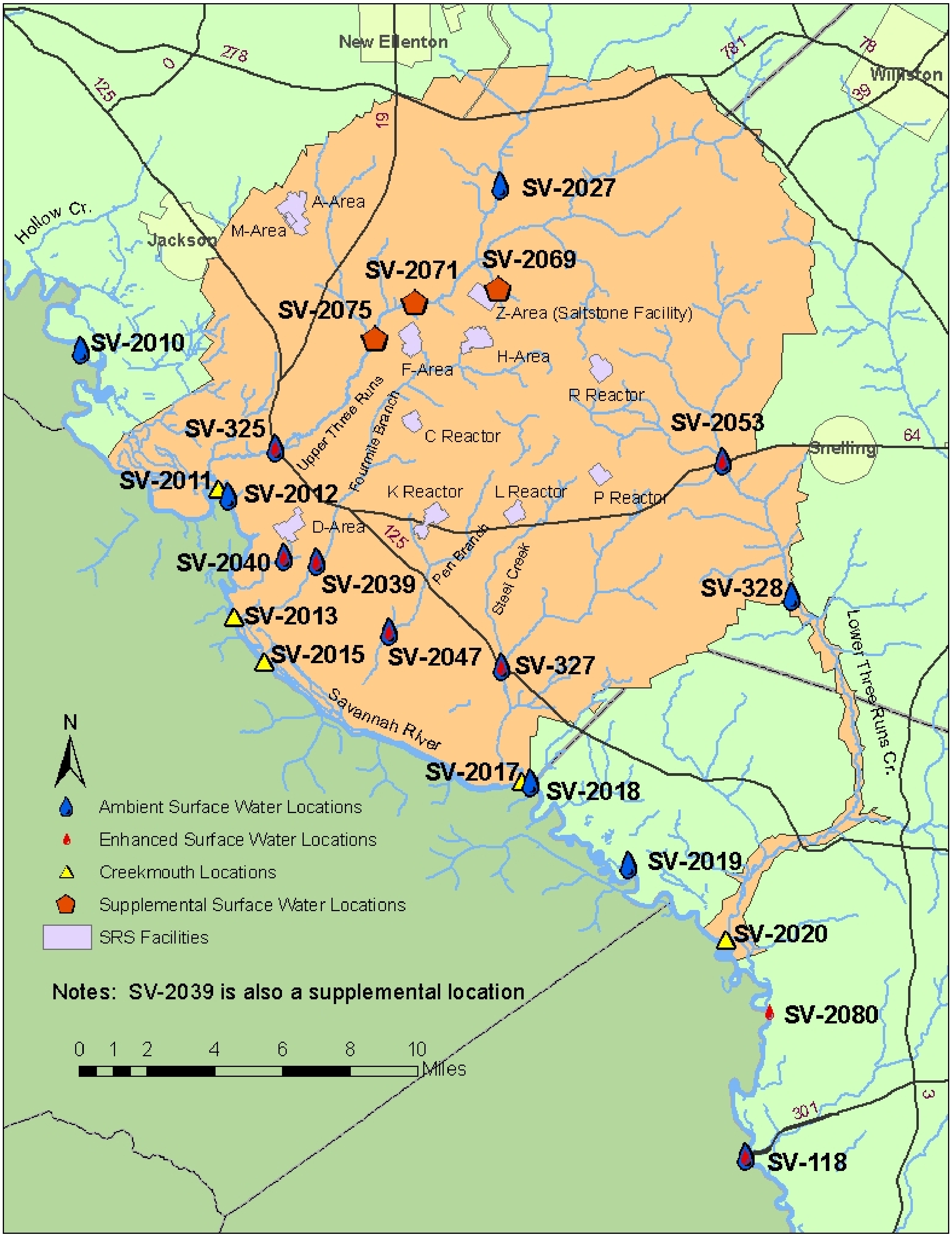
While tritium is detected at all public access locations, the results were below the USEPA MCL annual average of 20,000 pCi/L for drinking water, with the exception of the Fourmile Branch Creek Mouth (USEPA 2002). Data generated from samples collected at the mouth of Fourmile Branch (SV-2015) indicate that the public could come into contact with tritium activity greater than the MCL at that location.

Differences in average values between SCDHEC and DOE-SR could be attributed, in part, to the nature of the water medium and the specific point and time when the sample was collected.

The ESOP RSW Project will continue to independently collect and analyze surface water on and adjacent to SRS. This monitoring effort will provide an improved understanding of radionuclide levels in SRS surface waters and valuable information relative to human health exposure pathways. The RSW project will periodically evaluate modifications of 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. A historic location, Beaver Dam Creek (SV-2040), was removed near the end of 2012 due to the cessation of operational procedures at D-Area facilities. Beaver Dam Creek was a manmade creek that ceased to flow after operations at the facility stopped. The location at TNX Boat Landing (SV-2012) was also removed at this time as it was deemed redundant as it is upstream from SRS operations and Jackson Boat Landing should suffice for the upstream location. Monitoring will continue as long as there are activities at the SRS that create the potential for contamination entering the environment. Continued monitoring will provide an improved understanding of radionuclide activity in SRS surface waters and the Savannah River, which will provide valuable information to human health exposure pathways. This comparison of data results allows for independent data evaluation of DOE-SR monitoring activities.

4.0 Radiological Monitoring of Surface Water on and Adjacent to the SRS

Map 1. Surface Water Sampling Locations for 2012



5.0 Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Table 1. 2012 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; Above all SRS operations; Near Jackson population center; Upriver control; River monitoring	Weekly H3 / Monthly AB, Gamma Composite
SV-325	Upper Three Runs Creek at SC 125 (SRS Road A)	Within SRS perimeter; Below SRS operations areas; Tributary monitoring	Tri-Weekly H3 / Monthly AB, Gamma Composite
SV-2012	Savannah River at TNX Boat Landing	Adjacent to SRS perimeter; River monitoring	Weekly H3 Grab
SV-2040	Beaver Dam Creek at D-Area	Within SRS perimeter; Below SRS operations areas; Tributary monitoring	Tri-Weekly H3 / Monthly AB, Gamma Composite
SV-2039	Fourmile Branch at Road A-13.2	Within SRS perimeter; Below SRS operations areas; Tributary monitoring	Tri-Weekly H3 / Monthly AB, Gamma Composite
SV-2047	Pen Branch at Road A-13.2	Within SRS perimeter; Below SRS operations areas; Tributary monitoring	Tri-Weekly H3 / Monthly AB, Gamma Composite
SV-327	Steel Creek at SC 125 (SRS Road A)	Within SRS perimeter; Below SRS operations areas; Tributary monitoring	Tri-Weekly H3 / Monthly AB, Gamma Composite
SV-2018	Savannah River at RM 141 (Steel Creek Boat Landing)	Accessible to public; Adjacent to SRS perimeter; Below SRS operations and tributaries; River monitoring	Weekly H3 / Monthly AB, Gamma Composite
SV-2019	Savannah River at RM 134.5 (Little Hell Boat Landing)	Accessible to public; Below SRS operations and tributaries; River monitoring	Weekly H3 Grab
SV-2080	Svannah River at RM 125 (Johnson's Boat Landing)	Accessible to public; Below SRS operations and tributaries; River monitoring	Tri-Weekly H3 Grab
SV-118	Savannah River at RM 118.8 (Highway 301 Bridge)	Accessible to public; Below SRS operations and tributaries; River monitoring	Tri-Weekly H3 / Monthly AB, Gamma Composite
SV-328	Lower Three Runs Creek at Patterson Mill Rd.	Within SRS perimeter; Below SRS operations areas and PAR pond; Tributary monitoring	Weekly H3 Grab
SV-2053	Lower Three Runs Creek at Road B	Within SRS perimeter; Below SRS operations areas and PAR pond; Tributary monitoring	Tri-Weekly H3 / Monthly AB, 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 H3 Grab

Notes:
1. ID is Sampling Location Identification Code Number
2. RM is River Mile
3. H3 is Tritium
4. AB is Alpha/Beta
5. Tri-Weekly Enhanced sample data is not used for reporting purposes only for early detection

Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

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; Below SRS operations areas; Tributary monitoring	Quarterly H3 Grab
SV-2013	Beaver Dam Creek Mouth at RM 152.3	Accessible to public; Adjacent to SRS; Below SRS operations areas; Tributary monitoring	Quarterly H3 Grab
SV-2015a	Fourmile Branch at RM 150.6 (Creek Mouth)	Accessible to public; Adjacent to SRS; Below SRS operations areas; Tributary monitoring	Quarterly H3 Grab
SV-2015b	Fourmile Branch at RM 150.6 (30 ' downstream from Creek Mouth)	Accessible to public; Adjacent to SRS; Below SRS operations areas; Tributary monitoring	Quarterly H3 Grab
SV-2015c	Fourmile Branch at RM 150.6 (150' downstream from Creek Mouth)	Accessible to public; Adjacent to SRS; Below SRS operations areas; Tributary monitoring	Quarterly H3 Grab
SV-2017	Steel Creek Mouth at RM 141.5	Accessible to public; Adjacent to SRS; Downstream from SRS operations; Tributary monitoring	Quarterly H3 Grab
SV-2020	Lower Three Runs Creek Mouth at RM 129.1	Accessible to public; Adjacent to SRS; Downstream from SRS operations; Tributary monitoring	Quarterly H3 Grab

Supplemental Locations

ID	Location	Rationale	Frequency
SV-2069	McQueen Branch off Monroe Owens Rd.	Downstream from SRS operations; Z-Area	Weekly AB Grab
SV-2071	Upper Three Runs Creek at Road C-4	Downstream from F- & H-Area HLW Tanks	Weekly AB Grab
SV-2075	Upper Three Runs Creek at Road C	Downstream from F- & H-Area HLW Tanks	Weekly AB Grab
SV-2039	Fourmile Branch at Road A-12.2	Downstream from F- & H-Area HLW Tanks	Weekly AB Grab

Notes:
1. ID is Sampling Location Identification Code Number
2. RM is River Mile
3. H3 is Tritium
4. AB is Alpha/Beta
5. HLW is High Level Waste
6. Supplemental locations changed in August 2012 and will be reflected in the 2013 report.

Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Table 2. Radiological analytes for gamma spectroscopy analysis

Radioisotope	Abbreviation
Actinium-228	Ac-228
Americium-241	Am-241
Berylium-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
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
Ytrium-88	Y-88
Zinc-65	Zn-65
Zirconium-95	Zr-95

Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Table 3. 2012 Tritium Data Comparison for SCDHEC and DOE-SR Colocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Samples	Number of Detects
Upper Three Runs Creek at Road A	SV-325	622	236	593	241	1,298	52	52
	U3R-4	774	368	729	270	1,670	12	11
Fourmile Branch at Road A-12.2	SV-2039	44,039	6,157	46,470	25,889	54,691	52	52
	FM-6	43,558	8,364	42,300	33,000	65,400	12	12
Pen Branch at Road 13.2	SV-2047	31,950	9,438	34,808	4,047	46,184	52	52
	PB-3	28,448	7,267	30,650	9,270	36,800	12	12
Steel Creek at Road A	SV-327	2,286	453	2,257	1,464	3,631	52	52
	SC-4	2,254	401	2,320	1,590	3,030	12	12
Highway 301 Bridge at River Mile 118.8	SV-118	642	556	389	236	2,683	52	44
	River Mile 118	613	337	549	195	1,710	50	49
Lower Threee Runs Creek at Patterson Mill Road	SV-328	2,222	504	2,300	481	3,114	52	50
	L3R-2	2,389	571	2,310	1,760	3,950	12	12
Lower Three Runs Creek at Road B	SV-2053	373	74	367	216	589	52	49
	L3R-1A	405	150	395	162	684	12	4

Notes:
1. Shaded areas represent SCDHEC data and unshaded areas represent DOE-SR data
2. DOE-SR data is from the SRS Environmental Data Report for 2012 (SRNS 2013)

Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Table 4. 2012 Alpha Data Comparison for SCDHEC and DOE-SR Colocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Samples	Number of Detects
Upper Three Runs Creek at Road A	SV-325	8.20	4.38	7.28	3.57	16.60	12	6
	U3R-4	8.91	8.75	4.29	2.84	30.30	12	12
Fourmile Branch at Road A-12.2	SV-2039	ND	ND	ND	ND	ND	12	0
	FM-6	0.87	0.38	0.82	0.37	1.28	12	5
Pen Branch at Road 13.2	SV-2047	5.57	3.10	5.57	3.38	7.76	12	2
	PB-3	*1.84	NA	1.84	1.84	1.84	12	1
Steel Creek at Road A	SV-327	3.39	0.68	3.39	2.91	3.87	12	2
	SC-4	1.31	0.39	1.15	1.03	1.76	12	3
Highway 301 Bridge at River Mile 118.8	SV-118	ND	ND	ND	ND	ND	12	0
	River Mile 118	*1.62	NA	1.62	1.62	1.62	49	1
Lower Three Runs Creek at Road B	SV-2053	ND	ND	ND	ND	ND	12	0
	L3R-1A	1.91	0.67	1.91	1.43	2.38	12	2

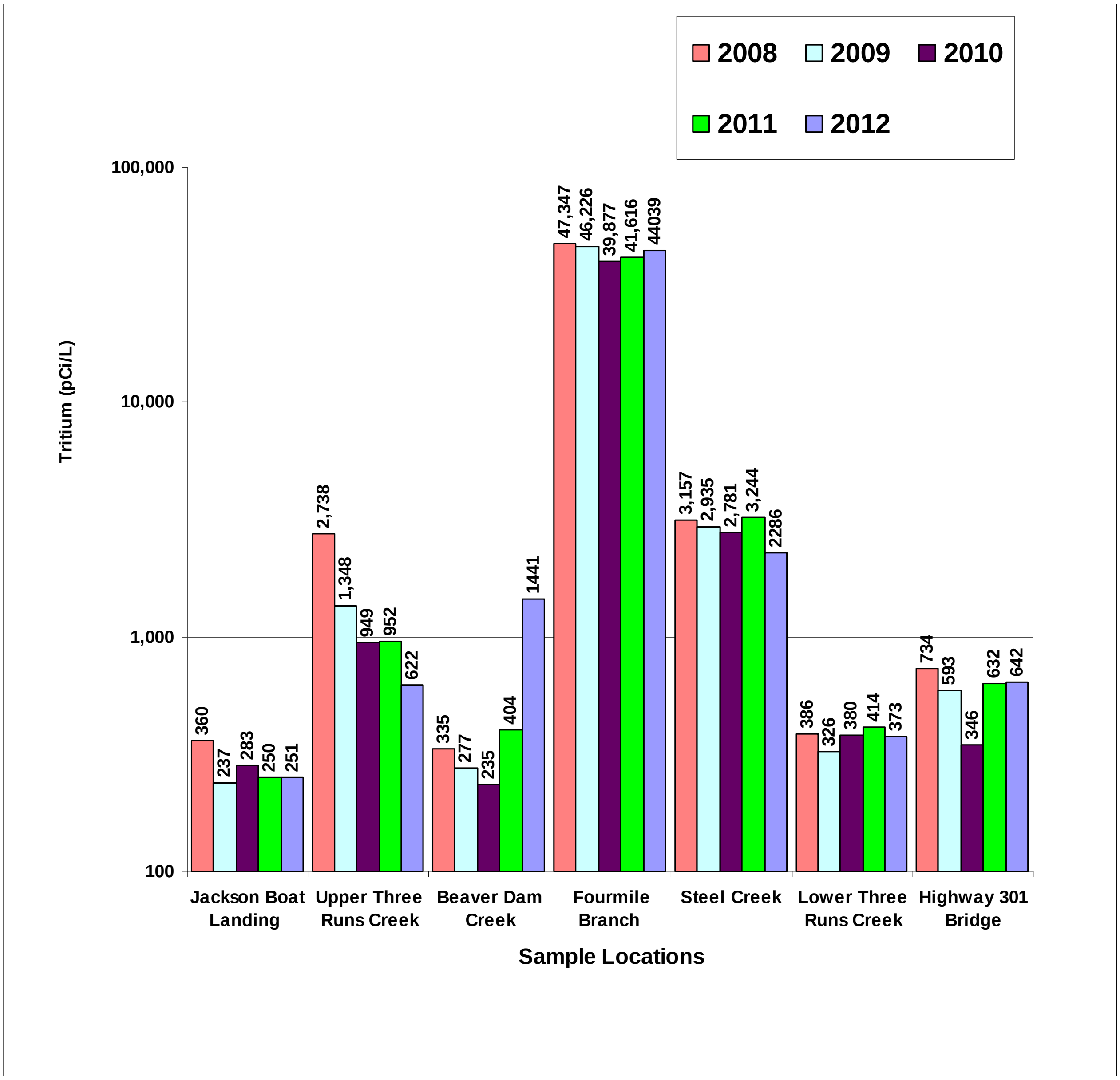
Table 5. 2012 Beta Data Comparison for SCDHEC and DOE-SR Colocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Samples	Number of Detects
Upper Three Runs Creek at Road A	SV-325	ND	ND	ND	ND	ND	12	0
	U3R-4	5.87	4.44	5.08	1.99	15.20	12	7
Fourmile Branch at Road A-12.2	SV-2039	4.47	1.56	3.66	3.39	7.73	12	7
	FM-6	6.06	0.96	5.98	4.27	7.78	12	12
Pen Branch at Road 13.2	SV-2047	ND	ND	ND	ND	ND	12	0
	PB-3	*1.76	NA	1.76	1.76	1.76	12	1
Steel Creek at Road A	SV-327	*2.75	N/A	2.75	2.75	2.75	12	1
	SC-4	1.31	0.31	1.21	0.84	1.78	12	10
Highway 301 Bridge at River Mile 118.8	SV-118	*4.94	N/A	4.94	4.94	4.94	12	1
	River Mile 118	2.47	0.50	2.39	1.75	3.57	49	40
Lower Three Runs Creek at Road B	SV-2053	ND	ND	ND	ND	ND	12	0
	L3R-1A	2.87	0.69	3.16	1.88	3.65	12	7

Notes:
1. Shaded areas represent SCDHEC data and unshaded areas represent DOE-SR data
2. DOE-SR data is from the SRS Environmental Data Report for 2012 (SRNS 2013)
3. ND is No Detects
4. NA is Not Applicable
5. * denotes actual value and uncertainty (±2sd) for one detection for sampling location

Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

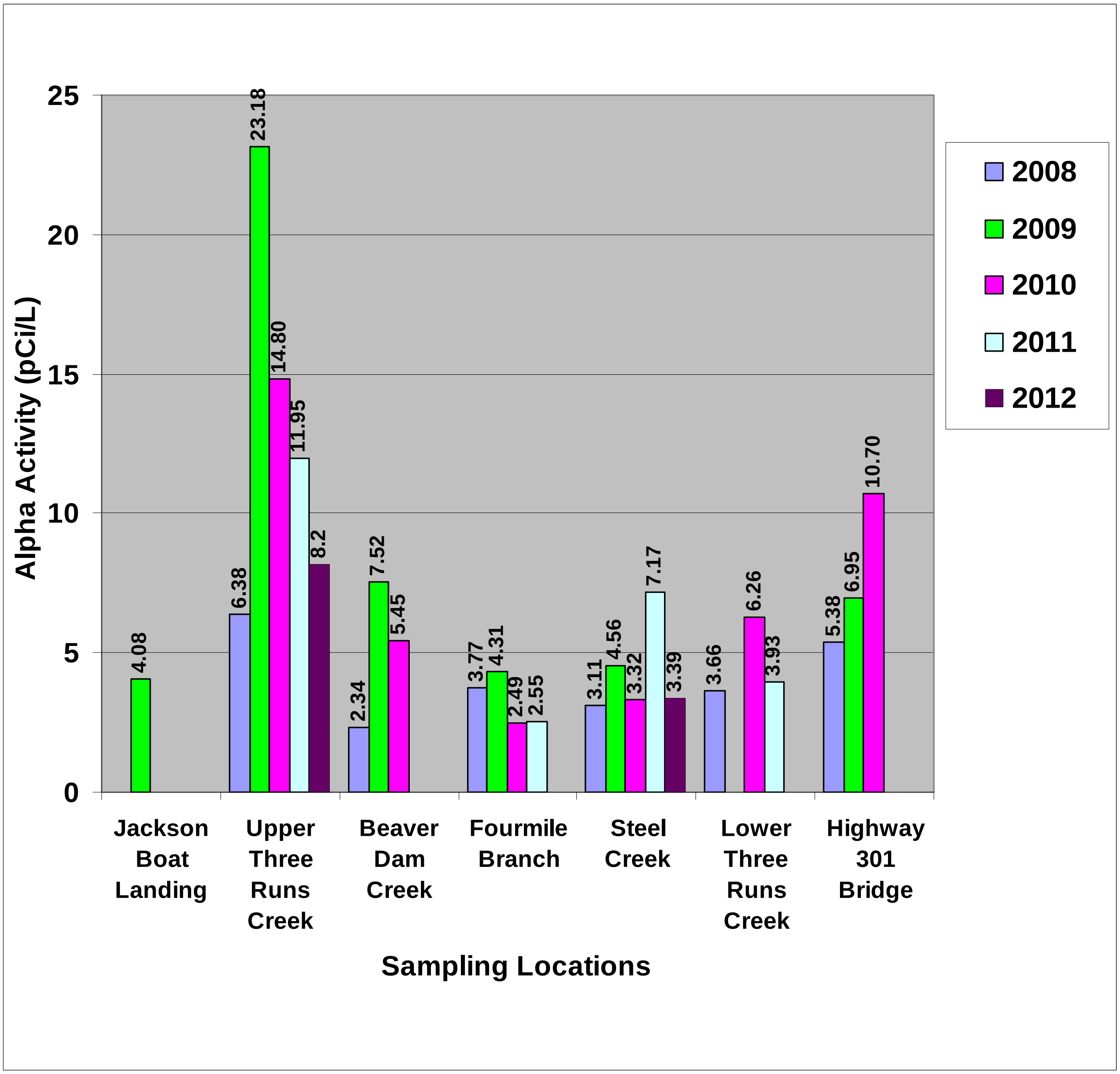
Figure 1. SCDHEC Average Tritium Trends for 2008-2012 (SCDHEC 2009-2012)



Note: Jackson Boat Landing is a background location.

Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

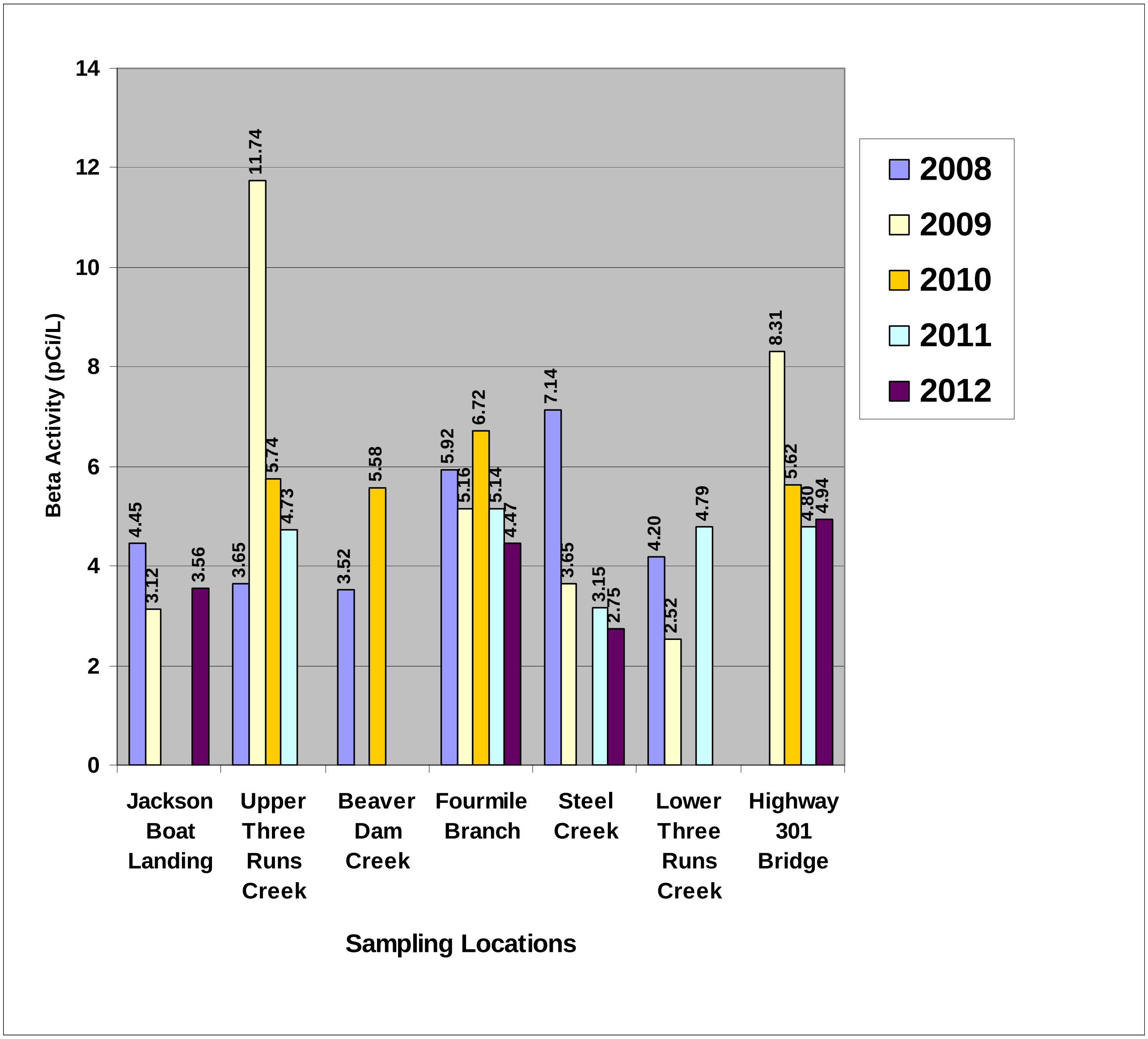
Figure 2. SCDHEC 2008-2012 Average Alpha Data (SCDHEC 2009-2012)



Notes:
1. No detections at Jackson Landing in 2008, 2010, 2011, and 2012
2. No detections at Beaver Dam Creek 2011, and 2012
3. No detections at Fourmile Branch in 2012
4. No detections at Lower Three Runs Creek in 2009 and 2012
5. No detections at Highway 301 Bridge in 2011 and 2012
6. The USEPA screening level MCL for Alpha is 15 pCi/L for drinking water

Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

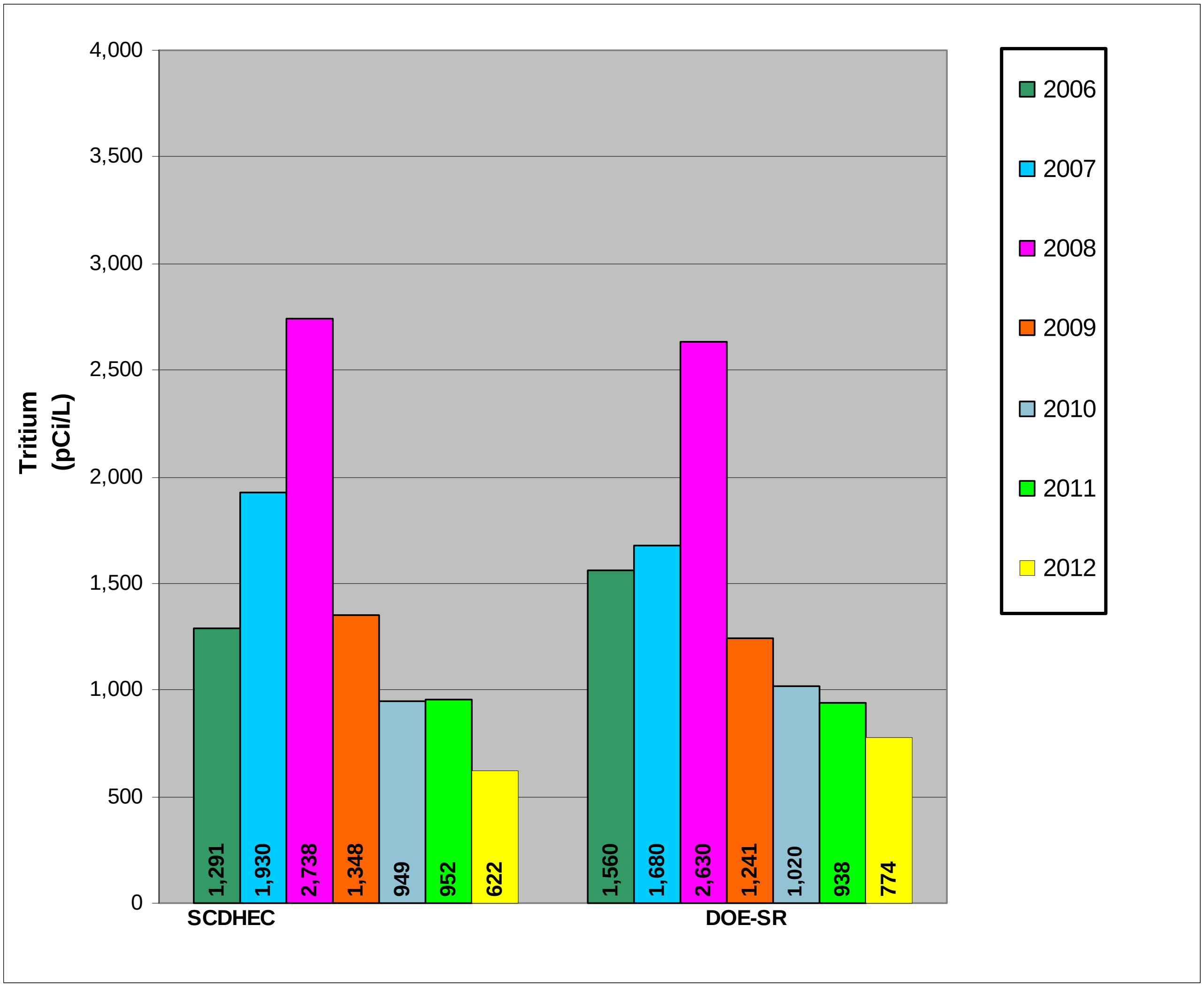
Figure 3. SCDHEC 2008-2012 Average Beta Data (SCDHEC 2009-2012)



Notes:
1. The USEPA screening level MCL for gross beta particles is 50 pCi/L for drinking water
2. No detections at Highway 301 in 2008
3. No detections at Beaver Dam Creek in 2009
4. No detections at Jackson Boat Landing, Steel Creek or Lower Three Runs in 2010
5. No detections at Jackson Boat Landing or Beaver Dam Creek in 2011
6. No detections at Upper Three Runs, Beaver Dam Creek, and Lower Three Runs in 2012

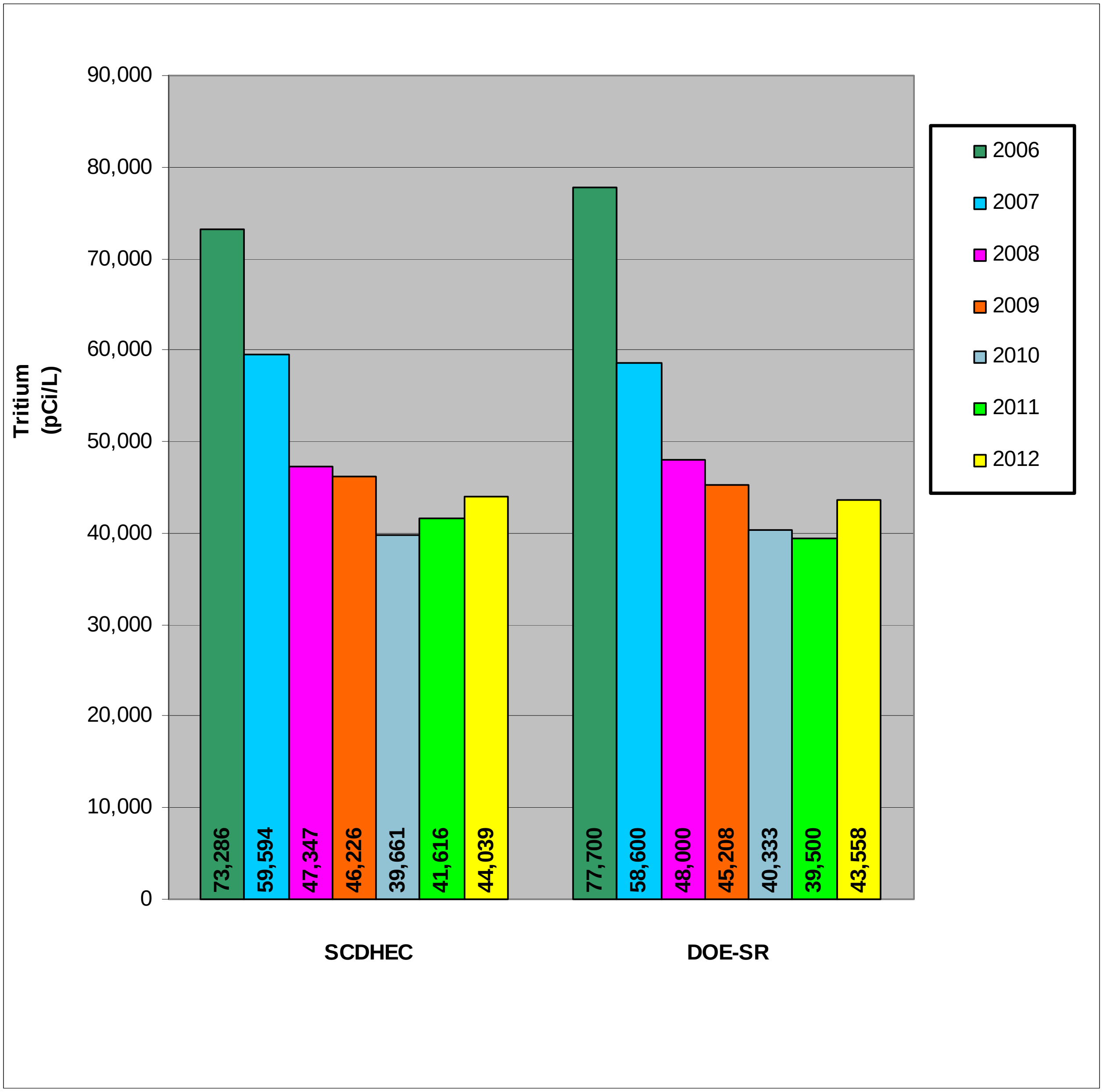
Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Figure 4. 2006-2012 Average Tritium Data Trends For SCDHEC and DOE-SR at Upper Three Runs Creek and SC Highway 125 (WSRC 2006-2008, SRNS 2009-2013, SCDHEC 2007-2012).



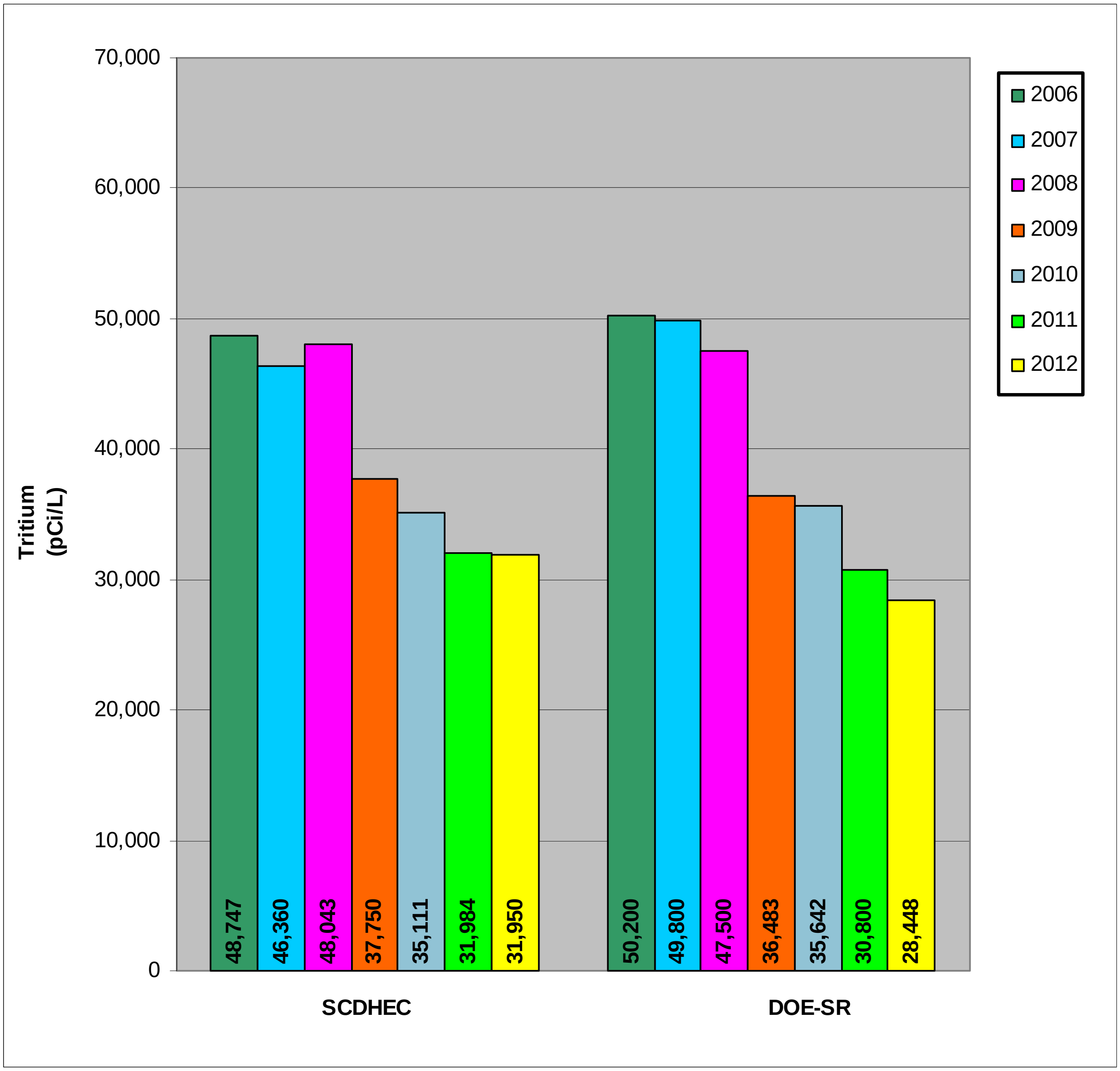
Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Figure 5. 2006-2012 Average Tritium Data Trends For SCDHEC and DOE-SR at Fourmile Branch and USFS Road 12.2 (WSRC 2006-2008, SRNS 2009-2013, SCDHEC 2007-2012).



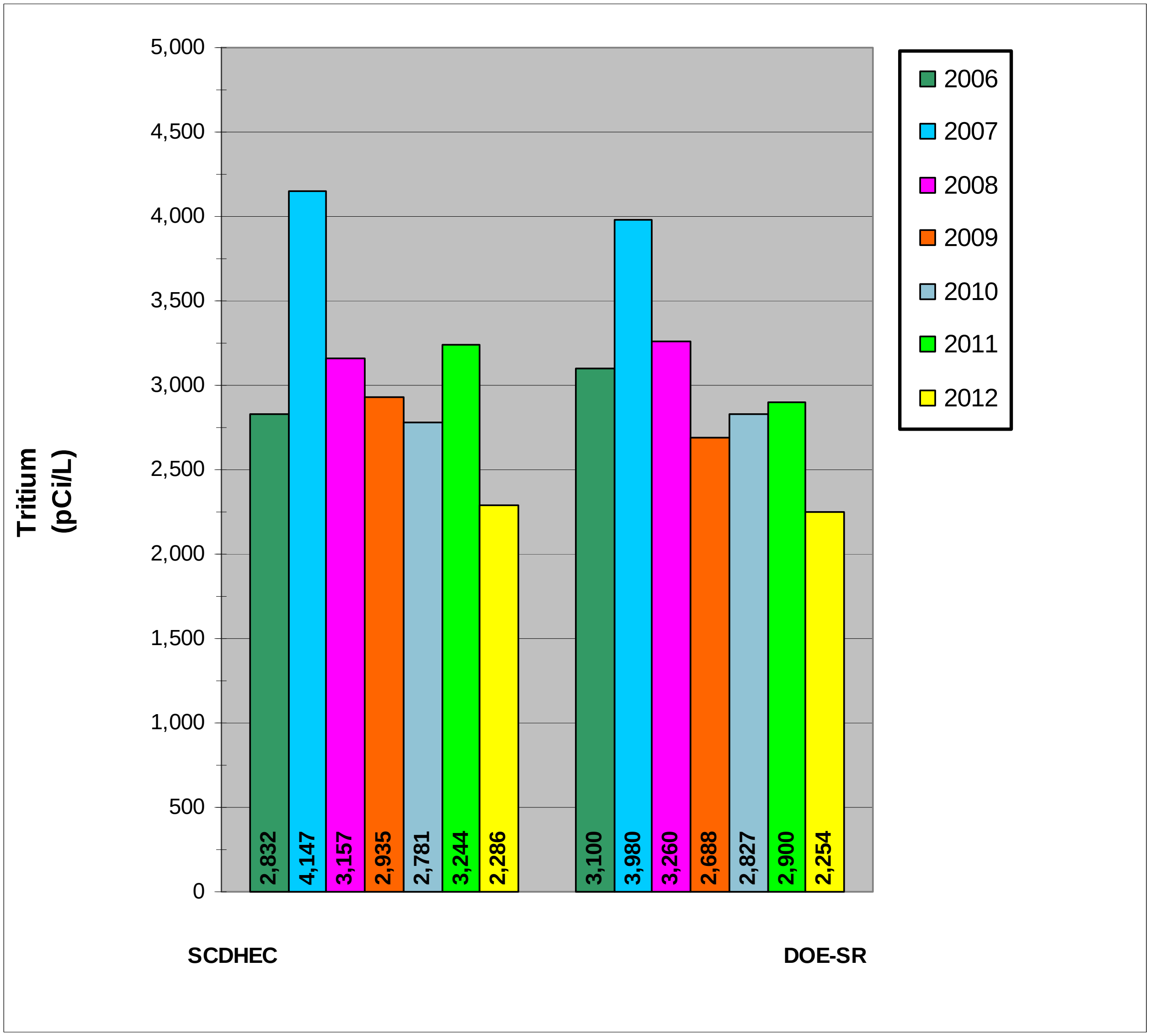
Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Figure 6. 2006-2012 Average Tritium Data Trends For SCDHEC and DOE-SR at Pen Branch and USFS Road 13.2 (WSRC 2006-2008, SRNS 2009-2013, SCDHEC 2007-2012).



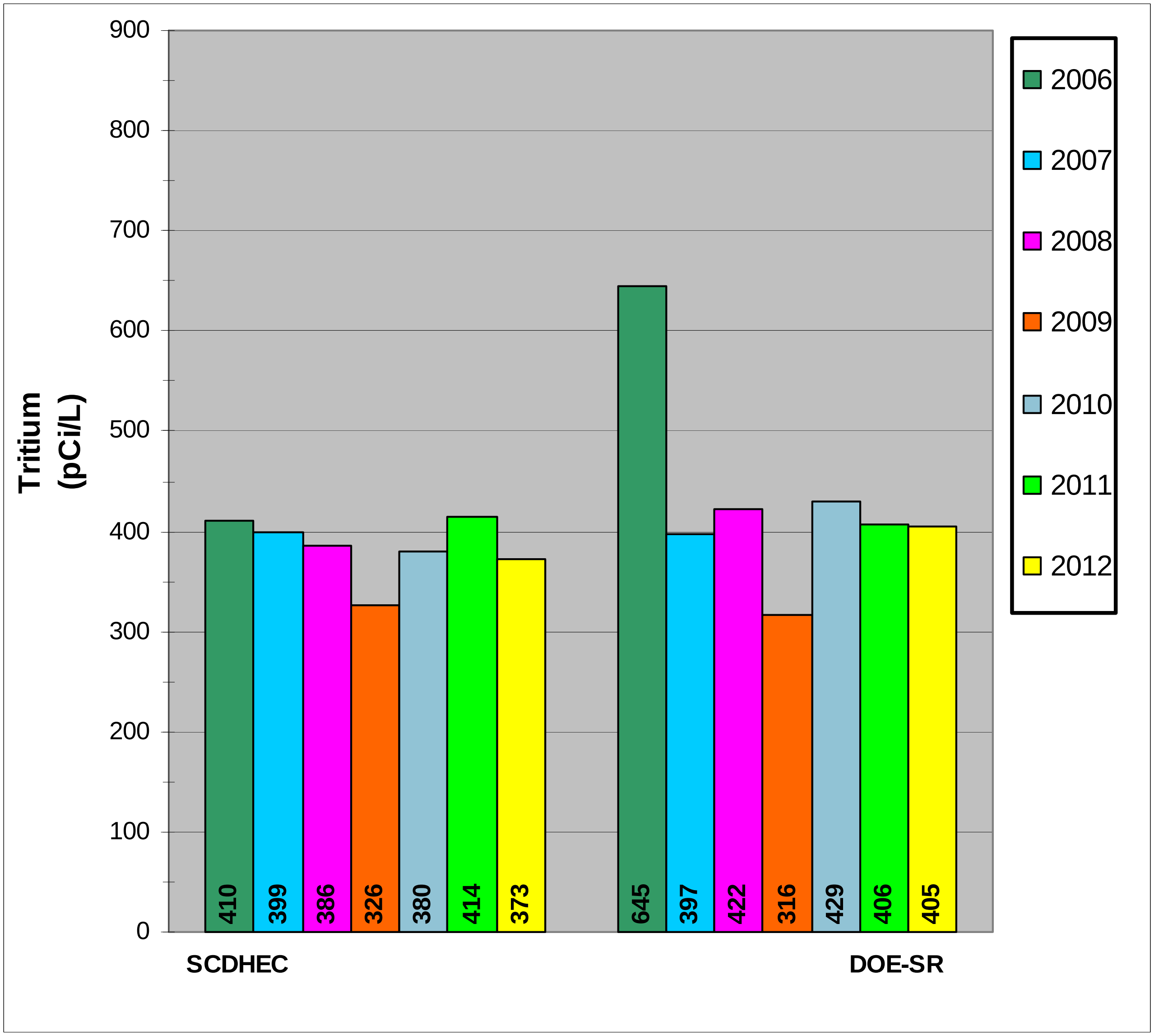
Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Figure 7. 2006-2012 Average Tritium Data Trends For SCDHEC and DOE-SR at Steel Creek and SC Highway 125 (WSRC 2006-2008, SRNS 2009-2013, SCDHEC 2007-2012).



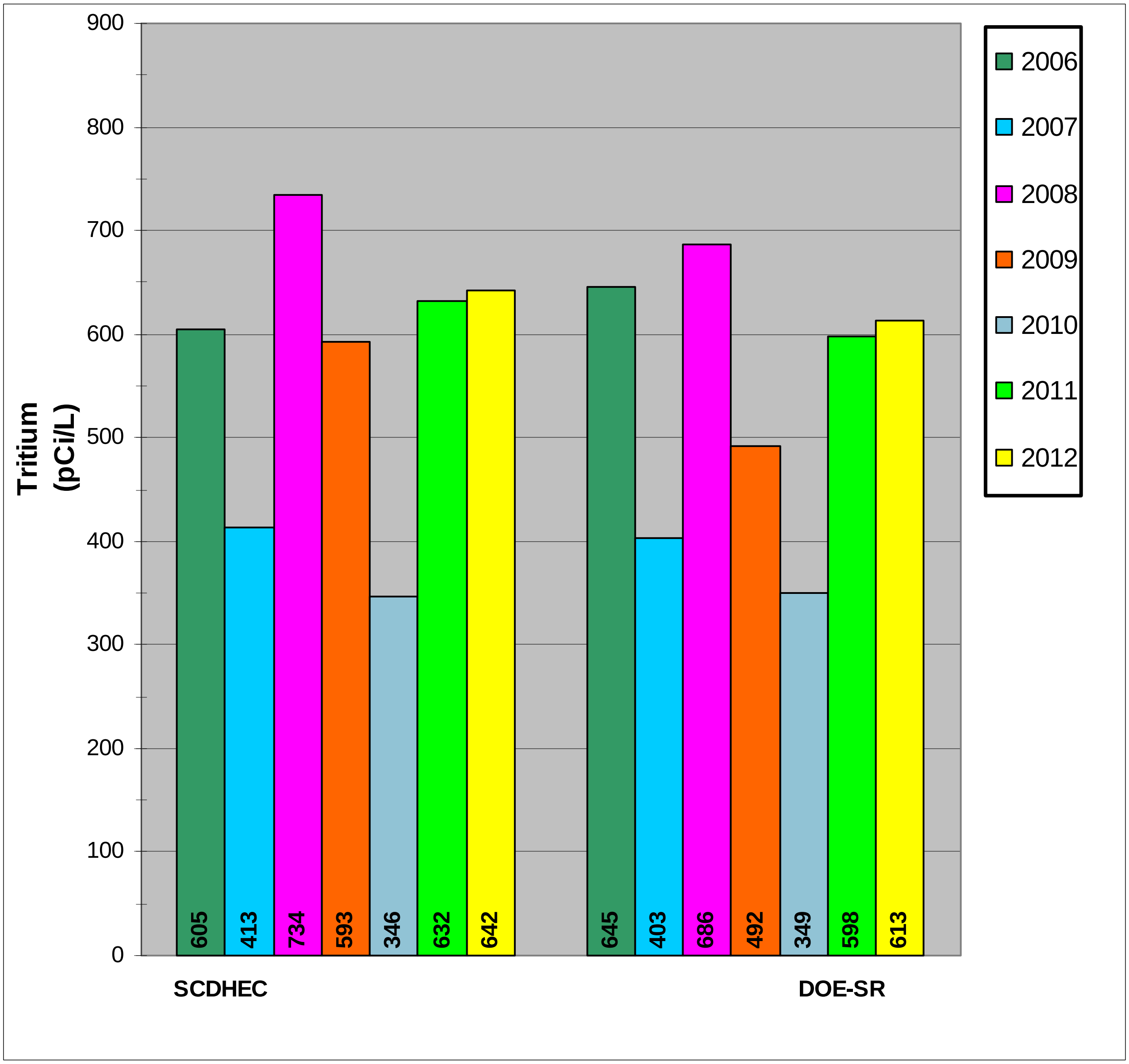
Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Figure 8. 2006-2012 Average Tritium Data Trends For SCDHEC and DOE-SR at Lower Three Runs Creek and SRS Road B (WSRC 2006-2008, SRNS 2009-2013, SCDHEC 2007-2012).



Tables and Figures
Radiological Monitoring of Surface Water On and Adjacent to the SRS

Figure 9. 2006-2012 Average Tritium Data Trends For SCDHEC and DOE-SR at the Savannah River and US Highway 301 Bridge (WSRC 2006-2008, SRNS 2009-2013, SCDHEC 2007-2012).



6.0 Data
Radiological Monitoring of Surface Water On and Adjacent to the SRS

2012 Ambient Monitoring Data-Tritium 24
2012 Ambient Monitoring Data-Gamma 31
2012 Ambient Monitoring Data-Alpha/Beta 34
2012 Creek Mouth Data-Tritium 37
2012 Fourmile Branch Data-Iodine-129 and Technetium-99 38

Notes:
1. Activity is in pCi/L
2. "MDA" is Minimum Detectable Activity
3. "NA" is Non applicable
4. "NS" is No Sample
5. "LLD" is Lower Limit of Detection
6. "AE" is Analytical Error

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Tritium

SV-2010 Jackson Boat Landing

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	<LLD	NA	210
	1/11/12	<LLD	NA	217
	1/18/12	284	100	205
	1/25/12	<LLD	NA	217
	2/1/12	<LLD	NA	216
February	2/8/12	<LLD	NA	217
	2/15/12	234	96	205
	2/22/12	<LLD	NA	223
	2/29/12	<LLD	NA	216
March	3/7/12	<LLD	NA	224
	3/14/12	<LLD	NA	209
	3/21/12	<LLD	NA	198
	3/28/12	248	107	229
April	4/4/12	<LLD	NA	214
	4/11/12	<LLD	NA	209
	4/18/12	<LLD	NA	213
	4/25/12	<LLD	NA	209
May	5/2/12	<LLD	NA	226
	5/9/12	<LLD	NA	212
	5/16/12	<LLD	NA	215
	5/23/12	<LLD	NA	216
	5/30/12	<LLD	NA	219
June	6/6/12	<LLD	NA	229
	6/13/12	<LLD	NA	218
	6/20/12	<LLD	NA	221
	6/27/12	<LLD	NA	220
July	7/4/12	<LLD	NA	223
	7/11/12	<LLD	NA	216
	7/18/12	<LLD	NA	216
	7/25/12	<LLD	NA	216
August	8/1/12	<LLD	NA	219
	8/8/12	<LLD	NA	239
	8/15/12	217	102	216
	8/22/12	280	100	210
	8/29/12	257	99	211
September	9/5/12	<LLD	NA	220
	9/12/12	<LLD	NA	211
	9/19/12	<LLD	NA	206
	9/26/12	<LLD	NA	216
October	10/3/12	<LLD	NA	227
	10/10/12	<LLD	NA	219
	10/17/12	<LLD	NA	215
	10/24/12	<LLD	NA	213
	10/31/12	<LLD	NA	226
November	11/7/12	<LLD	NA	207
	11/14/12	<LLD	NA	217
	11/21/12	273	103	217
	11/28/12	<LLD	NA	221
December	12/5/12	<LLD	NA	211
	12/12/12	<LLD	NA	214
	12/19/12	<LLD	NA	214
	12/26/12	212	97	208

SV-325 Upper Three Runs at SC Highway 125

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	717	116	210
	1/11/12	754	121	217
	1/18/12	702	114	205
	1/25/12	453	110	217
	2/1/12	468	108	216
February	2/8/12	528	113	217
	2/15/12	589	109	205
	2/22/12	485	113	223
	2/29/12	671	117	216
March	3/7/12	638	118	224
	3/14/12	1192	130	209
	3/21/12	1102	125	198
	3/28/12	1089	136	229
April	4/4/12	1184	133	214
	4/11/12	865	119	209
	4/18/12	520	109	213
	4/25/12	603	112	209
May	5/2/12	469	113	226
	5/9/12	724	116	212
	5/16/12	656	116	215
	5/23/12	797	121	216
June	5/30/12	389	108	219
	6/6/12	821	127	229
	6/13/12	618	116	218
	6/20/12	578	117	221
	6/27/12	259	101	220
July	7/4/12	241	100	223
	7/11/12	580	113	216
	7/18/12	608	115	216
	7/25/12	393	107	216
August	8/1/12	356	106	219
	8/8/12	320	112	239
	8/15/12	539	114	216
	8/22/12	488	108	210
	8/29/12	390	106	211
September	9/5/12	599	116	220
	9/12/12	609	114	211
	9/19/12	754	115	206
	9/26/12	557	111	216
October	10/3/12	396	110	227
	10/10/12	528	112	219
	10/17/12	486	109	215
	10/24/12	675	115	213
November	10/31/12	312	108	226
	11/7/12	1298	132	207
	11/14/12	934	124	217
	11/21/12	466	110	217
	11/28/12	695	119	221
December	12/5/12	561	109	211
	12/12/12	403	106	214
	12/19/12	598	115	214
	12/26/12	663	115	208

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Tritium

SV-2012 TNX Boat Landing D-Area SRS

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	<LLD	NA	210
	1/11/12	<LLD	NA	217
	1/18/12	280	98	205
	1/25/12	<LLD	NA	217
	2/1/12	<LLD	NA	216
February	2/8/12	<LLD	NA	217
	2/15/12	314	99	205
	2/22/12	<LLD	NA	223
	2/29/12	<LLD	NA	216
March	3/7/12	<LLD	NA	224
	3/14/12	<LLD	NA	209
	3/21/12	229	94	198
	3/28/12	<LLD	NA	229
April	4/4/12	<LLD	NA	214
	4/11/12	<LLD	NA	209
	4/18/12	<LLD	NA	213
	4/25/12	<LLD	NA	209
May	5/2/12	<LLD	NA	226
	5/9/12	<LLD	NA	212
	5/16/12	<LLD	NA	215
	5/23/12	237	101	216
June	5/30/12	<LLD	NA	219
	6/6/12	<LLD	NA	229
	6/13/12	262	103	218
	6/20/12	<LLD	NA	221
	6/27/12	<LLD	NA	220
July	7/4/12	<LLD	NA	223
	7/11/12	267	102	216
	7/18/12	<LLD	NA	216
	7/25/12	286	103	216
August	8/1/12	275	102	219
	8/8/12	<LLD	NA	239
	8/15/12	<LLD	NA	216
	8/22/12	282	100	210
	8/29/12	433	108	211
September	9/5/12	<LLD	NA	220
	9/12/12	<LLD	NA	211
	9/19/12	345	101	206
	9/26/12	<LLD	NA	216
October	10/3/12	<LLD	NA	227
	10/10/12	NS	NS	NS
	10/17/12	NS	NS	NS
	10/24/12	NS	NS	NS
November	10/31/12	NS	NS	NS
	11/7/12	NS	NS	NS
	11/14/12	NS	NS	NS
	11/21/12	NS	NS	NS
	11/28/12	NS	NS	NS
December	12/5/12	NS	NS	NS
	12/12/12	NS	NS	NS
	12/19/12	NS	NS	NS
	12/26/12	NS	NS	NS

SV-2040 Beaver Dam Creek D-Area

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	<LLD	NA	210
	1/11/12	<LLD	NA	217
	1/18/12	241	96	205
	1/25/12	<LLD	NA	217
	2/1/12	<LLD	NA	216
February	2/8/12	<LLD	NA	217
	2/15/12	208	94	205
	2/22/12	<LLD	NA	223
	2/29/12	<LLD	NA	216
March	3/7/12	<LLD	NA	224
	3/14/12	<LLD	NA	209
	3/21/12	228	93	198
	3/28/12	<LLD	NA	229
April	4/4/12	239	99	214
	4/11/12	<LLD	NA	209
	4/18/12	266	101	213
	4/25/12	<LLD	NA	209
May	5/2/12	<LLD	NA	226
	5/9/12	212	98	212
	5/16/12	<LLD	NA	215
	5/23/12	<LLD	NA	216
June	5/30/12	<LLD	NA	219
	6/6/12	<LLD	NA	229
	6/13/12	370	106	218
	6/20/12	<LLD	NA	221
	6/27/12	<LLD	NA	220
July	7/4/12	<LLD	NA	223
	7/11/12	<LLD	NA	216
	7/18/12	<LLD	NA	216
	7/25/12	<LLD	NA	216
August	8/1/12	<LLD	NA	219
	8/8/12	<LLD	NA	239
	8/15/12	<LLD	NA	216
	8/22/12	268	100	210
	8/29/12	12113	319	211
September	9/5/12	<LLD	NA	220
	9/12/12	267	101	211
	9/19/12	<LLD	NA	206
	9/26/12	<LLD	NA	216
October	10/3/12	<LLD	NA	227
	10/10/12	<LLD	NA	219
	10/17/12	NS	NS	NS
	10/24/12	NS	NS	NS
November	10/31/12	NS	NS	NS
	11/7/12	NS	NS	NS
	11/14/12	NS	NS	NS
	11/21/12	NS	NS	NS
	11/28/12	NS	NS	NS
December	12/5/12	NS	NS	NS
	12/12/12	NS	NS	NS
	12/19/12	NS	NS	NS
	12/26/12	NS	NS	NS

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Tritium

SV-2039 Fourmile Branch at Rd. 13.2

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	46844	603	210
	1/11/12	51155	626	217
	1/18/12	50464	626	205
	1/25/12	45624	594	217
	2/1/12	49515	619	216
February	2/8/12	50697	627	217
	2/15/12	48498	601	205
	2/22/12	47779	620	223
	2/29/12	48776	619	216
March	3/7/12	42237	576	224
	3/14/12	47643	611	209
	3/21/12	47954	612	198
	3/28/12	48642	640	229
April	4/4/12	33373	521	214
	4/11/12	43707	587	209
	4/18/12	47944	615	213
	4/25/12	44243	582	209
May	5/2/12	41743	574	226
	5/9/12	40995	574	212
	5/16/12	40749	580	215
	5/23/12	31215	506	216
June	5/30/12	38776	562	219
	6/6/12	25889	458	216
	6/13/12	40578	578	218
	6/20/12	41080	576	214
	6/27/12	46519	610	220
July	7/4/12	50280	632	213
	7/11/12	37482	543	216
	7/18/12	34442	539	216
	7/25/12	35667	537	216
August	8/1/12	31560	495	219
	8/8/12	42364	605	239
	8/15/12	37225	560	216
	8/22/12	35921	536	210
	8/29/12	41532	572	211
September	9/5/12	35819	539	220
	9/12/12	41504	580	211
	9/19/12	47015	608	206
	9/26/12	48081	608	216
October	10/3/12	47623	608	227
	10/10/12	48292	617	219
	10/17/12	45639	588	215
	10/24/12	49255	615	213
November	10/31/12	48467	612	226
	11/7/12	50660	621	207
	11/14/12	48001	604	217
	11/21/12	46518	606	217
	11/28/12	48529	612	221
December	12/5/12	46422	587	211
	12/12/12	54691	653	214
	12/19/12	50269	632	214
	12/26/12	44124	595	208

SV-2047 Pen Branch at USFS Rd. 13.2

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	37838	539	210
	1/11/12	30667	484	217
	1/18/12	5824	226	205
	1/25/12	4557	206	217
	2/1/12	4047	196	216
February	2/8/12	27481	464	217
	2/15/12	12809	315	205
	2/22/12	34457	528	223
	2/29/12	35458	530	216
March	3/7/12	27883	471	224
	3/14/12	30267	488	209
	3/21/12	30723	491	198
	3/28/12	28059	486	229
April	4/4/12	46021	607	214
	4/11/12	35579	530	209
	4/18/12	36593	534	213
	4/25/12	42580	579	209
May	5/2/12	37317	547	226
	5/9/12	37112	544	212
	5/16/12	42810	585	215
	5/23/12	41609	582	216
June	5/30/12	34586	529	219
	6/6/12	25834	463	229
	6/13/12	27546	479	218
	6/20/12	29524	493	221
	6/27/12	35977	537	220
July	7/4/12	37267	528	223
	7/11/12	36399	543	216
	7/18/12	25512	464	216
	7/25/12	36601	544	216
August	8/1/12	40498	570	219
	8/8/12	46184	627	239
	8/15/12	27380	478	216
	8/22/12	27027	465	210
	8/29/12	26068	459	211
September	9/5/12	18767	403	220
	9/12/12	22385	428	211
	9/19/12	32369	504	206
	9/26/12	36362	526	216
October	10/3/12	37373	541	227
	10/10/12	36955	537	219
	10/17/12	36931	532	215
	10/24/12	39559	551	213
November	10/31/12	37095	531	226
	11/7/12	39474	550	207
	11/14/12	39533	549	217
	11/21/12	34530	522	217
	11/28/12	32659	505	221
December	12/5/12	39998	554	211
	12/12/12	35031	525	214
	12/19/12	31013	499	214
	12/26/12	25289	454	208

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Tritium

SV-327 Steel Creek at SC Highway 125

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	2756	169	210
	1/11/12	2700	169	217
	1/18/12	2289	158	205
	1/25/12	1739	147	217
	2/1/12	2023	154	216
February	2/8/12	2311	161	217
	2/15/12	2096	150	205
	2/22/12	1660	148	223
	2/29/12	1804	150	216
March	3/7/12	1645	148	224
	3/14/12	2282	159	209
	3/21/12	2346	160	198
	3/28/12	2045	161	229
April	4/4/12	2363	163	214
	4/11/12	2600	166	209
	4/18/12	3010	177	213
	4/25/12	2544	166	209
May	5/2/12	2956	178	226
	5/9/12	3631	213	212
	5/16/12	2240	161	215
	5/23/12	2404	165	216
June	5/30/12	2470	168	219
	6/6/12	1776	153	229
	6/13/12	1976	155	218
	6/20/12	2245	163	221
	6/27/12	3168	183	220
July	7/4/12	2925	172	223
	7/11/12	3198	183	216
	7/18/12	1857	157	216
	7/25/12	2563	173	216
August	8/1/12	2821	174	219
	8/8/12	2479	175	239
	8/15/12	2238	162	216
	8/22/12	2233	158	210
	8/29/12	2184	159	211
September	9/5/12	1557	146	220
	9/12/12	2255	161	211
	9/19/12	2437	163	206
	9/26/12	2571	165	216
October	10/3/12	2370	165	227
	10/10/12	2135	157	219
	10/17/12	2231	157	215
	10/24/12	2323	159	213
November	10/31/12	2259	161	226
	11/7/12	2348	159	207
	11/14/12	2222	158	217
	11/21/12	1847	151	217
	11/28/12	1705	146	221
December	12/5/12	2055	153	211
	12/12/12	2015	154	214
	12/19/12	1464	141	214
	12/26/12	1519	141	208

SV-2018 Steel Creek Boat Landing

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	264	99	210
	1/11/12	326	104	217
	1/18/12	472	106	205
	1/25/12	223	100	217
	2/1/12	544	110	216
February	2/8/12	530	111	217
	2/15/12	956	120	205
	2/22/12	472	111	223
	2/29/12	486	109	216
March	3/7/12	854	124	224
	3/14/12	645	113	209
	3/21/12	512	105	198
	3/28/12	391	110	229
April	4/4/12	355	105	214
	4/11/12	318	101	209
	4/18/12	273	101	213
	4/25/12	434	105	209
May	5/2/12	<LLD	NA	226
	5/9/12	252	100	212
	5/16/12	326	103	215
	5/23/12	505	110	216
June	5/30/12	1193	133	219
	6/6/12	266	105	229
	6/13/12	457	110	218
	6/20/12	377	108	221
	6/27/12	<LLD	NA	220
July	7/4/12	246	104	223
	7/11/12	344	104	216
	7/18/12	313	103	216
	7/25/12	233	101	216
August	8/1/12	291	103	219
	8/8/12	<LLD	NA	239
	8/15/12	<LLD	NA	216
	8/22/12	282	101	210
	8/29/12	343	103	211
September	9/5/12	378	108	220
	9/12/12	1511	141	211
	9/19/12	450	104	206
	9/26/12	373	105	216
October	10/3/12	251	106	227
	10/10/12	617	115	219
	10/17/12	265	100	215
	10/24/12	317	103	213
November	10/31/12	<LLD	NA	226
	11/7/12	410	103	207
	11/14/12	<LLD	NA	217
	11/21/12	675	117	217
	11/28/12	244	103	221
December	12/5/12	337	102	211
	12/12/12	5694	225	214
	12/19/12	445	107	214
	12/26/12	507	104	208

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Tritium

SV-2019 Little Hell Landing

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	<LLD	NA	210
	1/11/12	<LLD	NA	217
	1/18/12	325	100	205
	1/25/12	<LLD	NA	217
	2/1/12	<LLD	NA	216
February	2/8/12	336	105	217
	2/15/12	459	104	205
	2/22/12	512	113	223
	2/29/12	582	113	216
March	3/7/12	<LLD	NA	224
	3/14/12	211	97	209
	3/21/12	250	94	198
	3/28/12	230	105	229
April	4/4/12	245	101	214
	4/11/12	280	100	209
	4/18/12	<LLD	NA	213
	4/25/12	897	121	209
May	5/2/12	334	108	226
	5/9/12	662	115	212
	5/16/12	267	104	215
	5/23/12	485	111	216
June	5/30/12	<LLD	NA	219
	6/6/12	512	114	229
	6/13/12	317	104	218
	6/20/12	<LLD	NA	221
	6/27/12	280	104	220
July	7/4/12	<LLD	NA	223
	7/11/12	270	102	216
	7/18/12	464	110	216
	7/25/12	239	102	216
August	8/1/12	358	106	219
	8/8/12	<LLD	NA	239
	8/15/12	938	125	216
	8/22/12	605	112	210
	8/29/12	635	113	211
September	9/5/12	317	105	220
	9/12/12	355	104	211
	9/19/12	1262	131	206
	9/26/12	1135	129	216
October	10/3/12	546	116	227
	10/10/12	651	116	219
	10/17/12	305	102	215
	10/24/12	231	99	213
November	10/31/12	<LLD	NA	226
	11/7/12	317	100	207
	11/14/12	283	102	217
	11/21/12	220	101	217
	11/28/12	<LLD	NA	221
December	12/5/12	506	108	211
	12/12/12	<LLD	NA	214
	12/19/12	394	105	214
	12/26/12	394	104	208

SV-118 US Highway 301 Bridge

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	296	100	210
	1/11/12	311	103	217
	1/18/12	389	102	205
	1/25/12	271	102	217
	2/1/12	2386	162	216
February	2/8/12	336	105	217
	2/15/12	325	99	205
	2/22/12	<LLD	NA	223
	2/29/12	370	105	216
March	3/7/12	304	106	224
	3/14/12	314	101	209
	3/21/12	275	95	198
	3/28/12	<LLD	NA	229
April	4/4/12	316	105	214
	4/11/12	390	103	209
	4/18/12	<LLD	NA	213
	4/25/12	1189	130	209
May	5/2/12	541	114	226
	5/9/12	864	121	212
	5/16/12	280	102	215
	5/23/12	316	106	216
June	5/30/12	266	103	219
	6/6/12	933	129	229
	6/13/12	407	108	218
	6/20/12	554	112	214
	6/27/12	512	111	220
July	7/4/12	<LLD	NA	223
	7/11/12	281	102	216
	7/18/12	409	108	216
	7/25/12	2683	169	216
August	8/1/12	512	112	219
	8/8/12	<LLD	NA	239
	8/15/12	659	115	216
	8/22/12	318	102	210
	8/29/12	1216	136	211
September	9/5/12	733	119	220
	9/12/12	386	105	211
	9/19/12	1367	134	206
	9/26/12	1598	141	216
October	10/3/12	1069	132	227
	10/10/12	<LLD	NA	219
	10/17/12	278	101	215
	10/24/12	236	99	213
November	10/31/12	<LLD	NA	226
	11/7/12	467	106	207
	11/14/12	303	102	217
	11/21/12	356	106	217
	11/28/12	<LLD	NA	221
December	12/5/12	883	120	211
	12/12/12	255	100	214
	12/19/12	1570	143	214
	12/26/12	542	110	208

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Tritium

SV-328 Lower Three Runs at Patterson Mill Rd.

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	2792	170	210
	1/11/12	2300	160	217
	1/18/12	2420	161	205
	1/25/12	2300	160	217
	2/1/12	<LLD	NA	216
February	2/8/12	2416	164	217
	2/15/12	2237	154	205
	2/22/12	2058	157	223
	2/29/12	1999	153	216
March	3/7/12	1968	155	224
	3/14/12	1832	146	209
	3/21/12	2115	151	198
	3/28/12	1930	156	229
April	4/4/12	2629	169	214
	4/11/12	2669	167	209
	4/18/12	2618	169	213
	4/25/12	2392	161	209
May	5/2/12	2075	155	226
	5/9/12	2676	169	212
	5/16/12	1683	148	215
	5/23/12	2509	167	216
June	5/30/12	674	124	219
	6/6/12	2437	170	229
	6/13/12	1687	149	218
	6/20/12	2705	173	221
	6/27/12	2414	166	220
July	7/4/12	2837	176	223
	7/11/12	2144	159	216
	7/18/12	2133	159	216
	7/25/12	<LLD	NA	216
August	8/1/12	2502	166	219
	8/8/12	1881	161	239
	8/15/12	3114	183	216
	8/22/12	1787	146	210
	8/29/12	481	108	211
September	9/5/12	2036	157	220
	9/12/12	2163	158	211
	9/19/12	2589	166	206
	9/26/12	2736	169	216
October	10/3/12	2522	169	227
	10/10/12	2415	166	219
	10/17/12	2445	163	215
	10/24/12	2393	162	213
November	10/31/12	2302	161	226
	11/7/12	2994	172	207
	11/14/12	2553	167	217
	11/21/12	2240	160	217
	11/28/12	2140	158	221
December	12/5/12	2225	157	211
	12/12/12	2164	156	214
	12/19/12	1689	146	214
	12/26/12	1098	131	208

SV-2053 Lower Three Runs at SRS Rd. B

Month	Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	435	105	210
	1/11/12	316	103	217
	1/18/12	482	106	205
	1/25/12	306	104	217
	2/1/12	318	102	216
February	2/8/12	507	112	217
	2/15/12	367	100	205
	2/22/12	245	103	223
	2/29/12	401	106	216
March	3/7/12	328	106	224
	3/14/12	346	101	209
	3/21/12	216	92	198
	3/28/12	321	108	229
April	4/4/12	320	101	214
	4/11/12	369	102	209
	4/18/12	361	104	213
	4/25/12	327	100	209
May	5/2/12	<LLD	NA	226
	5/9/12	419	106	212
	5/16/12	310	102	215
	5/23/12	374	105	216
June	5/30/12	366	106	219
	6/6/12	478	114	229
	6/13/12	376	106	218
	6/20/12	348	107	221
	6/27/12	330	105	220
July	7/4/12	320	106	223
	7/11/12	<LLD	NA	216
	7/18/12	461	110	216
	7/25/12	232	100	216
August	8/1/12	446	110	219
	8/8/12	492	123	239
	8/15/12	385	106	216
	8/22/12	405	104	210
	8/29/12	369	103	211
September	9/5/12	386	113	220
	9/12/12	406	107	211
	9/19/12	456	106	206
	9/26/12	305	102	216
October	10/3/12	589	126	227
	10/10/12	234	100	219
	10/17/12	432	108	215
	10/24/12	371	104	213
November	10/31/12	343	109	226
	11/7/12	363	101	207
	11/14/12	417	114	217
	11/21/12	388	106	217
	11/28/12	<LLD	NA	221
December	12/5/12	326	102	211
	12/12/12	367	104	214
	12/19/12	363	104	214
	12/26/12	438	106	208

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Tritium

SV-2027 Upper Three Runs at USFS Rd. E-2

Month	**Collection Date**	Tritium Activity	Tritium Confidence Interval	Tritium LLD
January	1/4/12	261	99	210
	1/11/12	<LLD	NA	217
	1/18/12	282	99	205
	1/25/12	<LLD	NA	217
	2/1/12	NS	NS	NS
February	2/8/12	276	104	217
	2/15/12	224	95	205
	2/22/12	<LLD	NA	223
	2/29/12	<LLD	NA	216
March	3/7/12	<LLD	NA	224
	3/14/12	<LLD	NA	209
	3/21/12	<LLD	NA	198
	3/28/12	<LLD	NA	229
April	4/4/12	<LLD	NA	214
	4/11/12	<LLD	NA	209
	4/18/12	<LLD	NA	213
	4/25/12	<LLD	NA	209
May	5/2/12	<LLD	NA	226
	5/9/12	<LLD	NA	212
	5/16/12	<LLD	NA	215
	5/23/12	<LLD	NA	216
June	5/30/12	<LLD	NA	219
	6/6/12	<LLD	NA	229
	6/13/12	159	99	218
	6/20/12	<LLD	NA	221
	6/27/12	<LLD	NA	220
July	7/4/12	<LLD	NA	223
	7/11/12	<LLD	NA	216
	7/18/12	<LLD	NA	216
	7/25/12	<LLD	NA	216
August	8/1/12	<LLD	NA	219
	8/8/12	<LLD	NA	239
	8/15/12	<LLD	NA	216
	8/22/12	<LLD	NA	210
	8/29/12	211	99	211
September	9/5/12	<LLD	NA	220
	9/12/12	<LLD	NA	211
	9/19/12	223	96	206
	9/26/12	223	99	216
October	10/3/12	<LLD	NA	227
	10/10/12	<LLD	NA	219
	10/17/12	<LLD	NA	215
	10/24/12	<LLD	NA	213
November	10/31/12	<LLD	NA	226
	11/7/12	207	96	207
	11/14/12	<LLD	NA	217
	11/21/12	300	104	217
	11/28/12	<LLD	NA	221
December	12/5/12	<LLD	NA	211
	12/12/12	<LLD	NA	214
	12/19/12	228	100	214
	12/26/12	<LLD	NA	208

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Gamma

SV-2010 Jackson Boat Landing

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	1.85E+00	<MDA	NA	2.21E+00	<MDA	NA	2.20E+01
February	1/25/2012	2/29/2012	<MDA	NA	2.64E+00	<MDA	NA	3.23E+00	<MDA	NA	6.58E+01
March	2/29/2012	3/28/2012	<MDA	NA	2.58E+00	<MDA	NA	3.28E+00	<MDA	NA	6.81E+01
April	3/28/2012	5/2/2012	<MDA	NA	3.11E+00	<MDA	NA	3.20E+00	<MDA	NA	6.79E+01
May	5/2/2012	5/30/2012	<MDA	NA	3.08E+00	<MDA	NA	3.55E+00	<MDA	NA	6.85E+01
June	5/30/2012	7/4/2012	<MDA	NA	3.09E+00	<MDA	NA	3.21E+00	<MDA	NA	6.74E+01
July	7/4/2012	8/1/2012	<MDA	NA	1.91E+00	<MDA	NA	2.44E+00	<MDA	NA	4.02E+01
August	8/1/2012	8/29/2012	<MDA	NA	1.85E+00	<MDA	NA	1.27E+00	<MDA	NA	7.08E+01
September	8/29/2012	10/3/2012	<MDA	NA	9.04E+00	<MDA	NA	2.13E+00	<MDA	NA	8.59E+01
October	10/3/2012	10/31/2012	<MDA	NA	2.67E+00	<MDA	NA	3.40E+00	<MDA	NA	7.14E+01
November	10/31/2012	12/5/2012	<MDA	NA	2.43E+00	<MDA	NA	3.04E+00	<MDA	NA	7.51E+01
December	12/5/2012	1/2/2013	<MDA	NA	1.87E+00	<MDA	NA	1.85E+00	<MDA	NA	2.01E+01

SV-325 Upper Three Runs at SC Highway 125

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	1.77E+00	<MDA	NA	2.32E+00	<MDA	NA	2.15E+01
February	1/25/2012	2/29/2012	<MDA	NA	2.90E+00	<MDA	NA	3.41E+00	<MDA	NA	6.78E+01
March	2/29/2012	3/28/2012	<MDA	NA	2.86E+00	<MDA	NA	3.42E+00	<MDA	NA	6.50E+01
April	3/28/2012	5/2/2012	<MDA	NA	3.23E+00	<MDA	NA	3.48E+00	<MDA	NA	6.64E+01
May	5/2/2012	5/30/2012	<MDA	NA	2.83E+00	<MDA	NA	3.07E+00	<MDA	NA	7.01E+01
June	5/30/2012	7/4/2012	<MDA	NA	3.07E+00	<MDA	NA	3.67E+00	<MDA	NA	7.08E+01
July	7/4/2012	8/1/2012	<MDA	NA	2.25E+00	<MDA	NA	1.98E+00	<MDA	NA	8.73E+01
August	8/1/2012	8/29/2012	<MDA	NA	2.10E+00	<MDA	NA	2.54E+00	<MDA	NA	7.02E+01
September	8/29/2012	10/3/2012	<MDA	NA	2.06E+00	<MDA	NA	1.57E+00	<MDA	NA	4.05E+01
October	10/3/2012	10/31/2012	<MDA	NA	2.81E+00	<MDA	NA	3.30E+00	<MDA	NA	7.12E+01
November	10/31/2012	12/5/2012	<MDA	NA	2.69E+00	<MDA	NA	3.29E+00	<MDA	NA	7.13E+01
December	12/5/2012	1/2/2013	<MDA	NA	3.01E+00	<MDA	NA	3.14E+00	<MDA	NA	5.54E+01

SV-2040 Beaver Dam Creek

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	1.99E+00	<MDA	NA	2.41E+00	<MDA	NA	2.21E+01
February	1/25/2012	2/29/2012	<MDA	NA	3.05E+00	<MDA	NA	3.45E+00	<MDA	NA	6.63E+01
March	2/29/2012	3/28/2012	<MDA	NA	2.81E+00	<MDA	NA	3.12E+00	<MDA	NA	6.86E+01
April	3/28/2012	5/2/2012	<MDA	NA	2.73E+00	<MDA	NA	3.25E+00	<MDA	NA	6.73E+01
May	5/2/2012	5/30/2012	<MDA	NA	2.95E+00	<MDA	NA	3.28E+00	<MDA	NA	6.75E+01
June	5/30/2012	7/4/2012	<MDA	NA	2.79E+00	<MDA	NA	3.20E+00	<MDA	NA	6.91E+01
July	7/4/2012	8/1/2012	<MDA	NA	2.37E+00	<MDA	NA	1.06E+00	<MDA	NA	5.54E+01
August	8/1/2012	8/29/2012	<MDA	NA	1.20E+00	<MDA	NA	1.93E+00	<MDA	NA	6.61E+01
September	8/29/2012	10/3/2012	<MDA	NA	2.46E+00	<MDA	NA	1.64E+00	<MDA	NA	8.40E+01
October	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
November	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Gamma

SV-2039 Fourmile Branch at USFS Rd. A-13

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	1.77E+00	<MDA	NA	2.58E+00	<MDA	NA	2.07E+01
February	1/25/2012	2/29/2012	<MDA	NA	2.35E+00	<MDA	NA	3.99E+00	<MDA	NA	6.70E+01
March	2/29/2012	3/28/2012	<MDA	NA	2.68E+00	<MDA	NA	3.96E+00	<MDA	NA	6.76E+01
April	3/28/2012	5/2/2012	<MDA	NA	2.76E+00	<MDA	NA	3.74E+00	<MDA	NA	6.73E+01
May	5/2/2012	5/30/2012	<MDA	NA	2.53E+00	<MDA	NA	3.84E+00	<MDA	NA	6.85E+01
June	5/30/2012	7/4/2012	<MDA	NA	2.72E+00	<MDA	NA	3.42E+00	<MDA	NA	7.33E+01
July	7/4/2012	8/1/2012	<MDA	NA	1.59E+00	<MDA	NA	2.89E+00	<MDA	NA	8.02E+01
August	8/1/2012	8/29/2012	<MDA	NA	2.18E+00	<MDA	NA	2.97E+00	<MDA	NA	8.21E+01
September	8/29/2012	10/3/2012	<MDA	NA	1.69E+00	<MDA	NA	2.68E+00	<MDA	NA	8.44E+01
October	10/3/2012	10/31/2012	<MDA	NA	2.59E+00	<MDA	NA	3.54E+00	<MDA	NA	6.99E+01
November	10/31/2012	12/5/2012	<MDA	NA	3.28E+00	<MDA	NA	3.79E+00	<MDA	NA	7.04E+01
December	12/5/2012	1/2/2013	<MDA	NA	1.77E+00	<MDA	NA	2.33E+00	<MDA	NA	2.18E+01

SV-2047 Pen Branch at USFS Rd. A-13

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	1.73E+00	<MDA	NA	1.93E+00	<MDA	NA	2.02E+01
February	1/25/2012	2/29/2012	<MDA	NA	2.97E+00	<MDA	NA	3.45E+00	<MDA	NA	6.93E+01
March	2/29/2012	3/28/2012	<MDA	NA	2.63E+00	<MDA	NA	3.13E+00	<MDA	NA	7.09E+01
April	3/28/2012	5/2/2012	<MDA	NA	2.95E+00	<MDA	NA	3.14E+00	<MDA	NA	7.04E+01
May	5/2/2012	5/30/2012	<MDA	NA	3.09E+00	<MDA	NA	3.29E+00	<MDA	NA	6.92E+01
June	5/30/2012	7/4/2012	<MDA	NA	3.07E+00	<MDA	NA	3.70E+00	<MDA	NA	6.57E+01
July	7/4/2012	8/1/2012	<MDA	NA	2.30E+00	<MDA	NA	2.78E+00	<MDA	NA	6.38E+01
August	8/1/2012	8/29/2012	<MDA	NA	2.33E+00	<MDA	NA	1.96E+00	<MDA	NA	3.70E+01
September	8/29/2012	10/3/2012	<MDA	NA	2.39E+00	<MDA	NA	2.13E+00	<MDA	NA	8.53E+01
October	10/3/2012	10/31/2012	<MDA	NA	2.91E+00	<MDA	NA	3.18E+00	<MDA	NA	6.55E+01
November	10/31/2012	12/5/2012	<MDA	NA	2.76E+00	<MDA	NA	3.60E+00	<MDA	NA	6.98E+01
December	12/5/2012	1/2/2013	<MDA	NA	1.75E+00	<MDA	NA	1.98E+00	<MDA	NA	2.05E+01

SV-327 Steel Creek at SC Highway 125

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	1.84E+00	<MDA	NA	2.12E+00	<MDA	NA	2.02E+01
February	1/25/2012	2/29/2012	<MDA	NA	3.12E+00	<MDA	NA	3.64E+00	<MDA	NA	6.70E+01
March	2/29/2012	3/28/2012	<MDA	NA	2.80E+00	<MDA	NA	3.43E+00	<MDA	NA	7.01E+01
April	3/28/2012	5/2/2012	<MDA	NA	2.80E+00	<MDA	NA	3.32E+00	<MDA	NA	6.99E+01
May	5/2/2012	5/30/2012	<MDA	NA	2.31E+00	<MDA	NA	3.37E+00	<MDA	NA	6.61E+01
June	5/30/2012	7/4/2012	<MDA	NA	2.84E+00	<MDA	NA	3.37E+00	<MDA	NA	7.09E+01
July	7/4/2012	8/1/2012	<MDA	NA	2.30E+00	<MDA	NA	2.85E+00	<MDA	NA	5.29E+01
August	8/1/2012	8/29/2012	<MDA	NA	2.33E+00	<MDA	NA	2.47E+00	<MDA	NA	7.66E+01
September	8/29/2012	10/3/2012	<MDA	NA	2.22E+00	<MDA	NA	2.24E+00	<MDA	NA	7.45E+01
October	10/3/2012	10/31/2012	<MDA	NA	2.30E+00	<MDA	NA	3.66E+00	<MDA	NA	6.84E+01
November	10/31/2012	12/5/2012	<MDA	NA	3.26E+00	<MDA	NA	3.49E+00	<MDA	NA	7.44E+01
December	12/5/2012	1/2/2013	<MDA	NA	2.84E+00	<MDA	NA	2.88E+00	<MDA	NA	6.33E+01

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Gamma

SV-2018 Steel Creek Boat Landing

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	1.89E+00	<MDA	NA	2.11E+00	<MDA	NA	2.11E+01
February	1/25/2012	2/29/2012	<MDA	NA	2.88E+00	<MDA	NA	3.46E+00	<MDA	NA	6.89E+01
March	2/29/2012	3/28/2012	<MDA	NA	2.38E+00	<MDA	NA	3.74E+00	<MDA	NA	6.07E+01
April	3/28/2012	5/2/2012	<MDA	NA	2.99E+00	<MDA	NA	3.35E+00	<MDA	NA	6.82E+01
May	5/2/2012	5/30/2012	<MDA	NA	2.92E+00	<MDA	NA	3.47E+00	<MDA	NA	6.68E+01
June	5/30/2012	7/4/2012	<MDA	NA	3.03E+00	<MDA	NA	3.06E+00	<MDA	NA	6.72E+01
July	7/4/2012	8/1/2012	<MDA	NA	2.20E+00	<MDA	NA	2.53E+00	<MDA	NA	7.02E+01
August	8/1/2012	8/29/2012	<MDA	NA	1.94E+00	<MDA	NA	2.15E+00	<MDA	NA	6.52E+01
September	8/29/2012	10/3/2012	<MDA	NA	2.89E+00	<MDA	NA	1.93E+00	<MDA	NA	7.06E+01
October	10/3/2012	10/31/2012	<MDA	NA	2.99E+00	<MDA	NA	3.45E+00	<MDA	NA	6.99E+01
November	10/31/2012	12/5/2012	<MDA	NA	2.65E+00	<MDA	NA	3.48E+00	<MDA	NA	6.92E+01
December	12/5/2012	1/2/2013	<MDA	NA	1.55E+00	<MDA	NA	1.92E+00	<MDA	NA	2.00E+01

SV-118 US Highway 301 at the Savannah River

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	1.92E+00	<MDA	NA	2.13E+00	<MDA	NA	2.09E+01
February	1/25/2012	2/29/2012	<MDA	NA	2.77E+00	<MDA	NA	3.51E+00	<MDA	NA	6.59E+01
March	2/29/2012	3/28/2012	<MDA	NA	2.81E+00	<MDA	NA	3.41E+00	<MDA	NA	6.85E+01
April	3/28/2012	5/2/2012	<MDA	NA	2.65E+00	<MDA	NA	3.30E+00	<MDA	NA	6.85E+01
May	5/2/2012	5/30/2012	<MDA	NA	2.93E+00	<MDA	NA	3.58E+00	<MDA	NA	6.83E+01
June	5/30/2012	7/4/2012	<MDA	NA	3.06E+00	<MDA	NA	3.73E+00	<MDA	NA	6.85E+01
July	7/4/2012	8/1/2012	<MDA	NA	2.09E+00	<MDA	NA	1.86E+00	<MDA	NA	6.48E+01
August	8/1/2012	8/29/2012	<MDA	NA	2.31E+00	<MDA	NA	2.33E+00	<MDA	NA	6.03E+01
September	8/29/2012	10/3/2012	<MDA	NA	1.04E+00	<MDA	NA	2.46E+00	<MDA	NA	3.81E+01
October	10/3/2012	10/31/2012	<MDA	NA	2.99E+00	<MDA	NA	3.18E+00	<MDA	NA	7.33E+01
November	10/31/2012	12/5/2012	<MDA	NA	2.47E+00	<MDA	NA	3.18E+00	<MDA	NA	6.82E+01
December	12/5/2012	1/2/2013	<MDA	NA	1.79E+00	<MDA	NA	1.95E+00	<MDA	NA	2.10E+01

SV-2053 Lower Three Runs at SRS Rd. B

Month	Sample Deployment Date	Collection Date	Co-60 Activity	Co-60 Confidence Interval	Co-60 MDA	Cs-137 Activity	Cs-137 Confidence Interval	Cs-137 MDA	Am-241 Activity	Am-241 Confidence Interval	Am-241 MDA
January	12/28/11	1/25/2012	<MDA	NA	2.08E+00	<MDA	NA	2.26E+00	<MDA	NA	2.08E+01
February	1/25/2012	2/29/2012	<MDA	NA	3.26E+00	<MDA	NA	3.56E+00	<MDA	NA	6.64E+01
March	2/29/2012	3/28/2012	<MDA	NA	3.04E+00	<MDA	NA	3.30E+00	<MDA	NA	6.62E+01
April	3/28/2012	5/2/2012	<MDA	NA	2.55E+00	<MDA	NA	3.47E+00	<MDA	NA	7.01E+01
May	5/2/2012	5/30/2012	<MDA	NA	3.02E+00	<MDA	NA	3.88E+00	<MDA	NA	6.94E+01
June	5/30/2012	7/4/2012	<MDA	NA	2.72E+00	<MDA	NA	3.60E+00	<MDA	NA	6.82E+01
July	7/4/2012	8/1/2012	<MDA	NA	2.22E+00	<MDA	NA	2.23E+00	<MDA	NA	5.89E+01
August	8/1/2012	8/29/2012	<MDA	NA	2.03E+00	<MDA	NA	3.14E+00	<MDA	NA	5.80E+01
September	8/29/2012	10/3/2012	<MDA	NA	2.43E+00	<MDA	NA	3.09E+00	<MDA	NA	5.92E+01
October	10/3/2012	10/31/2012	<MDA	NA	2.87E+00	<MDA	NA	4.00E+00	<MDA	NA	7.32E+01
November	10/31/2012	12/5/2012	<MDA	NA	2.80E+00	<MDA	NA	3.48E+00	<MDA	NA	7.13E+01
December	12/5/2012	1/2/2013	<MDA	NA	1.71E+00	<MDA	NA	2.14E+00	<MDA	NA	2.14E+01

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Alpha/Beta

SV-2010 Jackson Boat Landing

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	<LLD	NA	3.33	<LLD	NA	3.62
February	1/25/2012	2/29/2012	<LLD	NA	3.78	<LLD	NA	3.17
March	2/29/2012	3/28/2012	<LLD	NA	2.96	<LLD	NA	2.44
April	3/28/2012	5/2/2012	<LLD	NA	2.16	<LLD	NA	2.30
May	5/2/2012	5/30/2012	<LLD	NA	2.69	<LLD	NA	2.69
June	5/30/2012	7/4/2012	<LLD	NA	2.70	3.56	1.80	2.55
July	7/4/2012	8/1/2012	<LLD	NA	3.89	<LLD	NA	2.81
August	8/1/2012	8/29/2012	<LLD	NA	3.04	<LLD	NA	2.55
September	8/29/2012	8/29/2012	<LLD	NA	3.21	<LLD	NA	3.04
October	8/29/2012	10/31/2012	<LLD	NA	3.55	<LLD	NA	2.75
November	10/31/2012	12/5/2012	<LLD	NA	4.31	<LLD	NA	4.37
December	12/5/2012	1/2/2013	<LLD	NA	4.31	<LLD	NA	4.37

SV-325 Upper Three Runs and SC Highway 125

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	3.57	2.33	2.94	<LLD	NA	3.58
February	1/25/2012	2/29/2012	<LLD	NA	3.37	<LLD	NA	3.13
March	2/29/2012	3/28/2012	<LLD	NA	2.66	<LLD	NA	2.42
April	3/28/2012	5/2/2012	7.50	2.37	1.99	<LLD	NA	2.29
May	5/2/2012	5/30/2012	16.60	3.36	2.29	<LLD	NA	2.68
June	5/30/2012	7/4/2012	6.98	2.47	2.47	<LLD	NA	2.53
July	7/4/2012	8/1/2012	7.05	2.91	3.58	<LLD	NA	2.78
August	8/1/2012	8/29/2012	7.50	2.64	2.81	<LLD	NA	2.52
September	8/29/2012	8/29/2012	<LLD	NA	2.85	<LLD	NA	3.03
October	8/29/2012	10/31/2012	<LLD	NA	3.19	<LLD	NA	2.75
November	10/31/2012	12/5/2012	<LLD	NA	3.77	<LLD	NA	4.32
December	12/5/2012	1/2/2013	<LLD	NA	3.09	<LLD	NA	2.79

SV-2040 Beaver Dam Creek

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	<LLD	NA	3.40	<LLD	NA	3.62
February	1/25/2012	2/29/2012	<LLD	NA	3.81	<LLD	NA	3.17
March	2/29/2012	3/28/2012	<LLD	NA	2.97	<LLD	NA	2.44
April	3/28/2012	5/2/2012	<LLD	NA	2.17	<LLD	NA	2.30
May	5/2/2012	5/30/2012	<LLD	NA	2.41	<LLD	NA	2.69
June	5/30/2012	7/4/2012	<LLD	NA	2.66	<LLD	NA	2.55
July	7/4/2012	8/1/2012	<LLD	NA	3.90	<LLD	NA	2.81
August	8/1/2012	8/29/2012	<LLD	NA	3.01	<LLD	NA	2.54
September	8/29/2012	8/29/2012	<LLD	NA	3.16	<LLD	NA	3.04
October	NS	NS	NS	NS	NS	NS	NS	NS
November	NS	NS	NS	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS	NS	NS	NS

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Alpha/Beta

SV-2039 Fourmile Branch at USFS Rd. A-13

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	<LLD	NA	3.09	7.73	2.57	3.60
February	1/25/2012	2/29/2012	<LLD	NA	3.55	<LLD	NA	3.15
March	2/29/2012	3/28/2012	<LLD	NA	2.81	4.80	1.84	2.43
April	3/28/2012	5/2/2012	<LLD	NA	2.08	3.39	1.67	2.29
May	5/2/2012	5/30/2012	<LLD	NA	2.26	<LLD	NA	2.68
June	5/30/2012	7/4/2012	<LLD	NA	2.55	4.75	1.88	2.54
July	7/4/2012	8/1/2012	<LLD	NA	3.77	3.56	1.97	2.80
August	8/1/2012	8/29/2012	<LLD	NA	2.92	3.42	1.84	2.53
September	8/29/2012	8/29/2012	<LLD	NA	3.03	<LLD	NA	3.04
October	8/29/2012	10/31/2012	<LLD	NA	3.38	3.66	1.91	2.75
November	10/31/2012	12/5/2012	<LLD	NA	4.02	<LLD	NA	4.35
December	12/5/2012	1/2/2013	<LLD	NA	3.97	<LLD	NA	4.34

SV-2047 Pen Branch at USFS Rd. A-13

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	<LLD	NA	3.28	<LLD	NA	3.61
February	1/25/2012	2/29/2012	<LLD	NA	3.76	<LLD	NA	3.17
March	2/29/2012	3/28/2012	<LLD	NA	3.14	<LLD	NA	2.45
April	3/28/2012	5/2/2012	<LLD	NA	2.24	<LLD	NA	2.31
May	5/2/2012	5/30/2012	3.38	2.23	2.65	<LLD	NA	2.72
June	5/30/2012	7/4/2012	<LLD	NA	2.79	<LLD	NA	2.56
July	7/4/2012	8/1/2012	<LLD	NA	4.02	<LLD	NA	2.81
August	8/1/2012	8/29/2012	7.76	2.87	3.12	<LLD	NA	2.55
September	8/29/2012	8/29/2012	<LLD	NA	3.22	<LLD	NA	3.04
October	8/29/2012	10/31/2012	<LLD	NA	3.55	<LLD	NA	2.75
November	10/31/2012	12/5/2012	<LLD	NA	4.14	<LLD	NA	4.36
December	12/5/2012	1/2/2013	<LLD	NA	4.11	<LLD	NA	4.35

SV-327 Steel Creek at SC Highway 125

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	<LLD	NA	3.33	<LLD	NA	3.62
February	1/25/2012	2/29/2012	<LLD	NA	3.79	<LLD	NA	3.17
March	2/29/2012	3/28/2012	<LLD	NA	2.99	<LLD	NA	2.44
April	3/28/2012	5/2/2012	<LLD	NA	2.32	<LLD	NA	2.32
May	5/2/2012	5/30/2012	2.91	2.20	2.70	<LLD	NA	2.72
June	5/30/2012	7/4/2012	3.87	2.59	3.16	2.75	1.79	2.59
July	7/4/2012	8/1/2012	<LLD	NA	4.17	<LLD	NA	2.82
August	8/1/2012	8/29/2012	<LLD	NA	3.10	<LLD	NA	2.55
September	8/29/2012	8/29/2012	<LLD	NA	3.21	<LLD	NA	3.04
October	8/29/2012	10/31/2012	<LLD	NA	3.45	<LLD	NA	2.75
November	10/31/2012	12/5/2012	<LLD	NA	4.15	<LLD	NA	4.36
December	12/5/2012	1/2/2013	<LLD	NA	3.37	<LLD	NA	2.79

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Ambient Monitoring Data-Alpha/Beta

SV-2018 Steel Creek Boat Landing

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	<LLD	NA	3.33	<LLD	NA	3.62
February	1/25/2012	2/29/2012	<LLD	NA	3.76	<LLD	NA	3.17
March	2/29/2012	3/28/2012	<LLD	NA	3.00	<LLD	NA	2.44
April	3/28/2012	5/2/2012	<LLD	NA	2.17	<LLD	NA	2.30
May	5/2/2012	5/30/2012	<LLD	NA	2.37	<LLD	NA	2.69
June	5/30/2012	7/4/2012	<LLD	NA	2.69	<LLD	NA	2.55
July	7/4/2012	8/1/2012	<LLD	NA	3.90	<LLD	NA	2.81
August	8/1/2012	8/29/2012	<LLD	NA	3.04	<LLD	NA	2.55
September	8/29/2012	8/29/2012	<LLD	NA	3.23	<LLD	NA	3.04
October	8/29/2012	10/31/2012	<LLD	NA	3.58	<LLD	NA	2.75
November	10/31/2012	12/5/2012	<LLD	NA	4.32	<LLD	NA	4.37
December	12/5/2012	1/2/2013	<LLD	NA	4.26	<LLD	NA	4.37

SV-118 US Highway 301 at Savannah River

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	<LLD	NA	3.34	4.94	2.43	3.62
February	1/25/2012	2/29/2012	<LLD	NA	3.85	<LLD	NA	3.17
March	2/29/2012	3/28/2012	<LLD	NA	3.18	<LLD	NA	2.46
April	3/28/2012	5/2/2012	<LLD	NA	2.26	<LLD	NA	2.31
May	5/2/2012	5/30/2012	<LLD	NA	2.46	<LLD	NA	2.70
June	5/30/2012	7/4/2012	AE	AE	AE	<LLD	NA	2.55
July	7/4/2012	8/1/2012	<LLD	NA	4.05	<LLD	NA	2.82
August	8/1/2012	8/29/2012	<LLD	NA	3.08	<LLD	NA	2.55
September	8/29/2012	8/29/2012	<LLD	NA	3.24	<LLD	NA	3.04
October	8/29/2012	10/31/2012	<LLD	NA	3.58	<LLD	NA	2.75
November	10/31/2012	12/5/2012	<LLD	NA	4.35	<LLD	NA	4.37
December	12/5/2012	1/2/2013	<LLD	NA	4.35	<LLD	NA	4.37

SV-2053 Lower Three Runs at SRS Rd B

Month	Sample Deployment Date	Collection Date	Alpha Activity	Alpha Confidence Interval	Alpha LLD	Beta Activity	Beta Confidence Interval	Beta LLD
January	12/28/2011	1/25/2012	<LLD	NA	3.05	<LLD	NA	3.59
February	1/25/2012	2/29/2012	<LLD	NA	3.56	<LLD	NA	3.15
March	2/29/2012	3/28/2012	<LLD	NA	2.82	<LLD	NA	2.43
April	3/28/2012	5/2/2012	<LLD	NA	2.21	<LLD	NA	2.31
May	5/2/2012	5/30/2012	<LLD	NA	2.30	<LLD	NA	2.68
June	5/30/2012	7/4/2012	<LLD	NA	2.58	<LLD	NA	2.54
July	7/4/2012	8/1/2012	<LLD	NA	3.84	<LLD	NA	2.80
August	8/1/2012	8/29/2012	<LLD	NA	3.00	<LLD	NA	2.54
September	8/29/2012	8/29/2012	<LLD	NA	3.12	<LLD	NA	3.04
October	8/29/2012	10/31/2012	<LLD	NA	3.45	<LLD	NA	2.75
November	10/31/2012	12/5/2012	<LLD	NA	4.04	<LLD	NA	4.35
December	12/5/2012	1/2/2013	<LLD	NA	4.08	<LLD	NA	4.35

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Creek Mouth Data-Tritium

SV-2011 Upper Three Runs Creek

Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
3/5/2012	<LLD	NA	215
6/22/2012	496	111	219
9/17/2012	561	114	215
12/10/2012	482	109	213

SV-2013 Beaver Dam

Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
3/5/2012	236	100	215
6/22/2012	336	109	219
9/17/2012	<LLD	NA	215
12/10/2012	<LLD	NA	213

SV-2015a Fourmile Branch (Creek Mouth)

Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
3/5/2012	16824	367	215
6/22/2012	25453	449	219
9/17/2012	37042	546	215
12/10/2012	3031	176	213

SV-2015b Four Mile Creek (30')

Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
3/5/2012	424	105	215
6/22/2012	<LLD	NA	219
9/17/2012	9442	279	215
12/10/2012	<LLD	NA	213

SV-2015c Four Mile Creek (150')

Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
3/5/2012	<LLD	NA	215
6/22/2012	<LLD	NA	219
9/17/2012	8633	270	215
12/10/2012	<LLD	NA	213

SV-2017 Steel Creek

Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
3/5/2012	<LLD	NA	215
6/22/2012	239	101	219
9/17/2012	4126	201	215
12/10/2012	1540	142	213

SV-2020 Lower Three Runs Creek

Collection Date	Tritium Activity	Tritium Confidence Interval	Tritium LLD
3/5/2012	240	99	215
6/22/2012	725	119	219
9/17/2012	330	112	215
12/10/2012	846	121	213

Fourmile Branch Data-Iodine-129 and Technetium-99

Location Description	Collection Date	Iodine-129 Activity	Iodine-129 Confidence Interval	Iodine-129 MDA	Technetium-99 Activity	Technetium-99 Confidence Interval	Technetium-99 MDA
RWSV-2039	1/30/2012	<MDA	1.56E+00	3.26E+00	<MDA	2.85E+00	4.76E+00
RWSV-2039	5/16/2012	<MDA	1.98E+00	3.67E+00	6.79E+00	2.78E+00	4.53E+00
RWSV-2044	8/21/2012	<MDA	1.09E+00	2.18E+00	<MDA	1.75E+00	2.96E+00
RWSV-2044	12/10/2012	<MDA	1.04E+00	2.37E+00	3.05E+00	1.65E+00	2.17E+00

Note: The sampling location changed mid-year to coincide with the change in the supplemental location.

7.0 Summary Statistics

Radiological Monitoring of Surface Water On and Adjacent to the SRS

2012 Ambient Monitoring Data-Tritium 40
2012 Creek Mouth Data-Tritium 40
2012 Ambient Monitoring Data-Alpha 41
2012 Ambient Monitoring Data-Beta 41

Notes:
1. pCi/L is picocuries per Liter
2. ND is No Detection
3. NA is Not Applicable
4. NS is No Sample

Radiological Monitoring of Surface Water On and Adjacent to the SRS

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Samples	Number of Detects
Jackson Boat Landing (SV-2010)	251	28	253	212	284	52	8
Upper Three Runs Creek (SV-325)	622	236	593	241	1,298	52	52
TNX Boat Landing (SV-2012)	292	57	280	229	433	40	11
Beaver Dam Creek (SV-2040)	1,441	3,750	254	208	12,113	41	10
Fourmile Branch (SV-2039)	44,039	6,157	46,470	25,889	54,691	52	52
Pen Branch (SV-2047)	31,950	9,438	34,808	4,047	46,184	52	52
Steel Creek (SV-327)	2,286	453	2,257	1,464	3,631	52	52
Steel Creek Boat Landing (SV-2018)	564	813	377	223	5,694	52	46
Little Hell Landing (SV-2019)	452	250	355	211	1,262	52	39
Highway 301 Bridge (SV-118)	642	556	389	236	2,683	52	44
Lower Three Runs Creek and Patterson Mill Rd. (SV-328)	2,222	504	2,300	481	3,114	52	50
Lower Three Runs Creek (SV-2053)	373	74	367	216	589	52	49
Upper Three Runs Creek (SV-2027)	236	40	224	159	300	51	11

Summary Statistics
2012 Ambient Monitoring Data-Tritium

2012 Creek Mouth Data-Tritium

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Samples	Number of Detects
Upper Three Runs Creek Creek Mouth (SV-2011)	513	43	496	482	561	4	3
Beaver Dam Creek Creek Mouth (SV-2013)	286	71	286	236	336	4	2
Fourmile Branch Creek Mouth (SV-2015 a)	20,587	14,339	21,139	3,031	37,042	4	4
Fourmile Branch (SV-2015 b) 30' downstream from Creek Mouth	4,933	6,377	4,933	424	9,442	4	2
Fourmile Branch (SV-2015 c) 150' downstream from Creek Mouth	8,633	N/A	8,633	8,633	8,633	4	1
Steel Creek Creek Mouth (SV-2017)	1,968	1,979	1,540	239	4,126	4	3
Lower Three Runs Creek Creek Mouth (SV-2020)	535	295	527	240	846	4	4

Radiological Monitoring of Surface Water On and Adjacent to the SRS
Summary Statistics
2012 Ambient Monitoring Data-Alpha

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Samples	Number of Detects
Jackson Boat Landing (SV-2010)	N/A	N/A	N/A	N/A	N/A	12	0
Upper Three Runs Creek (SV-325)	8.20	4.38	7.28	3.57	16.6	12	6
Beaver Dam Creek (SV-2040)	N/A	N/A	N/A	N/A	N/A	9	0
Fourmile Branch Creek (SV-2039)	N/A	N/A	N/A	N/A	N/A	12	0
Pen Branch (SV-2047)	5.57	3.10	5.57	3.38	7.76	12	2
Steel Creek (SV-327)	3.39	0.68	3.39	2.91	3.87	12	2
Steel Creek Boat Landing (SV-2018)	N/A	N/A	N/A	N/A	N/A	12	0
Highway 301 Bridge (SV-118)	N/A	N/A	N/A	N/A	N/A	12	0
Lower Three Runs Creek (SV-2053)	N/A	N/A	N/A	N/A	N/A	12	0

2012 Ambient Monitoring Data-Beta

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Samples	Number of Detects
Jackson Boat Landing (SV-2010)	3.56	N/A	3.56	3.56	3.56	12	1
Upper Three Runs Creek (SV-325)	N/A	N/A	N/A	N/A	N/A	12	0
Beaver Dam Creek (SV-2040)	N/A	N/A	N/A	N/A	N/A	9	0
Fourmile Branch (SV-2039)	4.47	1.56	3.66	3.39	7.73	12	7
Pen Branch (SV-2047)	N/A	N/A	N/A	N/A	N/A	12	0
Steel Creek (SV-327)	2.75	N/A	2.75	2.75	2.75	12	1
Steel Creek Boat Landing (SV-2018)	N/A	N/A	N/A	N/A	N/A	12	0
Highway 301 Bridge (SV-118)	4.94	N/A	4.94	4.94	4.94	12	1
Lower Three Runs Creek (SV-2053)	N/A	N/A	N/A	N/A	N/A	12	0

Acronyms

Am-241	Americium-241
CDC	Centers for Disease Control and Prevention
Co-60	Cobalt-60
Cs-137	Cesium-137
DOE-SR	Department of Energy - Savannah River
ESOP	Environmental Surveillance and Oversight Program
ETF	Effluent Treatment Facility
EQC	Environmental Quality Control
H3	Tritium
I-129	Iodine-129
LLD	Lower Limit of Detection
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
NA	Not Applicable
ND	No Detection
NS	No Sample
REMD	Radiological Environmental Monitoring Division
RSW	Radiological Surface Water
SCDHEC	South Carolina Department of Health and Environmental Control
SD	Standard Deviation
SRS	Savannah River Site
SRNS	Savannah River Nuclear Solutions
Sr-90	Strontium-90
Tc-99	Technitium-99
U	Uranium
USEPA	United States Environmental Protection Agency
USFS	United States Forestry Service
WSRC	Washington Savannah River Company (formerly Westinghouse Savannah River Company)

Units of Measure

mL	milliliter
pCi/L	picocuries/liter
±	plus or minus one standard deviation
±2	plus or minus two standard deviations, represents uncertainty in single detects

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2012 Nonradiological Monitoring of Ambient Surface Water at Savannah River Site

Environmental Surveillance and Oversight Program

97NW004
Crystal L Robertson, Project Manager
January 1, 2012 – December 31, 2012

Midlands EQC Region – Aiken
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DHEC
PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

The streams located on the Savannah River Site (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. Data from SRS Environmental Reports and South Carolina Department of Health and Environmental Control's (SCDHEC) Environmental Surveillance and Oversight Program (ESOP) is used to monitor the ambient water quality of streams on SRS.

ESOP assessed the surface water quality for nonradiological parameters in 2012 at SRS by sampling the on-site streams for inorganic and organic contaminants. The streams on SRS are tributaries to the Savannah River and are classified as Freshwater (FW) by SCDHEC's Bureau of Water (SCDHEC 2008a). As an indication of possible water quality issues, ESOP data was compared to the FW standard guidelines in SCDHEC's Water Classifications and Standards (Regulation 61-68). 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 (SCDHEC 2008b). 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. Where appropriate, ESOP results were also compared to the Savannah River watershed data collected by SCDHEC's Bureau of Water from 2008 through 2012 (SCDHEC 2013). This data includes averages and data ranges for all streams in the entire Savannah River watershed basin.

Nine ESOP sample locations were strategically chosen to monitor ambient surface water conditions and detect the nonradiological impact from the Department of Energy – Savannah River (DOE-SR) operations. See Section 4.0 for a map of ESOP sample locations. 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 (Section 5, Table 1). Seven of the ESOP sample locations were co-located with DOE-SR sample locations to provide data comparisons (Section 5, Table 2). One sample location (NWSV-2040), a man-made stream used for operations in the D-Area of SRS, was discontinued from the sampling routine in October of 2012. Once D-Area operations ceased, the flow in this stream was eliminated.

Streams were tested for the following parameters on a monthly interval: pH, dissolved oxygen (DO), temperature, alkalinity, turbidity, biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, total Kjeldahl nitrogen (TKN), ammonia, nitrite/nitrate, total phosphorous, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc. Volatile organic compounds (VOC), pesticides and polychlorinated biphenyls (PCB) were sampled biannually. These are standard parameters used to indicate water quality in FW streams throughout South Carolina (SCDHEC 2011). In all, over 3200 individual analyses were performed with 118 of these individual parameters exceeding South Carolina or United States Environmental Protection Agency (USEPA) standards or other recommended guidelines. Data from SCDHEC surface water locations were compared to DOE-SR data where sample points were co-located (SCDHEC 2012). All surface water data can be found in Section 6.0, and surface water statistical analyses can be found in Section 7.0.

2.0 RESULTS AND DISCUSSION

pH Results

Many chemical and biological processes in surface waters can be affected by pH, a measurement that indicates the alkalinity or acidity of a substance (USEPA 1997). The streams encountered at SRS are typical of southeastern streams characterized as blackwater. A blackwater stream is a stream with 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 resulting 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 (USGS 2000).

The pH standard for all South Carolina freshwater streams is between 6.0 and 8.5 standard units (su), although lower pH is typical for blackwater streams (SCDHEC 2008b). ESOP personnel measured and recorded the pH at each sample location during the sampling event. There were 22 individual measurements at seven locations that were outside of the pH standard, including locations downstream and upstream of SRS operations (Section 6.0, Data and Section 7.0, Summary Statistics). Two of these locations had yearly averages that were below the pH standard; NWSV-324 (5.96 (±0.55)) and NWSV-2027 (5.92 (±0.58)). These are typical results for blackwater streams. The Savannah River basin's pH averaged 6.69, and ranged from 4.6 to 8.61 (SCDHEC 2013). All ESOP sample measurements were within this range. See Section 5.0, Figure 1 for a comparison of ESOP and DOE-SR data for co-located samples; there were no significant differences (SRNS 2013).

DO and BOD Results

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 DO. The 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 sustain higher forms of aquatic life (USEPA 1997).

Dissolved oxygen was measured and recorded in the field as part of each ESOP sampling event, and samples were collected for BOD analysis. The South Carolina freshwater standard for DO is a daily average no less than 5.0 milligrams per liter (mg/L) with a minimum of 4.0 mg/L (SCDHEC 2008b). The monthly sampling frequency employed by ESOP is insufficient for strict interpretation related to the standards. The ESOP grab sample method is considered to be representative and provides an indication of water quality relative to DO. All 2012 individual analyses and yearly averages were above 5.0 mg/L (Section 6.0, Data and Section 7.0, Summary Statistics). The Savannah River basin's DO averaged 8.83 mg/L, and ranged from 0.66 mg/L to 15.4 mg/L (SCDHEC 2013). All ESOP sample measurements were within this range. See Section 5.0, Figure 2 for a DO comparison of ESOP and DOE-SR data for co-located samples; there were no significant differences (SRNS 2013).

There are no numeric criteria in the South Carolina freshwater standards for a maximum BOD level; however, all 2012 ESOP samples were near or below the lower limit of detection (LLD) of 2.0 mg/L (Section 6.0, Data and Section 7.0, Summary Statistics). The ESOP results show 93%

of samples were below the LLD, and the detections over the LLD ranged from 2.1 mg/L to 2.9 mg/L. These results show no indication of water quality issues relative to BOD in SRS streams. The Savannah River basin results show that 92% of samples were below the LLD, and the detections ranged from 2.1 mg/L to 6.4 mg/L. All ESOP samples results were within this range. DOE-SR did not collect BOD samples in 2012; therefore, no comparison was made for BOD.

Temperature Results

Temperature can affect biological and chemical processes in a stream. All aquatic organisms can be negatively impacted by temperature that varies from the natural occurring range (USEPA 1997). The South Carolina freshwater standards state the temperature of free flowing freshwater shall not be increased more than 2.8°C above natural temperature conditions and shall not exceed a maximum of 32.2°C (SCDHEC 2008b).

ESOP field personnel measured and recorded the temperature during each sampling event in 2012. All streams were below the maximum. ESOP did not collect temperature data above and below every possible point of impact; therefore, the results were insufficient for strict interpretation related to the standard. However, ESOP data showed the stream temperatures at each sampling event were comparable to each other, including samples representative of natural conditions that were upstream of most SRS operations (Section 6.0, Data and Section 7.0, Summary Statistics). The only exception was location NWSV-2040, which is a manmade stream used as cooling water. NWSV-2040 was below the maximum, but was typically warmer than the other streams. The temperature difference for this location is addressed independent from ESOP under SCDHEC permit #SC0047431, which allows a greater deviation in temperature specified for this stream than the standard allows. Overall the results do not indicate any water quality issues relative to temperature. No comparisons were made between ESOP results and the Savannah River watershed or DOE-SR results due to the high variability in temperature dependent on the day and the time of day samples were collected.

Alkalinity Results

Alkalinity is important for aquatic life in freshwater systems because it buffers pH changes that occur naturally or as a result of anthropogenic (man-made) sources. Components of alkalinity, such as carbonate and bicarbonate, will incorporate some toxic heavy metals and reduce their toxicity (USEPA 1997). There are no numeric criteria in the South Carolina freshwater standards for alkalinity; however, the National Technical Advisory Committee recommends a minimum alkalinity of 20 mg/L and that natural alkalinity not be reduced by more than 25 percent (National Academy of Sciences (NAS) 1974). Waters having insufficient alkalinity due to natural conditions do not have to be supplemented with artificially added materials to increase the alkalinity. Alkalinity resulting from naturally occurring materials, such as carbonate and bicarbonate, is not considered a health hazard in drinking water supplies, and naturally occurring maximum levels up to approximately 400 mg/L, as calcium carbonate, are not considered a problem to human health (NAS 1974).

ESOP sampled each location monthly in 2012 for alkalinity. Fifty-eight individual samples at six locations were below the recommended minimum level (Section 6.0, Data and Section 7.0, Summary Statistics). All six of these locations had yearly averages below the recommended level; NWSV-324 (4.3 (±1.0) mg/L), NWSV-325 (5.4 (±4.9) mg/L), NWSV-2027 (1.2 (±0.093) mg/L), NWSV-2039 (17 (±2.4) mg/L), NWSV-2040 (19 (±5.6) mg/L), and NWSV-2061 (6.8 (±0.94) mg/L). The low alkalinity, as related to pH, in SRS streams may be due to the presence of naturally low buffering compounds in the streams. These conditions were consistent even in the samples upstream of most SRS operations, represented by NWSV-2027 and NWSV-2061. The Savannah River basin's alkalinity averaged 24.69 mg/L, and ranged from 1 mg/L to 160 mg/L (SCDHEC 2013). All ESOP sample results were within this range. DOE-SR did not sample for alkalinity in 2012, therefore no comparison was made.

Turbidity and TSS Results

Turbidity is a measure of water clarity, or the light that passes through the water. Turbidity is directly affected by the water's TSS, which refers to the amount of material suspended in the water (USEPA 1997). There is no freshwater quality standard for TSS. The ESOP sample results ranged from 1.0 mg/L to 23 mg/L (Section 6.0, Data and Section 7.0, Summary Statistics). This is comparable to the Savannah River basin's TSS ranging from 1 mg/L to 43 mg/L (SCDHEC 2013). All ESOP sample results were within this range. See Section 5.0, Figure 3 for a TSS comparison of ESOP and DOE-SR data for co-located samples; there were no significant differences (SRNS 2013).

The freshwater quality standard for turbidity in South Carolina streams is not to exceed 50 nephelometric turbidity units (NTU) provided existing uses are maintained (SCDHEC 2008b). All ESOP monitored streams were below the standard for turbidity in 2012 (Section 6.0, Data and Section 7.0, Summary Statistics). The ESOP sample results ranged from 0.90 mg/L to 12 mg/L. This is comparable to the Savannah River basin's turbidity ranging from 0.8 mg/L to 320 mg/L (SCDHEC 2013). All ESOP sample results were within this range. DOE-SR did not sample for turbidity in 2012; therefore, no comparison was made.

Fecal Coliform Results

Fecal coliform is generally not harmful itself; however, it is an indicator of possible sewage contamination because it is common in human and animal feces. High fecal coliform results can indicate the possible presence of pathogenic bacteria, viruses, and protozoans (USEPA 1997). According to the South Carolina freshwater fecal coliform standard, five consecutive stream samples during any 30-day period shall not exceed a geometric mean of 200 colonies/100 milliliters (mL), nor shall more than ten percent of total samples during any 30-day period exceed 400 colonies/100 mL (SCDHEC 2008b). The monthly sampling frequency employed by ESOP is insufficient for strict interpretation of the standards. The ESOP grab sample method is considered to be representative and an indication of water quality relative to fecal coliform.

ESOP field personnel collected monthly surface water samples for fecal coliform analysis at each location in 2012. There were nine individual samples at seven locations that exceeded 400 colonies/100 mL; however, no yearly average was above 400 colonies/100 mL (Section 6.0, Data and Section 7.0, Summary Statistics). The presence of fecal coliform in SRS streams does not necessarily indicate man-made causes, and may be due to natural conditions. Independent from the ESOP monitoring program, SCDHEC's Bureau of Water has placed location NWSV-325 on the state Section 303(d) List of Impaired Waters due to fecal coliform bacteria (SCDHEC 2010).

This means based on the Bureau of Water sampling, this stream was not in compliance with the standard for fecal coliform; however, this does not imply these conditions are due to a particular source. The ESOP sample results ranged from 3 colonies/100 mL to 1,500 colonies/100 mL. This is comparable to the Savannah River basin's fecal coliform ranging from 3 colonies/100 mL to 16,000 colonies/100 mL (SCDHEC 2013). All ESOP sample results were within this range. DOE-SR did not collect samples for fecal coliform in 2012; therefore, no comparison was made.

Nutrient Results

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 (USEPA 1997). In 2012, ESOP sampled for total phosphorous and various forms of nitrogen, including nitrite/nitrate, TKN, and ammonia. There are no numeric criteria in the South Carolina freshwater standard for any of these parameters.

ESOP 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 USEPA 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 (USEPA 2009). To provide a conservative approach, ESOP uses the maximum of 1 mg/L as an indication of possible water quality issues. There were two individual samples in 2012 that exceeded 1 mg/L of nitrate/nitrite, and both were from the Fourmile Branch location (NWSV-2039) (Section 6.0, Data). This stream typically has nitrogen levels higher than other SRS streams due to an upstream wastewater treatment plant or to groundwater beneath F-Area and H-Area seepage basins outcropping into Four Mile Branch (RAC 1999). However, no location, including NWSV-2039, had a 2012 yearly average that exceeded the drinking water standard (Section 7.0, Summary Statistics).

To further evaluate nutrient levels in SRS stream, comparisons were made between the ESOP results and the entire Savannah River watershed data. All ESOP results are included in Section 6.0, Data. The ESOP results for total phosphorous show 19% of samples were below the LLD, and the detections over the LLD ranged from 0.021 mg/L to 0.25 mg/L. The Savannah River basin results show that 23% of samples were below the LLD, and the detections ranged from 0.02 mg/L to 2.7 mg/L. All ESOP total phosphorous results were within this range. The ESOP nitrate/nitrite results show 4% of samples were below the LLD, and the detections over the LLD ranged from 0.023 mg/L to 1.1 mg/L. The Savannah River basin results show that 18% of samples were below the LLD, and the detections ranged from 0.02 mg/L to 7.6 mg/L. All ESOP nitrate/nitrite results were within this range. The ESOP TKN results show 21% of samples were below the LLD, and the detections over the LLD ranged from 0.10 mg/L to 0.64 mg/L. The Savannah River basin results show that 19% of samples were below the LLD, and the detections ranged from 0.11 mg/L to 2.4 mg/L. All ESOP TKN results were within this range. The ESOP ammonia results show 61% of samples were below the LLD, and the detections over the LLD ranged from 0.050 mg/L to 0.38 mg/L. The Savannah River basin results show that 51% of samples were below the LLD, and the detections ranged from 0.05 mg/L to 0.39 mg/L. All ESOP ammonia results were within this range.

Overall the nutrient levels on SRS are similar to the levels found throughout the Savannah River Basin. DOE-SR did not sample for TKN or ammonia in 2012; therefore, no comparison was made. See Section 5.0, Figure 4 and Figure 5 for a comparison of ESOP and DOE-SR data from co-located samples for total phosphorous and nitrate/nitrite; respectively. There were no significant differences (SRNS 2013).

Metals Results

Most metals are considered to be pollutants, including some that are toxic or known carcinogens. In 2012, ESOP personnel collected monthly samples at each sample location for the following metals: cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc. All metals data is included in Section 6.0, Data. Yearly averages were calculated for all metals; however, many of these averages are based on a single detection (Section 7.0, Summary Statistics). 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. All of these metals, except iron and manganese, have numeric criteria for the protection of human health and aquatic life in the South Carolina freshwater quality standards.

Iron and manganese are naturally occurring metals that do not have state freshwater standards. Iron has a recommended USEPA limit in freshwater streams of 1 mg/L (USEPA 2008). Fourteen individual ESOP samples at three locations had iron above this recommended level. One location had a yearly average above the recommended level, NWSV-324 (3.2 (±0.71) mg/L). DOE-SR results for co-located samples indicated the same location had a yearly average above the recommended level for iron (SRNS 2013).

Iron and manganese levels in SRS were comparable to the respective levels the Savannah River watershed. The ESOP sample results for iron ranged from 0.12 mg/L to 4.1 mg/L. The Savannah River basin’s iron levels ranged from 0.03 mg/L to 7.9 mg/L (SCDHEC 2013). All ESOP sample results were within this range. The ESOP manganese sample results ranged from 0.011 mg/L to 0.20 mg/L. The Savannah River basin’s manganese levels ranged from 0.01 mg/L to 5.4 mg/L (SCDHEC 2013). All ESOP sample results were within this range. See Section 5.0, Figure 6 and Figure 7 for an iron and manganese comparison of ESOP and DOE-SR data for co-located samples; there were no significant differences (SRNS 2013). Due to the lack of numeric data, none of the other metals results were compared to the Savannah River watershed data. Comparison figures to DOE-SR data were also not included.

The freshwater quality standard for cadmium in South Carolina streams is not to exceed 0.00010 mg/L (SCDHEC 2008b). Six individual ESOP samples at four locations had cadmium levels above the standard. These four sample locations had yearly averages above the standard; NWSV-327 (0.024 (±0.033) mg/L), NWSV-2027 (0.0015 (±0.0015) mg/L), NWSV-2039 (0.00019 mg/L (one detection)), and NWSV-2040 (0.00077 mg/L (one detection)). Data less than the LLD was not included in the yearly averages; therefore, some yearly averages may be based on a single sample. These four locations include streams upstream and downstream of most SRS operations. DOE-SR detected cadmium above the standard at one sample location in 2012. DOE-SR did not detect cadmium at any other co-located sample above the DOE-SR detection limit of 0.00050 mg/L (SRNS 2013).

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 (SCDHEC 2008b). Each of these metals was above the respective standard in one sample at one sample location in 2012. All three metals were above the standard in June 2012 at sample location NWSV-328. The three metals had yearly averages for this location above the respective standards based on the single June sample: chromium (0.055 mg/L), copper (0.016 mg/L), and nickel (0.023 mg/L). DOE-SR did not detect chromium or nickel above the standard in any 2012 co-located sample (SRNS 2013). DOE-SR detected copper above the standard in at least one sample from every co-located sample location; however, no DOE-SR yearly average was above the standard. The DOE-SR copper detections were found at levels below ESOP LLD.

The freshwater quality standard for lead in South Carolina streams is not to exceed 0.00054 mg/L (SCDHEC 2008b). Due to laboratory limitations, ESOP has an LLD higher than the standard at 0.0020 mg/L; therefore, any detection of lead is over the standard. One sample was over the standard in 2012, and this location had a yearly average above the standard based on the single sample: NWSV-327 (0.048 mg/L). DOE-SR did not detect lead in any 2012 samples above the DOE-SR detection limit of 0.0050 mg/L (SRNS 2013).

The freshwater quality standard for mercury in South Carolina streams is not to exceed 0.00091 mg/L (SCDHEC 2008b). Mercury was not detected above the LLD of 0.00020 mg/L in any of the ESOP samples in 2012; therefore, all SCDHEC monitored streams met the standard for this parameter. DOE-SR has a mercury detection limit of 0.00002 mg/L. DOE-SR detected mercury at levels below the SCDHEC LLD in several of the co-located samples. None of these detections were over the freshwater quality standard (SRNS 2013).

The freshwater quality standard for zinc in South Carolina streams is not to exceed 0.037 mg/L (SCDHEC 2008b). All of the 2012 ESOP detections for zinc were below the standard for this parameter. DOE-SR detected zinc above the standard in at least one sample from each co-located sample location except NWSV-324; however, no yearly average was above the standard. See Section 5.0, Figure 8 for a zinc comparison of ESOP and DOE-SR yearly averages for co-located samples, there were no significant differences (SRNS 2013).

VOC, PCB and Pesticide Results

Most VOC, PCB, and pesticides are considered to be pollutants including some that are toxic. Most have numeric criteria for the protection of human health and aquatic life in the South Carolina freshwater quality standards. ESOP field personnel collected surface water samples for VOC, PCB, and pesticides at each location biannually. ESOP sampled for 59 individual VOC, PCB, and pesticide parameters at each location during the spring and fall of 2012. All data is included in Section 6.0, Data. VOC and PCB samples were not detected above the LLD for any parameter in 2012. Five pesticide parameters were detected in a sample from NWSV-2061 in November of 2012 (Section 6.0, Data). Three of these parameters have freshwater quality standards, and were all above the standard as follows: endosulfan II (0.00031 mg/L) above the standard of 0.000056 mg/L, endrin (0.00032 mg/L) above the standard of 0.000036 mg/L, and dichlorodiphenyltrichloroethane (DDT) (0.00031 mg/L) above the standard of 0.000001 mg/L. Endosulfan sulfate and dichlorodiphenyldichloroethane (DDD) were also detected in the

November NWSV-2061 samples; however, there are no freshwater quality standards for these parameters. This location (NWSV-2061) is upstream of most SRS operations. Statistical calculations were not conducted for these parameters due to the lack of numeric data. DOE-SR collects VOC, PCB and pesticides samples at the beginning of each quarter, and the results showed endosulfan II at one location in April 2012. Endosulfan II in this one sample was above the freshwater standard of 0.000056 mg/L (SCDHEC 2008b). DOE-SR did not detect any other VOC, PCB, or pesticide parameters in 2012 (SRNS 2013).

SCDHEC and DOE-SR Data Comparison

Seven of the nine SCDHEC sampling locations were co-located with DOE-SR sampling locations: NWSV-324, NWSV-325, NWSV- 327, NWSV-328, NWSV-2039, NWSV-2040 and NWSV-2047 (SRNS 2012). Section 5.0, Table 1 defines the geographic locations of the ESOP sampling locations and Section 5.0, Table 3 defines the sampling schedule for ESOP. Section 5.0, Table 2 defines the geographic locations of all the DOE-SR sampling locations. Comparisons were made for each parameter individually in the text above. Some comparisons include graphs located in Section 5 that show data from the seven co-located samples to determine if there were any significant statistical differences in the following parameters: pH (Figure 1), DO (Figure 2), TSS (Figure 3), total phosphorous (Figure 4), nitrate/nitrite (Figure 5), iron (Figure 6), manganese (Figure 7), and zinc (Figure 8). Small discrepancies in data between DOE-SR and SCDHEC may be attributed to differences in sample collection date, sample collection time, sample preservation, and lab analysis. Differences in statistical calculations, such as the yearly averages, may also attribute to dissimilarities. All data less than the LLD were left out of ESOP statistical calculations due to the lack of numeric data.

3.0 CONCLUSION/ RECOMMENDATIONS

The parameters identified that were above or below USEPA or SCDHEC standards or recommended levels for particular streams will continue to be monitored to establish trends that may warrant further investigation. Overall, the nonradiological water quality on the SRS in 2012 compared favorably with the South Carolina Freshwaters Standard or other recommendations for the parameters and locations monitored in this study. The 2012 ESOP results for most parameters were similar to the SCDHEC's Bureau of Water data for the Savannah River watershed as a whole. ESOP will continue to sample on a monthly and biannual basis for routine parameters. ESOP will continue to evaluate water quality based on the independent nonradiological monitoring 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.

In October 2012, the sample location NWSV-2040 was dropped from the routine monthly sampling due to cessation in flow. Beginning in January 2013, a new sample location on McQueens Branch (NWSV-2055) was added to the monthly routine sampling. McQueens Branch is a tributary to Steel Creek that does not include waters downstream of L-Area or L-Lake and is reported to be unimpacted by SRS operations. This sample will provide a comparison to the current Steel Creek sample at NWSV-327. ESOP is also considering moving the background locations (NWSV-2027 and NWSV-2061) farther upstream and off SRS due to the number of detections of metals and pesticides in these upstream locations on SRS. The locations, number of samples, sample frequencies, and monitoring parameters are reviewed annually and modified as needed to maximize available resources and address SRS mission changes.

4.0 MAP

Map 1. Nonradiological Surface Water Monitoring Sample Locations

5.0 TABLES AND FIGURES

Table 1. SCDHEC 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	Upstream of most SRS Operations
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-2040	Beaver Dam Creek	Downstream from D-Area
NWSV-2039	Fourmile Branch at Road A-13.2	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

Table 2. DOE-SR Surface Water Sample Locations

SRS Stream Locations	Savannah River Locations
Tinker Creek near Northeast Site Boundary	River Mile 160
Tims Branch at Road C*	River Mile 150.4
Upper Three Runs at Road 1-A	River Mile 141.5
Upper Three Runs at Road A*	River Mile 129.1
Beaver Dam Creek at D-Area*	River Mile 118.8
Four Mile Creek at Road E	
Four Mile Creek at Road C	
Four Mile Creek adjacent to D-Area*	
Pen Branch at Road A-13.2*	
Steel Creek at Road A*	
Lower Three Runs at Patterson Mill Road*	

*Co-located with DHEC sample locations.

Table 3. Water Quality Parameter Analyses for SCDHEC

Laboratory	Frequency	Parameter
SCDHEC Lab Aiken, SC	Monthly	Turbidity, Alkalinity, Biochemical Oxygen Demand (BOD 5), Fecal Coliform, and Total Suspended Solids.
SCDHEC Lab Columbia, SC	Monthly	Ammonia, Nitrate/Nitrite, Total Phosphorus, Total Kjeldahl Nitrogen (TKN), and Metals.
	Semi-annually	Volatile Organic Compounds (VOCs), Pesticide Scan and Polychlorinated Biphenyls (PCBs).
Field	Monthly	Temperature, pH, and Dissolved Oxygen (DO).

Tables and Figures

Figure 1. pH Comparison

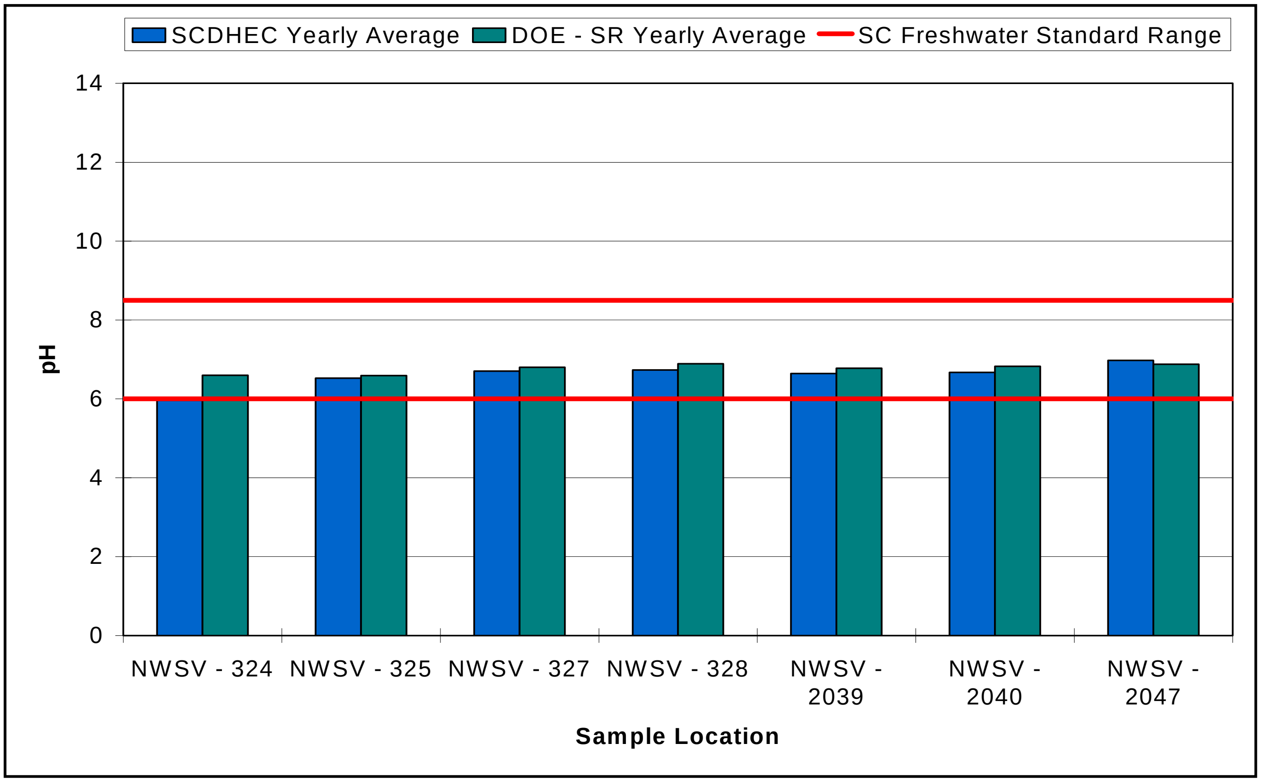
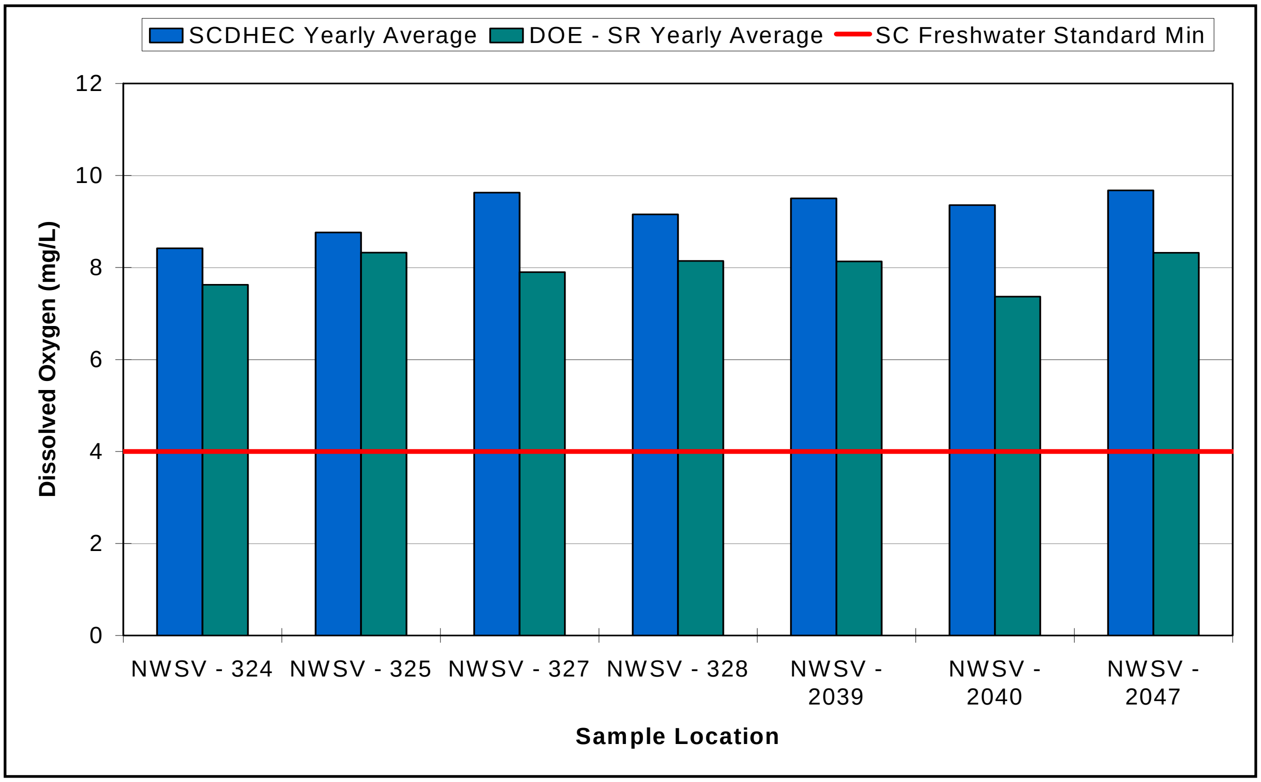


Figure 2. DO Comparison



Tables and Figures

Figure 3. TSS Comparison

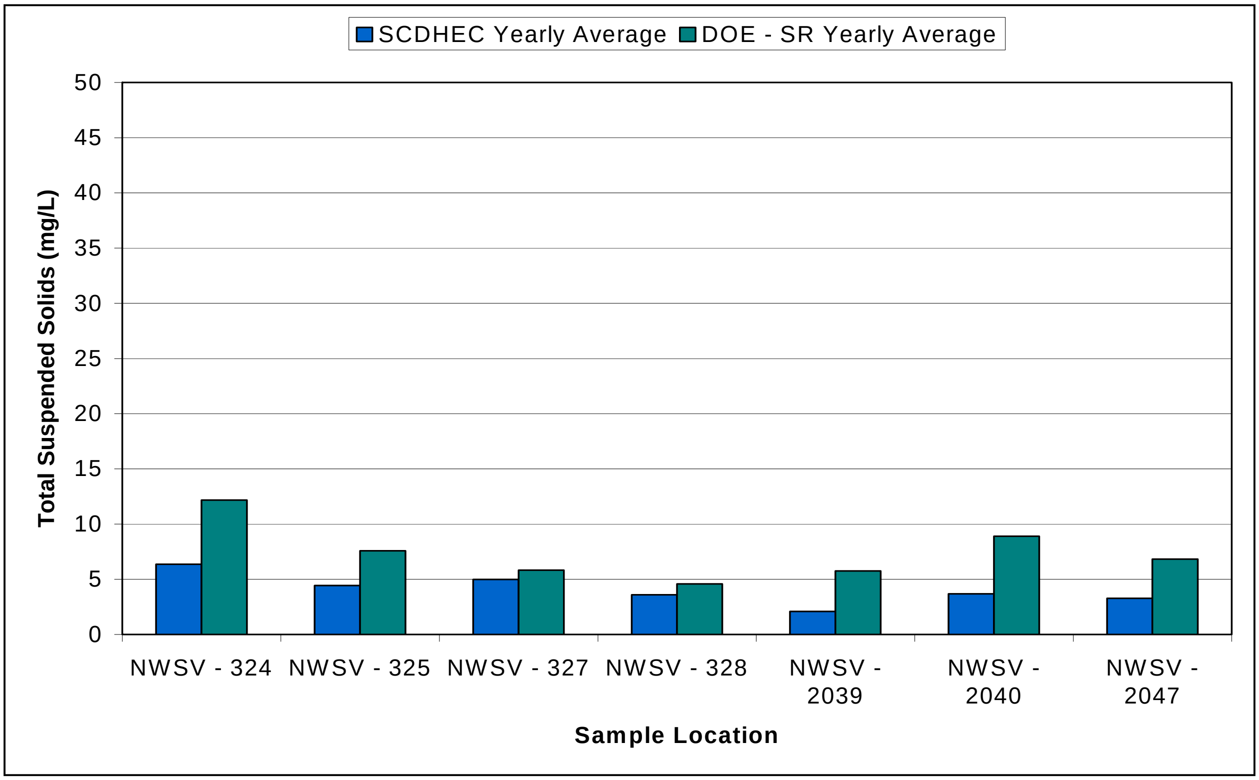
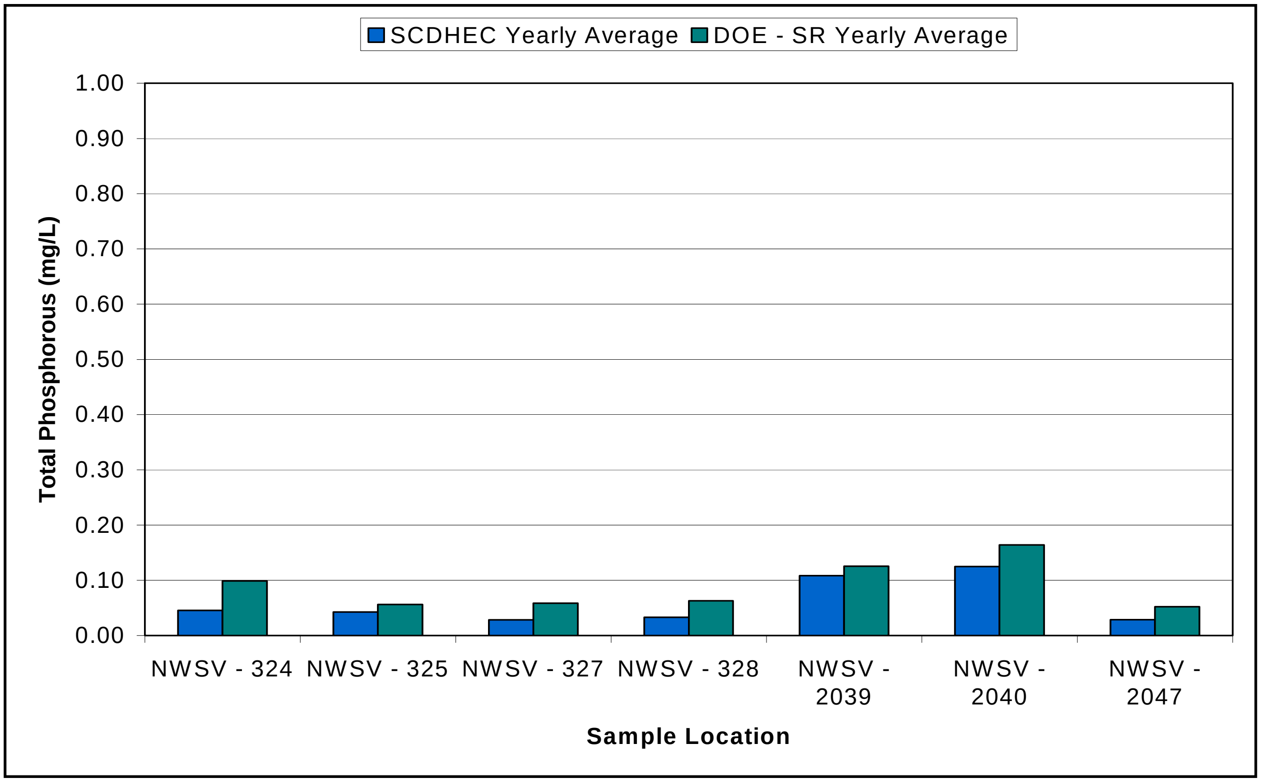


Figure 4. Total Phosphorous Comparison



Tables and Figures

Figure 5. Nitrate/Nitrite Comparison

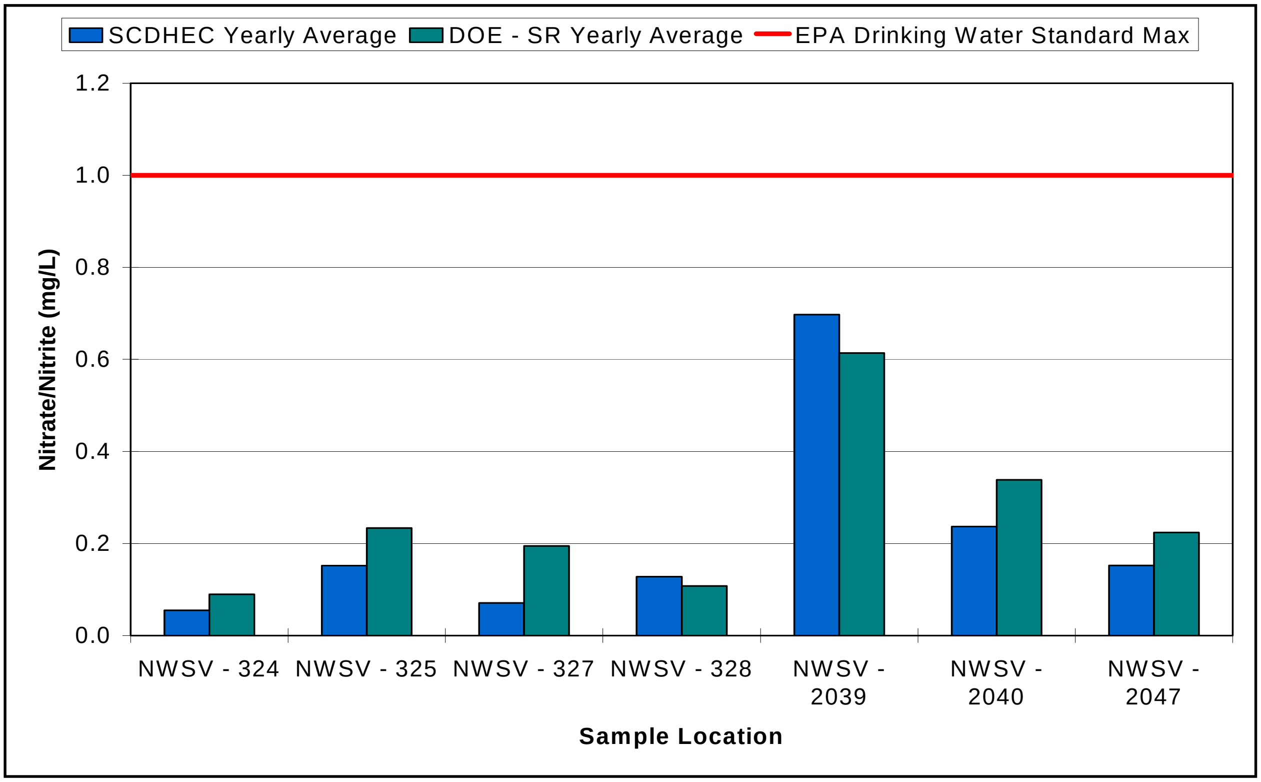
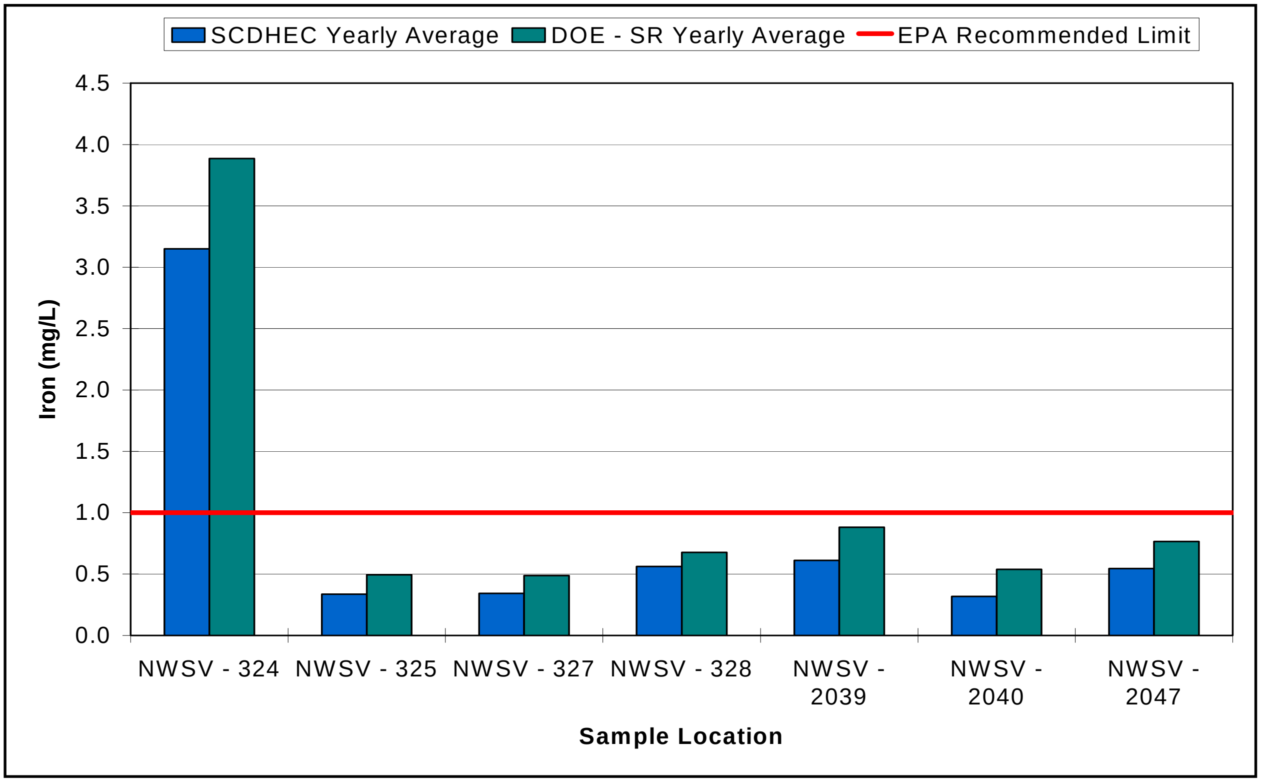


Figure 6. Iron Comparison



Tables and Figures

Figure 7. Manganese Comparison

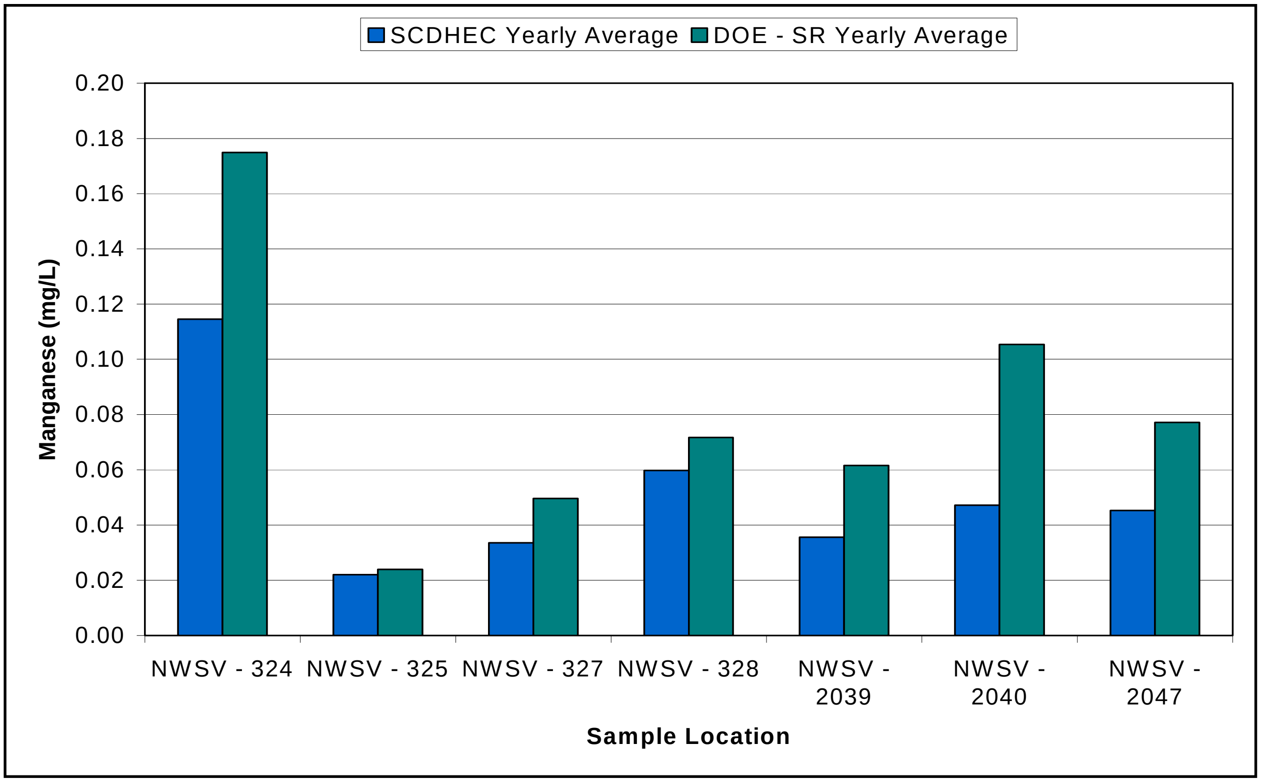
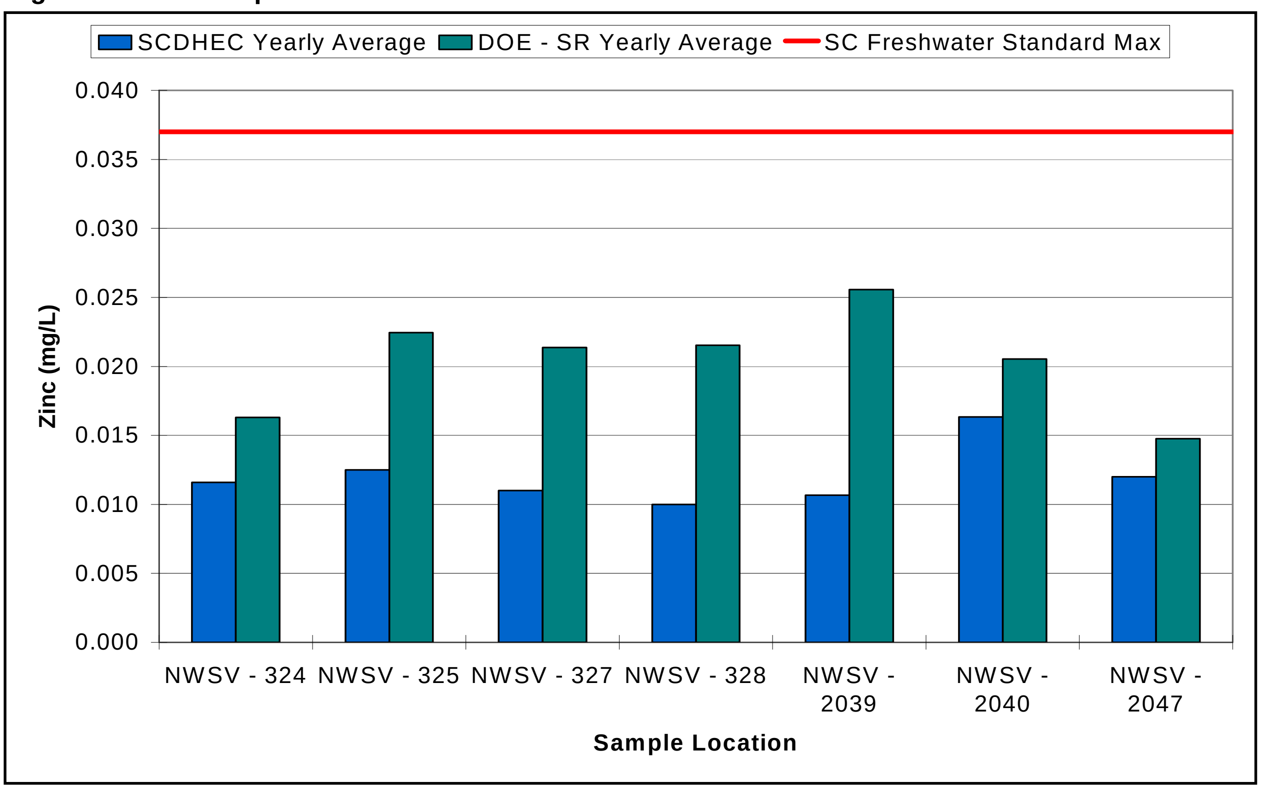


Figure 8. Zinc Comparison



6.0 DATA

Nonradiological Monitoring of Surface Water

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Notes:

1. NS = No sample available
2. AE = Analytical error
3. LE = Lab error
4. EST = Estimated amount
5. A blank shaded box indicates that parameter was not part of the routine collection for that month.

DATA TABLES

NWSV-324	Tims Branch at Road C											
	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
pH	6.93	6.19	**5.83**	**5.85**	6.66	6.56	**5.75**	**5.40**	**5.48**	**5.33**	6.22	**5.35**
DO	NC	11.80	8.42	8.19	8.40	8.31	8.09	6.91	7.82	7.49	8.70	8.45
Water Temp	7.30	7.93	20.32	19.42	21.21	20.95	24.94	23.50	19.89	16.23	11.03	12.93
Alkalinity	**3.3**	**3.8**	**6.4**	**5.9**	**4.8**	**4.6**	**4.2**	**4.0**	**4.6**	**3.9**	**3.2**	**3.4**
Turbidity	4.3	4.4	7.0	6.1	4.8	12	4.7	5.7	5.9	6.2	4.1	3.8
BOD	<2.0	<2.0	2.3	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	LE	<2.0	<2.0
TSS	3.4	4.8	9.4	8.8	6.0	11	5.4	6.3	8.0	6.0	3.3	4.0
Fecal Coliform	5 EST	10 EST	63	**>600**	40 EST	110	80	180	91	350	120	63
TKN	0.38	0.52	0.50	0.64	0.26	0.27	0.34	0.42	0.33	0.46	0.27	0.30
Ammonia	0.083	<0.050	0.072	0.36	0.079	0.093	0.075	0.12	0.058	<0.050	<0.050	<0.050
Nitrate/Nitrite	0.044	0.027	<0.020	0.044	0.030	<0.020	0.073	0.084	0.054	0.066	0.071	0.057
Total Phosphorus	0.042	0.029	0.060	0.06	0.048	0.040	0.051	0.045	0.050	0.049	0.033	0.038
Cadmium	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Chromium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron	**2.3**	**1.9**	**3.8**	**3.0**	**3.5**	**3.7**	**3.6**	**3.6**	**4.1**	**3.4**	**2.4**	**2.5**
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Manganese	0.063	0.042	0.13	0.14	0.096	0.20	0.14	0.16	0.12	0.15	0.062	0.072
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	<0.010	0.012	0.012	<0.010	<0.010	0.011	<0.010	0.013	<0.010	<0.010	0.010	<0.010
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
1,1,1-Trichloroethane			<0.00500								<0.00500	
1,1,2,2-Tetrachloroethane			<0.00500								<0.00500	
1,1,2-Trichloroethane			<0.00500								<0.00500	
1,1-Dichloroethane			<0.00500								<0.00500	
1,1-Dichloroethene			<0.00500								<0.00500	
1,2-Dichloroethane			<0.00500								<0.00500	
1,2-Dichloropropane			<0.00500								<0.00500	
2-Butanone			<0.00500								<0.00500	
4-Methyl-2-Pentanone			<0.00500								<0.00500	
Acetone			<0.0500								<0.0500	
Benzene			<0.00500								<0.00500	
Bromodichloromethane			<0.00500								<0.00500	
Bromoform			<0.00500								<0.00500	
Bromomethane			<0.00500								<0.00500	
Carbon Disulfide			<0.00500								<0.00500	
Carbon tetrachloride			<0.00500								<0.00500	
Chlorobenzene			<0.00500								<0.00500	
Chloroethane			<0.00500								<0.00500	
Chloroform			<0.00500								<0.00500	
Chloromethane			<0.00500								<0.00500	
cis-1,2-Dichloroethylene			<0.00500								<0.00500	
cis-1,3-Dichloropropene			<0.00500								<0.00500	
Dibromochloromethane			<0.00500								<0.00500	
Dichloromethane			<0.00500								<0.00500	
Ethyl benzene			<0.00500								<0.00500	
m,p-Xylenes			<0.0100								<0.0100	
o-Xylene			<0.00500								<0.00500	
Styrene			<0.00500								<0.00500	
Tetrachloroethene			<0.00500								<0.00500	
Toluene			<0.00500								<0.00500	
trans-1,2-Dichloroethene			<0.00500								<0.00500	
trans-1,3-Dichloropropene			<0.00500								<0.00500	
Trichloroethene			<0.00500								<0.00500	
Vinyl chloride			AE								<0.00500	
Aldrin				LE							<0.000050	
alpha-BHC				LE							<0.000050	
beta-BHC				LE							<0.000050	
Chlordane				LE							<0.00050	
delta-BHC				LE							<0.000050	
Dieldrin				LE							<0.000050	
Endosulfan I				LE							<0.000050	
Endosulfan II				LE							<0.000050	
Endosulfan Sulfate				LE							<0.000050	
Endrin				LE							<0.000050	
Endrin aldehyde				LE							<0.000050	
Heptachlor				LE							<0.000050	
Heptachlor epoxide				LE							<0.000050	
Lindane				LE							<0.000050	
p,p'-DDD				LE							<0.000050	
p,p'-DDE				LE							<0.000050	
p,p'-DDT				LE							<0.000050	
PCB 1016				LE							<0.00050	
PCB 1221				LE							<0.0010	
PCB 1232				LE							<0.00050	
PCB 1242				LE							<0.00050	
PCB 1248				LE							<0.00050	
PCB 1254				LE							<0.00050	
PCB 1260				LE							<0.00050	
Toxaphene				LE							<0.0025	

DATA TABLES

NWSV-325	Upper Three Runs at Road A											
	January	February	March	April	May	June	July	August	September	October	November	December
pH	7.30	6.74	6.80	**5.75**	6.99	6.75	6.49	**5.59**	6.49	6.31	6.89	6.23
DO	NC	11.68	8.05	8.68	8.61	8.55	8.25	7.05	8.84	8.19	9.43	9.03
Water Temp	7.46	8.61	19.24	18.91	19.49	20.30	22.92	22.46	19.17	16.03	11.85	14.03
Alkalinity	**3.8**	**4.1**	21	**4.0**	**4.1**	**3.8**	**2.8**	**3.8**	**4.3**	**4.2**	**4.9**	**4.5**
Turbidity	1.4	1.9	5.5	4.3	6.4	3.9	3.7	4.0	2.7	1.6	1.4	1.6
BOD	<2.0	<2.0	<2.0	<2.0	2.2	<2.0	<2.0	<2.0	<2.0	LE	<2.0	<2.0
TSS	1.2	2.7	5.0	7.9	12	4.3	4.8	6.9	3.3	2.0	1.6	1.6
Fecal Coliform	100	50 EST	15 EST	**880**	300	91	140	45 EST	120	240	220	130
TKN	0.26	0.24	0.29	0.42	0.21	<0.10	0.14	0.11	<0.10	<0.10	0.22	<0.10
Ammonia	<0.050	<0.050	0.068	0.38	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrate/Nitrite	0.19	0.18	0.23	0.15	0.15	0.11	0.15	0.14	0.13	0.14	0.11	0.14
Total Phosphorus	<0.020	<0.020	0.15	0.036	0.032	0.023	0.036	0.026	0.025	0.029	<0.020	0.026
Cadmium	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Chromium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron	0.20	0.21	0.36	0.42	0.56	0.35	0.40	0.35	0.42	0.25	0.22	0.29
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Manganese	0.012	<0.010	0.073	0.020	0.024	0.013	0.013	0.015	0.015	<0.010	<0.010	0.013
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	0.011	<0.010	<0.010	0.013	<0.010	<0.010	0.015	0.011	<0.010	<0.010	<0.010	<0.010
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
1,1,1-Trichloroethane			<0.00500								<0.00500	
1,1,2,2-Tetrachloroethane			<0.00500								<0.00500	
1,1,2-Trichloroethane			<0.00500								<0.00500	
1,1-Dichloroethane			<0.00500								<0.00500	
1,1-Dichloroethene			<0.00500								<0.00500	
1,2-Dichloroethane			<0.00500								<0.00500	
1,2-Dichloropropane			<0.00500								<0.00500	
2-Butanone			<0.00500								<0.00500	
4-Methyl-2-Pentanone			<0.00500								<0.00500	
Acetone			<0.0500								<0.0500	
Benzene			<0.00500								<0.00500	
Bromodichloromethane			<0.00500								<0.00500	
Bromoform			<0.00500								<0.00500	
Bromomethane			<0.00500								<0.00500	
Carbon Disulfide			<0.00500								<0.00500	
Carbon tetrachloride			<0.00500								<0.00500	
Chlorobenzene			<0.00500								<0.00500	
Chloroethane			<0.00500								<0.00500	
Chloroform			<0.00500								<0.00500	
Chloromethane			<0.00500								<0.00500	
cis-1,2-Dichloroethylene			<0.00500								<0.00500	
cis-1,3-Dichloropropene			<0.00500								<0.00500	
Dibromochloromethane			<0.00500								<0.00500	
Dichloromethane			<0.00500								<0.00500	
Ethyl benzene			<0.00500								<0.00500	
m,p-Xylenes			<0.0100								<0.0100	
o-Xylene			<0.00500								<0.00500	
Styrene			<0.00500								<0.00500	
Tetrachloroethene			<0.00500								<0.00500	
Toluene			<0.00500								<0.00500	
trans-1,2-Dichloroethene			<0.00500								<0.00500	
trans-1,3-Dichloropropene			<0.00500								<0.00500	
Trichloroethene			<0.00500								<0.00500	
Vinyl chloride			AE								<0.00500	
Aldrin				LE							<0.000050	
alpha-BHC				LE							<0.000050	
beta-BHC				LE							<0.000050	
Chlordane				LE							<0.00050	
delta-BHC				LE							<0.000050	
Dieldrin				LE							<0.000050	
Endosulfan I				LE							<0.000050	
Endosulfan II				LE							<0.000050	
Endosulfan Sulfate				LE							<0.000050	
Endrin				LE							<0.000050	
Endrin aldehyde				LE							<0.000050	
Heptachlor				LE							<0.000050	
Heptachlor epoxide				LE							<0.000050	
Lindane				LE							<0.000050	
p,p'-DDD				LE							<0.000050	
p,p'-DDE				LE							<0.000050	
p,p'-DDT				LE							<0.000050	
PCB 1016				LE							<0.00050	
PCB 1221				LE							<0.0010	
PCB 1232				LE							<0.00050	
PCB 1242				LE							<0.00050	
PCB 1248				LE							<0.00050	
PCB 1254				LE							<0.00050	
PCB 1260				LE							<0.00050	
Toxaphene				LE							<0.0025	

DATA TABLES

NWSV-327	Steel Creek at Road A											
	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
pH	7.00	6.70	6.80	**5.60**	6.76	7.03	6.96	6.55	6.78	6.47	7.03	6.75
DO	16.36	11.78	9.24	8.81	8.84	8.72	8.15	7.49	9.10	8.33	9.67	9.02
Water Temp	7.16	8.45	17.82	19.12	20.22	22.24	24.26	24.50	21.38	15.86	10.82	15.21
Alkalinity	28	28	29	30	25	28	28	28	29	30	29	30
Turbidity	2.0	2.2	3.3	4.6	9.2	3.1	3.2	2.6	1.7	1.9	1.7	1.8
BOD	<2.0	<2.0	<2.0	<2.0	2.2	<2.0	<2.0	<2.0	<2.0	LE	<2.0	<2.0
TSS	<1.0	4.5	2.9	9.8	20	3.1	3.1	2.8	1.4	1.2	1.0	<1.0
Fecal Coliform	110	300	320	260	320	120	160	**410**	240	280	**540**	150
TKN	<0.10	0.47	0.16	0.22	0.38	<0.10	0.13	0.31	0.27	0.16	0.32	0.36
Ammonia	<0.050	<0.050	<0.050	0.057	0.069	<0.050	0.065	0.080	<0.050	0.055	<0.050	0.050
Nitrate/Nitrite	0.056	0.058	0.24	0.057	0.064	0.050	0.078	0.07	0.041	0.043	<0.020	0.024
Total Phosphorus	<0.020	<0.020	<0.020	0.034	0.024	<0.020	0.027	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium	**0.00020**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	**0.047**	<0.00010	<0.00010	<0.00010	<0.00010
Chromium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron	0.25	0.28	0.21	0.47	0.80	0.29	0.42	0.34	0.30	0.22	0.20	0.33
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	**0.048**	<0.0020	<0.0020	<0.0020	<0.0020
Manganese	0.027	0.026	<0.010	0.052	0.093	0.025	0.040	0.032	0.025	0.016	0.012	0.021
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.011	<0.010
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
1,1,1-Trichloroethane			<0.00500								<0.00500	
1,1,2,2-Tetrachloroethane			<0.00500								<0.00500	
1,1,2-Trichloroethane			<0.00500								<0.00500	
1,1-Dichloroethane			<0.00500								<0.00500	
1,1-Dichloroethene			<0.00500								<0.00500	
1,2-Dichloroethane			<0.00500								<0.00500	
1,2-Dichloropropane			<0.00500								<0.00500	
2-Butanone			<0.00500								<0.00500	
4-Methyl-2-Pentanone			<0.00500								<0.00500	
Acetone			<0.0500								<0.0500	
Benzene			<0.00500								<0.00500	
Bromodichloromethane			<0.00500								<0.00500	
Bromoform			<0.00500								<0.00500	
Bromomethane			<0.00500								<0.00500	
Carbon Disulfide			<0.00500								<0.00500	
Carbon tetrachloride			<0.00500								<0.00500	
Chlorobenzene			<0.00500								<0.00500	
Chloroethane			<0.00500								<0.00500	
Chloroform			<0.00500								<0.00500	
Chloromethane			<0.00500								<0.00500	
cis-1,2-Dichloroethylene			<0.00500								<0.00500	
cis-1,3-Dichloropropene			<0.00500								<0.00500	
Dibromochloromethane			<0.00500								<0.00500	
Dichloromethane			<0.00500								<0.00500	
Ethyl benzene			<0.00500								<0.00500	
m,p-Xylenes			<0.0100								<0.0100	
o-Xylene			<0.00500								<0.00500	
Styrene			<0.00500								<0.00500	
Tetrachloroethene			<0.00500								<0.00500	
Toluene			<0.00500								<0.00500	
trans-1,2-Dichloroethene			<0.00500								<0.00500	
trans-1,3-Dichloropropene			<0.00500								<0.00500	
Trichloroethene			<0.00500								<0.00500	
Vinyl chloride			AE								<0.00500	
Aldrin				LE							<0.000050	
alpha-BHC				LE							<0.000050	
beta-BHC				LE							<0.000050	
Chlordane				LE							<0.00050	
delta-BHC				LE							<0.000050	
Dieldrin				LE							<0.000050	
Endosulfan I				LE							<0.000050	
Endosulfan II				LE							<0.000050	
Endosulfan Sulfate				LE							<0.000050	
Endrin				LE							<0.000050	
Endrin aldehyde				LE							<0.000050	
Heptachlor				LE							<0.000050	
Heptachlor epoxide				LE							<0.000050	
Lindane				LE							<0.000050	
p,p'-DDD				LE							<0.000050	
p,p'-DDE				LE							<0.000050	
p,p'-DDT				LE							<0.000050	
PCB 1016				LE							<0.00050	
PCB 1221				LE							<0.0010	
PCB 1232				LE							<0.00050	
PCB 1242				LE							<0.00050	
PCB 1248				LE							<0.00050	
PCB 1254				LE							<0.00050	
PCB 1260				LE							<0.00050	
Toxaphene				LE							<0.0025	

DATA TABLES

NWSV-328	Lower Three Runs at Patterson Mill Road											
	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
pH	6.72	6.78	7.18	**5.71**	6.27	7.08	7.10	6.72	6.96	6.59	6.95	6.74
DO	12.35	10.93	8.96	8.81	7.52	9.08	8.52	7.65	9.26	8.31	9.35	9.11
Water Temp	7.54	9.42	17.73	17.99	19.06	19.96	21.22	22.12	18.93	15.28	11.07	14.98
Alkalinity	53	52	55	54	25	55	53	51	56	55	54	56
Turbidity	1.1	1.6	2.1	2.3	7.8	3.1	2.5	3.3	2.7	2.6	2.1	1.8
BOD	<2.0	<2.0	<2.0	<2.0	2.7	<2.0	<2.0	<2.0	<2.0	LE	<2.0	<2.0
TSS	<1.0	1.3	2.7	4.6	11	3.1	3.2	5.2	1.8	1.7	1.4	<1.0
Fecal Coliform	230	220	120	130	**1500**	120 EST	180	220	320	240	270	120
TKN	0.13	0.41	0.20	0.38	0.37	<0.10	<0.10	0.36	0.24	0.31	0.24	0.35
Ammonia	<0.050	<0.050	<0.050	<0.050	0.092	0.067	0.056	0.074	<0.050	0.11	0.084	<0.050
Nitrate/Nitrite	0.080	0.68	0.028	0.069	0.17	0.092	0.083	0.10	0.086	0.087	0.023	0.034
Total Phosphorus	0.023	0.022	0.021	0.048	0.044	0.028	0.041	0.036	0.033	0.037	<0.020	0.027
Cadmium	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Chromium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	**0.055**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	**0.016**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron	0.24	0.27	0.48	0.46	0.67	0.54	0.54	0.82	1.0	**1.1**	0.29	0.32
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Manganese	0.046	0.048	0.084	0.090	0.11	0.054	0.050	0.066	0.055	0.037	0.034	0.043
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	**0.023**	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
1,1,1-Trichloroethane			<0.00500								<0.00500	
1,1,2,2-Tetrachloroethane			<0.00500								<0.00500	
1,1,2-Trichloroethane			<0.00500								<0.00500	
1,1-Dichloroethane			<0.00500								<0.00500	
1,1-Dichloroethene			<0.00500								<0.00500	
1,2-Dichloroethane			<0.00500								<0.00500	
1,2-Dichloropropane			<0.00500								<0.00500	
2-Butanone			<0.00500								<0.00500	
4-Methyl-2-Pentanone			<0.00500								<0.00500	
Acetone			<0.0500								<0.0500	
Benzene			<0.00500								<0.00500	
Bromodichloromethane			<0.00500								<0.00500	
Bromoform			<0.00500								<0.00500	
Bromomethane			<0.00500								<0.00500	
Carbon Disulfide			<0.00500								<0.00500	
Carbon tetrachloride			<0.00500								<0.00500	
Chlorobenzene			<0.00500								<0.00500	
Chloroethane			<0.00500								<0.00500	
Chloroform			<0.00500								<0.00500	
Chloromethane			<0.00500								<0.00500	
cis-1,2-Dichloroethylene			<0.00500								<0.00500	
cis-1,3-Dichloropropene			<0.00500								<0.00500	
Dibromochloromethane			<0.00500								<0.00500	
Dichloromethane			<0.00500								<0.00500	
Ethyl benzene			<0.00500								<0.00500	
m,p-Xylenes			<0.0100								<0.0100	
o-Xylene			<0.00500								<0.00500	
Styrene			<0.00500								<0.00500	
Tetrachloroethene			<0.00500								<0.00500	
Toluene			<0.00500								<0.00500	
trans-1,2-Dichloroethene			<0.00500								<0.00500	
trans-1,3-Dichloropropene			<0.00500								<0.00500	
Trichloroethene			<0.00500								<0.00500	
Vinyl chloride			AE								<0.00500	
Aldrin				LE							<0.000050	
alpha-BHC				LE							<0.000050	
beta-BHC				LE							<0.000050	
Chlordane				LE							<0.00050	
delta-BHC				LE							<0.000050	
Dieldrin				LE							<0.000050	
Endosulfan I				LE							<0.000050	
Endosulfan II				LE							<0.000050	
Endosulfan Sulfate				LE							<0.000050	
Endrin				LE							<0.000050	
Endrin aldehyde				LE							<0.000050	
Heptachlor				LE							<0.000050	
Heptachlor epoxide				LE							<0.000050	
Lindane				LE							<0.000050	
p,p'-DDD				LE							<0.000050	
p,p'-DDE				LE							<0.000050	
p,p'-DDT				LE							<0.000050	
PCB 1016				LE							<0.00050	
PCB 1221				LE							<0.0010	
PCB 1232				LE							<0.00050	
PCB 1242				LE							<0.00050	
PCB 1248				LE							<0.00050	
PCB 1254				LE							<0.00050	
PCB 1260				LE							<0.00050	
Toxaphene				LE							<0.0025	

DATA TABLES

NWSV-2027	Upper Three Runs at Road 2-1											
	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
pH	6.60	6.12	**5.51**	**5.82**	6.37	6.91	**5.64**	**4.75**	6.20	**5.65**	**5.97**	**5.44**
DO	NC	10.82	9.28	8.72	8.62	8.56	8.61	7.17	8.69	8.31	9.04	8.98
Water Temp	10.16	10.75	18.95	18.60	19.27	19.30	21.60	21.17	18.10	15.96	12.25	14.37
Alkalinity	**1.4**	**1.2**	**1.2**	**1.2**	**1.2**	**1.4**	**<1.0**	**1.1**	**1.3**	**1.2**	**1.2**	**1.3**
Turbidity	1.3	1.0	1.4	3.1	8.8	1.7	1.4	2.0	1.9	1.2	0.90	1.2
BOD	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	LE	<2.0	<2.0
TSS	1.6	1.6	1.5	6.4	7.0	4.0	1.8	3.2	2.5	1.0	1.1	1.0
Fecal Coliform	97	100	100	120	120	100	220	97	210	260	**440**	100
TKN	0.41	0.32	0.36	AE	<0.10	<0.10	0.23	0.26	<0.10	<0.10	0.19	0.21
Ammonia	<0.050	<0.050	<0.050	AE	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrate/Nitrite	0.31	0.30	0.028	0.51	0.23	0.26	0.26	0.23	0.24	0.26	0.25	0.28
Total Phosphorus	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	**0.0026**	<0.00010	**0.00047**	<0.00010	<0.00010	<0.00010
Chromium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron	0.15	0.12	0.57	0.28	0.33	0.25	0.21	0.26	0.95	0.20	0.19	0.22
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Manganese	<0.010	<0.010	0.057	<0.010	<0.010	<0.010	<0.010	<0.010	0.13	<0.010	<0.010	<0.010
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	<0.010	<0.010	<0.010	0.012	<0.010	<0.010	0.012	<0.010	0.022	<0.010	<0.010	<0.010
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
1,1,1-Trichloroethane			<0.00500								<0.00500	
1,1,2,2-Tetrachloroethane			<0.00500								<0.00500	
1,1,2-Trichloroethane			<0.00500								<0.00500	
1,1-Dichloroethane			<0.00500								<0.00500	
1,1-Dichloroethene			<0.00500								<0.00500	
1,2-Dichloroethane			<0.00500								<0.00500	
1,2-Dichloropropane			<0.00500								<0.00500	
2-Butanone			<0.00500								<0.00500	
4-Methyl-2-Pentanone			<0.00500								<0.00500	
Acetone			<0.0500								<0.0500	
Benzene			<0.00500								<0.00500	
Bromodichloromethane			<0.00500								<0.00500	
Bromoform			<0.00500								<0.00500	
Bromomethane			<0.00500								<0.00500	
Carbon Disulfide			<0.00500								<0.00500	
Carbon tetrachloride			<0.00500								<0.00500	
Chlorobenzene			<0.00500								<0.00500	
Chloroethane			<0.00500								<0.00500	
Chloroform			<0.00500								<0.00500	
Chloromethane			<0.00500								<0.00500	
cis-1,2-Dichloroethylene			<0.00500								<0.00500	
cis-1,3-Dichloropropene			<0.00500								<0.00500	
Dibromochloromethane			<0.00500								<0.00500	
Dichloromethane			<0.00500								<0.00500	
Ethyl benzene			<0.00500								<0.00500	
m,p-Xylenes			<0.0100								<0.0100	
o-Xylene			<0.00500								<0.00500	
Styrene			<0.00500								<0.00500	
Tetrachloroethene			<0.00500								<0.00500	
Toluene			<0.00500								<0.00500	
trans-1,2-Dichloroethene			<0.00500								<0.00500	
trans-1,3-Dichloropropene			<0.00500								<0.00500	
Trichloroethene			<0.00500								<0.00500	
Vinyl chloride			AE								<0.00500	
Aldrin				LE							<0.000050	
alpha-BHC				LE							<0.000050	
beta-BHC				LE							<0.000050	
Chlordane				LE							<0.00050	
delta-BHC				LE							<0.000050	
Dieldrin				LE							<0.000050	
Endosulfan I				LE							<0.000050	
Endosulfan II				LE							<0.000050	
Endosulfan Sulfate				LE							<0.000050	
Endrin				LE							<0.000050	
Endrin aldehyde				LE							<0.000050	
Heptachlor				LE							<0.000050	
Heptachlor epoxide				LE							<0.000050	
Lindane				LE							<0.000050	
p,p'-DDD				LE							<0.000050	
p,p'-DDE				LE							<0.000050	
p,p'-DDT				LE							<0.000050	
PCB 1016				LE							<0.00050	
PCB 1221				LE							<0.0010	
PCB 1232				LE							<0.00050	
PCB 1242				LE							<0.00050	
PCB 1248				LE							<0.00050	
PCB 1254				LE							<0.00050	
PCB 1260				LE							<0.00050	
Toxaphene				LE							<0.0025	

DATA TABLES

NWSV-2039	Fourmile Branch at Road A-13.2											
	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
pH	7.31	6.81	6.77	**5.83**	6.90	6.81	6.77	6.34	6.55	6.38	6.81	6.41
DO	NC	12.06	9.43	9.23	9.25	9.31	8.84	7.67	9.60	8.97	10.38	9.80
Water Temp	4.94	7.62	19.10	19.26	20.79	21.44	23.97	23.50	19.60	15.44	10.41	13.52
Alkalinity	**16**	**14**	21	**17**	**16**	**18**	20	21	**17**	**16**	**14**	**16**
Turbidity	1.9	1.9	3.2	5.2	3.8	2.7	3.2	2.8	2.8	2.2	1.8	2.3
BOD	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	LE	<2.0	<2.0
TSS	1.0	1.5	1.9	5.3	3.2	1.4	1.8	1.2	2.6	1.3	<1.0	1.8
Fecal Coliform	40 EST	60	71	180	57	88	260	71	**410**	**440**	180	370
TKN	0.35	0.31	0.22	0.42	0.35	0.10	0.35	0.20	0.29	0.20	0.53	0.23
Ammonia	<0.050	<0.050	<0.050	0.32	<0.050	0.061	<0.050	0.061	0.052	<0.050	<0.050	<0.050
Nitrate/Nitrite	**1.1**	0.83	0.77	0.80	0.35	0.40	0.38	0.36	0.40	0.96	0.92	**1.1**
Total Phosphorus	0.075	0.066	0.12	0.13	0.16	0.10	0.17	0.14	0.10	0.089	0.072	0.079
Cadmium	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	**0.00019**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Chromium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron	0.55	0.49	0.83	0.74	0.87	0.52	0.93	0.72	0.66	0.34	0.26	0.42
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Manganese	0.032	0.030	0.044	0.040	0.034	0.028	0.042	0.034	0.063	0.025	0.019	0.036
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	0.010	<0.010	<0.010	<0.010	<0.010	0.010	0.012	<0.010	<0.010	<0.010	<0.010	<0.010
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
1,1,1-Trichloroethane			<0.00500								<0.00500	
1,1,2,2-Tetrachloroethane			<0.00500								<0.00500	
1,1,2-Trichloroethane			<0.00500								<0.00500	
1,1-Dichloroethane			<0.00500								<0.00500	
1,1-Dichloroethene			<0.00500								<0.00500	
1,2-Dichloroethane			<0.00500								<0.00500	
1,2-Dichloropropane			<0.00500								<0.00500	
2-Butanone			<0.00500								<0.00500	
4-Methyl-2-Pentanone			<0.00500								<0.00500	
Acetone			<0.0500								<0.0500	
Benzene			<0.00500								<0.00500	
Bromodichloromethane			<0.00500								<0.00500	
Bromoform			<0.00500								<0.00500	
Bromomethane			<0.00500								<0.00500	
Carbon Disulfide			<0.00500								<0.00500	
Carbon tetrachloride			<0.00500								<0.00500	
Chlorobenzene			<0.00500								<0.00500	
Chloroethane			<0.00500								<0.00500	
Chloroform			<0.00500								<0.00500	
Chloromethane			<0.00500								<0.00500	
cis-1,2-Dichloroethylene			<0.00500								<0.00500	
cis-1,3-Dichloropropene			<0.00500								<0.00500	
Dibromochloromethane			<0.00500								<0.00500	
Dichloromethane			<0.00500								<0.00500	
Ethyl benzene			<0.00500								<0.00500	
m,p-Xylenes			<0.0100								<0.0100	
o-Xylene			<0.00500								<0.00500	
Styrene			<0.00500								<0.00500	
Tetrachloroethene			<0.00500								<0.00500	
Toluene			<0.00500								<0.00500	
trans-1,2-Dichloroethene			<0.00500								<0.00500	
trans-1,3-Dichloropropene			<0.00500								<0.00500	
Trichloroethene			<0.00500								<0.00500	
Vinyl chloride			AE								<0.00500	
Aldrin				<0.000050							<0.000050	
alpha-BHC				<0.000050							<0.000050	
beta-BHC				<0.000050							<0.000050	
Chlordane				<0.00050							<0.00050	
delta-BHC				<0.000050							<0.000050	
Dieldrin				<0.000050							<0.000050	
Endosulfan I				<0.000050							<0.000050	
Endosulfan II				<0.000050							<0.000050	
Endosulfan Sulfate				<0.000050							<0.000050	
Endrin				<0.000050							<0.000050	
Endrin aldehyde				<0.000050							<0.000050	
Heptachlor				<0.000050							<0.000050	
Heptachlor epoxide				<0.000050							<0.000050	
Lindane				<0.000050							<0.000050	
p,p'-DDD				<0.000050							<0.000050	
p,p'-DDE				<0.000050							<0.000050	
p,p'-DDT				<0.000050							<0.000050	
PCB 1016				<0.00050							<0.00050	
PCB 1221				<0.0010							<0.0010	
PCB 1232				<0.00050							<0.00050	
PCB 1242				<0.00050							<0.00050	
PCB 1248				<0.00050							<0.00050	
PCB 1254				<0.00050							<0.00050	
PCB 1260				<0.00050							<0.00050	
Toxaphene				<0.0025							<0.0025	

DATA TABLES

NWSV-2040	Bever Dam Creek in D-Area											
	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
pH	6.90	6.75	6.59	6.15	7.09	6.80	6.70	6.45	6.63			
DO	NC	10.77	9.48	9.56	9.91	9.21	8.95	7.89	9.10			
Water Temp	12.22	14.49	21.91	20.61	21.44	24.82	26.73	26.15	24.99			
Alkalinity	**18**	20	***4.5***	22	20	22	21	20	23			
Turbidity	4.1	2.5	*3.7*	2.2	1.9	3.7	3.9	4.6	4.1			
BOD	<2.0	<2.0	*<2.0*	<2.0	<2.0	2.1	<2.0	<2.0	<2.0			
TSS	4.5	2.2	*3.8*	4.0	2.8	5.3	3.8	3.8	3.0			
Fecal Coliform	14	15	*160*	3 EST	10	21	LE	>60	12			
TKN	0.28	0.44	*0.45*	0.34	0.29	0.26	0.24	0.32	0.12			
Ammonia	0.053	0.072	*<0.050*	0.34	0.096	0.075	0.058	0.076	<0.050			
Nitrate/Nitrite	0.26	0.25	*0.12*	0.20	0.24	0.20	0.27	0.28	0.31			
Total Phosphorus	0.16	0.10	*0.024*	0.17	0.10	0.088	0.12	0.11	0.25			
Cadmium	<0.00010	<0.00010	*<0.00010*	<0.00010	<0.00010	**0.00077**	<0.00010	<0.00010	<0.00010			
Chromium	<0.0050	<0.0050	*<0.0050*	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050			
Copper	<0.010	<0.010	*<0.010*	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			
Iron	0.27	0.16	*0.44*	0.20	0.20	0.34	0.36	0.40	0.50			
Lead	<0.0020	<0.0020	*<0.0020*	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020			
Manganese	0.070	0.035	*0.011*	0.038	0.041	0.051	0.055	0.060	0.064			
Nickel	<0.020	<0.020	*<0.020*	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020			
Zinc	<0.010	<0.010	*<0.010*	<0.010	0.011	0.023	<0.010	<0.010	0.015			
Mercury	<0.00020	<0.00020	*<0.00020*	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020			
1,1,1-Trichloroethane			*<0.00500*									
1,1,2,2-Tetrachloroethane			*<0.00500*									
1,1,2-Trichloroethane			*<0.00500*									
1,1-Dichloroethane			*<0.00500*									
1,1-Dichloroethene			*<0.00500*									
1,2-Dichloroethane			*<0.00500*									
1,2-Dichloropropane			*<0.00500*									
2-Butanone			*<0.00500*									
2-Hexanone												
4-Methyl-2-Pentanone			*<0.00500*									
Acetone			*<0.0500*									
Benzene			*<0.00500*									
Bromodichloromethane			*<0.00500*									
Bromoform			*<0.00500*									
Bromomethane			*<0.00500*									
Carbon Disulfide			*<0.00500*									
Carbon tetrachloride			*<0.00500*									
Chlorobenzene			*<0.00500*									
Chloroethane			*<0.00500*									
Chloroform			*<0.00500*									
Chloromethane			*<0.00500*									
cis-1,2-Dichloroethylene			*<0.00500*									
cis-1,3-Dichloropropene			*<0.00500*									
Dibromochloromethane			*<0.00500*									
Dichloromethane			*<0.00500*									
Ethyl benzene			*<0.00500*									
m,p-Xylenes			*<0.0100*									
o-Xylene			*<0.00500*									
Styrene			*<0.00500*									
Tetrachloroethene			*<0.00500*									
Toluene			*<0.00500*									
trans-1,2-Dichloroethene			*<0.00500*									
trans-1,3-Dichloropropene			*<0.00500*									
Trichloroethene			*<0.00500*									
Vinyl chloride			*AE*									
Aldrin				<0.000050								
alpha-BHC				<0.000050								
beta-BHC				<0.000050								
Chlordane				<0.00050								
delta-BHC				<0.000050								
Dieldrin				<0.000050								
Endosulfan I				<0.000050								
Endosulfan II				<0.000050								
Endosulfan Sulfate				<0.000050								
Endrin				<0.000050								
Endrin aldehyde				<0.000050								
Heptachlor				<0.000050								
Heptachlor epoxide				<0.000050								
Lindane				<0.000050								
p,p'-DDD				<0.000050								
p,p'-DDE				<0.000050								
p,p'-DDT				<0.000050								
PCB 1016				<0.00050								
PCB 1221				<0.0010								
PCB 1232				<0.00050								
PCB 1242				<0.00050								
PCB 1248				<0.00050								
PCB 1254				<0.00050								
PCB 1260				<0.00050								
Toxaphene				<0.0025								

DATA TABLES

NWSV-2047	Pen Branch at Road A-13.2											
	January	February	March	April	May	June	July	August	September	October	November	December
pH	8.14	7.52	7.03	6.06	6.94	7.12	6.90	6.57	6.77	6.59	7.19	6.87
DO	NC	12.15	9.85	9.35	9.56	9.23	9.03	7.90	9.31	9.43	10.86	9.79
Water Temp	6.08	8.05	18.22	18.90	19.87	20.95	23.44	23.43	19.84	15.20	10.16	15.22
Alkalinity	24	26	29	29	25	30	29	27	29	28	27	28
Turbidity	1.7	2.8	2.9	4.2	7.3	3.4	3.2	3.4	2.7	3.0	1.8	2.4
BOD	<2.0	<2.0	<2.0	<2.0	2.9	<2.0	<2.0	<2.0	<2.0	LE	<2.0	<2.0
TSS	<1.0	1.6	1.9	9.4	7.6	2.6	<1.0	1.6	1.6	2.0	<1.0	1.1
Fecal Coliform	95 EST	150	120	120	88	180 EST	160	60 EST	200	180	83	97
TKN	0.35	0.32	0.24	0.21	0.51	0.12	0.33	<0.10	0.28	<0.10	0.49	0.36
Ammonia	<0.050	<0.050	<0.050	<0.050	0.054	0.059	0.065	<0.050	<0.050	<0.050	<0.050	0.052
Nitrate/Nitrite	0.19	0.19	0.096	0.18	0.15	0.17	0.15	0.13	0.16	0.17	0.12	0.12
Total Phosphorus	0.021	0.024	<0.020	0.044	0.035	0.022	0.032	0.027	0.026	0.029	<0.020	0.025
Cadmium	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Chromium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron	0.34	0.40	0.62	0.56	**1.2**	0.57	0.65	0.62	0.53	0.39	0.24	0.42
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Manganese	0.043	0.056	0.068	0.053	0.058	0.066	0.050	0.034	0.046	0.032	0.014	0.023
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	<0.010	<0.010	<0.010	<0.010	<0.010	0.012	<0.010	<0.010	<0.010	0.012	<0.010	<0.010
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
1,1,1-Trichloroethane			<0.00500								<0.00500	
1,1,2,2-Tetrachloroethane			<0.00500								<0.00500	
1,1,2-Trichloroethane			<0.00500								<0.00500	
1,1-Dichloroethane			<0.00500								<0.00500	
1,1-Dichloroethene			<0.00500								<0.00500	
1,2-Dichloroethane			<0.00500								<0.00500	
1,2-Dichloropropane			<0.00500								<0.00500	
2-Butanone			<0.00500								<0.00500	
4-Methyl-2-Pentanone			<0.00500								<0.00500	
Acetone			<0.0500								<0.0500	
Benzene			<0.00500								<0.00500	
Bromodichloromethane			<0.00500								<0.00500	
Bromoform			<0.00500								<0.00500	
Bromomethane			<0.00500								<0.00500	
Carbon Disulfide			<0.00500								<0.00500	
Carbon tetrachloride			<0.00500								<0.00500	
Chlorobenzene			<0.00500								<0.00500	
Chloroethane			<0.00500								<0.00500	
Chloroform			<0.00500								<0.00500	
Chloromethane			<0.00500								<0.00500	
cis-1,2-Dichloroethylene			<0.00500								<0.00500	
cis-1,3-Dichloropropene			<0.00500								<0.00500	
Dibromochloromethane			<0.00500								<0.00500	
Dichloromethane			<0.00500								<0.00500	
Ethyl benzene			<0.00500								<0.00500	
m,p-Xylenes			<0.0100								<0.0100	
o-Xylene			<0.00500								<0.00500	
Styrene			<0.00500								<0.00500	
Tetrachloroethene			<0.00500								<0.00500	
Toluene			<0.00500								<0.00500	
trans-1,2-Dichloroethene			<0.00500								<0.00500	
trans-1,3-Dichloropropene			<0.00500								<0.00500	
Trichloroethene			<0.00500								<0.00500	
Vinyl chloride			AE								<0.00500	
Aldrin				LE							<0.000050	
alpha-BHC				LE							<0.000050	
beta-BHC				LE							<0.000050	
Chlordane				LE							<0.00050	
delta-BHC				LE							<0.000050	
Dieldrin				LE							<0.000050	
Endosulfan I				LE							<0.000050	
Endosulfan II				LE							<0.000050	
Endosulfan Sulfate				LE							<0.000050	
Endrin				LE							<0.000050	
Endrin aldehyde				LE							<0.000050	
Heptachlor				LE							<0.000050	
Heptachlor epoxide				LE							<0.000050	
Lindane				LE							<0.000050	
p,p'-DDD				LE							<0.000050	
p,p'-DDE				LE							<0.000050	
p,p'-DDT				LE							<0.000050	
PCB 1016				LE							<0.00050	
PCB 1221				LE							<0.0010	
PCB 1232				LE							<0.00050	
PCB 1242				LE							<0.00050	
PCB 1248				LE							<0.00050	
PCB 1254				LE							<0.00050	
PCB 1260				LE							<0.00050	
Toxaphene				LE							<0.0025	

DATA TABLES

NWSV-2061	Upper Three Runs at Road 2-1											
	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
pH	7.55	6.70	6.34	**5.97**	6.78	6.82	6.30	**5.83**	6.76	6.36	6.60	**5.98**
DO	NC	11.75	9.22	9.04	8.82	8.93	8.55	7.48	9.08	8.99	10.11	9.82
Water Temp	6.96	8.78	19.98	19.32	20.03	20.61	24.55	22.79	18.82	15.55	10.74	13.23
Alkalinity	**5.5**	**6.0**	**7.1**	**6.6**	**5.0**	**6.6**	**7.7**	**7.6**	**7.0**	**7.8**	**8.0**	**6.7**
Turbidity	1.4	2.7	4.4	4.6	3.6	3.4	3.0	2.7	2.9	1.8	1.7	1.8
BOD	<2.0	<2.0	<2.0	<2.0	2.2	<2.0	<2.0	<2.0	<2.0	LE	<2.0	<2.0
TSS	1.4	4.0	4.8	6.2	23	5.0	2.9	3.9	5.1	2.0	1.3	1.9
Fecal Coliform	60	160	210	260	380	150	160	140	320	300	**660**	86
TKN	0.24	0.46	0.28	0.54	0.36	0.27	0.24	0.31	<0.10	0.26	0.42	0.32
Ammonia	<0.050	<0.050	<0.050	0.31	0.074	<0.050	<0.050	0.077	<0.050	<0.050	0.055	<0.050
Nitrate/Nitrite	0.061	0.044	<0.020	0.033	0.034	0.032	0.057	0.04	0.027	0.030	0.026	0.032
Total Phosphorus	0.038	0.039	0.067	0.07	0.11	0.070	0.091	0.071	0.060	0.053	0.044	0.045
Cadmium	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Chromium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	AE	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	AE	<0.010	<0.010	<0.010
Iron	0.26	0.29	0.60	0.48	0.88	0.57	0.68	0.50	AE	0.27	0.36	0.32
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Manganese	0.020	0.013	0.022	0.024	0.044	0.017	0.019	0.021	AE	0.014	0.021	0.019
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	AE	<0.020	<0.020	<0.020
Zinc	<0.010	<0.010	0.010	<0.010	<0.010	<0.010	<0.010	0.014	AE	<0.010	0.014	0.019
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
1,1,1-Trichloroethane			<0.00500								<0.00500	
1,1,2,2-Tetrachloroethane			<0.00500								<0.00500	
1,1,2-Trichloroethane			<0.00500								<0.00500	
1,1-Dichloroethane			<0.00500								<0.00500	
1,1-Dichloroethene			<0.00500								<0.00500	
1,2-Dichloroethane			<0.00500								<0.00500	
1,2-Dichloropropane			<0.00500								<0.00500	
2-Butanone			<0.00500								<0.00500	
4-Methyl-2-Pentanone			<0.00500								<0.00500	
Acetone			<0.0500								<0.0500	
Benzene			<0.00500								<0.00500	
Bromodichloromethane			<0.00500								<0.00500	
Bromoform			<0.00500								<0.00500	
Bromomethane			<0.00500								<0.00500	
Carbon Disulfide			<0.00500								<0.00500	
Carbon tetrachloride			<0.00500								<0.00500	
Chlorobenzene			<0.00500								<0.00500	
Chloroethane			<0.00500								<0.00500	
Chloroform			<0.00500								<0.00500	
Chloromethane			<0.00500								<0.00500	
cis-1,2-Dichloroethylene			<0.00500								<0.00500	
cis-1,3-Dichloropropene			<0.00500								<0.00500	
Dibromochloromethane			<0.00500								<0.00500	
Dichloromethane			<0.00500								<0.00500	
Ethyl benzene			<0.00500								<0.00500	
m,p-Xylenes			<0.0100								<0.0100	
o-Xylene			<0.00500								<0.00500	
Styrene			<0.00500								<0.00500	
Tetrachloroethene			<0.00500								<0.00500	
Toluene			<0.00500								<0.00500	
trans-1,2-Dichloroethene			<0.00500								<0.00500	
trans-1,3-Dichloropropene			<0.00500								<0.00500	
Trichloroethene			<0.00500								<0.00500	
Vinyl chloride			AE								<0.00500	
Aldrin				LE							<0.000050	
alpha-BHC				LE							<0.000050	
beta-BHC				LE							<0.000050	
Chlordane				LE							<0.00050	
delta-BHC				LE							<0.000050	
Dieldrin				LE							<0.000050	
Endosulfan I				LE							<0.000050	
Endosulfan II				LE							**0.00031**	
Endosulfan Sulfate				LE							**0.00035**	
Endrin				LE							**0.00032**	
Endrin aldehyde				LE							<0.000050	
Heptachlor				LE							<0.000050	
Heptachlor epoxide				LE							<0.000050	
Lindane				LE							<0.000050	
p,p'-DDD				LE							**0.00030**	
p,p'-DDE				LE							<0.000050	
p,p'-DDT				LE							**0.00031**	
PCB 1016				LE							<0.00050	
PCB 1221				LE							<0.0010	
PCB 1232				LE							<0.00050	
PCB 1242				LE							<0.00050	
PCB 1248				LE							<0.00050	
PCB 1254				LE							<0.00050	
PCB 1260				LE							<0.00050	
Toxaphene				LE							<0.0025	

7.0 SUMMARY STATISTICS

Summary Statistics for Nonradiological Monitoring of Ambient Surface Water at SRS

Summary Statistics 27

Notes:

1. N/A = Not Applicable
2. AVG = Average
3. STDEV = Standard Deviation
4. MED = Median
5. MIN = Minimum
6. MAX = Maximum
7. N = Number of Detections
8. All summary statistics are rounded to two significant figures.

SUMMARY STATISTICS

Sample Location	NWSV-324	Tims Branch at Road C					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	**5.96**	0.55	**5.84**	5.33	6.93	12
	DO	8.42	1.23	8.31	6.91	11.80	11
	Water Temp	17.14	5.98	19.66	7.30	24.94	12
Lab Parameters	Alkalinity	**4.3**	1.0	**4.1**	3.2	6.4	12
	Turbidity	5.8	2.2	5.3	3.8	12	12
	BOD	2.3	N/A	2.3	2.3	2.3	1
	TSS	6.4	2.5	6.0	3.3	11	12
	Fecal Coliform	143	171	86	5.0	600	12
	TKN	0.39	0.12	0.36	0.26	0.64	12
	Ammonia	0.12	0.10	0.081	0.058	0.36	8
	Nitrate/Nitrite	0.055	0.019	0.056	0.027	0.084	10
	Total Phosphorus	0.045	0.010	0.047	0.029	0.060	12
	Cadmium	<0.00010	N/A	<0.00010	<0.00010	<0.00010	0
	Chromium	<0.0050	N/A	<0.0050	<0.0050	<0.0050	0
	Copper	<0.010	N/A	<0.010	<0.010	<0.010	0
	Iron	**3.2**	0.71	**3.5**	1.9	4.1	12
	Lead	<0.0020	N/A	<0.0020	<0.0020	<0.0020	0
	Manganese	0.11	0.048	0.13	0.042	0.20	12
	Nickel	<0.020	N/A	<0.020	<0.020	<0.020	0
	Zinc	0.012	0.0011	0.012	0.010	0.013	5
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

Sample Location	NWSV-325	Upper Three Runs at Road A					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	6.53	0.50	6.62	5.59	7.30	12
	DO	8.76	1.15	8.61	7.05	11.68	11
	Water Temp	16.71	5.15	19.04	7.46	22.92	12
Lab Parameters	Alkalinity	**5.4**	4.9	**4.1**	2.8	21	12
	Turbidity	3.2	1.7	3.2	1.4	6.4	12
	BOD	2.2	N/A	2.2	2.2	2.2	1
	TSS	4.4	3.2	3.8	1.2	12	12
	Fecal Coliform	194	232	125	15	880	12
	TKN	0.24	0.10	0.23	0.11	0.42	8
	Ammonia	0.22	0.22	0.22	0.068	0.38	2
	Nitrate/Nitrite	0.15	0.034	0.15	0.11	0.23	12
	Total Phosphorus	0.043	0.041	0.029	0.023	0.15	9
	Cadmium	<0.00010	N/A	<0.00010	<0.00010	<0.00010	0
	Chromium	<0.0050	N/A	<0.0050	<0.0050	<0.0050	0
	Copper	<0.010	N/A	<0.010	<0.010	<0.010	0
	Iron	0.34	0.11	0.35	0.20	0.56	12
	Lead	<0.0020	N/A	<0.0020	<0.0020	<0.0020	0
	Manganese	0.022	0.020	0.015	0.012	0.073	9
	Nickel	<0.020	N/A	<0.020	<0.020	<0.020	0
	Zinc	0.013	0.0019	0.012	0.011	0.015	4
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

SUMMARY STATISTICS

Sample Location	NWSV-327	Steel Creek at Road A					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	6.70	0.39	6.77	5.60	7.03	12
	DO	9.63	2.36	8.93	7.49	16.36	12
	Water Temp	17.25	5.90	18.47	7.16	24.50	12
Lab Parameters	Alkalinity	29	1.4	29	25	30	12
	Turbidity	3.1	2.1	2.4	1.7	9.2	12
	BOD	2.2	N/A	2.2	2.2	2.2	1
	TSS	5.0	5.9	3.0	1.0	20	10
	Fecal Coliform	268	126	270	110	540	12
	TKN	0.28	0.11	0.29	0.13	0.47	10
	Ammonia	0.063	0.011	0.061	0.050	0.080	6
	Nitrate/Nitrite	0.071	0.058	0.057	0.024	0.24	11
	Total Phosphorus	0.028	0.0051	0.027	0.024	0.034	3
	Cadmium	**0.024**	0.033	**0.024**	0.00020	0.047	2
	Chromium	<0.0050	N/A	<0.0050	<0.0050	<0.0050	0
	Copper	<0.010	N/A	<0.010	<0.010	<0.010	0
	Iron	0.34	0.17	0.30	0.20	0.80	12
	Lead	**0.048**	N/A	**0.048**	0.048	0.048	1
	Manganese	0.034	0.023	0.026	0.012	0.093	11
	Nickel	<0.020	N/A	<0.020	<0.020	<0.020	0
	Zinc	0.011	N/A	0.011	0.011	0.011	1
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

Sample Location	NWSV-328	Lower Three Runs at Patterson Mill Road					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	6.73	0.41	6.76	5.71	7.18	12
	DO	9.15	1.34	9.02	7.52	12.35	12
	Water Temp	16.28	4.72	17.86	7.54	22.12	12
Lab Parameters	Alkalinity	52	8.5	54	25	56	12
	Turbidity	2.8	1.7	2.4	1.1	7.8	12
	BOD	2.7	N/A	2.7	2.7	2.7	1
	TSS	3.6	2.9	2.9	1.3	11	10
	Fecal Coliform	306	382	220	120	1500	12
	TKN	0.30	0.092	0.33	0.13	0.41	10
	Ammonia	0.081	0.019	0.079	0.056	0.11	6
	Nitrate/Nitrite	0.13	0.18	0.085	0.023	0.68	12
	Total Phosphorus	0.033	0.0093	0.033	0.021	0.048	11
	Cadmium	<0.00010	N/A	<0.00010	<0.00010	<0.00010	0
	Chromium	**0.055**	N/A	**0.055**	0.055	0.055	1
	Copper	**0.016**	N/A	**0.016**	0.016	0.016	1
	Iron	0.56	0.29	0.51	0.24	1.1	12
	Lead	<0.0020	N/A	<0.0020	<0.0020	<0.0020	0
	Manganese	0.060	0.023	0.052	0.034	0.11	12
	Nickel	**0.023**	N/A	**0.023**	0.023	0.023	1
	Zinc	0.010	N/A	0.010	0.010	0.010	1
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

SUMMARY STATISTICS

Sample Location	NWSV-2027	Upper Three Runs at Road 2-1					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	**5.92**	0.58	**5.90**	4.75	6.91	12
	DO	8.80	0.86	8.69	7.17	10.82	11
	Water Temp	16.71	3.95	18.35	10.16	21.60	12
Lab Parameters	Alkalinity	**1.2**	0.093	**1.2**	1.1	1.4	11
	Turbidity	2.2	2.2	1.4	0.90	8.8	12
	BOD	<2.0	N/A	<2.0	<2.0	<2.0	0
	TSS	2.7	2.1	1.7	1.0	7.0	12
	Fecal Coliform	164	104	110	97	440	12
	TKN	0.28	0.082	0.26	0.19	0.41	7
	Ammonia	<0.050	N/A	<0.050	<0.050	<0.050	0
	Nitrate/Nitrite	0.26	0.11	0.26	0.028	0.51	12
	Total Phosphorus	<0.020	N/A	<0.020	<0.020	<0.020	0
	Cadmium	**0.0015**	0.0015	**0.0015**	0.00047	0.0026	2
	Chromium	<0.0050	N/A	<0.0050	<0.0050	<0.0050	0
	Copper	<0.010	N/A	<0.010	<0.010	<0.010	0
	Iron	0.31	0.23	0.24	0.12	0.95	12
	Lead	<0.0020	N/A	<0.0020	<0.0020	<0.0020	0
	Manganese	0.094	0.052	0.094	0.057	0.13	2
	Nickel	<0.020	N/A	<0.020	<0.020	<0.020	0
	Zinc	0.015	0.0058	0.012	0.012	0.022	3
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

Sample Location	NWSV-2039	Fourmile Branch at Road A-13.2					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	6.64	0.37	6.77	5.83	7.31	12
	DO	9.50	1.08	9.31	7.67	12.06	11
	Water Temp	16.63	6.26	19.18	4.94	23.97	12
Lab Parameters	Alkalinity	**17**	2.4	**17**	14	21	12
	Turbidity	2.8	1.0	2.8	1.8	5.2	12
	BOD	<2.0	N/A	<2.0	<2.0	<2.0	0
	TSS	2.1	1.2	1.8	1.0	5.3	11
	Fecal Coliform	186	149	134	40	440	12
	TKN	0.30	0.12	0.30	0.10	0.53	12
	Ammonia	0.12	0.13	0.061	0.052	0.32	4
	Nitrate/Nitrite	0.70	0.30	0.79	0.35	1.1	12
	Total Phosphorus	0.11	0.035	0.10	0.066	0.17	12
	Cadmium	**0.00019**	N/A	**0.00019**	0.00019	0.00019	1
	Chromium	<0.0050	N/A	<0.0050	<0.0050	<0.0050	0
	Copper	<0.010	N/A	<0.010	<0.010	<0.010	0
	Iron	0.61	0.21	0.61	0.26	0.93	12
	Lead	<0.0020	N/A	<0.0020	<0.0020	<0.0020	0
	Manganese	0.036	0.011	0.034	0.019	0.063	12
	Nickel	<0.020	N/A	<0.020	<0.020	<0.020	0
	Zinc	0.011	0.0012	0.010	0.010	0.012	3
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

SUMMARY STATISTICS

Sample Location	NWSV-2040	Bever Dam Creek in D-Area					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	6.67	0.27	6.70	6.15	7.09	9
	DO	9.36	0.82	9.35	7.89	10.77	8
	Water Temp	21.48	5.10	21.91	12.22	26.73	9
Lab Parameters	Alkalinity	**19**	5.6	20	4.5	23	9
	Turbidity	3.4	1.0	3.7	1.9	4.6	9
	BOD	2.1	N/A	2.1	2.1	2.1	1
	TSS	3.7	0.93	3.8	2.2	5.3	9
	Fecal Coliform	37	53	15	3	160	8
	TKN	0.30	0.10	0.29	0.12	0.45	9
	Ammonia	0.11	0.10	0.075	0.053	0.34	7
	Nitrate/Nitrite	0.24	0.056	0.25	0.12	0.31	9
	Total Phosphorus	0.12	0.063	0.11	0.024	0.25	9
	Cadmium	**0.00077**	N/A	**0.00077**	0.00077	0.00077	1
	Chromium	<0.0050	N/A	<0.0050	<0.0050	<0.0050	0
	Copper	<0.010	N/A	<0.010	<0.010	<0.010	0
	Iron	0.32	0.12	0.34	0.16	0.50	9
	Lead	<0.0020	N/A	<0.0020	<0.0020	<0.0020	0
	Manganese	0.047	0.018	0.051	0.011	0.070	9
	Nickel	<0.020	N/A	<0.020	<0.020	<0.020	0
	Zinc	0.016	0.0061	0.015	0.011	0.023	3
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

Sample Location	NWSV-2047	Pen Branch at Road A-13.2					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	6.98	0.52	6.92	6.06	8.14	12
	DO	9.68	1.08	9.43	7.90	12.15	11
	Water Temp	16.61	5.80	18.56	6.08	23.44	12
Lab Parameters	Alkalinity	28	1.8	28	24	30	12
	Turbidity	3.2	1.5	3.0	1.7	7.3	12
	BOD	2.9	N/A	2.9	2.9	2.9	1
	TSS	3.3	3.0	1.9	1.1	9.4	9
	Fecal Coliform	128	45	120	60	200	12
	TKN	0.32	0.12	0.33	0.12	0.51	10
	Ammonia	0.058	0.0058	0.057	0.052	0.065	4
	Nitrate/Nitrite	0.15	0.030	0.16	0.096	0.19	12
	Total Phosphorus	0.029	0.0069	0.027	0.021	0.044	10
	Cadmium	<0.00010	N/A	<0.00010	<0.00010	<0.00010	0
	Chromium	<0.0050	N/A	<0.0050	<0.0050	<0.0050	0
	Copper	<0.010	N/A	<0.010	<0.010	<0.010	0
	Iron	0.55	0.24	0.55	0.24	1.2	12
	Lead	<0.0020	N/A	<0.0020	<0.0020	<0.0020	0
	Manganese	0.045	0.017	0.048	0.014	0.068	12
	Nickel	<0.020	N/A	<0.020	<0.020	<0.020	0
	Zinc	0.012	0.0	0.012	0.012	0.012	2
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

SUMMARY STATISTICS

Sample Location	NWSV-2061	Upper Three Runs at Road 2-1					
Statistical Analysis		AVG	STDEV	MED	MIN	MAX	N
Field Parameters	pH	6.50	0.48	6.48	5.83	7.55	12
	DO	9.25	1.07	9.04	7.48	11.75	11
	Water Temp	16.78	5.67	19.07	6.96	24.55	12
Lab Parameters	Alkalinity	**6.8**	0.94	**6.9**	5.0	8.0	12
	Turbidity	2.8	1.0	2.8	1.4	4.6	12
	BOD	2.2	N/A	2.2	2.2	2.2	1
	TSS	5.1	5.9	4.0	1.3	23	12
	Fecal Coliform	241	164	185	60	660	12
	TKN	0.34	0.10	0.31	0.24	0.54	11
	Ammonia	0.13	0.12	0.076	0.055	0.31	4
	Nitrate/Nitrite	0.038	0.012	0.033	0.026	0.061	11
	Total Phosphorus	0.063	0.022	0.064	0.038	0.11	12
	Cadmium	<0.00010	N/A	<0.00010	<0.00010	<0.00010	0
	Chromium	<0.0050	N/A	<0.0050	<0.0050	<0.0050	0
	Copper	<0.010	N/A	<0.010	<0.010	<0.010	0
	Iron	0.47	0.20	0.48	0.26	0.88	11
	Lead	<0.0020	N/A	<0.0020	<0.0020	<0.0020	0
	Manganese	0.021	0.0082	0.020	0.013	0.044	11
	Nickel	<0.020	N/A	<0.020	<0.020	<0.020	0
	Zinc	0.014	0.0037	0.014	0.010	0.019	4
	Mercury	<0.00020	N/A	<0.00020	<0.00020	<0.00020	0

List Of Acronyms

BOD	Biochemical Oxygen Demand
DDD	Dichlorodiphenyldichloroethane
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DOE-SR	Department of Energy - Savannah River
ESOP	Environmental Surveillance and Oversight Program
FW	Freshwater – fresh waters that are suitable for recreation, as a source for drinking water, and for the survival and propagation of a balanced indigenous aquatic community of fauna and flora (SCDHEC 2008).
LLD	Lower Limit of Detection – the smallest concentration of a constituent in a sample that can be detected at a 95 percent confidence level.
NAS	National Academy of Sciences
PCB	Polychlorinated Biphenyls
SCDHEC	South Carolina Department of Health and Environmental Control
SRS	Savannah River Site
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solid
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds

Units Of Measure

C	temperature in Celsius
mg/L	milligrams per liter
mL	milliliter
NTU	Nephelometric Turbidity Unit
su	standard units
±	plus or minus one standard deviation unless otherwise noted

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2012 Radiological and Nonradiological Monitoring of Sediments

Environmental Surveillance and Oversight Program

06SM001
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January 01, 2012 – December 31, 2012

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D H E C
PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

The accumulation of radiological and nonradiological contaminants in sediment can have direct impacts on aquatic organisms that can result in human exposure. Point source and nonpoint source pollutants impact water bodies through direct discharge, atmospheric fallout, or through runoff. These accumulated contaminants may become resuspended in streams and rivers. Contaminants dispersed downstream potentially impact drinking water supplies and fish consumed by the public. The high mobility of sediments is a complicated issue as 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 (USEPA 1987).

The United States Atomic Energy Commission established the Savannah River Site (SRS) in 1950 to produce plutonium, tritium, and other materials for national defense and civilian purposes (Till et al. 2001). SRS streams receive surface water runoff and water from permitted discharges. Stormwater basins may receive runoff and atmospheric fallout from diffuse and fugitive sources (USDOE 1995). Cesium-137 (Cs-137) contamination due to accidental releases of nuclear materials from past operations occurs along the entire length of Lower Three Runs and Steel Creek on SRS, and the private property of Creek Plantation. Although DOE-SR conducted sediment remediation along Lower Three Runs creek in 2012, Lower Three Runs and Steel Creek watersheds still represent a possible pathway for release of contamination from SRS activities to both on-site and off-site receptors in the environment (WSRC 2002). Flooding and dam releases from Par Pond and L-Lake scour creek bottoms that may result in the resuspension of contaminated sediments. 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 publicly accessible Savannah River.

Cesium-137 is an artificially produced fission product. Atmospheric Cs-137 was released from the separation areas and was a key radionuclide released to water and air, mainly from F-Area and H-Area (CDC 2006). The liquid releases were also from the reactors as a result of leaking fuel elements in the 1950s and 1960s (WSRC 1998). The largest single source of Cs-137 was fallout from atmospheric nuclear weapons tests in the 1950s and 1960s, which dispersed and deposited Cs-137 world-wide. However, much of the Cs-137 from testing has now decayed. Due to its half-life of 30 years, Cs-137 has an impact on the SRS environment. Additionally, the biological behavior of Cs-137 is similar to potassium, which is essential to the function of living cells (USEPA 2009a). Therefore, the potential for Cs-137 uptake into humans is important considering the potential health effects.

Americium-241 (Am-241) is a man-made transuranic nuclide produced during the fission process. With a half-life of 432 years, this radionuclide may be a legacy of past nuclear fallout events. Previous studies indicate that Am-241 was released in significant quantities from the SRS. Therefore, this warrants the sampling of Am-241 to detect any potential impacts from the significant quantities of Am-241 released from SRS (Till et. al. 2001). Along with Cs-137, Am-241 was released to the air from SRS (CDC 2006).

Alpha-emitting radionuclides were released to liquid effluent from M-Area, F-Area, H-Area, and the reactor areas. The primary stream affected by the M-Area releases was Tims Branch, which ultimately flows into Upper Three Runs Creek. Fourmile Branch is the stream most affected by releases coming from the separation areas. Releases from the reactor areas affected all streams with the exception of Upper Three Runs Creek (Till et al. 2001).

Beta-emitting radionuclides were released to liquid effluent from F-Area, H-Area, and the reactors. Fourmile Branch is the stream primarily affected by releases from the separations areas. Steel Creek, Pen Branch, and Lower Three Runs Creek were mainly affected by 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 releases at SRS occurred primarily through the discharge of liquid effluent. Plutonium was manufactured on SRS in H-Area from fuel rods and in F-Area from targets (Till et al. 2001). Iodine-129 (I-129) is a fission product of reactor fuel that has a very long (~16 million year) half-life. Most releases occurred during fuel processing (Till et al. 2001). Technetium-99 (Tc-99) was produced in SRS production reactors as a fission byproduct of uranium and plutonium. This radionuclide was released to the environment from the separation areas ventilation systems, the aqueous environment from liquid waste in waste tanks, and the Solid Waste Disposal Facility (WSRC 1993a). Technetium-99 has also been released to the environment from atmospheric weapons tests, nuclear reactor airborne emissions, nuclear fuel reprocessing plant airborne emissions, and facilities that treat or store radioactive waste (USEPA 2009b). Although historical fallout from weapons testing has been the most important man-made contributor to radioactive contamination of the global environment, there are other anthropogenic sources such as SRS operations. Also, some radionuclides occur naturally in the environment. Separating radioactivity contributed by releases from the SRS from weapons fallout is difficult for some radioisotopes (Till et al. 2001).

Ten metals were analyzed in creek mouth and boat landing samples collected in 2012. A complete list of all nonradiological analytes can be found in Section 5.0, Table 3.

Barium has been a constituent of the H-Area Hazardous Waste Management Facility (WSRC 1993b). Beryllium is a strong light weight metal used in nuclear weapons work (Till et al. 2001). Cadmium enters the atmosphere through fuel and coal combustion (Till et al. 2001). Chromium solutions were used at the SRS as corrosion inhibitors. Chromium was a part of wastewater solutions resulting from dissolving stainless steel. It was also used in cleaning solutions in the separation areas (Till et al. 2001). Copper, while naturally occurring, can also be released to the environment through the combustion of wood, coal, and oil (Alloway 1995). These mechanisms are possible sources of elevated copper in the sediments. Atmospheric emissions of lead from SRS occurred through coal and fuel combustion (Till et al. 2001). Lead can deposit in sediment, due to its immobility, and have a long residence time when compared to other pollutants (Alloway 1995). Manganese has been released in the separations area processes and discharged to liquid waste tanks. It is also a byproduct of coal burning (Till et al. 2001). Mercury in sediment may be attributed to atmospheric fallout. SRS facilities such as F-Area and H-Area, tritium facilities, waste tanks, and the coal-fired power plants have emitted mercury to the atmosphere (Till et al. 2001). Nickel was released to Tims Branch from M-Area processes (Till et al. 2001). Upper Three Runs creek is the receptor of effluent from Tims Branch. Zinc was released in relatively small amounts to the separations area seepage basins as well as the M-Area seepage basin (Till et al. 2001).

The South Carolina Department of Health and Environmental Control (SCDHEC) Environmental Surveillance and Oversight Program (ESOP) provides independent evaluation of the Department of Energy-Savannah River (DOE-SR) environmental monitoring programs. ESOP personnel independently evaluated sediment samples for radionuclide and nonradionuclide contaminant concentrations in SRS streams, SRS stormwater basins, creek mouths along the boundary of SRS, the Savannah River, and publicly accessible sites in the SRS vicinity. Background locations are sampled to compare ambient levels of radionuclides from offsite locations to determine potential impacts due to SRS operations. Sediment samples on SRS are routinely split with DOE-SR in order to compare results.

The ESOP ambient sediment monitoring project changed in 2007 to include more background sediments (those greater than 50 miles from the SRS center point) within the boundaries of the state of South Carolina. This sampling program was implemented to allow statistical comparisons of the SRS perimeter and South Carolina background contaminant levels in sediment.

ESOP sampled 16 locations at SRS in 2012 with the cooperation of DOE-SR personnel. SRS sediment sampling locations are illustrated in Section 4.0, Map 1. Split samples were collected from seven stream locations on SRS, Jackson Boat Landing, and from three SRS stormwater basins. These locations are not publicly accessible. Creek mouth sediment samples at five publicly accessible locations along the Savannah River were also co-sampled (Section 5.0, Table 1). The Pen Branch creek mouth was not sampled because it flows into a swamp area where there is no creek mouth access. Ten sediment samples were also collected from publicly accessible boat landings. In addition, ESOP independently sampled six random background sediments.

All SRS split samples were analyzed for gross alpha, gross beta, and gamma. Additionally, SRS creek mouths, and publicly accessible boat landings were analyzed for metals. All samples collected from random background locations were analyzed for gross alpha, gross beta, and gamma. Additionally, isotopic analysis was conducted on five SRS accessible creek mouths, and four SRS stream locations. Evaluation of radiological and nonradiological contaminants in sediment is necessary to detect any impact from DOE-SR operations beyond historically impacted areas. Radionuclide detections in sediment are typically the result of accumulation over many years and do not represent yearly depositions.

The continuation of sediment sampling and analysis, along with trending of data, is necessary to closely monitor SRS sediments. The potential for contaminants to impact the environment of SRS along with the publicly accessible creek mouths and the Savannah River warrants these long-term monitoring efforts.

2.0 RESULTS AND DISCUSSION

Radiological Parameter Results

SCDHEC 2012 radiological data can be found in Section 6.0 and statistical data can be found in Section 7.0.

Sediments were evaluated for gross alpha and gross non-volatile beta as well as a suite of 24 gamma-emitting radionuclides. Selected samples were also analyzed for plutonium-238 (Pu-238) and plutonium-239/240 (Pu-239/240). A complete list of gamma-emitting radionuclides that SCDHEC analyzed for in 2012 can be found in Section 5.0, Table 2.

Gamma spectroscopy analysis led to detections of man-made radionuclides. Cesium-137 activity trends highest at the SRS creek mouths, followed by publicly accessible boat landings, and SRS on-site streams. Figure 1 in Section 5.0 illustrates Cs-137 activity in sediment samples collected from SRS stormwater basins, SRS streams, SRS creek mouths and publicly accessible boat landings.

Samples collected from six of the eight on-site non-publicly accessible SRS stream samples locations had Cs-137 detections averaging 0.16 (±0.16) picocuries per gram (pCi/g) and ranged from less than minimum detectable activity (MDA) to 0.48 pCi/g at Fourmile Creek mouth (SMSV-2049). All of the three SRS stormwater basins had detections of Cs-137 at an average of 0.06 (± .01) pCi/g.

Cesium-137 was detected at all five publicly accessible SRS creek mouth locations (Section 5.0, Figure 2). The Cs-137 averaged 0.39 (± 0.32) pCi/g and ranged from 0.04 pCi/g at Beaver Dam Creek mouth (SMSV-2013) to 0.69 pCi/g at Steel Creek mouth (SMSV-2017). Cesium-137 was detected at four of the ten publicly accessible boat landing locations at an average of 0.19 (± 0.11) pCi/g and ranged from less than MDA to 0.33 pCi/g.

The concentration of background terrestrial radionuclides varies from place to place in much the same way that mineral deposits can be expected to vary from geologic processes that occur over time. The average value of background will fluctuate from site to site and its value is dependent on the data collected at a particular site.

Five out of six background samples had Cs-137 detections. The random background sample detection average was 0.11 (±0.8) pCi/g. The random background samples had detections ranging from less than MDA to 0.24 pCi/g. Cesium-137, on average, was highest in the SRS creek mouth samples followed by publicly accessible boat landings.

There were detections of actinium-228, potassium-40, lead-212, lead-214, and radium-226. These Naturally Occurring Radioactive Material (NORM) decay products may account for these detections (Section 5, Table 2). All other gamma-emitting radionuclides had no detections above their respective MDA.

Gross alpha activity was detected in two of the seven on-site non-publicly accessible SRS stream samples locations averaging 28.4 (±10.3) pCi/g and ranging from less than MDA to 35.7 pCi/g. The highest detection was located at Upper Three Runs (SMSV-2071). Gross alpha activity was detected in one of the three SRS stormwater basin sample locations (SME-003) and in one of the six background locations (SMLEX12). Gross alpha activity was not detected in any of the ten publicly accessible boat landings. Gross alpha activity was only detected in Upper Three Runs Creek mouth (SMSV-2011). These results can be found in Section 5.0 Figure 3.

Gross non-volatile beta was detected in three of the seven on-site SRS stream locations averaging 17.1 (±2.4) pCi/g. Activities ranged from less than MDA to 18.5 pCi/g. The highest detection was located at Upper Three Runs (SMSV-2073). Two out of the five creek mouth locations had gross non-volatile beta detections averaging 20.0 (±1.8) pCi/g. Activities ranged from 18.7 pCi/g to 21.2 pCi/g. The highest detection was located at Upper Three Runs creek mouth (SMSV-2011). Gross non-volatile beta was detected at 15.1 pCi/g at the SRS SME-003 basin (Section 5.0 Figure 3).

Gross-beta was detected in one of the background locations (SMLEX12).

Isotopic analysis of Pu-238 and Pu-239/240 was performed on samples from the five SRS creek mouths and four on-site SRS stream locations. Plutonium-238 was detected in all of the SRS creek mouth sampling locations. Activities ranged from 0.006 pCi/g at SMSV-2020 to 0.011 pCi/g at SMSV-2017. Pu-238 was detected in all of the selected SRS stream locations ranging from 0.001 pCi/g at SMSV-2048 to 0.0562 pCi/g at SMSV-2069. Plutonium-239/240 was detected in all of the five SRS creek mouth locations. Activities ranged from 0.001 pCi/g at SMSV-2015 to 0.004 pCi/g at SMSV-2017. Plutonium-239/240 was detected in all of the selected SRS stream locations ranging from 0.001 pCi/g at SMSV-2048 to 0.0342 pCi/g at SMSV-2069.

Nonradiological Parameter Results

A United States Environmental Protection Agency (USEPA) Target Analyte List of ten metals was analyzed in all of the SRS creek mouth locations and the public boat landings in 2012. Metals data can be found in Section 5.0, Figure 5. Comparisons were made to the Ecological Screening Value (ESV) for sediment which does not represent remediation goals or cleanup levels, but is used to identify constituents of potential concern (WSRC 2005). The South Carolina state averages are from “Elements in South Carolina Inferred Background Soil and Stream Sediment Samples” (Canova 1999).

Barium was detected above the ESV of 20 milligrams per kilogram (mg/kg) in four of the five SRS creek mouth locations collected. The SRS creek mouth average was 45.7 (±27.7) mg/kg with a minimum of 7.6 mg/kg at SMSV-2011 and a maximum of 74 mg/kg at SMSV-2020. The public boat landing average was 36.0 (±28.2) mg/kg with a minimum of 6.1 mg/kg at Little Hell Boat landing (SMLHL12) and a maximum of 90 mg/kg at River View Park Boat landing (SMRVP12).

All 2012 samples were below the ESV of 0.5 mg/kg for Beryllium. Beryllium was detected above the minimum detection level (MDL) at only one of the five SRS creek mouth locations at concentration of 0.42 mg/kg at SMSV-2013. Beryllium was not detected above the MDL at any of the ten public boat landing locations.

Cadmium was found above the ESV of 0.6 mg/kg in two of the five SRS creek mouth locations collected. The SRS creek mouth average was 1.5(±0.07) mg/kg with a minimum of 1.42 mg/kg at SMSV-2017 mg/kg and a maximum of 1.5 mg/kg at SMSV-2020. The public boat landing average was 1.98 (±1.26) mg/kg with a minimum of 1.3 mg/kg at Fury's Ferry Boat landing (SMFF12), Jackson's Boat Landing (SMJBL12), and Steel Creek Boat landing (SMSCL12) and a maximum of 4.2 mg/kg at Steven's Creek Boat Landing (SMSC12).

Chromium was detected in four of the five SRS creek mouth locations and none were above the ESV of 36 mg/kg. The SRS creek mouth average was 6.7(±3.3) mg/kg with a minimum of 3.7 mg/kg at SMSV-2015 and a maximum of 10 mg/kg at SV-2020. The public boat landing average was 5.7 (±4.3) mg/kg with a minimum of 1.0 mg/kg at Little Hell Boat landing (SMLHL12) and a maximum of 14 mg/kg at Riverview Park Boat landing (SMRVP12).

All 2012 samples were below the ESV of 18.7 mg/kg for copper. The SRS creek mouth average was 4.5 (±2.2) mg/kg with a minimum of 1.2 mg/kg at SMSV-2015 and a maximum of 5.6 mg/kg at SMSV-2020. The public boat landing average was 3.4 (±2.2) mg/kg with a minimum of 1.3 mg/kg at Jackson Boat landing (SMJBL12) and a maximum of 8.1 mg/kg at Riverview Park Boat landing (SMRVP12).

All 2012 samples were below the ESV of 30.2 mg/kg for lead. Lead was detected in two of the five SRS creek mouth samples at an average of 6.0 (±0.07) mg/kg with a minimum of 5.9 mg/kg at SMSV-2017 and a maximum of 6.0 mg/kg at SMSV-2020. Six of the ten public boat landings yielded detections for lead. The average was 8.7 (±2.4) mg/kg with a minimum of 5.6 mg/kg at Stoke's Bluff Boat landing (SMSBL12) and a maximum of 12.0 mg/kg at Jackson Boat landing (SMJBL12).

All 2012 samples were below the ESV of 630 mg/kg for manganese except for SMSV-2020. Manganese was detected in all SRS creek mouths and public boat landing samples. SRS creek mouth samples had an average of 349 (±261) mg/kg with a minimum of 36 mg/kg at SMSV-2011 and a maximum of 660 mg/kg at SMSV-2020. The public boat landing average was 296 (±207) mg/kg with a minimum of 10.0 mg/kg at Little Hell Boat landing (SMLHL12) and a maximum of 620 mg/kg at Fury's Ferry Boat landing (SMFF12).

There was no mercury detected in any samples collected in 2012.

All 2012 samples were below the ESV of 15.9 mg/kg for nickel. Nickel was detected in three of the five SRS creek mouth samples. The SRS creek mouth average was 4.7 (±0.66) mg/kg with a minimum of 4.1 mg/kg at SMSV-2017 and a maximum of 5.4 mg/kg at SMSV-2013. The public boat landing average was 4.4 (±1.7) mg/kg with a minimum of 2.7 mg/kg at Johnson's Boat landing (SMJL12) and a maximum of 6.8 mg/kg at Riverview Park Boat landing (SMRVP12).

All 2012 samples were below the ESV of 98 mg/kg for zinc. Zinc was detected in all of the SRS creek mouth samples. The SRS creek mouth average was 17.0 (±9.9) mg/kg with a minimum of 4.1 mg/kg at SMSV-2011 and a maximum of 28 mg/kg at SMSV-2020. The public boat landing average was 20.2 (±9.2) mg/kg with a minimum of 6.7 mg/kg at Little Hell boat landing (SMLHL12) and maximum of 39.0 mg/kg at Steven's Creek Boat Landing (SMSC12). SCDHEC nonradiological sediment data can be found in Section 6.0 and nonradiological statistical data can be found in Section 7.0.

SCDHEC and DOE-SR Data Comparison

Radiological data comparison of 2012 sediment samples from SCDHEC and DOE-SR resulted in similar findings. SCDHEC Cs-137 data from the SRS creek mouths were trended for 2008-2012 (Section 5.0, Figure 4). Average Cs-137 levels were highest in 2008 and trends lower in the subsequent years of 2009-2012. Due to flooding disturbances in sediments and other media characteristics, variability in sediment samples can be anticipated.

DOE-SR and SCDHEC split seven SRS stream sediment and three stormwater basin sediment samples in 2012. All SCDHEC samples were analyzed for gross alpha and gross beta-emitting particles and gamma-emitting radionuclides. Select samples were also analyzed for Pu-238, Pu-239/40.

Both agencies detected Cs-137 concentrations in SRS streams, SRS stormwater basins and Savannah River locations. DOE-SR highest Cs-137 concentration (27.3 ± 1.8 pCi/g) was detected in stream sediment at FM-2 at Road 4 which is not accessible to the public. When averaging all the SRS on-site stream sediment samples, SCDHEC averaged 0.16 (± 0.16) pCi/g for Cs-137 while DOE-SR averaged 3.7 (± 1.3) pCi/g for Cs-137. The publicly accessible Savannah River and SRS creek mouths averaged 0.39 (±.32) pCi/g in the SCDHEC data. DOE-SR detected Cs-137 above the minimum detectable concentration (MDC) at 6 locations along the Savannah River and creek mouths at an average of 0.38 (±.18) pCi/g. Cs-137 was only detected at two of the three basins sampled by SCDHEC averaging 0.06(± 0.01). The DOE-SR on site stormwater basins results ranged from less than MDC to a maximum Cs-137 concentration of 87.8(± 5.6) pCi/g at the Z-Area Basin.

SCDHEC had no detections of Am-241 in sediment samples collected in 2012. The on-site DOE-SR stream sediments Am-241 detections ranged from less than MDC to 0.073 pCi/g at Pond 400. DOE-SR detected Am-241 in only one of the Savannah River and SRS creek mouths samples (Highway 301 RM 118) above MDC. The average MDA for the 2012 SCDHEC sediment samples was 0.156 pCi/g, which is much higher than the DOE-SR MDC of 0.0039 pCi/g (SRNS 2013). Since DOE-SR has a much lower MDC, this may explain why the SCDHEC data does not report more detections above the MDA. Also, values less than the MDC are included in the DOE-SR data (SRNS 2013). Only detections are averaged from the SCDHEC data.

DOE-SR did not detect any Pu-238 above the MDC in any of the Savannah River sediment samples. SCDHEC detected Pu-238 at three Savannah River locations averaging 0.006(± 0.006) pCi/g. DOE-SR did not detect any Pu-239 above the MDC in any of the Savannah River sediment samples. SCDHEC detected Pu-239/240 at four Savannah River locations averaging 0.003 (± 0.001) pCi/g.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The creek mouths of SRS are a conduit for the dispersal of radionuclides into publicly accessible water. Cesium-137, Pu-238, and Pu-239/240 were found in the sediment within several creek mouths at the Savannah River.

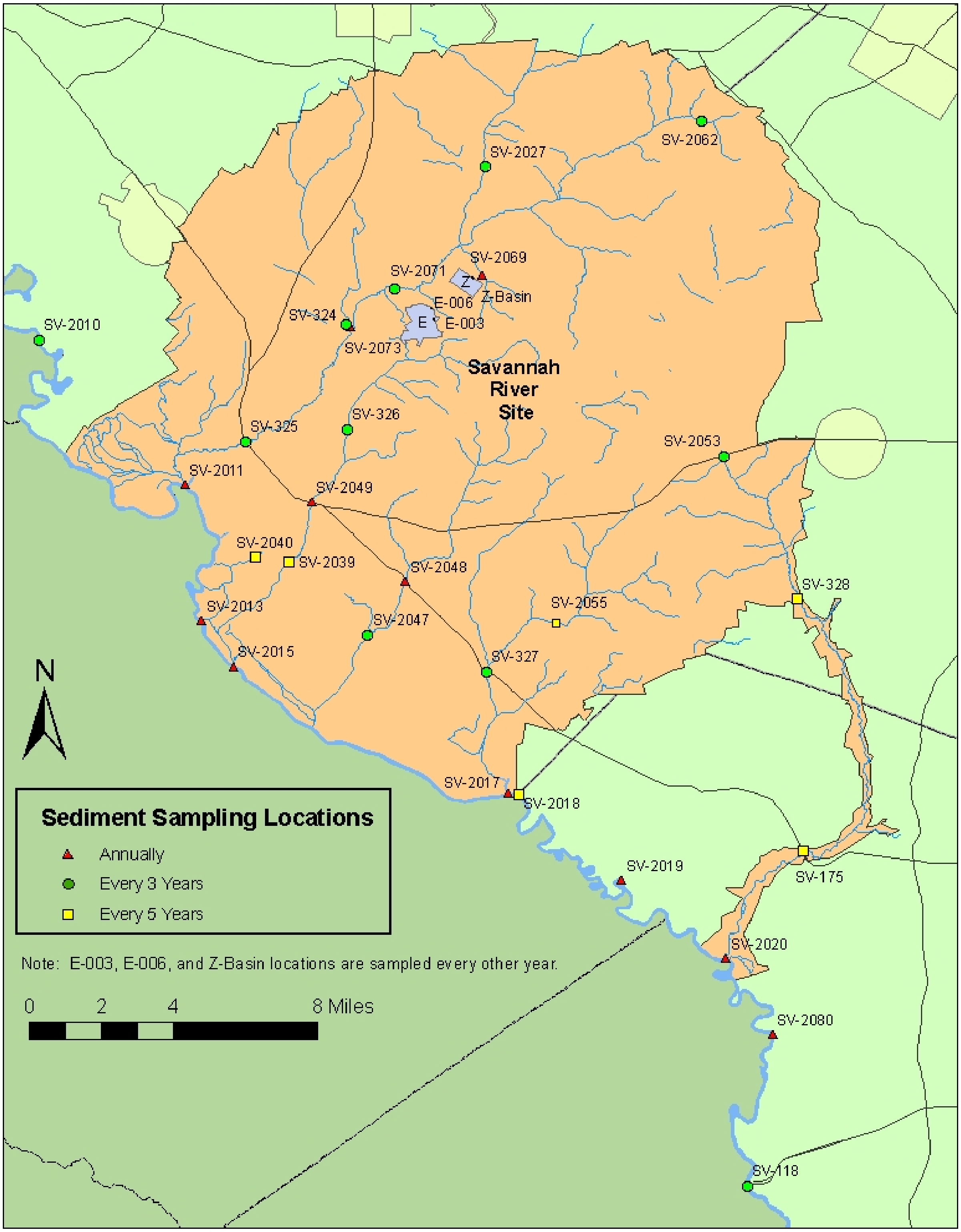
Cesium-137 is the most abundant anthropogenic radionuclide found in the sediment samples. Cesium-137 levels of 2012 from all the samples collected outside of SRS boundaries are within the expected range consistent with previous SCDHEC background data and may be attributed, in part, to fallout from past nuclear events in the 1950s and 1960s. The highest average level of Cs-137 from all 2012 sediment samples occurred in the SRS creek mouth samples.

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 the SRS. Re-distribution of sediment from flooding can mobilize contaminants to downstream locations. Geological factors in the Savannah River basin contribute to the levels of metals through erosion and sediment deposition. All 2012 samples were below the ESV for beryllium, chromium, copper, mercury, nickel, zinc and lead.

SRS sediments should continue to be monitored due to current releases 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. 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 the movement of sediment. Monitoring of on-site sediments is of great importance as streams are a migration route for radionuclides to enter waters and sediment outside of the SRS boundary. ESOP will continue independent monitoring of SRS and Savannah River sediments and will periodically evaluate modification of the monitoring activities to better accomplish project goals and objectives. Continued monitoring will provide an improved understanding of radionuclide and non-radionuclide levels in SRS sediments and the Savannah River sediments which will impart valuable information to human health exposure pathways. Trending of data over multiple years demonstrates whether radionuclide concentrations in the SRS area are declining due to radioactive decay or possibly increasing due to disturbances on SRS. The comparison of data results allows for independent data evaluation of DOE-SR monitoring activities. To compare the environmental monitoring programs of ESOP and DOE-SR, the sediment samples from SRS will be collected in cooperation with DOE-SR personnel. Each program will then independently analyze the samples for radiological and nonradiological parameters and results will be compared in the 2012 ESOP Data Report. Cooperation between DOE-SR and SCDHEC provides credibility and confidence in the information being provided to the public.

4.0 Radiological and Nonradiological Monitoring of Sediments

Map 1. SRS Sediment Sampling Locations



5.0 Tables and Figures
Radiological and Nonradiological Monitoring of Sediments

Table 1. Locations of SRS Sediment Samples

2012 ESOP Sediment Sample Locations on SRS	
Sample Location	**Location Description**
SMSV-2011	Upper Three Runs Mouth @ RM 157.4
SMSV-2013	Beaver Dam Creek Mouth@151.2
SMSV-2015	Fourmile Branch Creek Mouth @ RM 150.6
SMSV-2017	Steel Creek Mouth @ RM 141.5
SMSV-2020	Lower Three Runs Mouth @ RM 129.1
SMSV-2062	Tinker Creek on Kennedys Pond Road
SMSV-2010	Savannah River @ RM 170.5 (Jackson Landing)
SMSV-2039	Fourmile Creek
SMSV-2048	Pen Branch @ Road 125
SMSV-2049	Fourmile Branch @ Road 125
SMSV-2071	Upper Three Runs off Road 4.
SMSV-2069	McQueen Branch off Monroe Owens Road.
SMSV-2073	Upper Three Runs off Road C.
SME-003	E-003 E Area stormwater basin
SME-004	E-004 E Area stormwater basin
SME-006	E-006 E Area stormwater basin
SME-005	E-005 E Area stormwater basin

2012 Publicly Accessable Boat Landing Sediment Sampling Locations		
Sample Name	**Abbr.**	**Location Description**
Upstream of SRS		
SMFF12	FF	Fury's Ferry Boat Landing
SMSC12	SC	Steven's Creek Landing
SMRVP12	RVP	North Augusta Riverview Park Boat Landing
SMJBL12	JBL	Jackson Boat Landing
Downstream of SRS		
SMSCL12	SCL	Steel Creek Landing, Barnwell County
SMLHL12	LHL	Little Hell Landing
SMJL12	JL	Johnson's Landing
SMBFL12	BFL	Burtons' Ferry Landing
SMCB12	CB	Cohen's Bluff Landing
SMSBL12	SBL	Stoke's Bluff Landing

Tables and Figures
Radiological and Nonradiological Monitoring of Sediments

Table 2. Gamma Analytes

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

Note: Units are reported in pCi/g.

Table 3. Inorganic Metal Analytes

Analyte	Abbreviation	ESV
Barium	Ba	20
Beryllium	Be	0.5
Cadmium	Cd	0.6
Chromium	Cr	36
Copper	Cu	18.7
Lead	Pb	30.2
Manganese	Mn	630
Mercury	Hg	0.13
Nickel	Ni	15.9
Zinc	Zn	98

Note: Units are reported in mg/kg.

Tables and Figures
Radiological and Nonradiological Monitoring of Sediments

Figure 1. Comparisons of Cs-137 Activity Among Sample Groups

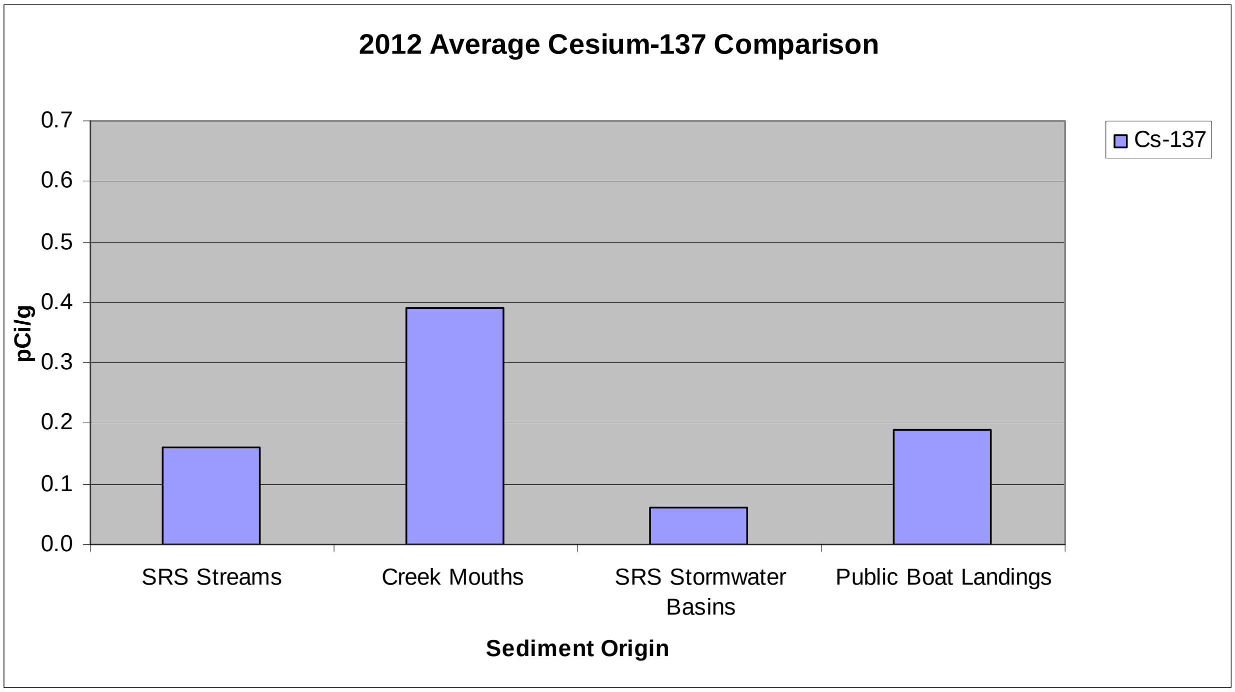
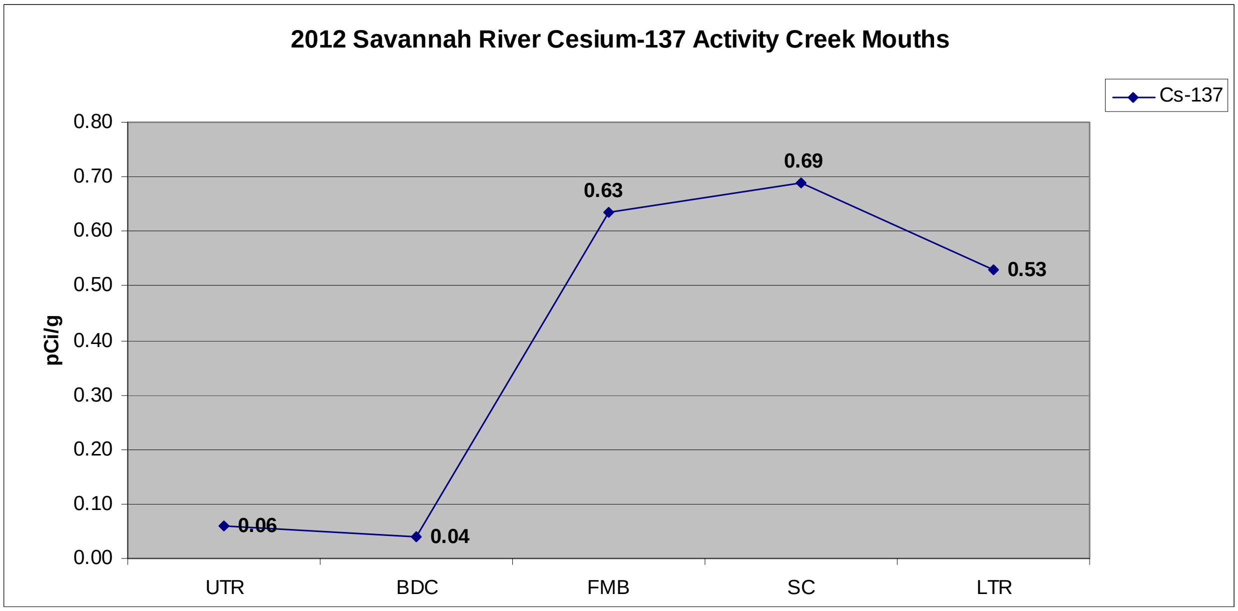


Figure 2. Cesium-137 Activity in Savannah River Sediment Samples



Tables and Figures
Radiological and Nonradiological Monitoring of Sediments

Figure 3. Comparisons of Gross-Alpha and Non-volatile Beta Activity Among Sample Groups

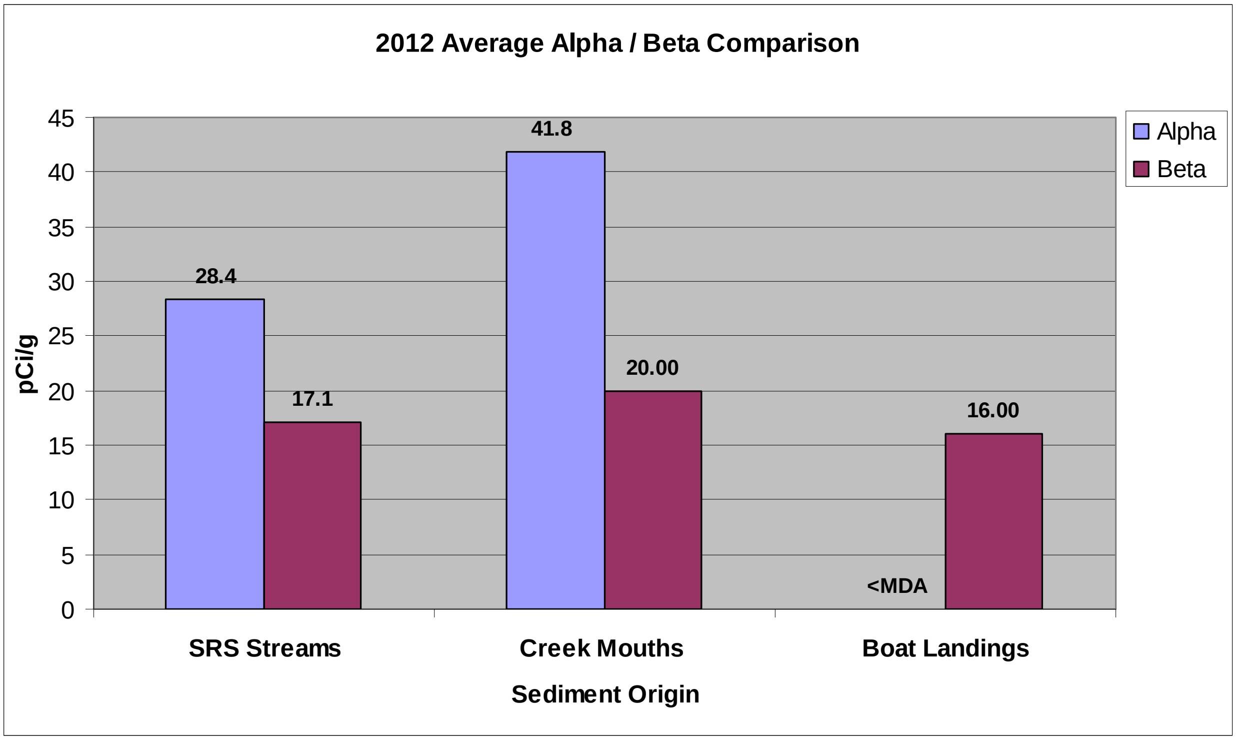
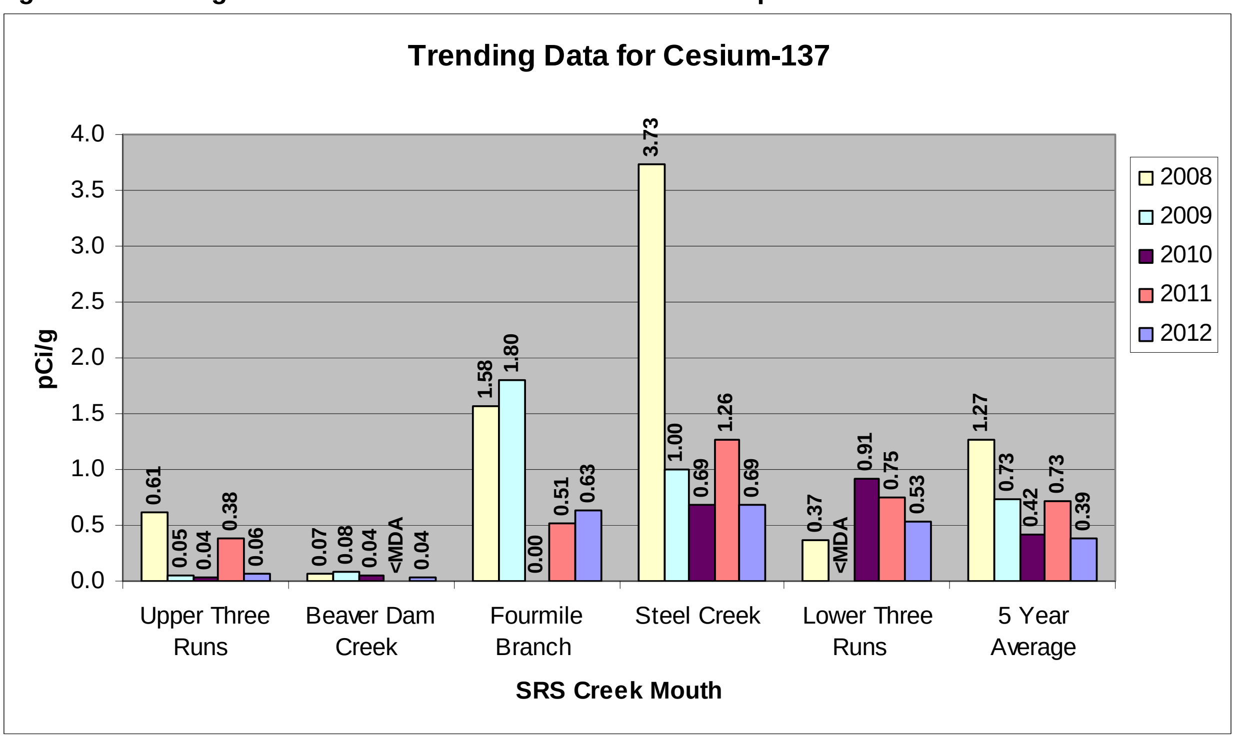


Figure 4. Trending Data for Cs-137 in SRS Creek Mouth Samples



Tables and Figures
Radiological and Nonradiological Monitoring of Sediments

Figure 5. SRS Creek mouth Metals Average

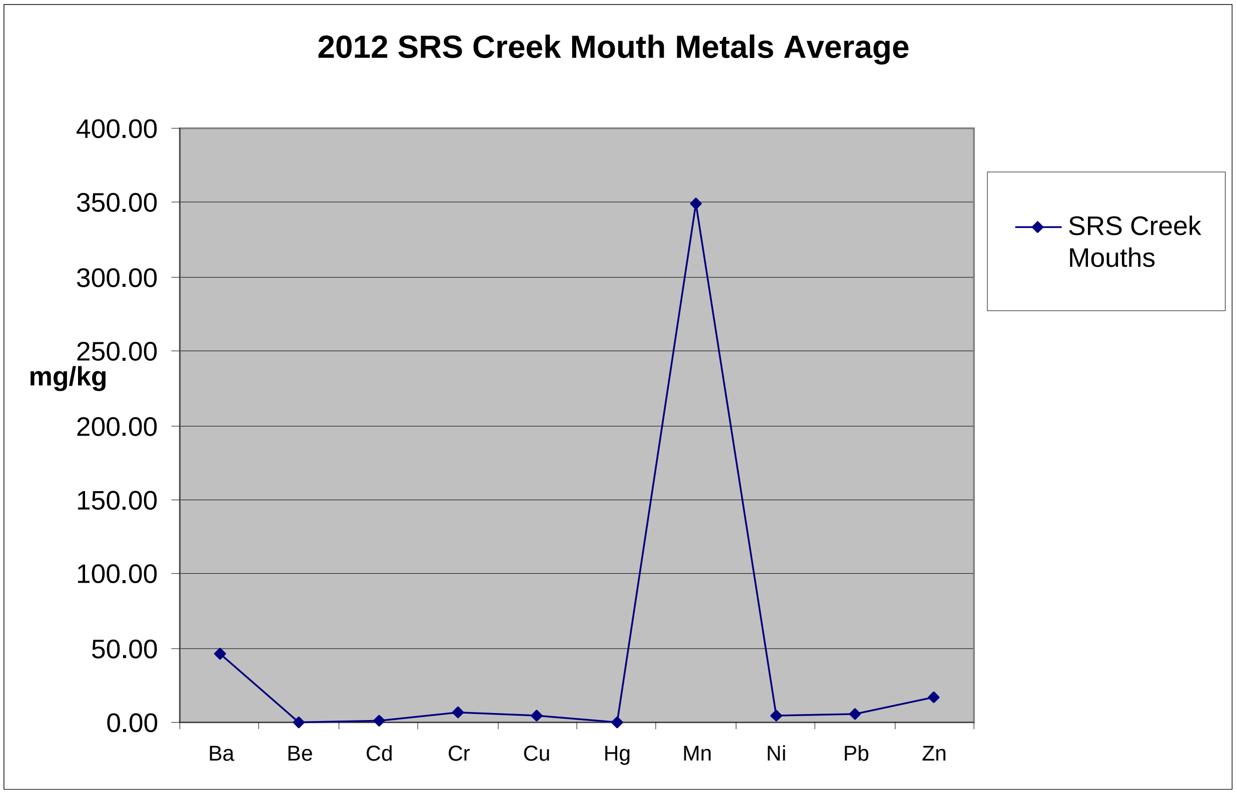
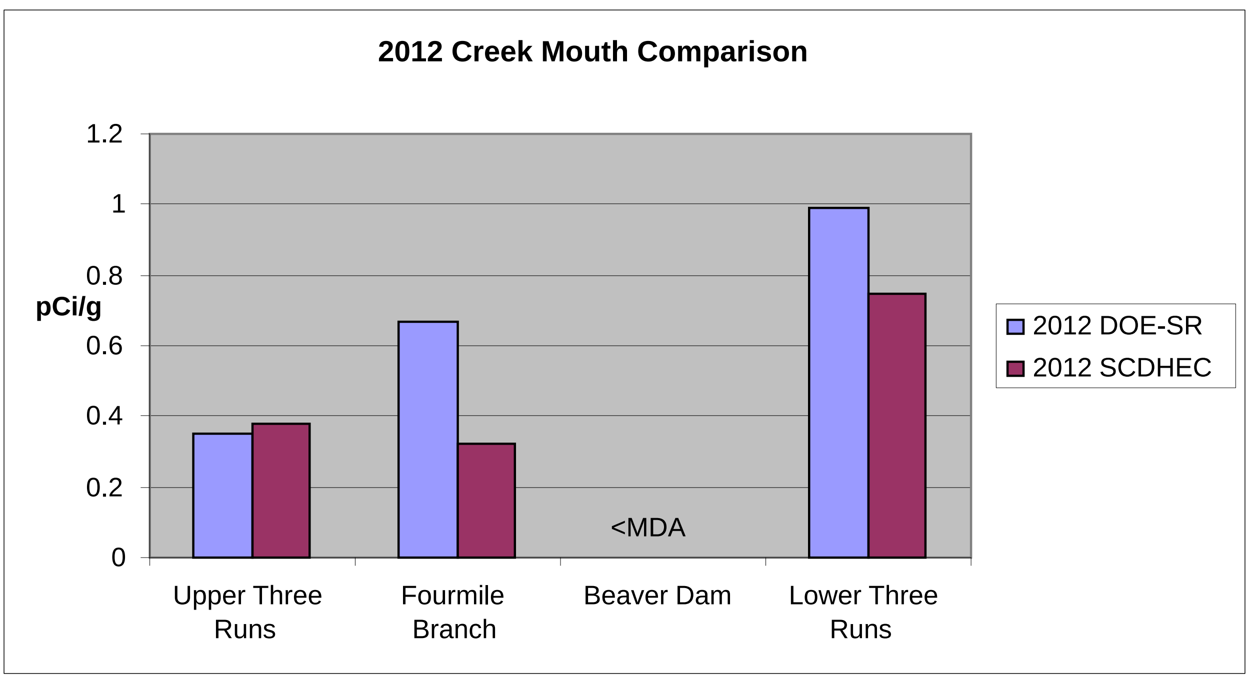


Figure 6. Cesium-137 in Savannah River Creek Mouths – SCDHEC Comparison to DOE-SR Data



6.0 Data

Radiological and Nonradiological Monitoring of Sediments

2012 Radiological Data 16

2012 Nonradiological Data 26

Notes:
1. Bold numbers denotes a detection.
2. NA=Not Applicable
3. LLD= Lower Limit of Detection
4. MDA= Minimum Detectable Activity

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Savannah River and Creek Mouths

Location Description	SMSV-2011	SMSV-2013	SMSV-2015	SMSV-2017	SMSV-2020
Collection Date	3/28/2012	3/28/2012	3/28/2012	3/28/2012	3/28/2012
Alpha Activity	41.80	<LLD	<LLD	<LLD	<LLD
Alpha Confidence Interval	15.10	NA	NA	NA	NA
Alpha LLD	12.90	12.90	12.90	12.90	13.20
Beta Activity	21.20	<LLD	<LLD	18.70	<LLD
Beta Confidence Interval	8.36	NA	NA	7.96	NA
Beta LLD	11.10	11.20	11.10	11.10	11.30
K-40 Activity	1.840	7.828	11.600	14.460	14.110
K-40 Confidence Interval	0.241	0.583	0.794	0.981	1.001
K-40 MDA	0.248	0.262	0.251	0.287	0.371
Cs-137 Activity	0.058	0.037	0.634	0.691	0.530
Cs-137 Confidence Interval	0.015	0.015	0.048	0.053	0.047
Cs-137 MDA	0.018	0.019	0.023	0.025	0.029
Pb-212 Activity	0.607	0.842	1.839	1.101	1.048
Pb-212 Confidence Interval	0.056	0.070	0.125	0.087	0.089
Pb-212 MDA	0.048	0.051	0.046	0.058	0.065
Pb-214 Activity	1.860	1.037	1.359	1.110	1.226
Pb-214 Confidence Interval	0.129	0.082	0.103	0.087	0.101
Pb-214 MDA	0.047	0.047	0.056	0.052	0.063
Ra-226 Activity	3.954	1.870	3.270	2.576	3.271
Ra-226 Confidence Interval	0.502	0.428	0.546	0.523	0.604
Ra-226 MDA	0.565	0.561	0.671	0.661	0.731
Ac-228 Activity	0.735	0.942	1.864	1.128	1.062
Ac-228 Confidence Interval	0.082	0.092	0.141	0.113	0.113
Ac-228 MDA	0.059	0.061	0.055	0.075	0.076

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Savannah River Site Streams That Are Not Publicly Accessible

Location Description	SM SV-2073	SMSV-2069	SMSV-2062	SM SV-2049
Collection Date	3/19/2012	3/19/2012	3/19/2012	3/19/2012
Alpha Activity	21.10	<LLD	<LLD	<LLD
Alpha Confidence Interval	12.10	NA	NA	NA
Alpha LLD	13.10	13.10	13.00	13.20
Beta Activity	18.50	<LLD	<LLD	<LLD
Beta Confidence Interval	8.10	NA	NA	NA
Beta LLD	11.20	11.20	11.10	11.20
K-40 Activity	0.987	1.897	0.350	0.576
K-40 Confidence Interval	0.255	0.303	0.158	0.131
K-40 MDA	0.355	0.357	0.252	0.185
Cs-137 Activity	0.059	0.150	<MDA	0.476
Cs-137 Confidence Interval	0.018	0.025	NA	0.035
Cs-137 MDA	0.023	0.026	0.017	0.012
Pb-212 Activity	1.129	0.836	0.370	0.396
Pb-212 Confidence Interval	0.096	0.075	0.039	0.036
Pb-212 MDA	0.074	0.060	0.037	0.029
Pb-214 Activity	2.975	1.821	0.486	0.392
Pb-214 Confidence Interval	0.205	0.135	0.051	0.038
Pb-214 MDA	0.070	0.063	0.041	0.031
Ra-226 Activity	8.373	3.885	0.939	0.905
Ra-226 Confidence Interval	0.921	0.679	0.309	0.274
Ra-226 MDA	0.910	0.802	0.442	0.376
Ac-228 Activity	1.190	1.042	0.446	0.422
Ac-228 Confidence Interval	0.124	0.107	0.065	0.048
Ac-228 MDA	0.089	0.067	0.051	0.033

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Savannah River Site Streams That Are Not Publicly Accessible

Location Description	SM SV-2010	SM SV-2039	SM SV-2048	SM SV-2071
Collection Date	3/20/2012	3/20/2012	3/20/2012	3/20/2012
Alpha Activity	<LLD	<LLD	<LLD	35.70
Alpha Confidence Interval	NA	NA	NA	14.30
Alpha LLD	13.10	13.00	13.20	13.00
Beta Activity	14.30	<LLD	<LLD	18.40
Beta Confidence Interval	7.70	NA	NA	8.15
Beta LLD	11.20	11.10	11.30	11.10
K-40 Activity	13.300	0.367	0.600	1.530
K-40 Confidence Interval	0.905	0.126	0.175	0.363
K-40 MDA	0.265	0.193	0.232	0.445
Cs-137 Activity	0.033	0.155	<MDA	0.106
Cs-137 Confidence Interval	0.015	0.017	NA	0.028
Cs-137 MDA	0.019	0.012	0.018	0.034
Pb-212 Activity	0.963	0.165	1.527	1.709
Pb-212 Confidence Interval	0.075	0.023	0.107	0.133
Pb-212 MDA	0.047	0.027	0.049	0.090
Pb-214 Activity	0.843	0.238	1.010	6.895
Pb-214 Confidence Interval	0.074	0.028	0.081	0.446
Pb-214 MDA	0.052	0.027	0.049	0.097
Ra-226 Activity	1.870	0.751	1.649	14.720
Ra-226 Confidence Interval	0.457	0.262	0.421	1.405
Ra-226 MDA	0.594	0.350	0.574	1.262
Ac-228 Activity	0.978	0.250	1.795	2.353
Ac-228 Confidence Interval	0.100	0.041	0.141	0.208
Ac-228 MDA	0.068	0.035	0.060	0.126

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Savannah River Site Stormwater Basins

Location Description	SM E-003	SM E-006	SM E-004
Collection Date	3/19/2012	3/19/2012	3/19/2012
Alpha Activity	31.7	<LLD	<LLD
Alpha Confidence Interval	13.8	NA	NA
Alpha LLD	13.10	13.40	12.90
Beta Activity	15.10	<LLD	<LLD
Beta Confidence Interval	7.94	NA	NA
Beta LLD	11.20	11.40	11.10
K-40 Activity	6.37	3.76	3.43
K-40 Confidence Interval	0.54	0.40	0.35
K-40 MDA	0.33	0.34	0.30
Cs-137 Activity	0.05	0.06	0.06
Cs-137 Confidence Interval	0.02	0.02	0.02
Cs-137 MDA	0.03	0.03	0.02
Pb-212 Activity	2.01	1.92	1.67
Pb-212 Confidence Interval	0.14	0.13	0.12
Pb-212 MDA	0.05	0.05	0.06
Pb-214 Activity	1.32	1.43	1.33
Pb-214 Confidence Interval	0.11	0.11	0.10
Pb-214 MDA	0.07	0.07	0.06
Ra-226 Activity	3.69	3.34	3.18
Ra-226 Confidence Interval	0.68	0.62	0.56
Ra-226 MDA	0.82	0.77	0.70
Ac-228 Activity	1.92	1.81	1.46
Ac-228 Confidence Interval	0.16	0.15	0.13
Ac-228 MDA	0.08	0.07	0.10

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Publicly Accessible Boat Landings

	Fury's Ferry Boat Landing	Stevens Creek Boat Landing	Riverview Park Boat Landing	Jackson Boat Landing
Location Description	**SM FF 12**	**SM SC 12**	**SM RVP 12**	**SM JBL 12**
Collection Date	**9/5/2012**	**9/5/2012**	**9/11/2012**	**9/11/2012**
Alpha Activity	<LLD	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA	NA
Alpha LLD	11.00	11.00	11.10	11.10
Beta Activity	<LLD	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA	NA
Beta LLD	8.94	8.92	8.98	8.96
K-40 Activity	<MDA	<MDA	<MDA	6.01
K-40 Confidence Interval	NA	NA	NA	0.48
K-40 MDA	0.26	0.28	0.33	0.26
Cs-137 Activity	<MDA	0.17	0.22	<MDA
Cs-137 Confidence Interval	NA	0.02	0.03	NA
Cs-137 MDA	0.02	0.02	0.02	0.02
Pb-212 Activity	0.70	0.59	0.90	0.89
Pb-212 Confidence Interval	0.06	0.06	0.08	0.07
Pb-212 MDA	0.04	0.05	0.06	0.05
Pb-214 Activity	0.50	0.63	0.85	0.81
Pb-214 Confidence Interval	0.06	0.06	0.08	0.07
Pb-214 MDA	0.05	0.05	0.06	0.05
Ra-226 Activity	<MDA	<MDA	1.75	<MDA
Ra-226 Confidence Interval	NA	NA	0.50	NA
Ra-226 MDA	0.52	0.56	0.68	0.53
Ac-228 Activity	0.67	0.59	0.88	0.84
Ac-228 Confidence Interval	0.08	0.07	0.10	0.08
Ac-228 MDA	0.06	0.06	0.08	0.06

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Publicly Accessible Boat Landings

	Steel Creek Boat Landing	Little Hell Boat Landing	Johnson's Boat Landing
Location Description	**SM SCL 12**	**SM LHL 12**	**SM JL 12**
Collection Date	**9/17/2012**	**9/17/2012**	**9/17/2012**
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA
Alpha LLD	11.00	10.90	11.20
Beta Activity	29.00	<LLD	9.64
Beta Confidence Interval	7.68	NA	6.24
Beta LLD	8.92	8.93	9.01
K-40 Activity	12.72	<MDA	6.13
K-40 Confidence Interval	0.91	NA	0.49
K-40 MDA	0.36	0.20	0.27
Cs-137 Activity	0.33	<MDA	0.06
Cs-137 Confidence Interval	0.03	NA	0.01
Cs-137 MDA	0.02	0.01	0.02
Pb-212 Activity	0.96	0.28	0.58
Pb-212 Confidence Interval	0.08	0.03	0.05
Pb-212 MDA	0.06	0.03	0.04
Pb-214 Activity	0.93	0.23	0.57
Pb-214 Confidence Interval	0.09	0.03	0.06
Pb-214 MDA	0.07	0.03	0.05
Ra-226 Activity	<MDA	<MDA	1.12
Ra-226 Confidence Interval	NA	NA	0.37
Ra-226 MDA	0.69	0.34	0.51
Ac-228 Activity	0.94	0.29	0.59
Ac-228 Confidence Interval	0.10	0.04	0.07
Ac-228 MDA	0.08	0.04	0.06

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Publicly Accessible Boat Landings

	Burton's Ferry Boat Landing	Cohen's Bluff Boat Landing	Stokes Bluff Boat Landing
Location Description	**SM SBL 12**	**SM CB 12**	**SM SBL 12**
Collection Date	**10/8/2012**	**10/8/2012**	**10/8/2012**
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA
Alpha LLD	10.90	11.00	10.90
Beta Activity	<LLD	<LLD	9.31
Beta Confidence Interval	NA	NA	6.19
Beta LLD	8.91	8.93	8.91
K-40 Activity	4.58	4.39	9.26
K-40 Confidence Interval	0.39	0.37	0.66
K-40 MDA	0.25	0.24	0.25
Cs-137 Activity	<MDA	<MDA	<MDA
Cs-137 Confidence Interval	NA	NA	NA
Cs-137 MDA	0.02	0.02	0.02
Pb-212 Activity	0.67	0.61	1.27
Pb-212 Confidence Interval	0.06	0.05	0.09
Pb-212 MDA	0.04	0.04	0.05
Pb-214 Activity	0.52	0.47	0.94
Pb-214 Confidence Interval	0.05	0.05	0.08
Pb-214 MDA	0.04	0.04	0.05
Ra-226 Activity	1.06	1.07	1.80
Ra-226 Confidence Interval	0.30	0.33	0.44
Ra-226 MDA	0.43	0.45	0.59
Ac-228 Activity	0.67	0.66	1.28
Ac-228 Confidence Interval	0.07	0.07	0.11
Ac-228 MDA	0.06	0.05	0.07

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Random Background “B” Samples > 50 miles from the SRS Center Point

Location Description	SM EDG 12	SM GWD 12	SM JSP 12
Collection Date	10/16/2012	10/16/2012	11/20/2012
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA
Alpha LLD	10.10	9.89	9.73
Beta Activity	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA
Beta LLD	9.27	9.12	9.11
Na-22 MDA	0.01	0.01	0.01
K-40 Activity	<MDA	<MDA	0.55
K-40 Confidence Interval	NA	NA	0.18
K-40 MDA	0.25	0.29	0.27
Cs-137 Activity	0.12	0.04	0.10
Cs-137 Confidence Interval	0.02	0.01	0.02
Cs-137 MDA	0.02	0.02	0.02
Pb-212 Activity	1.12	0.93	0.77
Pb-212 Confidence Interval	0.08	0.08	0.06
Pb-212 MDA	0.05	0.05	0.05
Pb-214 Activity	0.91	0.73	0.67
Pb-214 Confidence Interval	0.08	0.07	0.06
Pb-214 MDA	0.05	0.05	0.05
Ra-226 Activity	1.78	<MDA	<MDA
Ra-226 Confidence Interval	0.42	NA	NA
Ra-226 MDA	0.56	0.59	0.52
Ac-228 Activity	1.05	0.88	0.84
Ac-228 Confidence Interval	0.10	0.09	0.09
Ac-228 MDA	0.06	0.07	0.06

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Data for Random Background "B" Samples > 50 miles from the SRS Center Point

Location Description	SM HMP 12	SM LEX 12	SM SLD 12
Collection Date	11/20/2012	12/4/2012	12/4/2012
Alpha Activity	<LLD	10.60	<LLD
Alpha Confidence Interval	NA	8.89	NA
Alpha LLD	9.76	9.96	9.83
Beta Activity	<LLD	9.65	<LLD
Beta Confidence Interval	NA	6.41	NA
Beta LLD	9.08	9.17	9.09
Na-22 MDA	0.01	0.01	0.01
K-40 Activity	0.38	6.25	<MDA
K-40 Confidence Interval	0.14	0.50	NA
K-40 MDA	0.22	0.28	0.29
Cs-137 Activity	<MDA	0.05	0.24
Cs-137 Confidence Interval	NA	0.01	0.03
Cs-137 MDA	0.01	0.02	0.02
Pb-212 Activity	0.67	0.56	0.54
Pb-212 Confidence Interval	0.06	0.05	0.05
Pb-212 MDA	0.04	0.05	0.04
Pb-214 Activity	0.54	0.60	0.47
Pb-214 Confidence Interval	0.05	0.06	0.05
Pb-214 MDA	0.04	0.05	0.05
Ra-226 Activity	<MDA	<MDA	<MDA
Ra-226 Confidence Interval	NA	NA	NA
Ra-226 MDA	0.47	0.54	0.54
Ac-228 Activity	0.64	0.60	0.51
Ac-228 Confidence Interval	0.07	0.08	0.07
Ac-228 MDA	0.06	0.07	0.06

Note: Units are in pCi/g. There were no detections in any 2012 sediment sample above the MDA for: Be-7 Am-241, Th-234, Na-22, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, and Eu-154. Mn-54 not reported due to interference from Ac-228. Eu-155 not reported due to interference from Ac-228 or U-235.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Radiological Isotopic Data for SRS Creek Mouths

Location Description	SMSV-2011	SMSV-2013	SMSV-2015	SMSV-2017	SMSV-2020
Collection Date	**3/28/2012**	**3/28/2012**	**3/28/2012**	**3/28/2012**	**3/28/2012**
Pu-238 Activity	0.0088	0.0059	0.0099	0.0108	0.0058
Pu-238 Confidence Interval	0.0057	0.0040	0.0058	0.0072	0.0051
Pu-238 LLD	0.0046	0.0035	0.0046	0.0065	0.0058
Pu-239/40 Activity	0.0029	0.0031	0.0008	0.0043	0.0024
Pu-239/40 Confidence Interval	0.0034	0.0030	0.0023	0.0048	0.0034
Pu-239/40 LLD	0.0046	0.0037	0.0051	0.0065	0.0054

Note: Units are in pCi/g

2012 Radiological Isotopic Data for SRS Streams

Location Description	SMSV-2073	SMSV-2069	SMSV-2049	SMSV-2048
Collection Date	**3/19/2012**	**3/19/2012**	**3/19/2012**	**3/19/2012**
Pu-238 Activity	0.0074	0.0558	0.0117	0.0009
Pu-238 Confidence Interval	0.0056	0.0181	0.0062	0.0033
Pu-238 LLD	0.0071	0.0098	0.0066	0.0066
Pu-239/40 Activity	0.0096	0.0340	0.0037	0.0009
Pu-239/40 Confidence Interval	0.0059	0.0132	0.0039	0.0017
Pu-239/40 LLD	0.0061	0.0060	0.0059	0.0032

Radiological and Nonradiological Monitoring of Sediments Data

2012 Nonradiological Data for Savannah River Site Creek Mouths

Location Description	SMSV-2011	SMSV-2013	SMSV-2015	SVSV-2017	SMSV-2020
Collection Date	**3/12/2012**	**3/12/2012**	**3/12/2012**	**3/12/2012**	**3/12/2012**
Barium in Sediment	**7.6**	**60**	**26**	**61**	**74**
Beryllium in Sediment	<0.30	**0.42**	<0.30	<0.30	<0.30
Cadmium in Sediment	<1.0	<1.0	<1.0	**1.4**	**1.5**
Chromium in Sediment	<1.0	**4**	**3.7**	**9.2**	**10**
Copper in Sediment	<1.0	**5.5**	**1.2**	**5.5**	**5.6**
Mercury in Sediment	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese in Sediment	**36**	**530**	**140**	**380**	**660**
Nickel in Sediment	<2.0	**5.4**	<2.0	**4.1**	**4.6**
Lead in Sediment	<5.0	<5.0	<5.0	**5.9**	**6**
Zinc in Sediment	**4.1**	**19**	**10**	**24**	**28**

Note: Units are in mg/kg.

2012 Nonradiological Data for Publicly Accessible Boat Landings

Location Description	SMFF12	SMSC12	SMRVP12	SMJBL12	SMSCL12
Collection Date	**9/5/2012**	**9/5/2012**	**9/5/2012**	**9/5/2012**	**9/17/2012**
Barium in Sediment	**72**	**34**	**90**	**28**	**59**
Beryllium in Sediment	<0.30	<0.30	<0.30	<0.30	<0.30
Cadmium in Sediment	**1.3**	**4.2**	**1.8**	**1.3**	**1.3**
Chromium in Sediment	**2.9**	**9.2**	**14**	**3.4**	**11**
Copper in Sediment	**NS**	**3**	**8.1**	**1.3**	**5.5**
Mercury in Sediment	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese in Sediment	**620**	**320**	**520**	**340**	**540**
Nickel in Sediment	<2.0	<2.0	**6.8**	<2.0	**4.0**
Lead in Sediment	**11**	**7.5**	**7.7**	**12**	**8.6**
Zinc in Sediment	**17**	**39**	**27**	**16**	**27**

Note: Units are in mg/kg.

Radiological and Nonradiological Monitoring of Sediments Data

2012 Nonradiological Data for Publicly Accessible Boat Landings

Location Description	SMLHL12	SMJL12	SMSBL12	SMCB12	SMSBL12
Collection Date	9/17/2012	9/17/2012	8/10/2012	8/10/2012	8/10/2012
Barium in Sediment	**6.1**	**26**	**18**	**11**	**16**
Beryllium in Sediment	<0.30	<0.30	<0.30	<0.30	<0.30
Cadmium in Sediment	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium in Sediment	**1.0**	**5.4**	**4.8**	**2.7**	**2.1**
Copper in Sediment	**1.6**	**2.6**	**2.1**	**2**	4.2
Mercury in Sediment	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese in Sediment	**10**	**180**	**180**	**110**	**140**
Nickel in Sediment	**4.2**	**2.7**	<2.0	<2.0	<2.0
Lead in Sediment	<5.0	<5.0	<5.0	<5.0	**5.6**
Zinc in Sediment	**6.7**	**18**	**20**	**10**	**22**

Note: Units are in mg/kg.

7.0 Summary Statistics

Radiological and Nonradiological Monitoring of Sediments

2012 Radiological Statistics 29

2012 Nonradiological Statistics 30

Notes:

1. N/A = Not Applicable
2. MIN. = Minimum
3. MAX. = Maximum
4. AVG = Average
5. SD = Standard Deviation
6. MED = Median

2012 Statistics – SCDHEC Radiological Data
SRS Creek Mouths

	AVG:	SD:	MED:	MIN:	MAX:	Total Number of Samples	Number of Detections
Alpha	41.8	N/A	41.8	41.8	41.8	5	1
Beta	20	1.8	20	18.7	21.2	5	2
K-40	10	5.3	11.6	1.8	14.5	5	5
Cs-137	0.39	0.32	0.53	0.04	0.69	5	5
Pb-212	1.09	0.46	1.05	0.61	1.84	5	5
Pb-214	1.32	0.33	1.23	1.04	1.86	5	5
Ra-226	2.99	0.79	3.27	1.87	3.95	5	5
Ac-228	1.15	0.43	1.06	0.74	1.86	5	5

2012 Statistics – SCDHEC Radiological Data
Non Publicly Accessible SRS Streams

	AVG:	SD:	MED:	MIN:	MAX:	Total Number of Samples	Number of Detections
Alpha	28.4	10.3	28.4	21.1	35.7	8	2
Beta	17.1	2.4	18.4	14.3	18.5	8	3
K-40	2.45	4.42	0.79	0.35	13.3	8	8
Cs-137	0.16	0.16	0.13	0.03	0.48	8	6
Pb-212	0.89	0.56	0.9	0.16	1.71	8	8
Pb-214	1.83	2.24	0.93	0.24	6.9	8	8
Ra-226	4.14	4.98	1.76	0.75	14.72	8	8
Ac-228	1.06	0.72	1.01	0.25	2.35	8	8

2012 Statistics – SCDHEC Radiological Data
Publicly Accessible Boat Landings

	AVG:	SD:	MED:	MIN:	MAX:	Total Number of Samples	Number of Detections
Alpha	N/A	N/A	N/A	N/A	N/A	10	0
Beta	16	11.3	9.6	9.3	29	10	3
K-40	7.18	3.23	6.07	4.39	12.72	10	6
Cs-137	0.19	0.11	0.2	0.06	0.33	10	4
Pb-212	0.74	0.27	0.68	0.28	1.27	10	10
Pb-214	0.64	0.23	0.6	0.23	0.94	10	10
Ra-226	1.36	0.38	1.12	1.06	1.8	10	5
Ac-228	0.74	0.26	0.67	0.29	1.28	10	10

Note: Units are in pCi/g.

2012 Statistics – SCDHEC Radiological Data
Non-Publicly Accessible SRS Stormwater Basins

	AVG:	SD:	MED:	MIN:	MAX:	Total Number of Samples	Number of Detections
Alpha	31.7	N/A	31.7	31.7	31.7	3	1
Beta	15.1	N/A	15.1	15.1	15.1	3	1
K-40	4.52	1.61	3.76	3.43	6.37	3	3
Cs-137	0.06	0.01	0.06	0.05	0.06	3	3
Pb-212	1.87	0.17	1.92	1.67	2.01	3	3
Pb-214	1.36	0.06	1.33	1.32	1.43	3	3
Ra-226	3.4	0.26	3.34	3.18	3.69	3	3
Ac-228	1.73	0.24	1.81	1.46	1.92	3	3

2012 Statistics – SCDHEC Radiological Data
Nonrandom Background Samples

	AVG:	SD:	MED:	MIN:	MAX:	Total Number of Samples	Number of Detections
Alpha	10.6	N/A	10.6	10.6	10.6	6	1
Beta	9.7	N/A	9.7	9.7	9.7	6	1
K-40	2.4	3.3	0.5	0.4	6.2	6	4
Cs-137	0.11	0.08	0.1	0.04	0.24	6	5
Pb-212	0.76	0.22	0.72	0.54	1.12	6	6
Pb-214	0.65	0.16	0.64	0.47	0.91	6	6
Ra-226	1.78	N/A	1.78	1.78	1.78	6	1
Ac-228	0.75	0.2	0.74	0.51	1.05	6	6

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2012 Statistics – SCDHEC Sediment Metals Data
SRS Streams Creek Mouths

	AVG:	SD:	MED:	MIN:	MAX:	Total Number of Samples	Number of Detections
Barium	45.7	27.7	60	7.6	74	5	5
Beryllium	0.42	N/A	0.42	0.42	0.42	5	1
Cadmium	1.45	0.07	1.45	1.4	1.5	5	2
Chromium	6.73	3.34	6.6	3.7	10	5	4
Copper	4.45	2.17	5.5	1.2	5.6	5	4
Mercury	N/A	N/A	N/A	N/A	N/A	5	0
Manganese	349	261	380	36	660	5	5
Nickel	4.7	0.66	4.6	4.1	5.4	5	3
Lead	5.95	0.07	5.95	5.9	6	5	2
Zinc	17.02	9.87	19	4.1	28	5	5

Note: Units are in mg/kg.

2012 Statistics – SCDHEC Sediment Metals Data
Publicly Accessible Boat Landings

	AVG:	SD:	MED:	MIN:	MAX:	Total Number of Samples	Number of Detections
Barium	52.7	28.6	48	24	110	10	9
Beryllium	0.4	0	0.4	0.3	0.4	10	3
Cadmium	1.7	0.4	1.8	1.2	2.1	10	6
Chromium	11.2	5.5	12	4.9	18	10	9
Copper	5.5	3.1	4.5	2.2	10	10	10
Mercury	N/A	N/A	N/A	N/A	N/A	10	0
Manganese	316.7	268.2	215	9.1	860	10	10
Nickel	4.4	1.2	4.1	3.3	6.2	10	4
Lead	9	2.9	8.2	6.1	13	10	7
Zinc	21.9	15.7	18	2.4	54	10	10

Note: Units are in mg/kg

List Of Acronyms

CDC	Centers for Disease Control
DOE-SR	Department of Energy – Savannah River
ESOP	Environmental Surveillance and Oversight Program
ESV	Ecological Screening Value
LLD	Lower Limit of Detection
LTR	Lower Three Runs
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDL	Minimum Detection Limit
NORM	Naturally Occurring Radioactive Material
SCDHEC	South Carolina Department of Health and Environmental Control
SMSV	Sediment from Savannah River Study area
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
WSRC	Washington Savannah River Company, formerly Westinghouse Savannah River Company

Units Of Measure

mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
±	plus or minus. Refers to one standard deviation unless otherwise stated

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Section 3 2012 Terrestrial Monitoring

Chapter 7	Surface Soil Monitoring Adjacent to SRS
Chapter 8	Radiological Vegetation Monitoring Associated with the Savannah River Site
Chapter 9	Radiological Monitoring of Edible Vegetation
Chapter 10	Radiological Monitoring of Dairy Milk

2012 Surface Soil Monitoring Adjacent to SRS

Environmental Surveillance and Oversight Program

97SS006
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January 01, 2012 - December 31, 2012

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1.0 PROJECT SUMMARY

The South Carolina Department of Health and Environmental Control (SCDHEC) Environmental Surveillance and Oversight Program (ESOP) provides independent evaluation of the Department of Energy – Savannah River (DOE-SR) environmental monitoring programs. ESOP personnel independently evaluated surface soils from ground surface to a 12 inch depth for gross alpha and gross non-volatile beta and select gamma-emitting radionuclides, as well as specific metals of concern at SRS. These soil samples were collected to determine if SRS activities might have impacted areas outside of the site boundary. Radionuclide detections in soil are the result of accumulation over many years and do not represent yearly depositions.

Surface soil is an important medium that can be contaminated by radionuclides and metals, and transported to other ecological systems. Plants absorb contaminants from soil that in turn introduce contaminants to the food chain. Radionuclides and metals in soil can leach into groundwater and possibly emerge into surface water, potentially contaminating aquatic systems (Corey 1980). Air and water are subject to a much greater mixing than soil; therefore, dilution of metals does not occur as much in soil as in air or water. As a result, the accumulation of metals in surface soils is often more intense on both local and global scales than in the other components of the biosphere (Alloway 1995). The re-suspension and subsequent airborne contamination of materials due to cleanup processes that include soil excavation and disturbance during remediation and prescribed burns facilitates the movement of contaminants to areas outside of the Savannah River Site (SRS) boundary.

The ESOP surface soil monitoring project changed in 2004 to include more random background soils (those greater than 50 miles from an SRS center point) within the boundaries of the state of South Carolina. A 50 mile SRS center point study area was chosen for comparison to the DOE-SR study area. Sampling outside of the 50 mile study area was implemented to allow statistical comparisons between the SRS perimeter and South Carolina background contaminant levels in soils. ESOP initiated the random sampling system to determine if elevated levels of contaminants are attributable to SRS activities. SRS Perimeter and SC background averages were used to determine if SCDHEC data were comparable to radiological data from DOE-SR. Since DOE-SR environmental monitoring division does not report metals data for surface soil, no direct data comparisons can be made. Assessment of radiological and nonradiological contaminants in surface soil is necessary to detect any impact from DOE-SR operations beyond the historically impacted areas within the SRS boundaries. In addition to samples collected near the perimeter of SRS, publicly accessible boat landings were included in the sampling regime in 2007 to exemplify areas where direct contact to surface soil by the public can occur.

ESOP collected samples in 2012 from six random background sites outside of the 50 mile SRS center point radius. Nineteen nonrandom samples were collected from SRS perimeter locations (Section 5.0, Table 1). Ten riverbank samples were collected from publicly accessible boat landings (Section 5.0, Table 2). Nonrandom SRS perimeter sampling locations are depicted on Map 1 of Section 4.0. A list of all nonrandom sampling locations is located in Section 5.0, Table 1. The majority of samples had detectable amounts of cesium-137 (Cs-137), an anthropogenic radionuclide, that may be a legacy of releases by SRS and atmospheric fallout from past nuclear weapons testing (USEPA 2013). Cesium-137 activity in 2012 is comparable to levels detected by ESOP in the past. There were no surface soil samples collected in 2012 that were above the

United States Environmental Protection Agency (USEPA) Preliminary Remediation Goals (PRGs) or the USEPA Regional Screening Levels (RSLs) (USEPA 2013). There were no riverbank soil samples in 2012 that exceeded the radiological USEPA Soil Screening Levels (SSLs) (USEPA 2013). SSLs are more conservative screening values that are utilized when soil is in close proximity to groundwater (e.g. near rivers and other surface water bodies). USEPA PRGs are generic/default screening values for radioactive contamination in soil. USEPA RSLs are generic/default values for the toxicity of chemical contaminants in soil. The PRGs, RSLs and SSLs of select radionuclides and metals sampled by SCDHEC are listed in Section 5.0, Tables 5, 6 and 7.

There were no gross alpha-emitting radionuclides detected in any of the samples collected in 2012. Gross non-volatile beta was detected among all sample types.

Results for all metal analytes were below the USEPA RSLs. Metals data has been trended over time and the samples collected near the SRS perimeter are similar to those collected randomly throughout South Carolina.

A data comparison of 2012 surface soil data from SCDHEC and DOE-SR resulted in similar findings. Both data sets report average Cs-137 levels lower outside the 50 mile radius of SRS than within the SRS perimeter. SCDHEC data from 2012 perimeter samples show a slight increase in the average level of Cs-137 from the 2011 data. DOE-SR reports in 2012 that Cs-137 concentrations are consistent with historical results. Metals data could not be compared to SCDHEC results since the DOE-SR environmental monitoring division does not analyze nonradiological contaminants.

2.0 RESULTS AND DISCUSSION

Radiological Parameter Results

All radiological data can be found in Section 6.0, and summary statistics found in Sect 7.0.

Surface soils were evaluated for gross alpha and gross non-volatile beta as well as a suite of 24 gamma-emitting radionuclides. The suite of 24 gamma-emitting radionclides is part of a gamma spectroscopy analysis performed by the Radiological Environmental Monitoring Division Laboratory in Columbia, SC (Section 5.0, Table 3). Radioisotopes were detected not only in samples collected on SRS, but in background samples as well. The USEPA PRGs are used as a screening tool that corresponds to certain levels of human health risk in regards to radioactivity in soil (USEPA 2013). The conservative PRGs, correspond to a risk for chronic soil ingestion for a residential scenario and a one in one million (1E-06) increased cancer risk. Uranium has both a PRG and an RSL because it is both carcinogenic and toxic (USEPA 2010). In 2012, ESOP analyzed for all of the radioisotopes listed in Section 5.0, Table 3.

Cesium-137 is a man-made fission product. Atmospheric Cs-137 was released from the separation areas and was a key radionuclide released to water and air, mainly from F- and H-areas (CDC 2006). Cesium-137 was detected in all 19 SRS nonrandom perimeter samples at an average of 0.14 ($\pm$0.10) picocuries per gram (pCi/g) and ranged from 0.04 to 0.41 pCi/g. The highest detection was located at SSALN12 in Allendale County. Seven of the 10 riverbank soil samples had Cs-137 detections at an average of 0.18 (±0.10) pCi/g. The samples ranged from less than Minimum Detectable Activity (MDA) to 0.36 pCi/g. The highest detection of all samples was at Cohen's Bluff boat landing.

Analysis for Cs-137 in riverbank soils collected at the public boat landings show that samples in 2012 had Cs-137 levels that could be potentially from SRS activities and/or atmospheric fallout from past nuclear weapons testing. Results are depicted in Section 5.0, Figure 1.

Five of six background samples had Cs-137 detections. The random background sample detection average was 0.12 (±0.09) pCi/g. The random background samples had detections ranging from less than MDA to 0.25 pCi/g. Cesium-137, on average, was highest in the public boat landings followed by SRS perimeter sample soils. The results are depicted in Section 5.0, Figure 2.

In addition, potassium-40, lead-212, lead-214, radium-226, and actinium-228 were the only other gamma-emitting radionuclides detected among surface soil samples. These are Naturally Occurring Radioactive Material (NORM) decay products that may account for these detections. All other gamma-emitting radionuclides had no detections above their respective MDA.

Gross alpha-emitting radionuclides were released to the air at SRS primarily from M-area, the reactor areas, and the separations facilities (CDC 2006). Analyses were conducted on gross alpha-emitting radionuclides in surface soil samples collected during 2012. There were no detections of gross alpha-emitting radionuclides in any of the soil samples collected in 2012.

Gross beta-emitting radionuclides were released from the separations areas on the SRS (CDC 2006). Gross beta was detected in only one SRS nonrandom perimeter sample (SSALD12) at 9.85 pCi/g. Two riverbank boat landing soil samples had detections for gross beta-emitting radionuclides. The riverbank landing average was 15.2 (±5.9) pCi/g, and the values ranged from less than MDA to 19.3 pCi/g. Steel Creek Landing (SSSCL12) yielded the highest riverbank soil detection. There were no detections of gross beta-emitting radionuclides in any of the background soil samples collected in 2012. Results are depicted in Figure 3 of Section 5.0.

Nonradiological Parameter Results

Data for all metals detected can be found in Section 6.0. The statistical data tables are found in Section 7.0. SRS perimeter averages of select metal results are depicted in Figure 4 of Section 5.0.

Ten metals were analyzed in 19 nonrandom SRS perimeter surface soil samples collected in 2012. A complete list of all nonradiological analytes can be found in Section 5.0, Table 3. Findings were compared to the USEPA RSLs that are used as a screening tool, corresponding to certain levels of human health risk in soils (USEPA 2013). All sample results were below the conservative generic/default USEPA RSLs, corresponding to a risk for chronic soil ingestion for a residential scenario. ESOP 2012 samples had detections of barium, chromium, copper, lead, manganese, and zinc. There were no detections above the Minimum Detection Limit (MDL) for mercury, cadmium, beryllium and nickel in the SRS perimeter samples. The following discussion of individual analytes will be limited to those of potential concern due to SRS operations.

Barium has been a constituent of the H-Area Hazardous Waste Management Facility (WSRC 1993). Barium was detected in all 19 SRS nonrandom perimeter samples at an average of 15.4 (±12.4) milligrams per kilogram (mg/kg) and ranged from 5.4 to 58 mg/kg. The highest detection was located at SSJAK12 in Aiken County. All samples were well below the RSL of 15,000 mg/kg and also below the South Carolina (SC) average of 38 mg/kg (Canova 1999).

Beryllium is a strong light weight metal used in nuclear weapons work as a shield for radiation and as a neuton source (Till et al. 2001). Beryllium was not detected in any of the SRS nonrandom perimeter samples. The RSL for beryllium in soil is 160 mg/kg.

Chromium solutions were used at the 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 separation 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. Fly ash particles can travel considerable distance in the air and contain trace elements of chromium (Alloway 1995). Chromium was detected in all 19 SRS nonrandom perimeter samples at an average of 2.6 (±0.89) mg/kgand ranged from 1.2 to 4.6 mg/kg. The highest detection was located in SSALN12 in Allendale County. For comparison, the most conservative RSL screening level (ChromiumVI) is 230 mg/kg. The SC average for total chromium in soil is 16 mg/kg (Canova 1999).

Copper, while naturally occurring, can also be released to the environment through the combustion of wood, coal and oil (Alloway 1995). 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 in surface soils. Copper was detected in 12 SRS nonrandom perimeter samples at an average of 1.7 (±0.53) mg/kg and ranged from 1.2 to 3.2 mg/kg. The highest detection was located in SSJAK12 in AikenCounty. All samples were below the RSL of 3,100 mg/kg. The SC average for copper in soil is 9 mg/kg (Canova 1999).

Atmospheric emissions of lead from SRS occurred through coal and fuel combustion (Till et al. 2001). Lead can deposit in soil, due to its immobility, and have a long residence time when compared to other pollutants. Lead tends to accumulate in soil where its bioavailability can exist far into the future (Alloway 1995). Lead was detected in six SRS nonrandom perimeter samples at an average of 6.9 (±1.73) mg/kg and ranged from 5.1 to 9.7 mg/kg. The highest detection was located at SSALD12 in Allendale County. For comparison, the RSL is 400 mg/kg and the state average for lead in soil is 16 mg/kg (Canova 1999).

Manganese has been released in the separations area processes and discharged to liquid waste tanks (Till et al. 2001). It is also a byproduct of coal burning. Manganese was detected in all 19 SRS nonrandom perimeter samples at an average of 54.9 (±85.6) mg/kg and ranged from 3.7 to 380 mg/kg. The highest detection was located at SSJAK12 in Aiken County. SSJAK12 exceeded the state average of 100 mg/kg (Canova 1999), and all were below the RSL of 1,800 mg/kg.

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 not detected in any of the SRS nonrandom perimeter samples. The state average for nickel is 6 mg/kg (Canova 1999), and the RSL of nickel is 1,500 mg/kg.

Zinc was released in relatively small amounts to the separations area seepage basins as well as the M-area seepage basin (Till et al. 2001). Zinc was detected in all 19 SRS nonrandom perimeter samples at an average of 5.9 (±2.6) mg/kg and ranged from 2.0 to 12.0 mg/kg. The highest detection was located at both SSALD12 and SSALN12 Allendale County. The RSL is 23,000 mg/kg. All samples were also below the state average of 23 mg/kg (Canova 1999).

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. None of the surface soil samples collected in 2012 yielded detections above the MDL of 0.1 mg/kg for mercury. The RSL for mercury is 5.6 mg/kg.

Cadmium enters the atmosphere through fuel and coal combustion (Till et al. 2001). None of the surface soil samples collected in 2012 yielded detections above the MDL of 1.0 mg/kg for cadmium. The RSL for cadmium in soil is 70 mg/kg.

SCDHEC and DOE-SR Data Comparison

Cesium-137 (Cs-137), Cobalt-60 (Co-60) and Americium-241 (Am-241) were the only gamma-emitting radionuclides that SCDHEC and DOE-SR shared in analytical results. DOE-SR did not have any detections of Co-60 above the MDA. DOE-SR did detect Am-241 in five perimeter locations at an average of 0.006 (± .003) pCi/g as well as one detection in a 25 mile perimeter location at 0.006 pCi/g. Since SCDHEC did not have any detections of Co-60 or Am-241 above the MDA, only the Cs-137 detections are compared. DOE-SR did not analyze for alpha or beta-emitting radionuclides, nor did they analyze for metals; therefore, no comparisons could be made. Sediment samples from both programs varied by location and in number. DOE-SR collected 12 samples near the SRS perimeter and three samples within 25 miles. ESOP collected 19 nonrandom SRS perimeter samples. ESOP also sampled six background locations greater than 50 miles from SRS. DOE-SR sampled one background location 100 miles from SRS at Savannah, Georgia. It should be taken into consideration that samples were collected from a variety of soil types and locations when interpreting data.

Cesium-137 was detected by both DOE-SR and SCDHEC. Cesium-137 was detected above the Minimum Detectable Concentration (MDC) in all 12 DOE-SR perimeter samples. SCDHEC detected Cs-137 in all of the 19 nonrandom perimeter SCDHEC samples. Cesium-137 was detected in both the DOE-SR background location and the SCDHEC background locations. For the 2012 samples, the SCDHEC nonrandom perimeter average for Cs-137 was 0.14 (± 0.10) pCi/g. The average for all the SCDHEC background samples was 0.12 (± 0.09) pCi/g. The DOE-SR Cs-137 average for all SRS perimeter samples was 0.22 (± 0.08) pCi/g, and 0.14 (± 0.1) pCi/g for those locations within 25 miles of SRS. The DOE-SR 100 mile background Cs-137 activity was 0.25 pCi/g (SRNS 2013). The DOE-SR data average for Cs-137 activity falls within one standard deviation of the SCDHEC data. Comparative data can be found in Section 5.0, Tables 8 and 9.

Cesium-137 was the only consistently detected parameter over past years. Trending data for Cs-137 in SRS perimeter samples is in Section 5.0, Figure 5. SCDHEC has trended Cs-137 since 2007 (SCDHEC 2007-2012). Data shows that SCDHEC levels of Cs-137 in perimeter surface soils from 2007 to 2012 averaged 0.52 pCi/g. DOE-SR data of Cs-137 in perimeter surface soils from 2007 through 2012 averaged 0.15 pCi/g (WSRC 2007-2012). DOE-SR data shows steady Cs-137 levels from 2007-2012 although 2012 Cs-137 (0.22 pCi/g) results were higher than the average of 0.15 pCi/g from 2007-2012. SCDHEC Cs-137 data during 2007-2012 shows a steady decline from Cs-137 levels of 1.01 pCi/g in 2007. The results found by both SCDHEC 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 increase of Cs-137 activity in the perimeter SCDHEC samples in 2007 through 2009 could be due to the addition of samples in closer proximity to the boundary of SRS, specifically in the Steel Creek floodplain. In the previous years only random samples within 50 miles of the SRS center point were sampled to determine the yearly average. In 2007, the addition of sampling at public boat landings was initiated. Excursions outside normally expected levels, contributed through unplanned Cs-137 releases, occurred at boat landings downstream of SRS specifically in the Steel Creek floodplain area. These areas have historically been impacted by SRS operations and higher than background results are to be expected. These yielded higher averages in 2007 through 2009. DOE-SR does not collect samples at these locations.

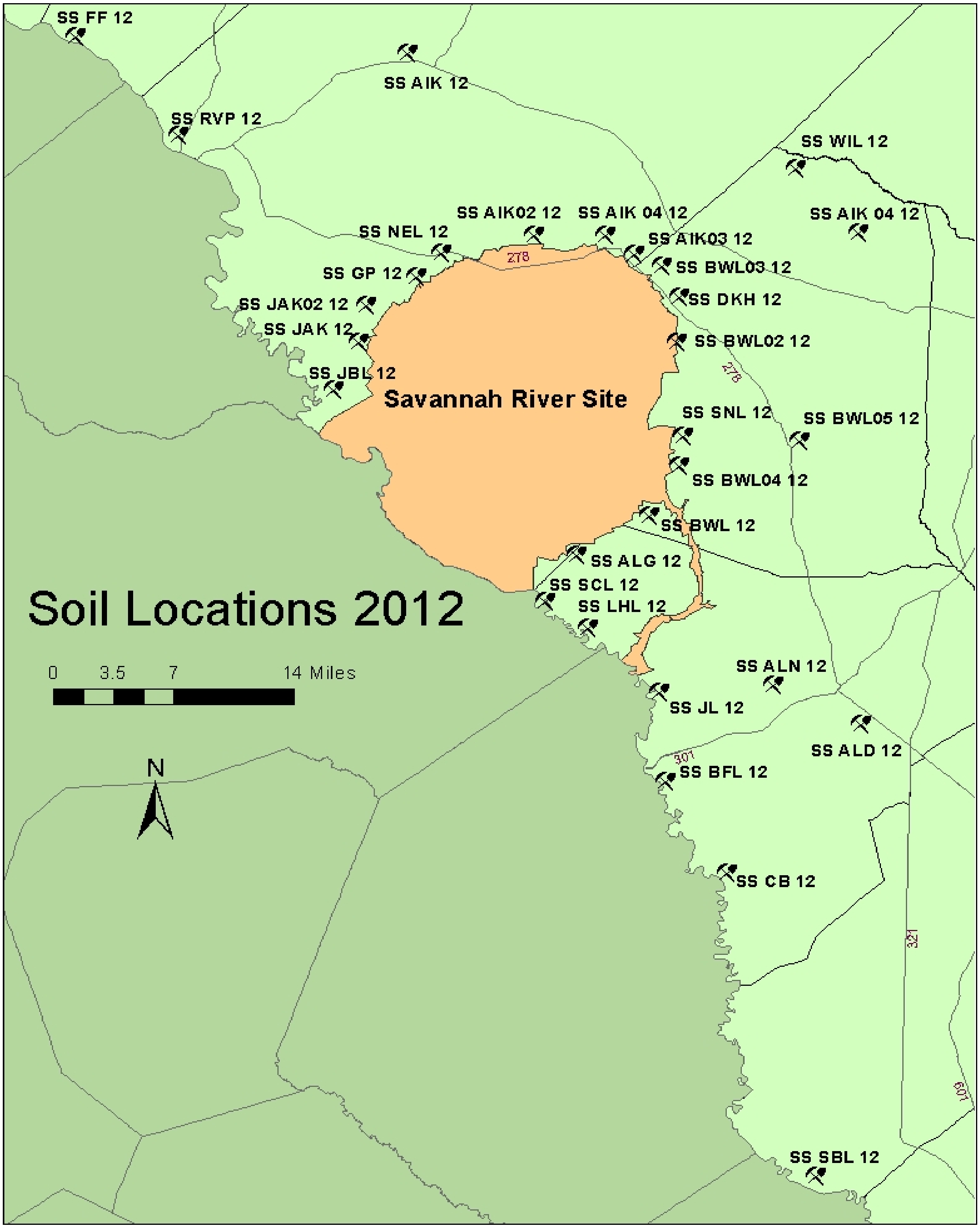
3.0 CONCLUSIONS AND RECOMMENDATIONS

ESOP will continue independent monitoring of 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 the SRS that create the potential for contamination entering 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 results allows for independent data verification of DOE-SR monitoring activities. Cooperation between DOE-SR and SCDHEC provides credibility and confidence in the information being provided to the public.

In 2013, SCDHEC will continue to monitor the surface soil along the perimeter of SRS for radionuclides. Riverbank soil samples will be collected from the publicly accessible Savannah River watershed boat landings where human exposure is likely. The SCDHEC data at this time does not show there is an impact of elevated metal concentrations to areas outside of SRS. However, continued monitoring along the perimeter of SRS is still necessary due to the potential impact of SRS site operations to the surrounding environments. Possible atmospheric releases due to prescribed forest burning and soil disturbance at SRS could elevate metals in the surrounding area. Only through continued monitoring will this be determined. If perimeter samples show elevated metals concentration, additional samples will be evaluated.

4.0

Map 1. SRS Perimeter Surface Soil Monitoring and River Bank Locations



5.0 Tables and Figures
Surface Soil Monitoring Adjacent to SRS

Table 1. Nonrandom Soil Samples Collected in 2012

SAMPLE ID	LOCATION	COUNTY
SS ALG 12	Allendale Gate	Allendale
SS SNL 12	Snelling Gate	Barnwell
SS DKH 12	Darkhorse	Barnwell
SS ALN 12	Allendale	Allendale
SS GP 12	Green Pond	Aiken
SS JAK 12	Jackson	Aiken
SS AIK 12	Aiken	Aiken
SS JAK02 12	Jackson	Aiken
SS NEL 12	New Ellenton	Aiken
SS BWL 12	Co-located at VEG site BWL-004	Barnwell
SS AIK02 12	Boggy Gut Road	Aiken
SS BWL02 12	Co-located at VEG site BWL-002	Barnwell
SS BWL03 12	Co-located at VEG site BWL-001	Barnwell
SS AIK03 12	Co-located at EV site AIK 0903	Barnwell
SS ALD 12	Co-located at Allendale VEG Site ALD-251	Allendale
SS BWL04 12	Co-located at VEG site BWL-003	Barnwell
SS AIK04 12	Upper Three Runs @ Old Barnwell Rd.	Aiken
SS BWL05 12	Barnwell Lake Edgar Brown	Barnwell
SS WIL 12	Williston Plum Location EVBWL-02	Barnwell

Table 2. Riverbank Soil Samples Collected in 2012

Sample Name	Abbr.	Location Description
Upstream of SRS		
SSFF12	FF	Fury's Ferry Boat Landing
SSSC12	SC	Steven's Creek Landing
SSRVP12	RVP	North Augusta Riverview Park Boat Landing
SSJBL12	JBL	Jackson Boat Landing
Downstream of SRS		
SSSCL12	SCL	Steel Creek Landing, Barnwell County
SSLHL12	LHL	Little Hell Landing
SSJL12	JL	Johnson's Landing
SSBFL12	BFL	Burtons' Ferry Landing
SSCB12	CB	Cohen's Bluff Landing
SSSBL12	SBL	Stoke's Bluff Landing

Tables and Figures
Surface Soil Monitoring Adjacent to SRS

Table 3 Gamma Analytes

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

Note: Units are reported in pCi/g.

Table 4. Inorganic Metal Analytes

Analyte	Abbreviation	MDL
Barium	Ba	5
Beryllium	Be	0.3
Cadmium	Cd	1
Chromium	Cr	1
Copper	Cu	1
Lead	Pb	5
Manganese	Mn	1
Mercury	Hg	0.1
Nickel	Ni	2
Zinc	Zn	1

Note: Units are reported in mg/kg.

Tables and Figures
Surface Soil Monitoring Adjacent to SRS

Table 5. Preliminary Remediation Goals of Anthropogenic Radionuclides Samples by SCDHEC

Radionuclide	Abbreviation	PRG
Americium-241	Am-241	**3.75 pCi/g**
Cesium-137	Cs-137	**25.4 pCi/g**
Cobalt-60	Co-60	**79.2 pCi/g**
Iodine-131	I-131	**5940 pCi/g**

Table 6. Regional Screening Levels of Metals sampled by SCDHEC

Analyte	Abbreviation	RSL
Barium	Ba	**15,000 mg/kg**
Beryllium	Be	**160 mg/kg**
Cadmium	Cd	**70 mg/kg**
Chromium	Cr	**230 mg/kg**
Copper	Cu	**3,100 mg/kg**
Mercury	Hg	**400 mg/kg**
Manganese	Mn	**1,800 mg/kg**
Nickel	Ni	**1,500 mg/kg**
Lead	Pb	**400 mg/kg**
Zinc	Zn	**23,000 mg/kg**

Table 7. Soil Screening Levels of Anthropogenic Radionuclides Samples by SCDHEC

Radionuclide	Abbreviation	SSL
Americium-241	Am-241	**0.088 pCi/g**
Cesium-137	Cs-137	**0.492 pCi/g**
Cobalt-60	Co-60	**0.081 pCi/g**
Iodine-131	I-131	**5.05 pCi/g**

Tables and Figures
Surface Soil Monitoring Adjacent to SRS

Table 8. Cs-137 Surface Soil Data Comparison: Nonrandom Perimeter SCDHEC and DOE-SR Perimeter Surface Soil Samples

SCDHEC

Sample ID	County	Cs-137
SS ALG 12	Allendale	0.16
SS SNL 12	Barnwell	0.10
SS DKH 12	Barnwell	0.05
SS ALN 12	Allendale	0.41
SS GP 12	Aiken	0.04
SS JAK 12	Aiken	0.20
SS AIK 12	Aiken	0.08
SS JAK02 12	Aiken	0.19
SS NEL 12	Aiken	0.20
SS BWL 12	Barnwell	0.08
SS BWL02 12	Barnwell	0.04
SS BWL03 12	Barnwell	0.04
SS AIK03 12	Barnwell	0.10
SS ALD 12	Allendale	0.30
SS BWL04 12	Barnwell	0.09
SS AIK04 12	Aiken	0.12
SS BWL05 12	Barnwell	0.17
SS WIL 12	Barnwell	0.23
SS AIK02 12	Aiken	0.07
AVG		**0.14**
MEDIAN		**0.10**
STD		**0.10**

DOE-SR

SRS Perimeter	Cs-137
Allendale Gate	0.18
Barnwell Gate	0.16
D-Area	0.34
Darkhorse @ Williston Gate	0.29
East Talatha	0.3
Green Pond	0.23
Highway 21/167	0.18
Jackson	0.14
Patterson Mill Road	0.28
Talatha Gate	0.1
West Jackson	0.27
Windsor Road	0.17
AVG	**0.22**
MEDIAN	**0.2**
STD	**0.07**

Tables and Figures
Surface Soil Monitoring Adjacent to SRS

Table 9. Cs-137 Surface Soil Data Comparison: SCDHEC and DOE-SR Surface Soil Samples Collected > 50 miles from the SRS Center Point.

SCDHEC

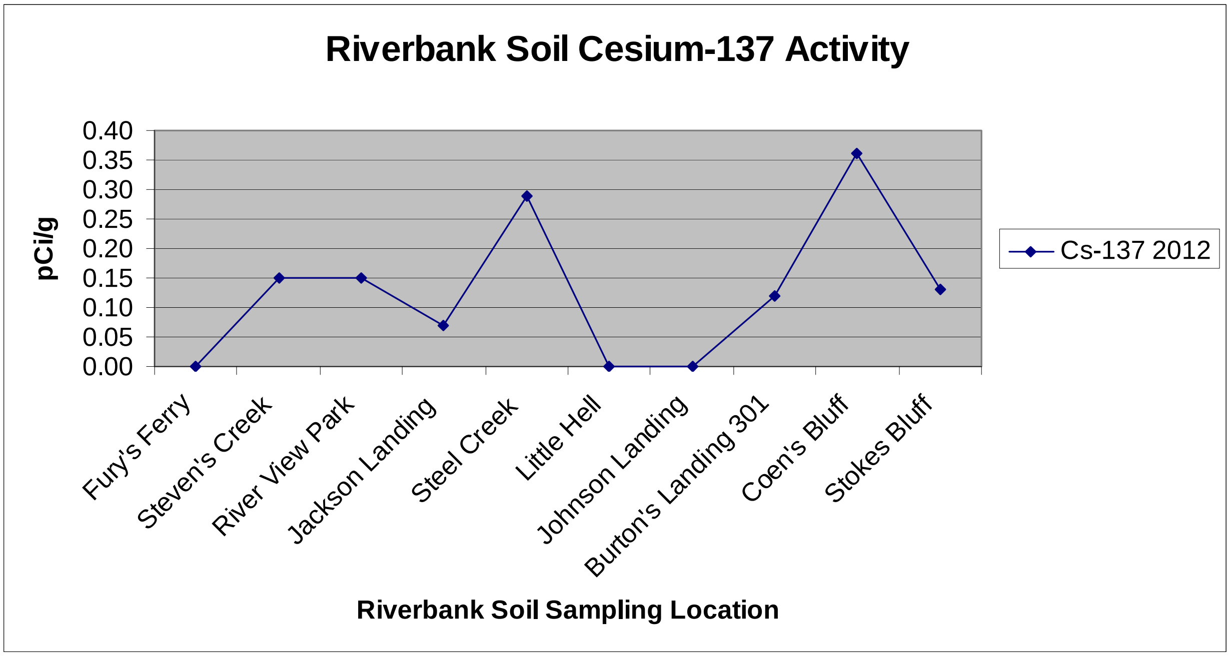
Sample ID	County	Cs-137
SS EDG 12	Edgefield	0.14
SS GWD 12	Greenwood	0.03
SS JSP 12	Jasper	<MDA
SS HMP 12	Hampton	0.25
SS LEX 12	Lexington	0.05
SS SLD 12	Saluda	0.15
AVG		**0.12**
Median		**0.14**
STD		**0.09**

DOE-SR

Sample ID	Sample Location	Cs-137
100-Mile Radius	Savannah, GA	**0.25**

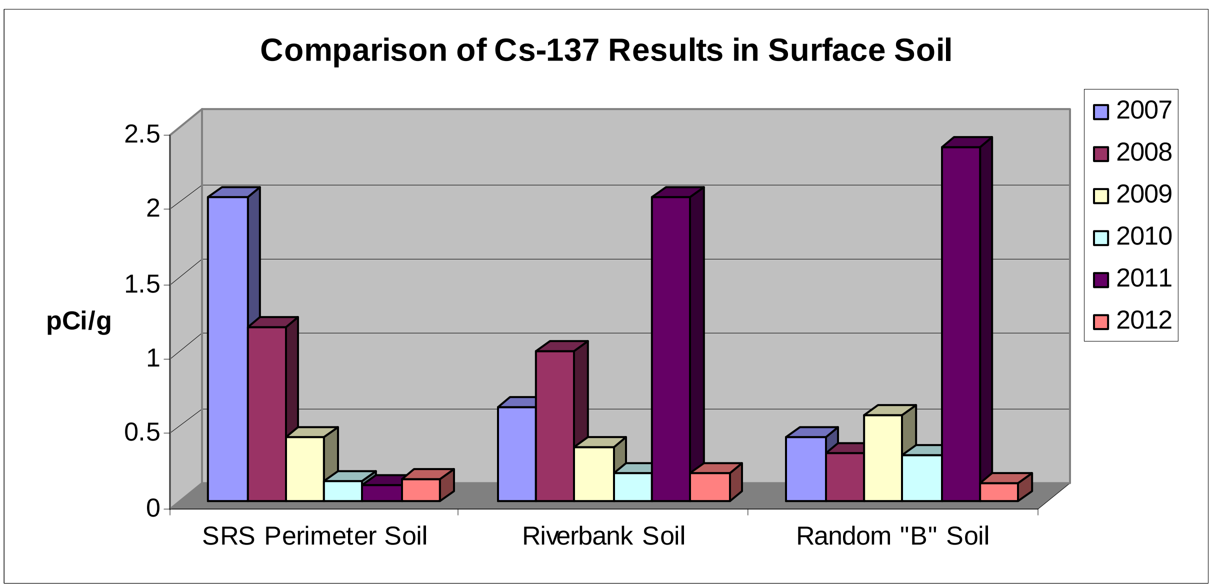
Tables and Figures
Surface Soil Monitoring Adjacent to SRS

Figure 1. Cesium-137 Levels in Savannah River Riverbank Surface Soil Samples



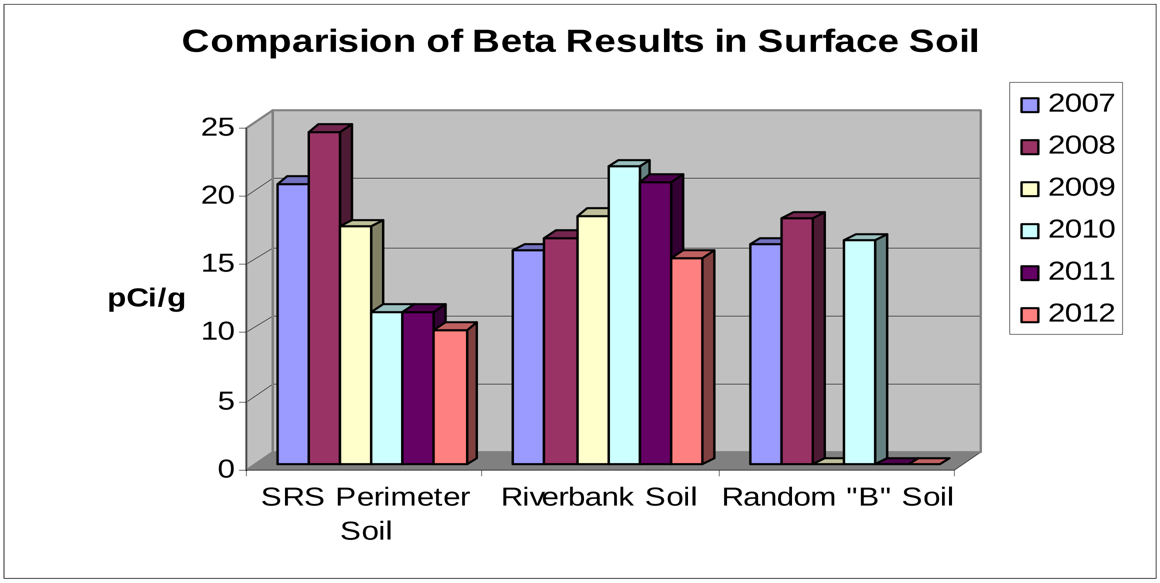
Note: Graph depicts samples in order of location along the Savannah River. The most upstream sample is on the left and the most downstream sample is on the right of the graph.

Figure 2. Trending Data for Cesium-137 by Yearly Averages of 2007-2012 and Individual Years



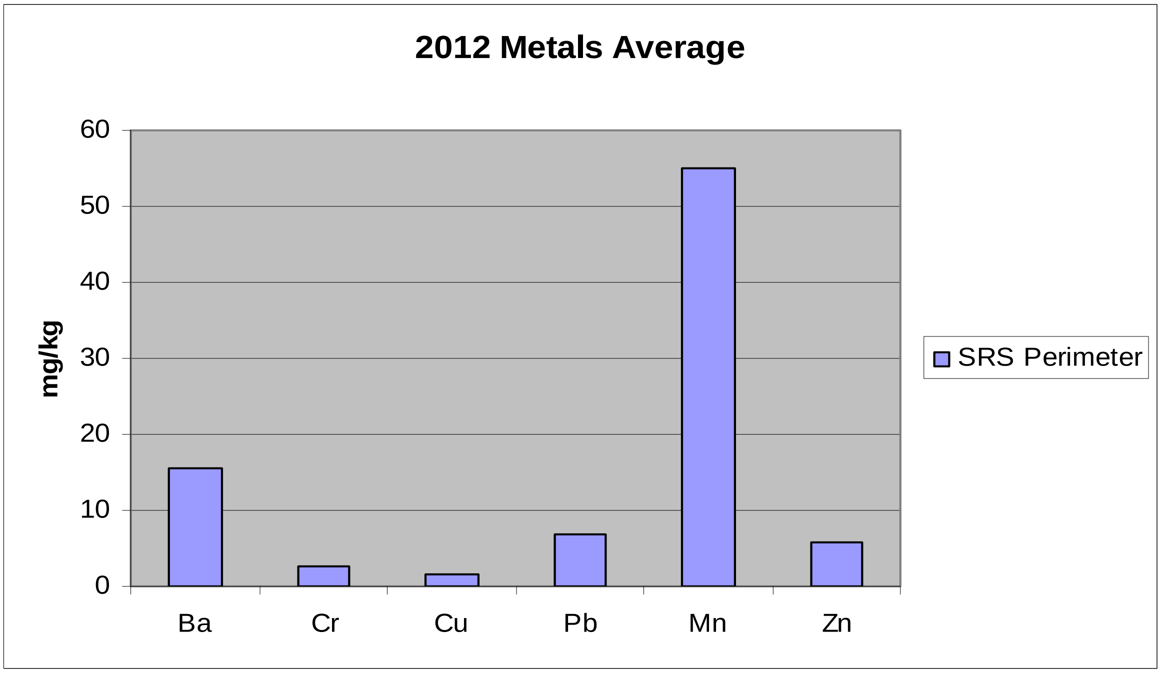
Tables and Figures
Surface Soil Monitoring Adjacent to SRS

Figure 3. Trending Data for Beta Detections by Yearly Averages of 2007-2012 and Individual Years



Note: There were no beta detections in any of the “B” soil samples collected in 2009, 2011 and 2012

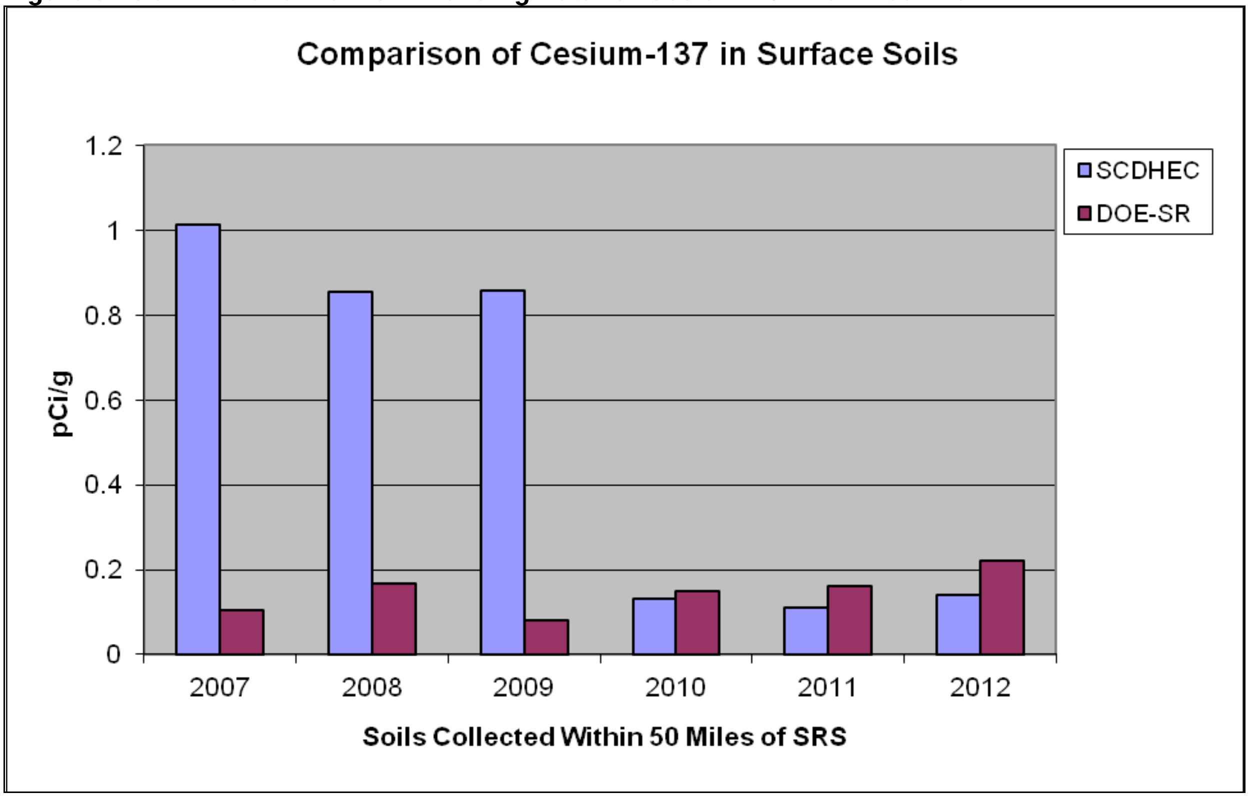
Figure 4. 2012 SRS perimeter metal averages



Note: There were no Ni detections in the SRS perimeter samples.

Tables and Figures
Surface Soil Monitoring Adjacent to SRS

Figure 5. SCDHEC and DOE-SR Trending Data for Cesium-137 from 2007-2012



6.0 Data

Surface Soil Monitoring Adjacent to SRS

2012 RADIOLOGICAL DATA **18**

2012 NONRADIOLOGICAL (METALS) DATA **28**

Notes:
1. LLD= Lower Limit of Detection
2. MDA= Minimum Detectable Activity
3. SS= Surface soil

Surface Soil Monitoring Adjacent to SRS

2012 Alpha, Beta and Gamma Detections for Nonrandom SRS Perimeter Surface Soil Samples

Location Description	SS SNL 12	SS DKH 12	SS GP 12	SS BWL 12
Collection Date	1/18/2012	1/18/2012	1/18/2012	1/18/2012
Alpha Activity	<LLD	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA	NA
Alpha LLD	12.60	12.80	13.00	13.10
Beta Activity	<LLD	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA	NA
Beta LLD	10.60	10.70	10.80	10.90
K-40 Activity	0.88	0.69	0.48	1.09
K-40 Confidence Interval	0.18	0.19	0.15	0.22
K-40 MDA	0.25	0.27	0.25	0.30
Cs-137 Activity	0.10	0.05	0.04	0.08
Cs-137 Confidence Interval	0.02	0.02	0.01	0.02
Cs-137 MDA	0.02	0.02	0.02	0.02
Pb-212 Activity	0.47	0.75	0.70	0.90
Pb-212 Confidence Interval	0.05	0.06	0.06	0.07
Pb-212 MDA	0.04	0.04	0.04	0.05
Pb-214 Activity	0.48	0.57	0.50	0.89
Pb-214 Confidence Interval	0.05	0.05	0.05	0.08
Pb-214 MDA	0.04	0.04	0.05	0.05
Ra-226 Activity	0.88	1.18	1.10	1.62
Ra-226 Confidence Interval	0.32	0.37	0.37	0.48
Ra-226 MDA	0.46	0.51	0.51	0.64
Ac-228 Activity	0.48	0.77	0.72	0.84
Ac-228 Confidence Interval	0.03	0.04	0.03	0.05
Ac-228 MDA	0.06	0.06	0.06	0.07

Note: Units are in pCi/g.
There were no detections in any 2011 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Alpha, Beta and Gamma Detections for Nonrandom SRS Perimeter Surface Soil Samples

Location Description	SS JAK 12	SS AIK 12	SS JAK02 12	SS NEL 12
Collection Date	1/31/2012	1/31/2012	1/31/2012	1/31/2012
Alpha Activity	<LLD	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA	NA
Alpha LLD	12.60	12.70	12.40	12.80
Beta Activity	<LLD	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA	NA
Beta LLD	10.50	10.60	10.40	10.70
K-40 Activity	1.91	0.54	0.93	5.20
K-40 Confidence Interval	0.30	0.18	0.20	0.45
K-40 MDA	0.34	0.28	0.27	0.29
Cs-137 Activity	0.20	0.08	0.19	0.20
Cs-137 Confidence Interval	0.03	0.01	0.02	0.02
Cs-137 MDA	0.03	0.01	0.02	0.02
Pb-212 Activity	0.95	0.28	0.51	0.88
Pb-212 Confidence Interval	0.08	0.03	0.05	0.07
Pb-212 MDA	0.05	0.04	0.04	0.05
Pb-214 Activity	0.97	0.28	0.56	0.74
Pb-214 Confidence Interval	0.08	0.04	0.06	0.06
Pb-214 MDA	0.06	0.04	0.05	0.05
Ra-226 Activity	2.37	<MDA	1.27	1.61
Ra-226 Confidence Interval	0.53	NA	0.40	0.41
Ra-226 MDA	0.68	0.46	0.53	0.55
Ac-228 Activity	0.91	0.30	0.54	0.89
Ac-228 Confidence Interval	0.06	0.05	0.02	0.03
Ac-228 MDA	0.08	0.05	0.06	0.06

Note: Units are in pCi/g.
There were no detections in any 2012 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Alpha, Beta and Gamma Detections for Nonrandom SRS Perimeter Surface Soil Samples

Location Description	SS ALG 12	SS AIK02 12	SS BWL02 12	SS BWL03 12
Collection Date	2/28/2012	2/28/2012	2/28/2012	2/28/2012
Alpha Activity	<LLD	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA	NA
Alpha LLD	12.70	12.10	12.10	12.20
Beta Activity	<LLD	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA	NA
Beta LLD	10.70	10.20	10.20	10.30
K-40 Activity	0.71	0.67	0.35	0.57
K-40 Confidence Interval	0.18	0.17	0.15	0.17
K-40 MDA	0.26	0.25	0.24	0.25
Cs-137 Activity	0.16	0.07	0.04	0.04
Cs-137 Confidence Interval	0.02	0.01	0.01	0.01
Cs-137 MDA	0.02	0.02	0.02	0.02
Pb-212 Activity	0.81	1.12	0.65	0.68
Pb-212 Confidence Interval	0.07	0.08	0.05	0.06
Pb-212 MDA	0.04	0.04	0.04	0.04
Pb-214 Activity	0.63	0.85	0.50	0.52
Pb-214 Confidence Interval	0.06	0.07	0.05	0.05
Pb-214 MDA	0.05	0.05	0.04	0.04
Ra-226 Activity	1.22	1.58	0.95	1.08
Ra-226 Confidence Interval	0.41	0.36	0.33	0.36
Ra-226 MDA	0.56	0.53	0.46	0.50
Ac-228 Activity	0.76	1.07	0.66	0.72
Ac-228 Confidence Interval	0.06	0.02	0.05	0.04
Ac-228 MDA	0.06	0.06	0.05	0.05

Note: Units are in pCi/g.
There were no detections in any 2012 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Alpha, Beta and Gamma Detections for Nonrandom SRS Perimeter Surface Soil Samples

Location Description	SS AIK03 12	SS AIK04 12	SS BWL04 12	SS BWL05 12
Collection Date	**2/28/2012**	**5/3/2012**	**5/3/2012**	**5/3/2012**
Alpha Activity	<LLD	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA	NA
Alpha LLD	12.60	11.10	11.00	11.20
Beta Activity	<LLD	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA	NA
Beta LLD	10.60	8.98	8.91	9.07
K-40 Activity	0.88	0.60	0.46	<MDA
K-40 Confidence Interval	0.21	0.18	0.20	NA
K-40 MDA	0.29	0.12	0.12	0.12
Cs-137 Activity	0.10	0.12	0.09	0.17
Cs-137 Confidence Interval	0.02	0.02	0.02	0.03
Cs-137 MDA	0.02	0.02	0.02	0.02
Pb-212 Activity	1.18	0.59	0.62	0.64
Pb-212 Confidence Interval	0.09	0.06	0.06	0.06
Pb-212 MDA	0.04	0.04	0.04	0.04
Pb-214 Activity	0.90	0.45	0.45	0.45
Pb-214 Confidence Interval	0.08	0.05	0.04	0.04
Pb-214 MDA	0.05	0.04	0.04	0.04
Ra-226 Activity	1.98	1.02	1.00	<MDA
Ra-226 Confidence Interval	0.48	0.48	0.44	NA
Ra-226 MDA	0.63	0.46	0.44	0.49
Ac-228 Activity	1.01	0.62	0.60	0.66
Ac-228 Confidence Interval	0.02	0.04	0.05	0.06
Ac-228 MDA	0.07	0.06	0.05	0.06

Note: Units are in pCi/g.

There were no detections in any 2012 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Alpha, Beta and Gamma Detections for Nonrandom SRS Perimeter Surface Soil Samples

Location Description	SS ALD 12	SS ALN 12	SS WIL 12
Collection Date	**5/30/2012**	**5/30/2012**	**5/30/2012**
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA
Alpha LLD	10.90	11.10	11.20
Beta Activity	9.85	<LLD	<LLD
Beta Confidence Interval	6.24	NA	NA
Beta LLD	8.92	8.95	9.03
K-40 Activity	1.35	1.34	1.36
K-40 Confidence Interval	0.24	0.24	0.26
K-40 MDA	0.11	0.13	0.14
Cs-137 Activity	0.30	0.41	0.23
Cs-137 Confidence Interval	0.04	0.05	0.03
Cs-137 MDA	0.02	0.02	0.02
Pb-212 Activity	0.30	0.33	1.03
Pb-212 Confidence Interval	0.04	0.05	0.10
Pb-212 MDA	0.04	0.04	0.04
Pb-214 Activity	0.25	0.28	0.82
Pb-214 Confidence Interval	0.04	0.04	0.07
Pb-214 MDA	0.04	0.04	0.05
Ra-226 Activity	<MDA	<MDA	1.84
Ra-226 Confidence Interval	NA	NA	0.50
Ra-226 MDA	0.47	0.50	0.59
Ac-228 Activity	0.24	<MDA	1.02
Ac-228 Confidence Interval	0.05	0.03	0.05
Ac-228 MDA	0.05	0.11	0.07

Note: Units are in pCi/g.
There were no detections in any 2012 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Beta and Gamma Detections for Public Boat Landing Riverbank Soil Samples

	Fury's Ferry Boat Landing	Stevens Creek Boat Landing	Riverview Park Boat Landing	Jackson Boat Landing
Location Description	**SS FF 12**	**SS SC 12**	**SS RVP 12**	**SS JBL 12**
Collection Date	**9/5/2012**	**9/5/2012**	**9/11/2012**	**9/11/2012**
Alpha Activity	<LLD	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA	NA
Alpha LLD	11.90	12.00	11.90	12.30
Beta Activity	<LLD	<LLD	<LLD	11.00
Beta Confidence Interval	NA	NA	NA	6.79
Beta LLD	9.57	9.58	9.58	9.71
K-40 Activity	<MDA	0.83	0.58	1.05
K-40 Confidence Interval	NA	0.25	0.21	0.27
K-40 MDA	0.40	0.14	0.13	0.15
Cs-137 Activity	<MDA	0.16	0.15	0.07
Cs-137 Confidence Interval	NA	0.03	0.02	0.03
Cs-137 MDA	0.02	0.02	0.02	0.02
Pb-212 Activity	0.75	0.54	0.64	0.93
Pb-212 Confidence Interval	0.08	0.06	0.07	0.09
Pb-212 MDA	0.04	0.04	0.04	0.04
Pb-214 Activity	0.49	0.64	0.53	0.90
Pb-214 Confidence Interval	0.05	0.05	0.05	0.07
Pb-214 MDA	0.04	0.04	0.04	0.04
Ra-226 Activity	<MDA	1.19	<MDA	1.46
Ra-226 Confidence Interval	NA	0.51	NA	0.53
Ra-226 MDA	0.48	0.44	0.46	0.55
Ac-228 Activity	0.76	0.52	0.65	0.99
Ac-228 Confidence Interval	0.08	0.07	0.07	0.08
Ac-228 MDA	0.06	0.05	0.06	0.07

Note: Units are in pCi/g.

There were no detections in any 2012 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Beta and Gamma Detections for Public Boat Landing Riverbank Soil Samples

	Steel Creek Boat Landing	Little Hell Boat Landing	Johnson's Boat Landing
Location Description	**SS SCL 12**	**SS LHL 12**	**SS JL 12**
Collection Date	**9/17/2012**	**9/17/2012**	**9/17/2012**
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA
Alpha LLD	12.00	12.00	12.30
Beta Activity	19.30	<LLD	<LLD
Beta Confidence Interval	7.26	NA	NA
Beta LLD	9.57	9.57	9.74
K-40 Activity	12.62	9.56	5.83
K-40 Confidence Interval	1.00	0.78	0.54
K-40 MDA	0.19	0.20	0.17
Cs-137 Activity	0.29	<MDA	<MDA
Cs-137 Confidence Interval	0.04	NA	NA
Cs-137 MDA	0.03	0.02	0.02
Pb-212 Activity	1.03	1.56	0.67
Pb-212 Confidence Interval	0.10	0.14	0.07
Pb-212 MDA	0.05	0.05	0.04
Pb-214 Activity	1.04	1.01	0.66
Pb-214 Confidence Interval	0.08	0.08	0.06
Pb-214 MDA	0.05	0.05	0.04
Ra-226 Activity	1.89	1.80	1.18
Ra-226 Confidence Interval	0.63	0.62	0.47
Ra-226 MDA	0.60	0.61	0.49
Ac-228 Activity	0.98	1.60	0.67
Ac-228 Confidence Interval	0.10	0.11	0.07
Ac-228 MDA	0.09	0.08	0.07

Note: Units are in pCi/g.
There were no detections in any 2011 boat landing surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Beta and Gamma Detections for Public Boat Landing Riverbank Soil Samples

	Burton's Ferry Boat Landing	Cohen's Bluff Boat Landing	Stokes Bluff Boat Landing
Location Description	**SS BFL 12**	**SS CB 12**	**SS SBL 12**
Collection Date	**10/8/2012**	**10/8/2012**	**10/8/2012**
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA
Alpha LLD	12.10	12.00	12.00
Beta Activity	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA
Beta LLD	9.60	9.58	9.57
K-40 Activity	<MDA	1.81	0.50
K-40 Confidence Interval	NA	0.34	0.19
K-40 MDA	0.15	0.19	0.13
Cs-137 Activity	0.12	0.36	0.13
Cs-137 Confidence Interval	0.03	0.04	0.02
Cs-137 MDA	0.02	0.02	0.02
Pb-212 Activity	0.61	0.34	0.82
Pb-212 Confidence Interval	0.06	0.05	0.08
Pb-212 MDA	0.04	0.04	0.04
Pb-214 Activity	0.56	0.49	0.62
Pb-214 Confidence Interval	0.06	0.06	0.05
Pb-214 MDA	0.04	0.05	0.04
Ra-226 Activity	1.44	<MDA	1.49
Ra-226 Confidence Interval	0.51	NA	0.49
Ra-226 MDA	0.47	0.55	0.46
Ac-228 Activity	0.64	<MDA	0.76
Ac-228 Confidence Interval	0.07	NA	0.08
Ac-228 MDA	0.06	0.14	0.06

Note: Units are in pCi/g.
There were no detections in any 2011 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Alpha, Beta and Gamma Detections for Random Background "B" (>50 miles) Surface Soil Samples

Location Description	SS EDG 12	SS GWD 12	SS JSP 12
Collection Date	**10/16/2012**	**10/16/2012**	**11/20/2012**
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA
Alpha LLD	12.30	11.90	12.20
Beta Activity	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA
Beta LLD	9.74	9.63	9.64
K-40 Activity	<MDA	<MDA	<MDA
K-40 Confidence Interval	NA	NA	NA
K-40 MDA	0.26	0.25	0.25
Cs-137 Activity	0.14	0.03	<MDA
Cs-137 Confidence Interval	0.02	0.01	NA
Cs-137 MDA	0.02	0.02	0.02
Pb-212 Activity	0.50	0.72	0.98
Pb-212 Confidence Interval	0.05	0.06	0.07
Pb-212 MDA	0.04	0.03	0.04
Pb-214 Activity	0.44	0.48	0.73
Pb-214 Confidence Interval	0.05	0.05	0.07
Pb-214 MDA	0.05	0.04	0.05
Ra-226 Activity	0.85	1.34	1.48
Ra-226 Confidence Interval	0.32	0.35	0.40
Ra-226 MDA	0.46	0.46	0.54
Ac-228 Activity	0.50	0.68	0.90
Ac-228 Confidence Interval	0.06	0.07	0.09
Ac-228 MDA	0.05	0.06	0.06

Note: Units are in pCi/g.
There were no detections in any 2011 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Alpha, Beta and Gamma Detections for Random Background "B" (>50 miles) Surface Soil

Location Description	**SS HMP 12**	**SS LEX 12**	**SS SLD 12**
Collection Date	**11/20/2012**	**12/4/2012**	**12/4/2012**
Alpha Activity	<LLD	<LLD	<LLD
Alpha Confidence Interval	NA	NA	NA
Alpha LLD	12.10	12.00	12.20
Beta Activity	<LLD	<LLD	<LLD
Beta Confidence Interval	NA	NA	NA
Beta LLD	9.60	9.57	9.68
K-40 Activity	<MDA	6.52	<MDA
K-40 Confidence Interval	NA	0.51	NA
K-40 MDA	0.30	0.27	0.25
Cs-137 Activity	0.25	0.05	0.15
Cs-137 Confidence Interval	0.03	0.02	0.02
Cs-137 MDA	0.02	0.02	0.02
Pb-212 Activity	0.27	0.61	0.76
Pb-212 Confidence Interval	0.04	0.05	0.06
Pb-212 MDA	0.04	0.04	0.04
Pb-214 Activity	0.34	0.61	0.62
Pb-214 Confidence Interval	0.05	0.06	0.06
Pb-214 MDA	0.05	0.05	0.04
Ra-226 Activity	<MDA	1.24	<MDA
Ra-226 Confidence Interval	NA	0.41	NA
Ra-226 MDA	0.50	0.55	0.50
Ac-228 Activity	0.24	0.47	0.77
Ac-228 Confidence Interval	0.05	0.07	0.08
Ac-228 MDA	0.07	0.08	0.06

Note: Units are in pCi/g.
There were no detections in any 2011 surface soil samples above the MDA for: Be-7, Na-22, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Ce-144, Eu-152, Eu-154, Eu-155, and Am-241.

Surface Soil Monitoring Adjacent to SRS

2012 Metal Detections in Nonrandom SRS Perimeter Samples

Location Description	SS DKH 12	SS SNL 12	SS BWL 12	SS ALG 12	SS AIK02 12
Collection Date	2/13/2012	2/13/2012	2/13/2012	2/28/2012	2/28/2012
Analyte					
Barium in Soil	**12**	**6.7**	**6.7**	**15**	**7**
Beryllium in Soil	<0.30	<0.30	<0.30	<0.30	<0.30
Cadmium in Soil	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium in Soil	**3.7**	**1.7**	**1.3**	**2.5**	**1.9**
Copper in Soil	**1.6**	<1.0	<1.0	**1.5**	<1.0
Mercury in Soil	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese in Soil	**26**	**3.7**	**4.6**	**58**	8.9
Nickel in Soil	<2.0	<2.0	<2.0	<2.0	<2.0
Lead in Soil	<5.0	<5.0	<5.0	<5.0	<5.0
Zinc in Soil	**5.7**	**2**	**2.4**	**3.6**	**9.5**

Note: Units are in mg/kg.

2012 Metal Detections in Nonrandom SRS Perimeter Samples

Location Description	SS BWL02 12	SS BWL03 12	SS AIK03 12	SS AIK04 12	SS BWL04 12
Collection Date	2/28/2012	2/28/2012	2/28/2012	5/3/2012	5/3/2012
Analyte					
Barium in Soil	**11**	**12**	**8.1**	**7.1**	**8.5**
Beryllium in Soil	<0.30	<0.30	<0.30	<0.30	<0.30
Cadmium in Soil	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium in Soil	**2.6**	**2.3**	**2.1**	**2.7**	**1.8**
Copper in Soil	**1.6**	**1.8**	<1.0	<1.0	<1.0
Mercury in Soil	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese in Soil	**23**	**23**	**8.9**	**13**	**15**
Nickel in Soil	<2.0	<2.0	<2.0	<2.0	<2.0
Lead in Soil	<5.0	<5.0	<5.0	<5.0	<5.0
Zinc in Soil	**5.4**	**5.4**	**3**	**4.7**	**4.3**

Note: Units are in mg/kg.

2012 Metal Detections in Nonrandom SRS Perimeter Samples

Location Description	SS BWL05 12	SS ALN 12	SS ALD 12	SS WIL 12
Collection Date	5/3/2012	5/30/2012	5/30/2012	5/30/2012
Analyte				
Barium in Soil	**9.6**	**28**	**11**	**15**
Beryllium in Soil	<0.30	<0.30	<0.30	<0.30
Cadmium in Soil	<1.0	<1.0	<1.0	<1.0
Chromium in Soil	**2.4**	**4.6**	**3.8**	**3.1**
Copper in Soil	**1.2**	**1.6**	**1.4**	**1.4**
Mercury in Soil	<0.10	<0.10	<0.10	<0.10
Manganese in Soil	**19**	**120**	**32**	**61**
Nickel in Soil	<2.0	<2.0	<2.0	<2.0
Lead in Soil	<5.0	**7.7**	**9.7**	**5.1**
Zinc in Soil	**5.1**	**12**	**12**	**7.6**

Note: Units are in mg/kg.

7.0 Summary Statistics

Surface Soil Monitoring Adjacent to SRS

2012 NONRADIOLOGICAL (METALS) STATISTICS 30

2012 RADIOLOGICAL STATISTICS 30

1. Notes: N/A = Not Applicable

Surface Soil Monitoring Adjacent to SRS

2012 Summary Statistics – SCDHEC Surface Soil Metals Data
Nonrandom Perimeter Samples

Analyte	AVG:	Standard Deviation	Median	Minimum	Maximum	Total Number Sampled	Number of Detections
Barium	15.4	12.4	11	5.4	58	19	19
Beryllium	N/A	N/A	N/A	N/A	N/A	19	0
Cadmium	N/A	N/A	N/A	N/A	N/A	19	0
Chromium	2.64	0.89	2.6	1.2	4.6	19	19
Copper	1.71	0.53	1.6	1.2	3.2	19	12
Mercury	N/A	N/A	N/A	N/A	N/A	19	0
Manganese	54.9	85.7	23	3.7	380	19	19
Nickel	N/A	N/A	N/A	N/A	N/A	19	0
Lead	6.93	1.73	6.8	5.1	9.7	19	6
Zinc	5.85	2.95	5.4	2	12	19	19

Note: Units are in mg/kg.

2012 Summary Statistics – SCDHEC Surface Soil Radiological Data
Nonrandom Perimeter Samples

Analyte	AVG:	Standard Deviation	Median	Minimum	Maximum	Total Number Sampled	Number of Detections
Alpha	N/A	N/A	N/A	N/A	N/A	19	0
Beta	9.85	N/A	9.85	9.85	9.85	19	1
K-40	1.11	1.1	0.8	0.35	5.2	19	18
Cs-137	0.14	0.1	0.1	0.04	0.41	19	19
Pb-212	0.71	0.26	0.68	0.28	1.18	19	19
Pb-214	0.58	0.22	0.52	0.25	0.97	19	19
Ra-226	1.38	0.44	1.22	0.88	2.37	19	15
Ac-228	0.71	0.23	0.72	0.24	1.07	19	18

Note: Units are in pCi/g.

2012 Summary Statistics – SCDHEC Surface Soil Radiological Data
Public Boat Landings

Analyte	AVG:	Standard Deviation	Median	Minimum	Maximum	Total Number Sampled	Number of Detections
Alpha	N/A	N/A	N/A	N/A	N/A	10	0
Beta	15.2	5.87	15.2	11	19.3	10	2
K-40	4.1	4.72	1.43	0.5	12.6	10	8
Cs-137	0.18	0.1	0.15	0.07	0.36	10	7
Pb-212	0.79	0.33	0.71	0.34	1.56	10	10
Pb-214	0.69	0.21	0.63	0.49	1.04	10	10
Ra-226	1.49	0.27	1.46	1.18	1.89	10	7
Ac-228	0.84	0.33	0.76	0.52	1.6	10	9

Note: Units are in pCi/g.

2012 Summary Statistics – SCDHEC Surface Soil Radiological Data
Background "B" Samples

Analyte	AVG:	Standard Deviation	Median	Minimum	Maximum	Total Number Sampled	Number of Detections
Alpha	N/A	N/A	N/A	N/A	N/A	6	0
Beta	N/A	N/A	N/A	N/A	N/A	6	0
K-40	6.52	N/A	6.52	6.52	6.52	6	1
Cs-137	0.12	0.09	0.14	0.03	0.25	6	5
Pb-212	0.64	0.24	0.67	0.27	0.98	6	6
Pb-214	0.54	0.14	0.54	0.34	0.73	6	6
Ra-226	1.23	0.27	1.29	0.85	1.48	6	4
Ac-228	0.59	0.24	0.59	0.24	0.9	6	6

Note: Units are in pCi/g

LIST OF ACRONYMS

CDC	Centers for Disease Control
Cs-137	Cesium-137
DOE-SR	Department of Energy – Savannah River
ESOP	Environmental Surveillance and Oversight Program
LLD	Lower Limit of Detection
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDL	Minimum Detection Level
NORM	Naturally Occurring Radioactive Material
PRG	Preliminary Remediation Goals
RSL	Regional Screening Level
SC	South Carolina
SCDHEC	South Carolina Department of Health and Environmental Control
SD	Standard Deviation
SRS	Savannah River Site
SRNS	Savannah River Nuclear Solutions
SS	Surface Soil
SSL	Soil Screening Level
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WSRC	Washington Savannah River Company (formerly Westinghouse Savannah River Company)

UNITS OF MEASURE

mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
±	Plus or minus. Refers to one standard deviation unless otherwise stated

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2012 Radiological Monitoring of Terrestrial Vegetation Related to the Savannah River Site

Environmental Surveillance and Oversight Program

97VG003
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January 01, 2012 – December 31, 2012

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PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

The Savannah River Site (SRS) is a Department of Energy (DOE) facility located about 20 miles from Aiken, SC and is contained within Aiken, Allendale, and Barnwell counties, with an area of approximately 300 square-miles (Till et al. 2001). From 1954 to 1992, the primary mission of SRS was the production of nuclear materials, primarily tritium and plutonium-239. During the course of normal operations radionuclides were released into the ground, water, and air. SRS is still operating today, although its primary mission has been changed to cleanup and remediation.

Terrestrial vegetation can be contaminated externally by direct deposition of airborne materials, water runoff, and precipitation that contains radioactivity. Vegetation can also be contaminated internally by uptake of radionuclides through the roots. Contaminated vegetation can be transported by physical means and, if eaten by animals, this radioactivity can enter the food chain.

The Department of Energy-Savannah River (DOE-SR) contracts for the collection and analysis of terrestrial vegetation, primarily Bermuda grass, to determine concentrations of radionuclides (SRNS 2013). The samples are obtained from twelve locations at the Savannah River Site (SRS) perimeter, one onsite location at the burial grounds, three 25-mile locations, and one 100-mile location. The Environmental Surveillance and Oversight Program (ESOP) of the South Carolina Department of Health and Environmental Control (SCDHEC) monitors for the presence of radionuclides in vegetation around SRS, collecting leaves from broad-leafed evergreen trees and shrubs, such as wax myrtle (*Myrica cerifera*), laurel oak (*Quercus laurifolia*), or Carolina laurelcherry (*Prunus caroliniana*).

In 2012, ESOP conducted independent vegetation monitoring at 17 locations along the perimeter of SRS as well as three former SRS monitoring locations 25 miles from the center of SRS. These 25-mile samples allow comparisons to be made between tritium levels at the site perimeter and tritium levels in the general SRS area. Sampling was performed on a quarterly basis with samples obtained in February, March, June, September, and December. ESOP and DOE-SR perimeter stations sampled in 2012 are shown in Section 4.0.

Samples from 11 of 17 perimeter stations exhibited tritium levels greater than the lower limit of detection (LLD; approximately 200 (± 20) picocuries per liter (pCi/L) with the highest activity found on the western side of SRS. Vegetation was also collected for gamma analysis at nine perimeter locations. Each gamma sample was analyzed for beryllium-7 (Be-7), sodium-22 (Na-22), potassium-40 (K-40), manganese-54 (Mn-54), cobalt-58 (Co-58), cobalt-60 (Co-60), zinc-65 (Zn-65), yttrium-88 (Y-88), zirconium-95 (Zr-95), ruthenium-103 (Ru-103), antimony-125 (Sb-125), iodine-131 (I-131), cesium-134 (Cs-134), cesium-137 (Cs-137), cerium-144 (Ce-144), europium-152 (Eu-152), europium-154 (Eu-154), europium-155 (Eu-155), lead-212 (Pb-212), lead-214 (Pb-214), radium-226 (Radium-226), actinium-228 (Ac-228), thorium-234 (Th-234), and americium-241 (Am-241).

Particular attention was paid to seven radionuclides: Be-7, K-40, Co-60, Cs-137, Pb-212, Pb-214, and Am-241, each of which has been detected in the past. During calendar year 2012, only Be-7, K-40, Cs-137, Pb-212, and Pb-214 were detected.

Cs-137 was detected at five of these locations, with the highest activities from stations on the northern and southern sides of SRS. Overall, both Cs-137 and tritium average detection activities have increased from last year, although it should be noted that the total number of detections actually decreased in both cases.

Tables and figures depicting average sample results as well as comparisons with SRS data are in Section 5.0. Sample results for Cs-137 and tritium are given in Section 6.0; summary statistics are in Section 7.0.

2.0 RESULTS AND DISCUSSION

Tritium in Vegetation

Tritium is a naturally occurring radioisotope of hydrogen that is normally found in very low concentrations (USEPA 2012). Pre-bomb tritium levels are estimated to have been approximately 24 pCi/L in rainwater (DEQ 2012). Sources of man-made tritium include nuclear reactors and government weapons production plants. Tritium releases on SRS include both atmospheric and liquid contributions (SRNS 2013). Although the United States Environmental Protection Agency (USEPA) has not established a Maximum Contaminant Level (MCL) for tritium in solid media (e.g. vegetation), the MCL for drinking water has been set at 20,000 pCi/L (USEPA 2012).

Tritium was detected in vegetation from 11 of the 17 perimeter sites sampled in 2012 (Section 5 Figures 1 and 2). The highest tritium levels detected during 2012 for each quarter were:

- Quarter 1 (February): AKN-002 at 1290 (± 67) pCi/L (wax myrtle)
- Quarter 2 (June): AKN-001 at 570 (± 55) pCi/L (wax myrtle)
- Quarter 3 (September): AKN-001 at 2142 (± 76) pCi/L (wax myrtle)
- Quarter 4 (December): AKN-007 at 1297 (± 66) pCi/L (Carolina laurel cherry)

There was one tritium detection at a 25-mile station: a 329 (± 51) pCi/L detection at AKN-251 in June, a level of activity significantly below the perimeter average of 742 (± 317) pCi/L, which falls just above the 160 pCi/L to 320 pCi/L range typically seen in the atmosphere today (DEQ 2012). The highest yearly average based on more than one detection was 1178 (± 426) pCi/L at AKN-003 (Section 7.0).

The highest tritium detection in 2012 was from AKN-001, located on the west side of SRS. AKN-002 and AKN-007 are on the west and northeast sides of SRS, respectively (Map 1). The three highest averages based on more than one detection were all on the west side of SRS, at AKN-001, AKN-002, and AKN-003. Samples were also collected at three stations located 25 miles from the SRS centerpoint. The only detection was at AKN-251, which is located northwest of SRS in Langley, S.C.

The average perimeter tritium detection increased from 572 (± 453) pCi/L in 2011 to 742 (± 317) pCi/L in 2012 (Section 5 Figures 1 and 2). Seven locations (AKN-001, AKN-002, AKN-003, AKN-004, AKN-007, BWL-003, and ALD-001) showed increases relative to 2011, although the AKN-004, AKN-007, BWL-003, and ALD-001 averages are based on one detection only. Four locations (AKN-005, AKN-006, AKN-008, and BWL-009) showed decreased activity in 2012.

Six locations (BWL-001, BWL-002, BWL-004, BWL-006, BWL-007, and BWL-008) showed no change.

Tritium analysis results from ESOP and DOE-SR sampling are presented in Section 5.0, Table 1. However, differences between the two programs in sampling dates, the vegetation sampled, and analysis methods should be considered during comparison. Data comparison of associated locations from the two programs was conducted by converting from picocuries per gram (pCi/g) to pCi/L, using a dry/wet weight ratio of 0.3 furnished by DOE-SR, using the formula:

$$pCi/L = [pCi/g \times (1/0.3)] / (1 - 0.3) = pCi/mL \times 1000.$$

Two colocations (i.e. sample locations in relatively close proximity in space and time) are relevant to this report: the Patterson Mill Road and Allendale Gate locations. The Patterson Mill Road DOE-SR sample showed a tritium activity level of 323 (± 90) pCi/L while the corresponding ESOP sample, BWL-004, was less than LLD. Tritium was also detected by DOE-SR at the Allendale Gate/BWL-006 colocation, at 637 (± 124) pCi/L (SRNS 2013). ESOP did not detect tritium at this location.

The DOE-SR program detected tritium from twelve perimeter stations that had comparable ESOP locations in 2012 (SRNS 2013); ESOP detected tritium at four comparable locations. The DOE-SR average, 513 (± 130) pCi/L, was within one standard deviation of the ESOP average, 801 (± 369) pCi/L. All measures of central tendency and standard deviation were calculated using detections only. It should also be noted that temporal proximity was also taken into account when ESOP samples were “matched” to DOE-SR samples.

Gamma in Vegetation

The naturally occurring isotopes potassium-40 (K-40) and beryllium-7 (Be-7) were detected from all stations where gamma samples were collected in 2012. The lead (Pb) isotopes Pb-212, a member of the thorium decay series, and Pb-214, a member of the radium decay series, were also detected, but not from all locations. Because these are naturally occurring isotopes the results will not be discussed in this section, but are presented in Section 6.0.

The man-made isotopes Cobalt-60 (Co-60) and Americium-241 (Am-241) were not detected during 2012; Cesium-137 (Cs-137), however, was detected at multiple locations. Cesium-137 is a man-made fission product and was a constituent of air and water releases on SRS, mainly from F and H-Areas. Liquid releases also occurred from the production reactors as a result of leaking fuel elements in the 1950s and 1960s (WSRC 1999).

Cesium-137 was detected at five of the nine perimeter stations sampled in 2012, and two of these stations produced Cs-137 results greater than the Minimum Detectable Activity (MDA) in all four quarters (Section 6.0). AKN-005, located on the north side of SRS (Map 1), exhibited the highest Cs-137 activity in all four quarters: 0.30 (± 0.02) pCi/g in March, 0.59 (± 0.02) pCi/g in June, 0.42 (± 0.02) pCi/g in September, and 0.57 (± 0.02) pCi/g in December. AKN-005 also showed the highest yearly average Cs-137 activity, at 0.47 pCi/g (± 0.14; Section 5 Figure 3).

Results of analysis for Cs-137 at AKN-002, BWL-004, and ALD-001 showed lower levels than results from the previous calendar year (Section 5 Figure 3). Averages for AKN-001, AKN-003, and AKN-008 showed no change in activity from 2011; AKN-005, AKN-006, and BWL-006 each showed activity increases for 2012. The overall average for Cs-137 detections is higher than in 2011. However, it should be noted that the total number of detections is lower.

Gamma analysis results for Cs-137 from ESOP and DOE-SR sampling in 2012 are presented in Section 5.0, Table 2. The Patterson Mill Road/BWL-004 colocations showed less than minimum detectable concentration for the DOE-SR sample and 0.04 (± 0.006) pCi/g for the ESOP sample. The Allendale Gate/BWL-006 colocations each had detections, with the DOE-SR sample showing 0.30 (± 0.044) pCi/g and the ESOP sample showing 0.19 (± 0.011) pCi/g (SRNS 2012). Differences in analysis, sampling methods, and the dates samples were obtained may account for any discrepancies between the data.

For the other DOE-SR stations, the closest ESOP stations were selected for comparison, except for the DOE-SR Highway 21/167 detection of 0.23 (± 0.038) pCi/g (SRNS 2013). This gamma sampling location does not have a corresponding ESOP sampling location and any attempted comparison would be invalid. For this reason, it was not used for calculating the DOE-SR mean, median, and standard deviation and is also not shown in Table 2.

DOE-SR detected Cs-137 at 5 of 11 sampling stations that had a comparable ESOP location or colocation. ESOP had detections at 5 of 11 comparable locations, although some ESOP locations correspond with more than one DOE-SR location. ALD-001, which has no comparable DOE-SR location, had no detections in 2012.

Average Cs-137 levels were also compared, using only detections to calculate the mean, median, and standard deviation (Section 5 Table 2). The DOE-SR average of 0.17 (± 0.095) pCi/g (SRNS 2013) was within one standard deviation of the ESOP average of 0.14 (± 0.128) pCi/g.

3.0 CONCLUSIONS AND RECOMMENDATIONS

ESOP conducted independent vegetation monitoring in 2012 at 17 locations around the perimeter of SRS and three locations 25 miles from the center of SRS. Tritium was detected in vegetation from 11 of 17 of the perimeter stations and one of the 25-mile stations. The highest activity sample, at 2142 (± 71) pCi/L, was collected on the west side of SRS at SCDHEC location AKN-001. The average tritium activity detected at the SRS perimeter increased from 572 (± 453) pCi/L in 2011 to 742 (± 317) pCi/L in 2012. The average Cs-137 level was also higher in 2012, at 0.17 (± 0.19) pCi/g, but the total number of detections was lower.

A comparison of ESOP and DOE-SR tritium data was performed. Tritium was detected at one of two colocations by DOE-SR (Patterson Mill Road) and at neither location by ESOP (SRNS 2013). At the SRS perimeter locations, DOE-SR had detections in four samples while ESOP had detections in two. While the DOE-SR and ESOP tritium data sets appear to be dissimilar, both the mean and median are within one SD of each other.

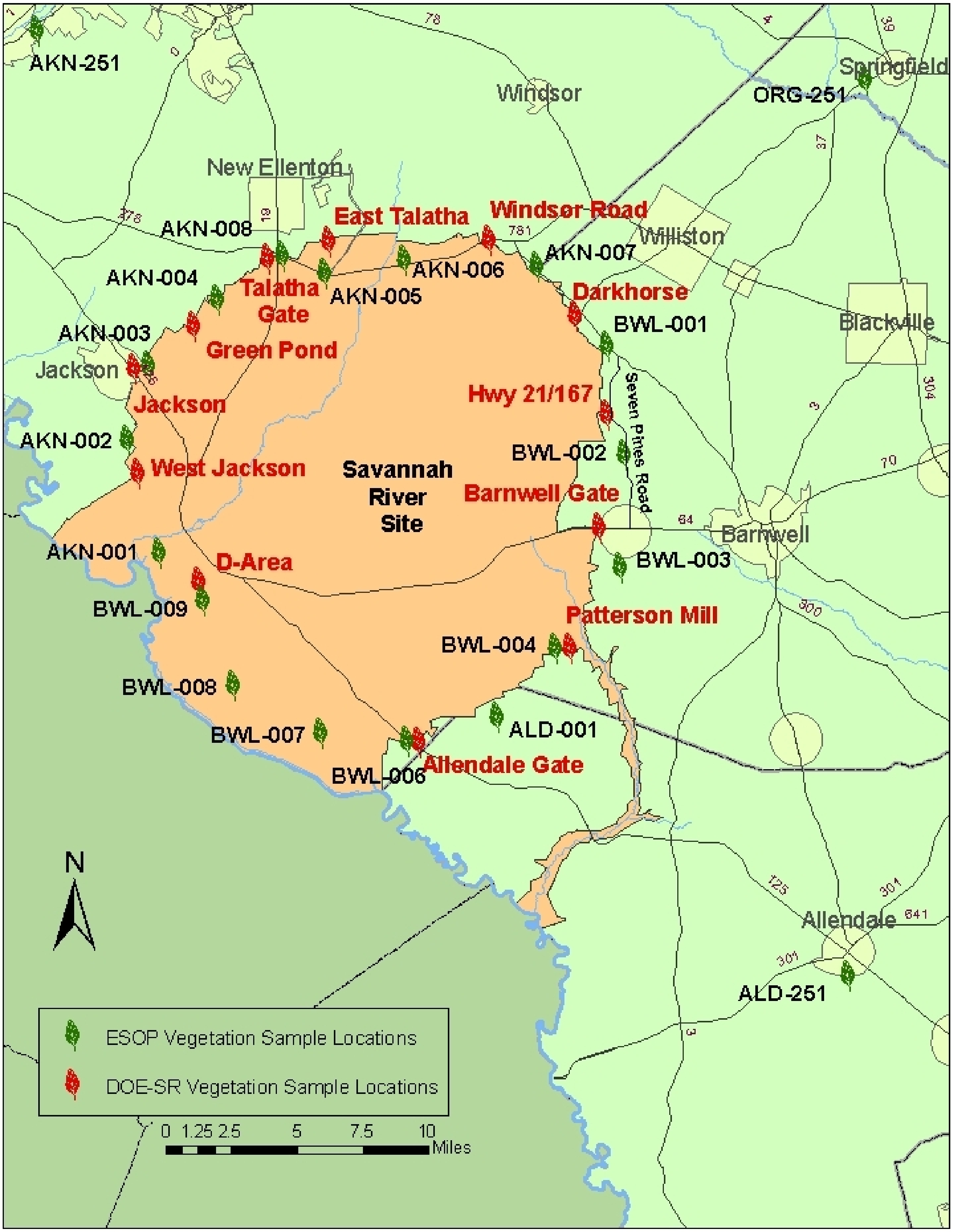
A comparison of DOE-SR data and ESOP Cs-137 data was also performed. DOE-SR and ESOP data were similar, within two standard deviations of each other. Six ESOP locations showed either decreasing or static activity in 2012 while three showed increasing activity.

ESOP data supports the DOE-SR conclusion that elevated tritium levels at the site perimeter are due to atmospheric releases from SRS, although Plant Vogtle, a commercial nuclear power plant across the Savannah River from SRS, may also have an effect. The average tritium level at the SRS perimeter was higher than the average tritium level at the 25-mile locations, which serves as an indicator of decreasing tritium levels as the distance from SRS increases.

There are differences in analysis and sampling methods between the programs (e.g., ESOP collects leaves from trees, whereas DOE-SR conducts annual grass collections). Perhaps reconciling ESOP and DOE-SR methods would provide better comparability of data. Additionally, DOE-SR tritium data is reported in pCi/g without denoting whether this activity relates to a gram of water or a gram of wet vegetation. ESOP recommends that DOE-SR report tritium activity in both pCi/g and pCi/mL, to reflect the tritium activity in the water extracted from the sample.

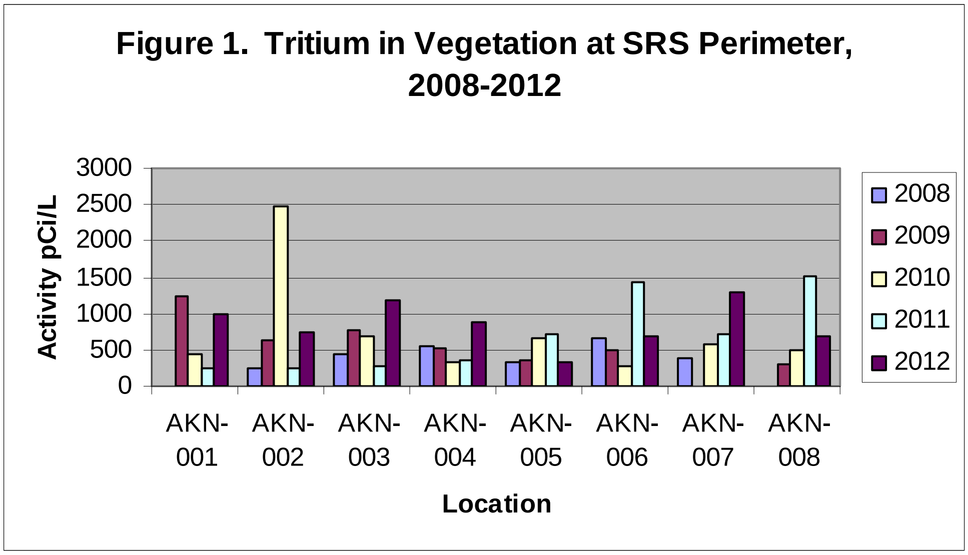
4.0 Radiological Monitoring of Terrestrial Vegetation

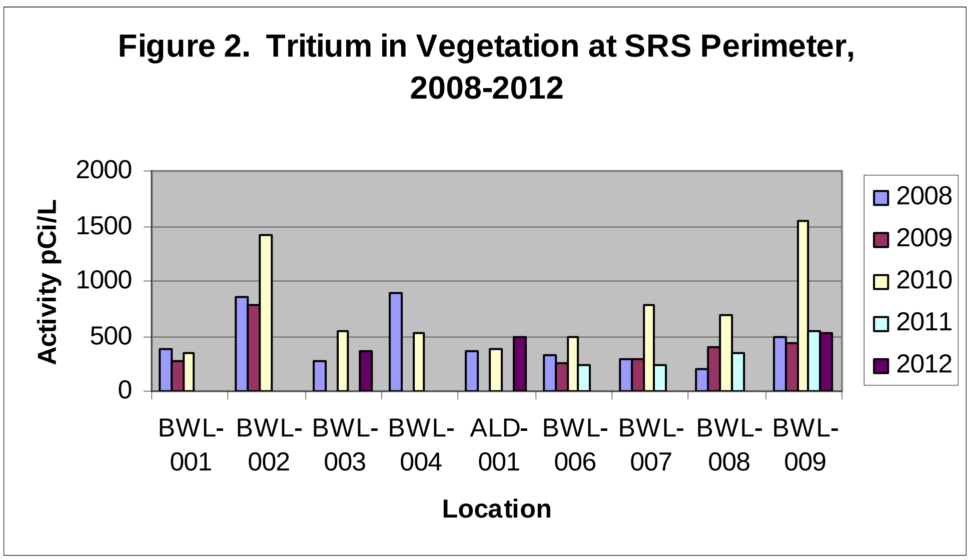
Map 1. ESOP and DOE-SR Radiological Vegetation Sampling Locations, 2012



5.0 Tables and Figures

Radiological Monitoring of Terrestrial Vegetation

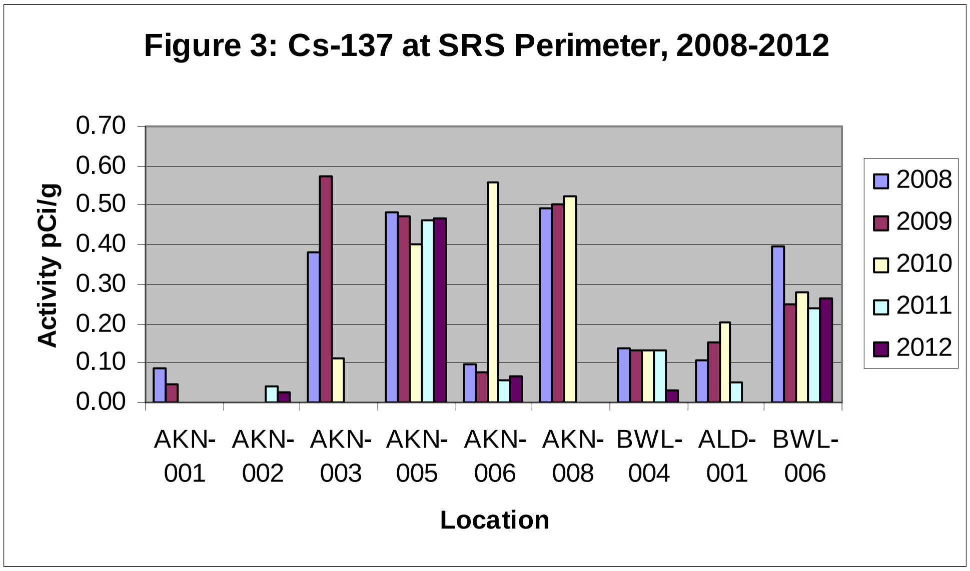




Notes:
(1) These graphs depict the average of all detections for calendar years 2008-2012 by sampling station.
(2) 2009 was the first year AKN-008 was sampled for tritium.
(3) Missing bars indicate an average that was less than the lower limit of detection.
(4) The bars for AKN-004, 006, and 007 as well as BWL-003 and ALD-001 represent a single detection.
(5) There was one 25-mile location detection in 2012: a 329 pCi/L detection at AKN-251 in June.

Tables and Figures

Radiological Monitoring of Terrestrial Vegetation



Notes:
(1) This graph depicts the average of all detections for calendar years 2008-2012 by sampling station.
(2) Missing bars indicate an average that was less than the minimum detectable activity.
(4) The bar for AKN-002 represents a single detection.

Tables and Figures

Radiological Monitoring of Terrestrial Vegetation

Table 1. Comparison of Tritium Analyses, DOE-SR and ESOP Data, 2012

DOE-SR Data					ESOP Data			
Station	**Date**	**pCi/g**	**+/- 1 sig**	**pCi /L[a]**	**Station**	**Date**	**pCi/L**	**+/- 2 sig**
D-Area	4/17/2012	0.080	0.024	381	BWL-009 [b]	3/23/2012	271	101
West Jackson	4/16/2012	0.090	0.022	428	AKN-002 [b]	2/28/2012	1290	135
Jackson	4/16/2012	0.121	0.121	576	AKN-003 [b]	3/20/2012	876	122
Green Pond	4/16/2012	0.102	0.026	485	AKN-004 [b]	3/20/2012	876	122
Talatha Gate	4/16/2012	0.130	0.022	618	AKN-005 b	3/20/2012	<LLD	NA
East Talatha	4/16/2012	0.154	0.026	733	AKN-006 [b]	3/20/2012	690	116
Windsor Road	4/16/2012	0.077	0.024	366	AKN-007 [b]	2/28/2012	<LLD	NA
Darkhorse	4/17/2012	0.134	0.021	637	BWL-001 [b]	2/28/2012	<LLD	NA
Highway 21/167	4/17/2012	0.089	0.024	423	BWL-002 [b]	2/28/2012	<LLD	NA
Barnwell Gate	4/17/2012	0.114	0.025	542	BWL-004 [a]	2/28/2012	<LLD	NA
Patterson Mill Road [c]	4/17/2012	0.068	0.019	323	BWL-004 [c]	2/28/2012	<LLD	NA
Allendale Gate [c]	4/17/2012	0.134	0.026	637	BWL-006 [c]	3/23/2012	<LLD	NA

	DOE-SR		ESOP
Average	513	**Average**	801
Std Dev	130	**Std Dev**	369
Median	514	**Median**	876

< LLD Denotes Less Than Reported Lower Limit of Detection
NA Denotes Not Applicable
[a] Converted Using the Following Formula: pCi/L = [pCi/g x (1/0.3)] / (1 - 0.3) = pCi/mL x 1000
The above formula is used for comparison purposes only.
b Comparable ESOP Location
c Colocation

Tables and Figures

Radiological Monitoring of Terrestrial Vegetation

Table 2. Comparison of Cs-137 Analyses, DOE-SR and ESOP Data, 2012

DOE-SR Data				ESOP Data			
Location	**Date**	**pCi/g (dry)**	**+/- 1 sig**	**Station**	**Date**	**pCi/g (fresh)**	**+/- 2 sig**
D-Area	4/17/2012	<MDC	NA	AKN-001[a]	3/20/2012	<MDA	NA
West Jackson	4/16/2012	<MDC	NA	AKN-002 [a]	2/28/2012	<MDA	NA
Jackson	4/16/2012	<MDC	NA	AKN-003 [a]	3/20/2012	<MDA	NA
Green Pond	4/16/2012	0.15	0.05	AKN-003 [a]	3/20/2012	<MDA	NA
Talatha Gate	4/16/2012	0.10	0.04	AKN-008 [a]	3/20/2012	<MDA	NA
East Talatha	4/16/2012	0.23	0.05	AKN-005 [a]	3/20/2012	0.30	0.03
Windsor Road	4/16/2012	<MDC	NA	AKN-006 [a]	3/20/2012	<MDA	NA
Darkhorse	4/17/2012	<MDC	NA	AKN-006 [a]	3/20/2012	<MDA	NA
Barnwell Gate	4/17/2012	0.07	0.02	BWL-004 [a]	2/28/2012	0.03	0.01
Patterson Mill Road [b]	4/17/2012	<MDC	NA	BWL-004 [b]	2/28/2012	0.03	0.01
Allendale Gate [b]	4/17/2012	0.30	0.04	BWL-006 [b]	3/23/2012	0.19	0.02

Average	0.17	**Average**	0.14
Std Dev	0.09	**Std Dev**	0.13
Median	0.15	**Median**	0.11

<MDC denotes less than the WSRC Minimum Detectable Concentration
<MDA denotes less than the SCDHEC/ESOP Minimum Detectable Concentration
[a] Comparable ESOP location
b Colocation

6.0 Data

Radiological Monitoring of Terrestrial Vegetation

2012 Tritium in Vegetation **12**

2012 Gamma in Vegetation **16**

Notes:
1. pCi/L - picocuries per liter
2. pCi/g - picocuries per gram
3. LLD - Lower Limit of Detection
4. MDA - Minimum Detectable Activity
5. NA-Not Applicable

Radiological Monitoring of Terrestrial Vegetation Data; Perimeter Stations
2012 Tritium in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/20/2012	6/26/2012	9/20/2012	12/13/2012
VGAKN-001	Tritium Activity	242	570	2142	<LLD
VGAKN-001	Tritium Confidence Interval	100	109	152	NA
VGAKN-001	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/13/2012	9/14/2012	12/1/2012
VGAKN-002	Tritium Activity	1290	<LLD	<LLD	207
VGAKN-002	Tritium Confidence Interval	135	NA	NA	95
VGAKN-002	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/20/2012	6/13/2012	9/27/2012	12/20/2012
VGAKN-003	Tritium Activity	876	<LLD	1479	<LLD
VGAKN-003	Tritium Confidence Interval	122	NA	136	NA
VGAKN-003	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/20/2012	6/13/2012	9/20/2012	12/13/2012
VGAKN-004	Tritium Activity	876	<LLD	<LLD	<LLD
VGAKN-004	Tritium Confidence Interval	122	NA	NA	NA
VGAKN-004	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/20/2012	6/27/2012	9/27/2012	12/18/2012
VGAKN-005	Tritium Activity	<LLD	239	<LLD	394
VGAKN-005	Tritium Confidence Interval	NA	97	NA	102
VGAKN-005	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/20/2012	6/26/2012	9/20/2012	12/18/2012
VGAKN-006	Tritium Activity	690	<LLD	<LLD	<LLD
VGAKN-006	Tritium Confidence Interval	116	NA	NA	NA
VGAKN-006	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/13/2012	9/14/2012	12/1/2012
VGAKN-007	Tritium Activity	<LLD	<LLD	<LLD	1297
VGAKN-007	Tritium Confidence Interval	NA	NA	NA	131
VGAKN-007	Tritium LLD	216	208	209	207

Radiological Monitoring of Terrestrial Vegetation Data; Perimeter Stations
2012 Tritium in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/20/2012	6/26/2012	9/27/2012	12/13/2012
VGAKN-008	Tritium Activity	937	<LLD	412	<LLD
VGAKN-008	Tritium Confidence Interval	124	NA	103	NA
VGAKN-008	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/13/2012	9/14/2012	12/1/2012
VGBWL-001	Tritium Activity	<LLD	<LLD	<LLD	<LLD
VGBWL-001	Tritium Confidence Interval	NA	NA	NA	NA
VGBWL-001	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/13/2012	9/14/2012	12/1/2012
VGBWL-002	Tritium Activity	<LLD	<LLD	<LLD	<LLD
VGBWL-002	Tritium Confidence Interval	NA	NA	NA	NA
VGBWL-002	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/13/2012	9/14/2012	12/1/2012
VGBWL-003	Tritium Activity	<LLD	<LLD	<LLD	367
VGBWL-003	Tritium Confidence Interval	NA	NA	NA	101
VGBWL-003	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/13/2012	9/14/2012	12/1/2012
VGBWL-004	Tritium Activity	<LLD	<LLD	<LLD	<LLD
VGBWL-004	Tritium Confidence Interval	NA	NA	NA	NA
VGBWL-004	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/13/2012	9/20/2012	12/18/2012
VGALD-001	Tritium Activity	<LLD	497	<LLD	<LLD
VGALD-001	Tritium Confidence Interval	NA	105	NA	NA
VGALD-001	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/23/2012	6/26/2012	9/20/2012	12/18/2012
VGBWL-006	Tritium Activity	<LLD	<LLD	<LLD	<LLD
VGBWL-006	Tritium Confidence Interval	NA	NA	NA	NA
VGBWL-006	Tritium LLD	216	208	209	207

Radiological Monitoring of Terrestrial Vegetation Data; Perimeter Stations
2012 Tritium in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/23/2012	6/26/2012	9/20/2012	12/18/2012
VGBWL-007	Tritium Activity	<LLD	<LLD	<LLD	<LLD
VGBWL-007	Tritium Confidence Interval	NA	NA	NA	NA
VGBWL-007	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/23/2012	6/26/2012	9/20/2012	12/13/2012
VGBWL-008	Tritium Activity	<LLD	<LLD	<LLD	<LLD
VGBWL-008	Tritium Confidence Interval	NA	NA	NA	NA
VGBWL-008	Tritium LLD	216	208	209	207

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	3/23/2012	6/26/2012	9/20/2012	12/13/2012
VGBWL-009	Tritium Activity	271	223	<LLD	1107
VGBWL-009	Tritium Confidence Interval	101	96	NA	125
VGBWL-009	Tritium LLD	216	209	216	211

Radiological Monitoring of Terrestrial Vegetation Data; 25-Mile Stations
2012 Tritium in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/11/2012	9/14/2012	12/1/2012
VGAKN-251	Tritium Activity	<LLD	329	<LLD	<LLD
VGAKN-251	Tritium Confidence Interval	NA	101	NA	NA
VGAKN-251	Tritium LLD	216	209	216	211

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/11/2012	9/14/2012	12/1/2012
VGORG-251	Tritium Activity	<LLD	<LLD	<LLD	<LLD
VGORG-251	Tritium Confidence Interval	NA	NA	NA	NA
VGORG-251	Tritium LLD	216	209	216	211

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/L)	2/28/2012	6/11/2012	9/14/2012	12/1/2012
VGALD-251	Tritium Activity	<LLD	<LLD	<LLD	<LLD
VGALD-251	Tritium Confidence Interval	NA	NA	NA	NA
VGALD-251	Tritium LLD	216	209	216	211

Radiological Monitoring of Terrestrial Vegetation Data; Perimeter Stations
2012 Gamma in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/g) fresh weight	3/20/12	6/26/12	9/20/12	12/13/12
VGAKN-001	Be-7 Activity	3.17	0.88	1.28	2.18
VGAKN-001	Be-7 Confidence Interval	0.63	0.20	0.27	0.33
VGAKN-001	Be-7 MDA	0.66	0.22	0.30	0.37
VGAKN-001	K-40 Activity	2.36	2.43	1.90	1.39
VGAKN-001	K-40 Confidence Interval	0.30	0.31	0.27	0.23
VGAKN-001	K-40 MDA	0.34	0.34	0.32	0.29
VGAKN-001	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-001	Co-60 Confidence Interval	NA	NA	NA	NA
VGAKN-001	Co-60 MDA	0.01	0.00	0.01	0.01
VGAKN-001	Cs-137 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-001	Cs-137 Confidence Interval	NA	NA	NA	NA
VGAKN-001	Cs-137 MDA	0.01	0.02	0.01	0.01
VGAKN-001	Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-001	Pb-212 Confidence Interval	NA	NA	NA	NA
VGAKN-001	Pb-212 MDA	0.03	0.04	0.04	0.03
VGAKN-001	Pb-214 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-001	Pb-214 Confidence Interval	NA	NA	NA	NA
VGAKN-001	Pb-214 MDA	0.04	0.04	0.04	0.04
VGAKN-001	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-001	Am-241 Confidence Interval	NA	NA	NA	NA
VGAKN-001	Am-241 MDA	0.17	0.28	0.30	0.09

	Results (pCi/g) fresh weight	2/28/12	6/26/12	9/14/12	12/11/12
VGAKN-002	Be-7 Activity	2.46	1.51	3.14	1.56
VGAKN-002	Be-7 Confidence Interval	0.70	0.25	0.47	0.34
VGAKN-002	Be-7 MDA	0.85	0.25	0.42	0.45
VGAKN-002	K-40 Activity	1.89	2.40	1.62	1.85
VGAKN-002	K-40 Confidence Interval	0.29	0.32	0.28	0.29
VGAKN-002	K-40 MDA	0.35	0.36	0.37	0.34
VGAKN-002	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-002	Co-60 Confidence Interval	NA	NA	NA	NA
VGAKN-002	Co-60 MDA	0.02	0.01	0.02	0.02
VGAKN-002	Cs-137 Activity	<MDA	0.03	<MDA	<MDA
VGAKN-002	Cs-137 Confidence Interval	NA	0.01	NA	NA
VGAKN-002	Cs-137 MDA	0.02	0.02	0.02	0.02
VGAKN-002	Pb-212 Activity	<MDA	0.06	0.06	0.17
VGAKN-002	Pb-212 Confidence Interval	NA	0.03	0.03	0.04
VGAKN-002	Pb-212 MDA	0.04	0.04	0.04	0.06
VGAKN-002	Pb-214 Activity	0.14	0.09	0.11	0.30
VGAKN-002	Pb-214 Confidence Interval	0.03	0.04	0.03	0.04
VGAKN-002	Pb-214 MDA	0.05	0.05	0.05	0.05
VGAKN-002	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-002	Am-241 Confidence Interval	NA	NA	NA	NA
VGAKN-002	Am-241 MDA	0.28	0.18	0.24	0.12

Radiological Monitoring of Terrestrial Vegetation Data; Perimeter Stations
2012 Gamma in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/g) fresh weight	3/20/12	6/27/12	9/27/12	12/20/12
VGAKN-003	Be-7 Activity	<MDA	0.54	<MDA	<MDA
VGAKN-003	Be-7 Confidence Interval	NA	0.18	NA	NA
VGAKN-003	Be-7 MDA	0.75	0.20	0.28	0.25
VGAKN-003	K-40 Activity	2.21	3.42	<MDA	2.46
VGAKN-003	K-40 Confidence Interval	0.30	0.35	NA	0.29
VGAKN-003	K-40 MDA	0.34	0.32	0.30	0.28
VGAKN-003	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-003	Co-60 Confidence Interval	NA	NA	NA	NA
VGAKN-003	Co-60 MDA	0.01	0.01	0.02	0.01
VGAKN-003	Cs-137 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-003	Cs-137 Confidence Interval	NA	NA	NA	NA
VGAKN-003	Cs-137 MDA	0.02	0.02	0.02	0.02
VGAKN-003	Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-003	Pb-212 Confidence Interval	NA	NA	NA	NA
VGAKN-003	Pb-212 MDA	0.03	0.03	0.04	0.03
VGAKN-003	Pb-214 Activity	<MDA	<MDA	<MDA	0.05
VGAKN-003	Pb-214 Confidence Interval	NA	NA	NA	0.02
VGAKN-003	Pb-214 MDA	0.04	0.04	0.04	0.04
VGAKN-003	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-003	Am-241 Confidence Interval	NA	NA	NA	NA
VGAKN-003	Am-241 MDA	0.25	0.15	0.31	0.09

	Results (pCi/g) fresh weight	3/20/12	6/27/12	9/27/12	12/18/12
VGAKN-005	Be-7 Activity	2.09	0.90	1.90	1.84
VGAKN-005	Be-7 Confidence Interval	0.66	0.26	0.43	0.32
VGAKN-005	Be-7 MDA	0.76	0.28	0.44	0.41
VGAKN-005	K-40 Activity	2.10	2.33	2.00	2.95
VGAKN-005	K-40 Confidence Interval	0.29	0.30	0.30	0.29
VGAKN-005	K-40 MDA	0.34	0.34	0.36	0.16
VGAKN-005	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-005	Co-60 Confidence Interval	NA	NA	NA	NA
VGAKN-005	Co-60 MDA	0.01	0.01	0.01	0.01
VGAKN-005	Cs-137 Activity	0.30	0.59	0.42	0.57
VGAKN-005	Cs-137 Confidence Interval	0.03	0.05	0.04	0.04
VGAKN-005	Cs-137 MDA	0.02	0.02	0.02	0.02
VGAKN-005	Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-005	Pb-212 Confidence Interval	NA	NA	NA	NA
VGAKN-005	Pb-212 MDA	0.03	0.03	0.04	0.03
VGAKN-005	Pb-214 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-005	Pb-214 Confidence Interval	NA	NA	NA	NA
VGAKN-005	Pb-214 MDA	0.05	0.04	0.05	0.03
VGAKN-005	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-005	Am-241 Confidence Interval	NA	NA	NA	NA
VGAKN-005	Am-241 MDA	0.32	0.27	0.20	0.10

Radiological Monitoring of Terrestrial Vegetation Data; Perimeter Stations
2012 Gamma in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/g) fresh weight	3/20/12	6/26/12	9/20/12	12/18/12
VGAKN-006	Be-7 Activity	2.56	1.41	1.60	2.67
VGAKN-006	Be-7 Confidence Interval	0.62	0.25	0.29	0.35
VGAKN-006	Be-7 MDA	0.70	0.24	0.31	0.37
VGAKN-006	K-40 Activity	1.23	1.26	1.73	1.61
VGAKN-006	K-40 Confidence Interval	0.25	0.25	0.27	0.20
VGAKN-006	K-40 MDA	0.36	0.35	0.32	0.17
VGAKN-006	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-006	Co-60 Confidence Interval	NA	NA	NA	NA
VGAKN-006	Co-60 MDA	0.02	0.01	0.02	0.01
VGAKN-006	Cs-137 Activity	<MDA	0.06	0.07	<MDA
VGAKN-006	Cs-137 Confidence Interval	NA	0.01	0.02	NA
VGAKN-006	Cs-137 MDA	0.02	0.01	0.02	0.01
VGAKN-006	Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-006	Pb-212 Confidence Interval	NA	NA	NA	NA
VGAKN-006	Pb-212 MDA	0.04	0.04	0.03	0.03
VGAKN-006	Pb-214 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-006	Pb-214 Confidence Interval	NA	NA	NA	NA
VGAKN-006	Pb-214 MDA	0.04	0.04	0.04	0.04
VGAKN-006	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-006	Am-241 Confidence Interval	NA	NA	NA	NA
VGAKN-006	Am-241 MDA	0.34	0.32	0.17	0.09

	Results (pCi/g) fresh weight	3/20/12	6/26/12	9/27/12	12/13/12
VGAKN-008	Be-7 Activity	1.61	0.69	1.11	0.99
VGAKN-008	Be-7 Confidence Interval	0.51	0.20	0.34	0.27
VGAKN-008	Be-7 MDA	0.63	0.22	0.38	0.39
VGAKN-008	K-40 Activity	2.39	2.68	<MDA	2.17
VGAKN-008	K-40 Confidence Interval	0.31	0.31	NA	0.27
VGAKN-008	K-40 MDA	0.34	0.32	0.35	0.27
VGAKN-008	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-008	Co-60 Confidence Interval	NA	NA	NA	NA
VGAKN-008	Co-60 MDA	0.02	0.01	0.02	0.01
VGAKN-008	Cs-137 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-008	Cs-137 Confidence Interval	NA	NA	NA	NA
VGAKN-008	Cs-137 MDA	0.02	0.02	0.02	0.01
VGAKN-008	Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-008	Pb-212 Confidence Interval	NA	NA	NA	NA
VGAKN-008	Pb-212 MDA	0.03	0.03	0.04	0.03
VGAKN-008	Pb-214 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-008	Pb-214 Confidence Interval	NA	NA	NA	NA
VGAKN-008	Pb-214 MDA	0.04	0.04	0.05	0.04
VGAKN-008	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGAKN-008	Am-241 Confidence Interval	NA	NA	NA	NA
VGAKN-008	Am-241 MDA	0.34	0.15	0.16	0.10

Radiological Monitoring of Terrestrial Vegetation Data; Perimeter Stations
2012 Gamma in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/g) fresh weight	2/28/12	6/13/12	9/14/12	12/11/12
VGBWL-004	Be-7 Activity	2.88	2.39	<MDA	2.05
VGBWL-004	Be-7 Confidence Interval	0.73	0.29	NA	0.39
VGBWL-004	Be-7 MDA	0.82	0.22	0.43	0.51
VGBWL-004	K-40 Activity	1.87	1.70	1.25	2.04
VGBWL-004	K-40 Confidence Interval	0.28	0.26	0.29	0.30
VGBWL-004	K-40 MDA	0.34	0.31	0.39	0.33
VGBWL-004	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGBWL-004	Co-60 Confidence Interval	NA	NA	NA	NA
VGBWL-004	Co-60 MDA	0.02	0.01	0.01	0.02
VGBWL-004	Cs-137 Activity	0.03	0.02	<MDA	<MDA
VGBWL-004	Cs-137 Confidence Interval	0.01	0.01	NA	NA
VGBWL-004	Cs-137 MDA	0.01	0.01	0.02	0.02
VGBWL-004	Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
VGBWL-004	Pb-212 Confidence Interval	NA	NA	NA	NA
VGBWL-004	Pb-212 MDA	0.03	0.03	0.04	0.06
VGBWL-004	Pb-214 Activity	<MDA	<MDA	<MDA	0.14
VGBWL-004	Pb-214 Confidence Interval	NA	NA	NA	0.03
VGBWL-004	Pb-214 MDA	0.04	0.04	0.05	0.05
VGBWL-004	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGBWL-004	Am-241 Confidence Interval	NA	NA	NA	NA
VGBWL-004	Am-241 MDA	0.36	0.28	0.20	0.12

	Results (pCi/g) fresh weight	2/28/12	6/13/12	9/20/12	12/18/12
VGALD-001	Be-7 Activity	<MDA	0.62	0.76	<MDA
VGALD-001	Be-7 Confidence Interval	NA	0.23	0.30	NA
VGALD-001	Be-7 MDA	0.80	0.27	0.37	0.28
VGALD-001	K-40 Activity	2.16	2.68	2.73	2.87
VGALD-001	K-40 Confidence Interval	0.29	0.31	0.35	0.30
VGALD-001	K-40 MDA	0.34	0.34	0.37	0.26
VGALD-001	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGALD-001	Co-60 Confidence Interval	NA	NA	NA	NA
VGALD-001	Co-60 MDA	0.00	0.01	0.02	0.01
VGALD-001	Cs-137 Activity	<MDA	<MDA	<MDA	<MDA
VGALD-001	Cs-137 Confidence Interval	NA	NA	NA	NA
VGALD-001	Cs-137 MDA	0.02	0.02	0.02	0.01
VGALD-001	Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
VGALD-001	Pb-212 Confidence Interval	NA	NA	NA	NA
VGALD-001	Pb-212 MDA	0.03	0.04	0.04	0.03
VGALD-001	Pb-214 Activity	0.07	<MDA	0.09	<MDA
VGALD-001	Pb-214 Confidence Interval	0.03	NA	0.04	NA
VGALD-001	Pb-214 MDA	0.04	0.04	0.05	0.04
VGALD-001	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGALD-001	Am-241 Confidence Interval	NA	NA	NA	NA
VGALD-001	Am-241 MDA	0.20	0.35	0.30	0.09

Radiological Monitoring of Terrestrial Vegetation Data; Perimeter Stations
2012 Gamma in Vegetation

Location Description	Analyte	Collection Date/Result	Collection Date/Result	Collection Date/Result	Collection Date/Result
	Results (pCi/g) fresh weight	3/23/12	6/26/12	9/20/12	12/18/12
VGBWL-006	Be-7 Activity	<MDA	0.76	1.45	1.25
VGBWL-006	Be-7 Confidence Interval	NA	0.18	0.45	0.35
VGBWL-006	Be-7 MDA	0.71	0.21	0.51	0.50
VGBWL-006	K-40 Activity	2.23	1.51	1.86	2.21
VGBWL-006	K-40 Confidence Interval	0.29	0.25	0.30	0.32
VGBWL-006	K-40 MDA	0.34	0.35	0.39	0.35
VGBWL-006	Co-60 Activity	<MDA	<MDA	<MDA	<MDA
VGBWL-006	Co-60 Confidence Interval	NA	NA	NA	NA
VGBWL-006	Co-60 MDA	0.01	0.02	0.01	0.02
VGBWL-006	Cs-137 Activity	0.19	0.30	0.42	0.16
VGBWL-006	Cs-137 Confidence Interval	0.02	0.03	0.04	0.02
VGBWL-006	Cs-137 MDA	0.02	0.02	0.02	0.03
VGBWL-006	Pb-212 Activity	<MDA	<MDA	<MDA	<MDA
VGBWL-006	Pb-212 Confidence Interval	NA	NA	NA	NA
VGBWL-006	Pb-212 MDA	0.03	0.04	0.04	0.04
VGBWL-006	Pb-214 Activity	<MDA	<MDA	<MDA	<MDA
VGBWL-006	Pb-214 Confidence Interval	NA	NA	NA	NA
VGBWL-006	Pb-214 MDA	0.04	0.04	0.05	0.04
VGBWL-006	Am-241 Activity	<MDA	<MDA	<MDA	<MDA
VGBWL-006	Am-241 Confidence Interval	NA	NA	NA	NA
VGBWL-006	Am-241 MDA	0.28	0.24	0.35	0.12

7.0 Summary Statistics

Radiological Monitoring of Terrestrial Vegetation Data

2012 Vegetation Tritium Statistics 22

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Notes:

1. pCi/L-picocuries per liter
2. pCi/g -picocuries per gram
3. N-Number of Samples With Detections
4. Std Dev-Standard Deviation
5. LLD-Lower Limit of Detection
6. MDA-Minimum Detectable Activity
7. ND-Non Detects
8. NA-Not Applicable

Radiological Monitoring of Terrestrial Vegetation Summary Statistics
2012 Vegetation Tritium Summary

Table 1. Tritium Levels in Vegetation from SRS Perimeter Stations

Tritium Levels (pCi/L) in Vegetation from SRS Perimeter Stations, 2012						
Station	**N (ND)**	**Average**	**SD**	**Median**	**Maximum**	**Minimum**
AKN-001	3 (1)	985	1015	570	2142	<LLD
AKN-002	2 (2)	749	766	749	1290	<LLD
AKN-003	2 (2)	1178	426	1178	1479	<LLD
AKN-004	1 (3)	876	NA	876	876	<LLD
AKN-005	2 (2)	317	110	317	394	<LLD
AKN-006	1 (3)	690	NA	690	690	<LLD
AKN-007	1 (3)	1297	NA	1297	1297	<LLD
AKN-008	2 (2)	675	372	675	937	<LLD
BWL-001	0 (4)	NA	NA	NA	<LLD	<LLD
BWL-002	0 (4)	NA	NA	NA	<LLD	<LLD
BWL-003	1 (3)	367	NA	367	101	<LLD
BWL-004	0 (4)	NA	NA	NA	<LLD	<LLD
ALD-001	1 (3)	497	NA	497	497	<LLD
BWL-006	0 (4)	NA	NA	NA	<LLD	<LLD
BWL-007	0 (4)	NA	NA	NA	<LLD	<LLD
BWL-008	0 (4)	NA	NA	NA	<LLD	<LLD
BWL-009	3 (1)	534	497	271	1107	<LLD

Table 2. Average Tritium Levels in Vegetation from SRS Perimeter Stations

Tritium Levels (pCi/L) in SRS Perimeter Vegetation Samples, 2012					
N (ND)	**Average**	**SD**	**Median**	**Maximum**	**Minimum**
19 (49)	742	317	675	983	<LLD

Table 3. Tritium Levels in 25-mile Radius Vegetation Samples

Tritium Levels (pCi/L) in 25-mile Radius Vegetation Samples, 2012						
Station	**N (ND)**	**Average**	**SD**	**Median**	**Maximum**	**Minimum**
AKN-251	1 (3)	329	NA	329	329	<LLD
ALD-251	0 (4)	NA	NA	NA	<LLD	<LLD
ORG-251	0 (4)	NA	NA	NA	<LLD	<LLD

Table 4. Average Tritium Levels in 25-mile Radius Vegetation Samples

Tritium Levels (pCi/L) in 25-mile Radius Vegetation Samples, 2012					
N (ND)	**Average**	**SD**	**Median**	**Maximum**	**Minimum**
1 (11)	329	NA	329	329	<LLD

Note: All measures of central tendency exclude non-detections.

Radiological Monitoring of Terrestrial Vegetation Summary Statistics
2012 Vegetation Cesium-137 Summary

Table 5. Cesium-137 Levels in SRS Perimeter Vegetation Samples

Cesium-137 Levels (pCi/g-fresh) in SRS Perimeter Vegetation Samples, 2012						
Station	**N (ND)**	**Average**	**SD**	**Median**	**Maximum**	**Minimum**
AKN-001	0 (4)	<MDA	NA	NA	<MDA	<MDA
AKN-002	1 (3)	0.03	NA	0.03	0.03	<MDA
AKN-003	0 (4)	<MDA	NA	NA	<MDA	<MDA
AKN-005	4 (0)	0.47	0.14	0.49	0.59	0.30
AKN-006	2 (2)	0.07	0.01	0.07	0.07	0.06
AKN-008	0 (4)	<MDA	NA	NA	<MDA	<MDA
BWL-004	2 (2)	0.03	0.01	0.03	0.03	0.02
ALD-001	0 (4)	<MDA	NA	0.05	<MDA	<MDA
BWL-006	4 (0)	0.27	0.12	0.24	0.42	0.16

Table 6. Average Cesium-137 Levels in SRS Perimeter Vegetation Samples

Cesium-137 Levels (pCi/g-fresh) in SRS Perimeter Samples, 2012					
N (ND)	**Average**	**SD**	**Median**	**Maximum**	**Minimum**
13 (23)	0.17	0.19	0.06	0.18	0.17

Note: All measures of central tendency exclude non-detections.

List of Acronyms

ALD Sample locations in Allendale County
AKN Sample locations in Aiken County
BWL Sample locations in Barnwell County
DOE-SR Department of Energy-Savannah River
ESOP Environmental Surveillance and Oversight Program
LLD Lower Limit of Detection: The lowest concentration of a radioactive isotope that can be detected by a given instrument.
MCL Maximum Contaminant Level: The threshold concentration of a contaminant above which water is not suitable for drinking.
MDA Minimum Detectable Activity: The smallest concentration of radioactivity in a sample that can be reliably detected.
SCDHEC South Carolina Department of Health and Environmental Control
SD Standard Deviation: A measure of the variation from the mean within a body of data.
SRS Savannah River Site
USEPA United States Environmental Protection Agency

Units of Measure

± plus or minus one standard deviation
pCi/g picocuries per gram
pCi/L picocuries per liter
pCi/mL picocuries per milliliter

List of Isotopes and Abbreviations

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

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2012 Radiological Monitoring of Edible Vegetation Adjacent to SRS

Environmental Surveillance and Oversight Program

01EV002
Robert Adams, Project Manager
January 01, 2012 - December 31, 2012

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D H E C
PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

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1.0 Project Summary

Radionuclide uptake by vegetation may occur by direct absorption into the plant through the foliage or roots, and grazing animal dose exposure occurs primarily by ingestion of the contaminated plant (Kathren 1984). Plant uptake of radionuclides depends upon many factors including species, tissue type, soil-water-plant relationships, soil type, and the chemical nature of the radionuclide in the soil (Hanlon 2004). "Sampling and analyzing native vegetation can provide information about the presence and movement of radionuclides in the environment" (Lawrence Livermore National Laboratory, LLNL 1997). Any acronyms not defined in the text are defined in the acronyms, units, reference, and appendix lists at the end of this report.

The Radiological Monitoring of Edible Vegetation (EV) Project is a component of the South Carolina Department of Health and Environmental Control's (SCDHEC) Environmental Surveillance and Oversight Program (ESOP) that monitors edible food in perimeter and background locations around the Savannah River Site (SRS). SCDHEC ESOP monitoring addresses public concerns pertaining to SRS operations through independent monitoring of radionuclide activities in edible vegetation and fungi found around the perimeter of SRS. Edible vegetation was collected based solely on availability, and was directly dependent upon the growing season. Farmers, gardeners, and/or businesses surrounding the perimeter of SRS occasionally contribute some domestically grown crops, and wild edible vegetation including fungi are collected to monitor potential consumer exposures. Typical domestic crops collected in 2012 include mustard, collards, lettuce, radishes, turnips, grapes, and pear. Typical wild food sources include pokeberry leaves, hog plums, persimmons, bamboo shoots, prickly pear, ferns, tree nuts, winged sumac drupes, and edible fungi used in food recipes, soups, salads, greens, pies, condiments and teas (Section 6.0 Data). Edible fungi were added in 2010 to address exposure for the wild mushroom consumer due to the evidence for bioconcentration of cesium-137 (Cs-137) in some fungi and historical detections in SRS fungi (Botsch 1999, Du Pont 1984). The consumption of wild-type edible vegetation including aquatics has increased in popularity due to Internet and public television broadcasts by naturalists and celebrity chefs.

Since 1988, when the last heavy water reactor at SRS was shut down, the tritium supply was re-established using the new Tritium Extraction Facility (TEF). This facility's mission is to transfer new tritium gas to the nation's tritium inventory (WSRC 2006). The Southern Nuclear Operating Company operates the Vogtle Electric Generating Plant (VEGP) located in Burke County, Georgia (GA) adjacent to the SRS. Permitted tritium releases coming from the VEGP are a result of spent fuel pools during power operation, reactor operation by the fission process, and from fuel assemblies mainly during reactor operation and shortly after shutdown (Federal Register 1968).

Section 4.0, Map 1 shows the inner perimeter of counties (IPC) adjacent to the SRS boundary and the outer perimeter of counties (OPC) that together make up the study area of concern (AOC) along with random quadrant designations used in the past. This study area was chosen for comparison to the Department of Energy – Savannah River (DOE-SR) 80-km (50-mile) radius data results. The IPC includes the counties of Barnwell (BWL), Aiken (AKN), and Allendale (ALD). The OPC consists of the county areas bordering the IPC and within 50-miles of an SRS center point, which include parts of Edgefield (EDF), McCormick (MCM), Saluda (SAL), Lexington (LEX), Calhoun (CAL), Orangeburg (ORG), Bamberg (BMB), and Hampton

(HMP). The AOC was sampled for edible vegetation including fungi and compared to their respective South Carolina backgrounds (SCbkg). Tritium (72 AOC and 13 SCbkg samples, Section 5.0, Table 1), a suite of 24 gamma radionuclides (90 AOC plus 17 SCbkg, Section 5.0, Table 2), and total strontium beta (7 AOC plus 1 SCbkg, Section 6.0, Data Table 7) were analyzed in 2012 for radionuclide activity. Samples collected in the IPC, OPC, and SCbkg may indicate if an exposure activity concentration trend is occurring in edible vegetation samples due to distance from potential sources. Fungi and green plant vegetation comparisons are also analyzed separate since edible fungi are typically saprophytic and do not contain chlorophyll. Fungi and woody perennial vegetation have relatively large absorptive surface areas for uptake of radionuclides deposited in past years compared to annual plants, i.e., fungal mycelia mats or woody plant root systems and leafy canopy areas. Both woody or perennial edible plants and fungi have a greater potential than annual or seasonal plants for concentrating some radionuclides deposited over many years. Annual plants tend to uptake recent depositions due to a decreased time for the leaching away of recent deposits from the absorptive surface to deeper layers. Radionuclide uptake over large areas is expected to be greater for plants with larger surface areas above or below ground through direct absorption and increased transpiration. The available absorptive surface area and competing or limiting factors such as soil chemistry interactions (potassium deficient soils allow cesium uptake) affect radionuclide uptake (Hanlon 2004).

The SCDHEC AOC detections are separated into IPC versus OPC detections to establish depositional pattern trends from the SRS boundary to the AOC and SCbkg. The subtraction of SCbkg helps to separate atomic test fallout contamination levels from other source potential contamination. However, fallout dispersion patterns and concentrations are weather related and not uniform, and no assignment of specific source may be made. These radionuclide detections are also broken down into various food types to determine the trends of exposure within different food groups. First, the green plant food and fungi category radionuclide concentrations in the AOC are compared with that in the SCbkg. All detections are then broken down into domestic versus wild food categories, and green plant and fern versus fungi categories. Differences in annual (domestic crops) versus perennial or woody types are also evident by inspection of the data tables (Section 6.0, Data). Due to detections in cattails and ferns, future sampling may compare terrestrial (atmospheric pathway) versus aquatic edible plants (liquid pathway downstream of SRS). The data section shows all detections by the specific sample type (e.g., mustard, onion, bolete mushroom), and in some cases genus/species is given, if known. These comparisons establish the trends of radionuclide exposure potential within the local green plant, fern, and wild fungi edible vegetation.

All detections given are above the particular method lower limit of detection (LLD) for tritium in water from distilled vegetation or the minimum detectable activity (MDA) for gamma radionuclides. SCDHEC detected activities, above the method limits (LLD or MDA), occurred in the following edible vegetation for the indicated radionuclides in 2012 (Section 6.0, Data):

1- tritium (H-3) in AOC plums, blackberries, collards, lettuce, pokeberry leaves, prickly pear cacti, bolete mushrooms, chanterelle mushrooms, and in the SCbkg domestic collards and wild lactaria mushrooms;

2- cesium-137 (Cs-137) in AOC ferns, deerberry, and fungi (bolete, chanterelle, lactaria, oyster, honey, and agaric mushrooms), and in SCbkg fungi (chanterelle, lactaria, and bolete mushrooms);
3- total strontium in AOC persimmons and domestic pear fruits.

The AOC green plants had detections of tritium, Be-7, K-40, Pb-212 (cattails only), Pb-214, Cs-137 (ferns only), and total strontium. AOC fungi had detections of tritium, Be-7, K-40, Pb-212, Pb-214, and Cs-137. The SCbkg had detections of tritium in collards and Lactaria mushrooms; Be-7 in collards and pokeberry leaves; K-40 in collards, pokeberry leaves, mustards, lettuce, onion, ferns, and pecans; Pb-212 in mustards and onion; Pb-214 in Hen-of-the-woods mushroom, bolete, honey mushrooms, pokeberry leaves, and onion; and Cs-137 in chanterelle, lactaria, and bolete mushrooms (Section 6.0, Data).

All of the detected radionuclides except tritium, Cs-137, and Sr-89/90 originated in naturally occurring radioactive material (NORM). NORM radionuclides were the source of most public exposure. NORM was not discussed herein as radionuclides of concern unless greater than a South Carolina background.

Previous years data indicated that the higher dose exposures occurred from consuming some woody perennials (e.g., wild plums), and certain edible fungi (e.g., bolete mushrooms) favored by wild mushroom and plant consumers. SCDHEC wild-type vegetation monitoring has increased since 2010, and now includes edible fungi. Public television and the internet indicate more people and celebrity chefs are sampling natural food sources. The 2012 data for cattails and ferns show higher levels of contaminants may be found in plants preferring an aquatic habitat, and the 2013 edible vegetation project will include more aquatic plants collected from the Savannah River backwater areas. Split sample plant comparisons with DOE-SR are occasionally conducted to compare method results, but increasing the variety of vegetation sampled is more likely to find previously unknown sources of dose exposure.

2.0 RESULTS AND DISCUSSION

The International Atomic Energy Agency (IAEA 2009) has established guideline levels for radionuclides in foods (alpha- beta-, and gamma-emitters) for general consumption. The appendix section shows the radionuclides of concern, the guideline levels, the intervention levels and their conversion to picocuries per gram (pCi/g) for data comparison (Appendix Tables, 1a,b,c). The IAEA guideline emphasizes the cumulative radioactivity guideline limits for food.

The US Food and Drug Administration (USFDA 2005) also has guidance levels for specific radionuclides called derived intervention levels (DILs). The USFDA adopted DILs to help determine whether domestic food in interstate commerce or food offered for import into the United States presents a safety concern (Strontium-90, Iodine-131, Cesium134+Cesium137, Plutonium-238+Plutonium-239+Americium-241, Ruthenium-103+Ruthenium-106; Appendix, Table 1c).

References to vegetation in this report refer to the edible parts of green plants and fungi. Otherwise, more specific terms are used to indicate a category or specific type of green plant or fungi. The general county and area statistics comparing radionuclide concentrations are in

Section 5.0. The EV type statistics are summarized in Section 7.0. The edible fungi collected are primarily heterotrophic (consume preformed organic matter) and saprophytic (digest and consume dead plant and animal matter), but not parasitic (consume living matter). Lichens are symbionts (benefit nutritionally) whose form (fungal thallus) is altered by the associated organism (e.g., algae). The collected edible fungi produce spores outside of a structure (mushroom basidia) or within a structure (mushroom asci), and in lichens (Moore-Landecker 1972). Plants or green vegetation are distinguished from fungi, and EV without a qualifier refers to both. Section 4.0, Map 1 depicts the counties around the perimeter of SRS and the United States Geological Survey (USGS) 7.5-minute quadrants that overlay those counties (USDOI 1992). All of the detections described herein are well below the IAEA and USFDA guidelines for the specific radionuclide in food (Appendix, 1b,c).

2012 Tritium

Tritium is naturally present as a very small percentage of hydrogen in water, both liquid and vapor (ANL 2007). Historically, the main sources of tritium releases from the SRS operations were the reactor areas, the chemical separation facilities, and the tritium packaging areas. Tritium releases on the SRS include both atmospheric and liquid contributions (SRNS 2012). Tritiated water is more hazardous biologically than tritium gas and reacts chemically in living cells, the same as nonradioactive water (CDC SRSHES 1997).

There were only 10 tritium detections out of 85 sample scans (AOC and SCbkg) of edible vegetation and fungi collected by SCDHEC in 2012 (Section 5.0, Table 1). Tritium samples were detected in all three IPC counties (AKN, BWL, ALD) bordering SRS, and there were two detections in the SCbkg that were near the typical LLD (usually <220 picocuries per liter, pCi/L) of the tritium method. There were no tritium detections in the OPC (BMB and EDF in 2012). Aerial deposition detections for tritium tend to be close to SRS sources (SRNS 2011), but occasional low-level detections occur within IPC counties. All IPC tritium detections (eight of 63) in distilled water from edible vegetation averaged 343 ±104 pCi/L with a median of 299 pCi/L and a maximum of 462 pCi/L that occurred in a chanterelle mushroom found in a ditch at Steel Creek in Allendale county (Section 5.0, Table 1 and Section 6.0, Data Table 1e,f). The tritium concentration found in this mushroom had potential contributions from both the liquid and atmospheric pathways due to flooding and aerial dispersions. Prickly pear cactus was second highest in tritium (424 pCi/L); bolete mushroom third (344 pCi/L); pokeberry leaf fourth (276 pCi/L); wild hog plums fifth (249 pCi/L); domestic collards sixth (240 pCi/L); wild blackberry seventh (224 pCi/L); and domestic lettuce eighth (217 pCi/L). The tritium detections that occurred in the IPC and not in the OPC counties were not aquatic samples, and probably only from atmospheric contributions. However, there were two detections (233 and 212 pCi/L) within the SCbkg that were near the tritium method LLD (214 and 205 pCi/L, respectively). The lack of detections in the OPC indicates that tritium concentrations were rapidly diluted with distance from the SRS boundary to below the method detection limits.

EV excluding fungi (green plants only) had lower tritium detection (six of 41) statistics (272 pCi/L average ± 77 with a median of 245 pCi/L and maximum of 424 pCi/L) than fungi (403 pCi/L average ± 83 with a median of 403 pCi/L and maximum of 462 pCi/L) (Section 7.0, Summary Statisics Table 2). Six out of eight tritum AOC detections occurred in green plants (four in leafy greens and two in plant fruits), and the other two in mushrooms (chanterelle and bolete) (Section 7.0, Summary Statistics Table 1). There was one green plant and one fungi tritium detection in the SCbkg. The maximum tritium detection occurred in a golden chanterelle mushroom near Steel Creek landing in Allendale county (462 pCi/L) that was subject to flooding. Second was the prickly pear tritium detection (424 pCi/L) near Boggy Gut creek in Aiken county outside SRS, and the third highest occurred in a bolete mushroom near Barnwell County highways 39/278 junction near the SRS Highway 39 entrance (344 pCi/L). All three occurred near the perimeter boundary of SRS. The two SCbkg tritium detections occurred in collards (233 pCi/L) and Lactaria mushrooms(212 pCi/L) and were near their respective LLD (Section 7.0, Summary Statistics Table 1).

A sample result may be included in more than one category (a general and/or more specific categories). The different category comparisons are fungi and green plants; leafy, fruit, and root parts; and wild versus domestic plants. Domestic plants are farm and garden varieties planted by man. The highest tritium detections occurred in the following category order: fungi, wild leafy, fruit, domestic, and <LLD in root EV categories (Section 7.0, Summary Statistics Table 2). The leafy category ranking was due mostly to higher detections in wild prickly pear pads (modified leaves) (424 pCi/L) and pokeberry greens (276 pCi/L) instead of domestic samples (Section 6.0, Data Table 1a,b,c,d). Wild type green plants had higher tritium detection statistics (293 pCi/L average ± 90 with a median of 262 pCi/L and maximum of 424 pCi/L) than domestic vegetation (229 pCi/L average ± 16 with a median of 229 pCi/L and maximum of 240 pCi/L) (Section 7.0, Summary Statistics Table 2). The AOC fruit tritium detections occurred in perennial hog plums (249 pCi/L) and wild blackberry (224 pCi/L) (Section 6.0, Data Table 1 a,b,c,d). The tritium in the AOC annuals, collards (240 pCi/L) and lettuce (217 pCi/L), were less than the tritium found in the perennial greens, pokeberry leaf (276 pCi/L) and prickly pear (424 pCi/L) (Section 6.0, Data Table 1a,b,c,d).

Fungi mycelia mats have very large absorptive surface areas (throughout the forest floor and vegetation) compared to individual green plants. The wild type vegetation collected tended to have larger absorptive surface areas (leaf canopies and root systems) and exposure times (perennials) than the domestic annual or seasonal crops. That trend continued after South Carolina background subtraction, but the maximum tritium rank changed to fungi, wild, leafy, fruit, domestic, and root categories of edible vegetation (Section 7.0, Summary Statistics Table 2). There were not any detections within the AOC and SCbkg green plant underground structures (bulbs, tubers, roots) versus three detections in fungi (two AOC and one SCbkg), which typically have large mycelia mats of cells within the soil, detritus, and plant substrate surfaces. Absorptive surface area size and residence exposure time (perennials) are the most notable differences between higher tritium absorption and lower tritium absorptions (annuals).

Any tritum aerial releases reaching the upper atmosphere would disperse over larger areas with increased distances resulting in reduced concentrations and unlikely detections at a distance. The primary mechanisms for aerial tritium depositions were wind and/or rain. Since sample numbers varied by counties, the number of detections (D#) divided by the number of samples (N#) gives frequency, which is the best indication of primary atmospheric depositional density. Allendale County had the highest frequency of detections, Barnwell County second, and Aiken County third. Areas not sampled to the southwest were in Georgia. The observed levels of tritium in edible vegetation were well below the IAEA Radionuclides Guidelines for Food based on a direct unit conversion (Appendix 1b, 270 pCi/g). This limit would equal {270 pCi/g x (1g/1ml) x (1000ml/L)} = 270,000 pCi/L, which is far above the USEPA drinking water limit of 20,000 pCi/L, and all tritium detections were <500 pCi/L (Section 7.0, Table 1). Note that 1g/1ml is one gram per one milliliter, and ml/L is milliliter per liter, but the actual content of tritium in food would be relative to the percent moisture and the food wet weight.

The previous comparisons were based on all results, general statistics by county and/or area (e.g., Section 7.0, Summary Statistics Table 1), and general EV categories (Section 7.0, Summary Statistics Table 2). The IPC or AOC county basis average (343 pCi/L) minus the SCbkg (223 pCi/L) gave a difference of 120 pCi/L. However, the sample basis average of all tritium detections in the AOC (304 pCi/L) minus the SCbkg average (223 pCi/L) shows an average difference of only 81 pCi/L. The SCbkg gave the same average whether by county or by sample detections (only two in each case). The observation is that the AOC tritium is higher than the SCbkg regardless of the comparison used; statistical, county, or sample basis.

Fungi AOC tritium detections in bolete (344 pCi/L) and chanterelle mushrooms (462 pCi/L) were similar to perennial plant tritium detections (range of 224 to 424 pCi/L). Note that the wild-type perennials and fungi mushrooms tend to have higher tritium detections than annual crops possibly due to their exposure to more than one season of deposited tritium and a generally larger absorptive surface area compared to annual crops (Section 7.0, Summary Statistics Table 1). All other AOC sample tritium determinations were less than the lower limit of detection (<LLD). Numerous (30 out of 38) AOC green plant nondetections (<LLD) occurred primarily in wild perennial species (22) (Section 7.0, Summary Statistics Table 1). Wild leafy greens are perennials with longer exposure periods to radionuclides and are generally larger than the domestic annual or seasonal samples. Most green plant detections (4 of 6) also occurred in WP, while fungi only had two tritium detections (D#) out of 31 samples in the AOC. Only one of eight samples had tritium detections in the SCbkg and one of five in fungi (Section 7.0, Summary Statistics Table 1). The overall D# in edible vegetation may reflect the difference in above ground exposure area at the time of tritium depositions (temporal exposure) as evidenced by the lack of detections in root crops (Section 7.0, Summary Statistics Table 1). There were two detections out of 14 in AOC fruit samples, and 4 detections out of 27 in leafy green samples. Notice the slight difference in tritium of domestic leafy greens (collards and lettuce, highest is 240 pCi/L) versus wild leafy greens (pokeberry leaf, 276 pCi/L) that have a generally larger surface area. The highest green plant tritium detection occurred in a perennial (prickly pear cactus pads, 424 pCi/L) with a higher water storage content.

2012 Gamma

The gamma-scan (24 radionuclides) detections found in naturally occurring radioisotopes (Be-7, K-40, Pb-214, Pb-212) are part of the South Carolina normal background exposure (Appendix Table 1a). Cesium-137 was the only non-NORM detected radionuclide. Only samples with radionuclide detection results are included in the data tables (Section 6.0). All other gamma scan results were less than the MDA.

South Carolina gamma-scan background detections occurred in fungi, ferns, fruits, greens, flowers, tubers and bulbs or root crops (Section 6.0, Data). The AOC plus SCbkg gamma samples N# included 54 AOC plus 12 SCbkg green plant samples, and 36 AOC plus 5 SCbkg edible fungi samples (Section 7.0, Table 3). Only potassium-40 (K-40), beryllium-7 (Be-7), lead-212 (Pb-212), lead-214 (Pb-214), and cesium-137 (Cs-137) were detected in AOC edible green vegetation in 2012, and in edible fungi. Cesium-137 was not found in the green plant sample SCbkgs, and Pb-212 and Be-7 were not found in the fungi SCbkgs. Alternately, in the SCbkg, Cs-137 was found only in fungi.

Section 6.0, Data statistics show AOC and SCbkg gamma detections in subcategories. Beryllium-7 detections occurred in collards, rosemary, mustard, pokeberry leaf, honey mushrooms, and lichen, which exhibited the highest detection (8.548 pCi/g in AOC). Potassium-40 occurred in all subcategories, but was highest in the honey mushroom (34.610 pCi/g), bolete mushrooms (32.20 pCi/g), cattails (11.0 pCi/g in AOC), and pokeberry leaf (11.18 pCi/g in SCbkg). All four locations had potential for past fertilizer applications nearby and two had ponds upstream. Lead-212 occurred only in mustards, onions, lichens, cattails and bolete mushrooms with the highest in a lichen (1.511 pCi/g). Lead-214 occurred in fungi, lichen, pokeberry leaf, onion, prickly pear cactus, mullein, cattails, radish, deerberry, and ferns with the highest in cattails (7.22 pCi/g) downstream from a community pond (potential lead piping influence). Cesium-137 detections occurred in AOC fungi, ferns, and deerberry, but not in other green plants. The SCbkg Cs-137 detections occurred only in fungi. The highest detections of Cs-137 occurred in bolete (8.240, 2.704, and 2.576 pCi/g) mushrooms, and five detections in ferns with the highest being 1.946 pCi/g (Section 6.0, Data Tables). The fungi and swamp or aquatic green plants (ferns and cattails) tended to have the higher detections overall.

Section 7.0 gives the radionuclide summary statistics for different categories of edible green vegetation and fungi. A comparison was made between the gamma radionuclides after SCbkg subtraction (Section 7.0, Summary Statistics Table 3) to evaluate the AOC or study area. The K-40 average and median were not greater than the SCbkg, but the maximum (34.61 pCi/g) did occur in an AOC honey mushroom (Section 7.0, Summary Statistics Table 3 and Section 6.0, Data Table 3b). After SCbkg subtraction of the average, the Pb-214 and Cs-137 activity concentrations were higher in green plants than fungi. However, Be-7, K-40, and Pb-212 were higher in fungi after SCbkg subtraction (Section 7.0, Summary Statistics Table 3). The median of Pb-214 was <SCbkg after background subtraction for both green plants and fungi. The maximum after background subtraction also occurred in the leafy greens (Section 7.0, Summary Statistics Table 7a). However, the maximum Cs-137 after background subtraction occurred in the AOC bolete fungi (Section 6.0, Data Table 3c). The higher maximums may be related to bioconcentration and the median is probably closer to the true central tendency than the average since many samples had no detections. The nondetections were less than a minimum detection activity (<MDA), and were actually unknowns that would decrease the statistical values, if known and included in the analysis.

Section 5.0, Table 2 evaluates the IPC, OPC, and AOC for comparison with the SCbkg. The regional area statistics for any radionuclide concentration activity greater than background is the best indication of any potential contaminant additions since atomic test fallout in the 1950-1980 time frame. The IPC and SCbkg were the only areas to have detections of all five radionuclides (Be-7, K-40, Pb-212, Pb-214, and Cs-137). The OPC minus the SCbkg indicates only two radionuclides (Pb-214 and Cs-137) above the overall EV SCbkg. The IPC minus the overall

SCbkg has Be-7 and Pb-212 in addition to Pb-214 and Cs-137 (Section 5.0, Table 2). The statistics that combines the IPC plus OPC into the entire AOC versus the SCbkg did not add any other radionuclides. Potassium-40 was <SCbkgfor all three comparisons (IPC, OPC, and AOC versus SCbkg). This may indicate differences in natural soil geology chemical characteristics and/or a greater addition of fertilizers in selected areas. The IPC detections >SCbkg (Be-7, Pb-212, Pb-214, and Cs-137) indicate a potential local influence in common with the SRS boundary. See Section 7.0, Summary Statistics Table 4a,b for a comparison of AOC and SCbkg EV sampled in both areas. When fungi were included, the EV average activity for K-40 went down and the EV averages for Pb-214 and Cs-137 went up. The Cs-137 detected levels >SCbkg are far less than the guidelines for radionuclides in food (Appendix, Tables 1b,c).

Section 7.0, Summary Statistics Tables 6a, 6b compare wild versus domestic EV overall statistics. Lead-212, Pb-214, Be-7, and Cs-137 were higher than the SCbkg in wild edible vegetation, and only Be-7 was higher than the SCbkg in domestic edible vegetation. Lead-214 was the maximum detection above background and occurred in wild edible vegetation.

The highest gamma detections in the AOC were Pb-214 (7.221 pCi/g) in cattail in Aiken county, Cs-137 (8.240 pCi/g) in bolete mushrooms in Barnwell county, Pb-212 (1.511 pCi/g) in an Aiken county reindeer lichen species, K-40 (34.610 pCi/g) in honey mushrooms in Aiken county, and Be-7 (8.548 pCi/g) in reindeer lichen species in Aiken county (Section 6.0, Data Tables 3a,b,c and 5a,b,c,d,e). The highest SCbkg detections per radionuclide detected were Be-7 (2.57 pCi/g) in pokeberry leaf in Saluda county, K-40 (11.180 pCi/g) in pokeberry leaf in Edgefield county, Pb-212 (0.321 pCi/g) in wild mustard leaf in Laurens (LAU) county, Pb-214 (0.549 pCi/g) in bolete fungi in Edgefield county, and Cs-137 (0.685 pCi/g) in a lactaria mushroom in Saluda county.

Leafy greens, root crops, and fruit were compared by categories in Section 7.0, Summary Statistics Table 7a,b,c. Lead-214, Be-7, K-40, and Cs-137 were found in leafy EV, but only Be-7 and Cs-137 were above the SCbkg averages and medians. Lead-214 was the only leafy green maximum greater than the SCbkg. Root crops had detections in K-40, Pb-212, and Pb-214, and all three were above the SCbkg averages, medians, and maximums. Fruit crops had detections in Pb-214, K-40, and Cs-137, but only Pb-214 and Cs-137 were above the SCbkg averages, medians, and maximums. The fruit K-40 maximum was also above the SCbkg. The higher Cs-137 above SCbkg occurred in several ferns of the leafy EV (Section 6.0, Data Table 6). The only other occurrence of Cs-137 in green plants was in a deerberry sample in Barnwell County (Section 6.0, Data Table 5e). The highest Pb-214 above SCbkg occurred in a cattail aquatic sample in Aiken County.

Beryllium-7, K-40, Pb-212, and Pb-214 were highest (AOC and IPC) in Aiken County edible vegetation (Section 5.0, Table 2) and Cs-137 was highest in Allendale County. All gamma backgrounds came from the Piedmont geological region. Fertilizers and cretaceous geology are the suspected factors affecting K-40 distribution in the AOC and SCbkgs. Potassium-40 activity is heavily influenced by fertilizer applications and Pb-214 is part of the naturally occurring uranium decay products prevalent in saprolitic rock found in fracture zones of the Piedmont, Blue Ridge, and Fall Line areas of South Carolina. High uranium concentrations occur in some well water in southern Greenville County and primordial U-238 in saprolitic rock decays to Pb-

214 and eventually Pb-206 (stable). Lead-212 is a decay product of the naturally occurring thorium series. Cesium-137 is a major radionuclide in spent nuclear fuel, high level radioactive waste resulting from the processing of spent nuclear fuel, and radioactive wastes associated with the operation of nuclear reactors and fuel reprocessing plants. Radioactive cesium is present in soil around the world largely as a result of fallout from past atmospheric nuclear weapons tests. The tritium and Cs-137 detections are related to manmade activities. Beryllium-7 is a naturally occurring radionuclide and was found in collards, pokeberry leaf, rosemary, mustard, lichens, and honey mushrooms. Strontium detections were determined based on beta decay and is discussed under the Total Strontium heading.

The gamma radionuclides and concentrations in green plants and edible fungi vary by types of vegetation, plant parts, and food use categories (Section 5.0, Tables 3). Food types or food use category detections help to determine where the detections occur in plant parts. Beryllium-7 detections occurred in leafy plant parts including onions and one mushroom species, but not in fruits or root crops. Potassium-40 detections occurred in nearly all green plants and fungi. Lead-212 detections occurred in lichens, mushrooms, and aquatic plants (cattails). Lead-214 detections occurred in lichens, mushrooms, leafy green plants, root crops, ferns, and aquatics. Cesium-137 detections occurred in fungi, ferns, and one Deerberry sample. The Cs-137 activity adds radionuclide exposure potentially due to historical depositions from atomic bomb tests fallout during 1950-1980. Cesium-137 detections occurred in certain AOC and SCbkg edible fungi such as bolete and chanterelles, and may be due to bioconcentration of depositions over many years (Botsch 1999, Yoshida 1998). Plants showed a higher K-40 trend activity in some annual crops (collards, lettuce, mustard) and in some perennials (pokeberry leaf, mullein, thistle, cattails, and winged sumac drupes) (Section 6.0, Data). This trend may be related to fertilizers and/or the geology of the surface soils and influence on uptake of radionuclides (Rommelt 1990, Seel 1995).

<u>Cesium-137</u>

The only non-natural decay series gamma and beta radionuclide detections found in edible vegetation including fungi were Cs-137 (gamma) and total strontium. The natural decay series radionuclide concentrations may be related primarily to fertilizers and natural soils and regional geology. Some of the Cs-137 and radioactive strontium concentrations found in edible vegetation were probably related to nuclear test radioactive fallout due to the wide dispersion pattern and occurrence in both SCbkg and AOC locations. Several nuclear test fallout depositions from past nuclear tests tracked across South Carolina and were deposited world-wide (Aracnet 1957). Only two half-lifes of Cs-137 and Sr-90 decay have passed since the earliest nuclear tests and these depositions may be detectable up to eight half-lifes (approximately 240 years) dependent on the technology and method used. The AOC concentrations >SCbkg are not assignable to SRS releases alone due to the wide dispersion of nuclear test fallout.

Cesium-137 is an alkali metal that is chemically and metabolically similar to potassium. If ingested, it is distributed relatively uniformly throughout the whole body including bone marrow (Federal Radiation Council 1965). The largest source of Cs-137 in the environment was fallout from atmospheric nuclear weapons tests in the 1950's and 1960's that dispersed and deposited Cs-137 worldwide. The highest Cs-137 detection (16 pCi/L) in South Carolina rainfall since January 1979 (most nuclear testing ceased after 1980) occurred in Barnwell, 15 May 1985

(USEPA 2013). The many Cs-137 potential contributions to the environment may be passed down through linked critical exposure pathways. However, cesium is poorly absorbed by vegetation from the soil. Cesium is relatively uniformly distributed throughout all portions of the plant and does not tend to bioconcentrate except in some grains and mushrooms. Grains tend to have relatively high concentrations, but fruits and root vegetables, having a higher water content, tend to have low concentrations of cesium (Kathren 1984). Some fungi appear to bioconcentrate cesium and contribute the highest Cs-137 radioactive exposure through wild mushrooms compared to other food types (Botsch 1999). The concentration of Cs-137 in surface soil from fallout ranges between 0.1 to 1 pCi/g and averages less than 0.4 pCi/g. Cesium is generally one of the less mobile radioactive metals in the environment. Cesium preferentially adheres quite well to the soil organic layer, and the concentration associated with sandy soil particles is estimated to be 280 times higher than in interstitial water. Concentration ratios are much higher in clay and loam soils (ANL 2007).

Cesium-137 in fungi was higher in the AOC (1.028 pCi/g) averages versus the SCbkg (0.294)(Section 7.0, Summary Statistics Table 5). This clear trend of deposition is not necessarily related to SRS for many nuclear bomb tests fallout tracked from the southwest across South Carolina to the northeast. Depositional concentrations would gradually decrease with each rain event (dilution effect). Also, RADNET (USEPA 2013) data maximums for rainfall in 1984 found along a path from Georgia (GA) (17 pCi/L in GA) to SC (14.2 pCi/L in SC) illustrate the potential exposure in one year. In 2012, less than one half-life for Cs-137 (30 yrs) has passed since 1984. Thus, maximums of >9.1 pCi/L (decay calculation for 17 pCi/L) remaining in rainfall from that period are potentially still detectable from those events. These were not necessarily the true population maximums, and other additive depositional events have occurred since and before that time. The maximum Cs-137 detection in 2012 occurred in bolete mushrooms (8.240 pCi/g near intersection of highway 278 and 39), which are proven bioconcentrators of Cs-137 (Section 5.0, Table 3c; Botsch 1999). Higher Cs-137 concentrations occurred in recent years, both in bolete and chanterelle mushrooms in the Steel Creek area (a flood plain of SRS) of Allendale County. Bolete mushrooms have large mycelia mats that draw water and chemical elements from the soil surface and store the element radionuclides through saprophytic intake over a long lifetime. These low level bioconcentrations are not above the health risk guidelines (Appendix Tables 1b,c). However, due to the higher radionuclide concentrations found in flood plain areas, increased aquatic edible vegetation sampling will occur in the future.

All of the detected radionuclides except tritium, Cs-137, and Sr-89/90 originate in NORM. Only some wild mushroom samples in 2012 would add radiation exposure to the individual consumer above NORM background. This was due to Cs-137 that is bioconcentrated by some mushrooms (Botsch 1999). The Cs-137 detections were generally <2 pCi/g except for lactaria, bolete, and chanterelle mushrooms (Section 6.0, Data). These detections reflect bioconcentrations over several years rather than a yearly depositional dose. These edible mushrooms are the fruiting bodies of long-lived organisms (with large mycelia mats), which are primarily saprophytes on dead vegetation. Thus, Cs-137 uptake by these fungi may be a reflection of the interactions between soil chemistry, the food host biochemistry, and the fungi. Cesium-137 tends to bind with organic material in the forest floor and is available to resident organisms before leaching to a confining layer such as clays (Linkov 1999). Many non-NORM radionuclides were distributed worldwide due to atomic tests primarily in the 1950's and 1960's, and the present detectable levels in soils today cannot be assigned to a single source (USEPA 2013 and RADNET 2006).

Total Strontium

Total strontium (Sr) contains many isotopes and the two most important are primarily beta emitters that contribute to dose exposure, i.e., Sr-89/90. Strontium-89 is short-lived (50.5 days) compared to Sr-90 (28.8 year half-life). Historical atomic test fallout depositions contained Sr-90 that is still detected. Eight EV samples were analyzed for total strontium in 2012 (Section 6.0 Table 7). Strontium was found in two AOC samples: persimmons (0.0566 pCi/g), and domestic pears (0.0328 pCi/g), but not in the SCbkg. The greatest exposure to total strontium occurred in wild persimmons. Strontium has four stable naturally occurring isotopes, but Sr-90 is a by-product of nuclear fission used primarily in nuclear auxiliary power devices (cheaper than Pu-238, but not as long-lived), and presents a health problem since strontium substitutes for calcium in bone. Alternately, Sr-89 and Sr-90 are used in the treatment of bone cancer and to increase bone density in women. Strontium is an abundant element and safe at low concentrations since it is used in toothpastes, treatments for osteoporosis, and fireworks. The IAEA guideline for total exposure to five radionuclides in food including Sr-90 is 2.7 pCi/g, and the USFDA DIL guideline is 4.32 pCi/g for Sr-90 alone in imported foods. The total strontium detected levels in the assayed samples were all well below those guidelines (Appendix Table 1b,c).

The total strontium detections occurred in one persimmon (0.0342 pCi/g) and one domestic pear (0.0088 pCi/g) in Barnwell County and both were above a total strontium SCbkg. Total strontium detections occurred in green plant fruit versus fungi, while most Cs-137 detections, especially maximums, occurred in fungi. Species-specific SCbkgs may eliminate even these detections as >SCbkg. The Sr-90 species is of concern due to the potential replacement of calcium in bone.

ESOP and DOE-SR Data Comparison

Comparisons are based on tables and data sections of this report, and the SRNS Environmental Report 2013 (SRNS 2013). DOE-SR tritium detection statistics are summarized based only on direct unit conversions for comparison to SCDHEC edible vegetation groups.

DOE-SR edible vegetation tritium detections occurred in collards, corn, and fruit (melons) (SRNS 2013). DOE-SR detections (two of five samples) in greens averaged 0.057 (±0.003 pCi/g), with a median of 0.057 pCi/g, and a maximum of 0.059 pCi/g. The SCDHEC leafy green averaged 56 pCi/L (0.056 pCi/g). DOE-SR radionuclide detections (three of 10 samples) in fruits and corn averaged 0.102 (±0.010 pCi/g), with a median of 0.097 pCi/g, and maximum 0.114 pCi/g. DOE-SR did not sample edible mushrooms. The SCDHEC fruit detections (all wild type) averaged 237 pCi/L (0.237 pCi/g). Note that leafy green plants and domestic crops generally have a small canopy for absorption compared to larger tree canopy fruits, especially wild types. Also, wild type plants have a longer residence time (life cycle) for potential exposure than domestic crops.

The DOE-SR gamma and other beta-emitting radionuclide detection maximums in edible vegetation were: Cs-137 in collards (0.064 pCi/g) and corn (0.010 pCi/g); Sr-89/90 in collards

(0.179 pCi/g); uranium-234 (U-234) in collards (0.005 pCi/g), fruit (0.0002 pCi/g), and soybeans (0.077 pCi/g); uranium-235 (U-235) in collards (0.0009 pCi/g) and soybeans (0.004 pCi/g); uranium-238 (U-238) in collards (0.005 pCi/g) and soybeans (0.058 pCi/g); and technetium-99 (Tc-99) in collards (1.78 pCi/g), corn (0.191 pCi/g), and soybeans (0.19 pCi/g). Cesium-137 occurred in three of five greens for a detection average of 0.0481±0.0222 pCi/g with a median of 0.0481 pCi/g and maximum of 0.0638 pCi/g (SRNS 2013).

The SCDHEC gamma radionuclide detection maximums in AOC edible vegetation were: Be-7 in lichens (8.548 pCi/g); K-40 in bolete fungi (32.20 pCi/g); Pb-212 in lichens (1.511 pCi/g); Pb-214 in cattails (7.221 pCi/g); and Cs-137 in bolete fungi (8.240 pCi/g) (Section 6.0, Data). There was one Cs-137 detection in fruits (deerberry at 0.059 pCi/g), five detections in ferns (averaged 1.064±0.646 pCi/g, median 1.117 pCi/g, and maximum 1.946 pCi/g), and 25 detections in fungi (averaged 1.028 ±1.706 pCi/g, median 0.423 pCi/g, and maximum 8.240 pCi/g). Only the single fruit detections of Cs-137 in both programs were comparable, 0.010 pCi/g in DOE-SR domestic corn versus 0.059 pCi/g in SCDHEC wild deerberry. Corn is a seasonal crop and deerberry is a perennial wild-type shrub. Thus, the longer exposure time for deerberry may be a factor for the higher Cs-137 absorption. All SCDHEC EV Cs-137 detections excluding fungi averaged 0.901±0.647 pCi/g with a maximum of 1.946 pCi/g (Section 7.0, Summary Statistics Table 4a,b). The SCDHEC Cs-137 detections occurred only in wild-type plants (deerberry, fern) versus domestic crop plants in DOE-SR samples (greens, corn) that averaged 0.034 pCi/g (±0.022) pCi/g (Section 6.0, Data Tables 5a,b,c,d,e and 6). The DOE domestic plant (greens and corn) average of 0.090 (±0.025) pCi/g was within two standard deviations of the SCDHEC wild-type average of 0.901 (±0.647) pCi/g, but not the reverse. This indicated a large difference between wild type EV and domestic EV Cs-137 absorption. The SCDHEC Cs-137 detections occurred in wild-type leafy greens (mostly ferns) and one fruit sample, but not in domestic green plant samples (Section 6.0, Data). This comparison highlights the greater exposure potential in wild edible vegetation versus domestic crops possibly due to differences in exposed surface area and life cycle residence time for the two plant categories.

SCDHEC AOC total strontium in fruit averaged 0.0447 (±0.0168) pCi/g with a median of 0.0447 pCi/g and a maximum of 0.0566 pCi/g (Section 6.0, Data Table 7). The DOE-SR Sr-89/90 detections occurred in only three of five greens samples that averaged 0.120 (±0.052) pCi/g with a median of 0.096 pCi/g and maximum of 0.179 pCi/g in collards (SRNS 2013). The SCDHEC strontium average (0.045 pCi/g) in fruit is within two standard deviations (SD) of DOE-SR leafy greens. Strontium uptake in leafy greens appears higher than in fruits, whether domestic or wild type.

The IAEA Radionuclides Guidelines for Food are 27 pCi/g total for Cs-137, Cs-134, S-35, Co-60, Sr-89, Ru-103, Ce-144, and Ir-192, and 2.7 pCi/g total for Sr-90, Ru-106, I-129, I-131, and U-235 (Appendix Table 1b). The USFDA Derived Intervention Levels (DILs) for food are 32.4 pCi/g total for Cs-134 plus Cs-137, and 4.32 pCi/g for Sr-90 (Appendix Table 1c). All DOE-SR and SCDHEC food sample Cs-137 radionuclide detections respective totals were less than these limits.

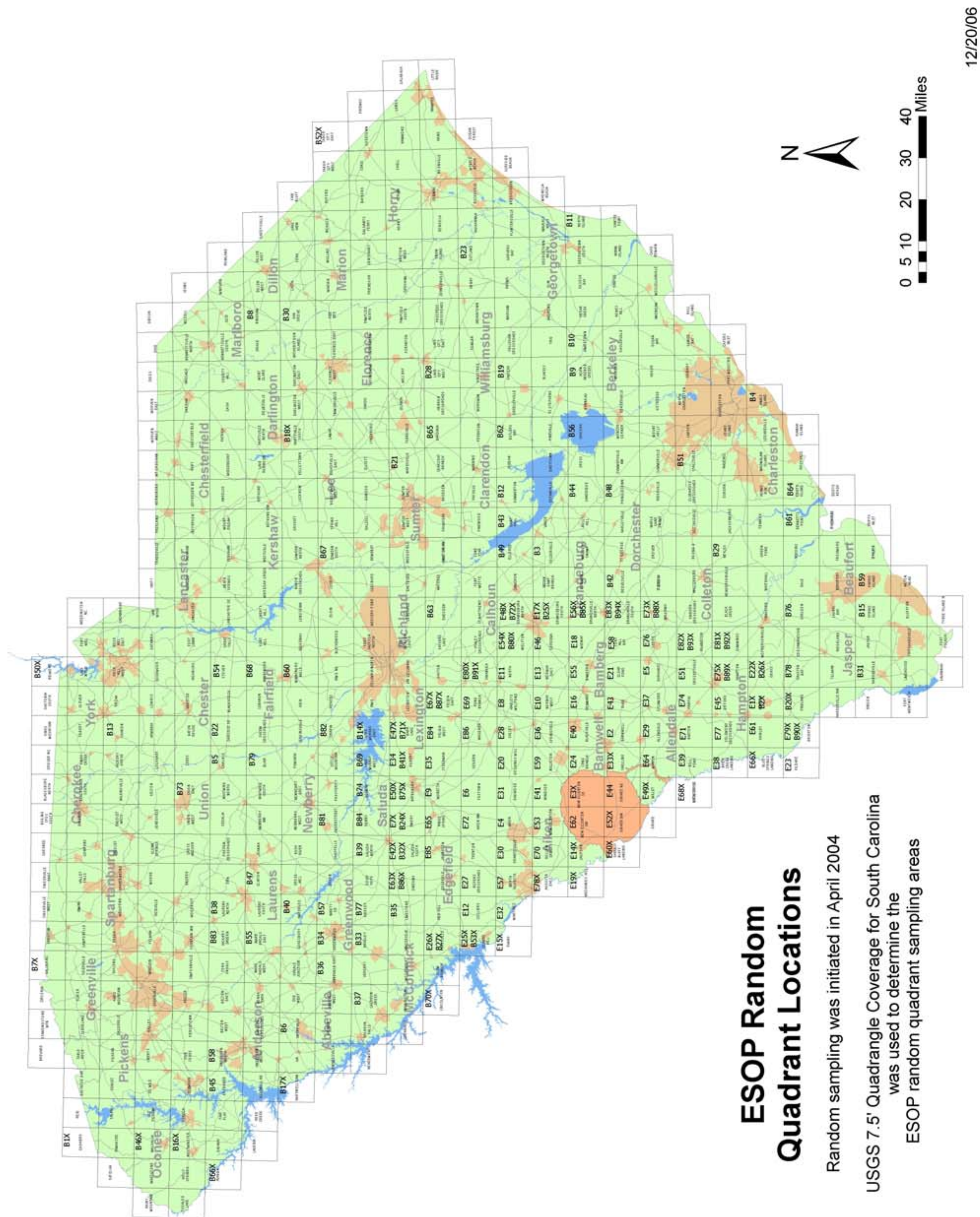
3.0 CONCLUSIONS AND RECOMMENDATIONS

Detected radionuclide concentrations found in edible vegetation sampled around SRS are well below the IAEA and USFDA standards for these emitters. Tritium continues to be the prevailing detectable analyte across all edible vegetation. However, Cs-137 dominates non-NORM gamma radionuclide exposure for the wild fern and mushroom consumer.

The highest tritium sample (462 pCi/L) occurred in a water distillation from a golden chanterelle mushroom, which is far below the 20,000 pCi/L USEPA limit for tritium in water and IAEA food guideline of 270 pCi/g (Section 7.0, Summary Statistics Table 1 and USEPA, 2013). Cesium-137 levels in certain edible ferns and fungi species, primarily chanterelles and boletes, add radionuclide exposure for the wild mushroom consumer, whether animal or human. The highest Cs-137 occurred in a bolete mushroom (8.240 pCi/g), and was the main contributor to exposure for the wild mushroom consumer (Section 6.0 Table 3c). Increased radionuclide exposure may be related to higher residence times and absorptive surface areas, whether tree canopy, root structure, or fungi mycelia mats. The highest total strontium detection occurred in a wild persimmon tree fruit sample (0.0566 pCi/g). The only domestic edible vegetation radionuclide detection was tritium in collards (240 pCi/L). The only wild green plant Cs-137 detection occurred in deerberry (0.059 pCi/g). Wild vegetation consumption, whether green plant or fungi, appears to have the greatest potential for radionuclide exposure for the maximally exposed individual.

SCDHEC and the DOE-SR have different edible vegetation sampling schemes. The DOE-SR samples primarily domestic plants and has annual participants in quadrants at 0-10 miles from the perimeter of the SRS and one quadrant at 25 miles. SCDHEC annual participants supply domestic plants, and the 2012 vegetation collections included perennial wild edible vegetation and fungi found usually within 10 miles of the SRS border. Backgrounds were generally along a 50-mile perimeter with one annual background participant in Laurens County. SCDHEC added emphasis in sampling a broader selection of wild edible vegetation, especially edible aquatics, woody species, and fungi in an attempt to detect any previously unknown radionuclide contamination exposure. ESOP plans to continue collecting various edible wild plants in addition to normal garden vegetation to help identify the maximally exposed individual.

4.0 2012 Radiological Monitoring of Edible Vegetation
Map 1. County and Quadrant Locations



5.0 Tables and Figures
2012 Radiological Monitoring of Edible Vegetation

Table 1. Tritium (pCi/L) Detections in Edible Vegetation (EV) by Counties/Areas, 2012

County/Group	Avg	SD	Median	Max	N#	D#	Frequency
All AOC (Sample Basis)	**304**	95	**262**	**462**	72	**8**	0.111
Aiken (AKN)	**299**	109	**249**	**424**	27	**3**	0.111
Barnwell (BWL)	**269**	55	**258**	**344**	33	**4**	0.121
Allendale (ALD)	**<u>462</u>**	NA	**<u>462</u>**	**<u>462</u>**	3	**1**	0.333
IPC (County Basis)	**343**	104	**299**	**462**	63	**8**	0.127
OPC (County Basis)	**<LLD**	NA	**<LLD**	**<LLD**	9	**0**	0.000
Bamberg (BMB)	**<LLD**	NA	**<LLD**	**<LLD**	5	**0**	0.000
Edgefield (EDF)	**<LLD**	NA	**<LLD**	**<LLD**	4	**0**	0.000
SCbkg (Sample Basis)	**223**	15	**223**	**233**	13	**2**	0.154
Laurens (LAU)	**233**	NA	**233**	**233**	8	**1**	0.125
Saluda (SAL)	**<LLD**	NA	**<LLD**	**<LLD**	2	**0**	0.000
Lexington (LEX)	**212**	NA	**212**	**212**	2	**1**	0.500
Edgefield (EDF)	**<LLD**	NA	**<LLD**	**<LLD**	1	**0**	0.000
AOC-SCbkg	**81**	NA	**39**	**229**	59	**6**	0.102
IPC -SCbkg	**120**	NA	**76**	**229**	50	**6**	0.120
OPC-SCbkg	**<SCbkg**	NA	**<SCbkg**	**<SCbkg**	<SCbkg	**<SCbkg**	NA

Notes: Bolded numbers highlight the importance of certain columns and underlining denotes highest value.

1 - Allendale county had highest tritium statistics (underlined) potentially due to detections at Steel Creek landing with flood contributions from liquid pathway.

2 - All tritium AOC detections occurred in the IPC close to SRS, and all but Savannah River locations were probably atmospheric contributions.

3 - Many BMB and EDF collections were near the 50-mile limit and are essentially SCbkg.

4 - The two tritium detections in the SCbkg were near the tritium method LLD (typically 200 +or- 20pCi/L).

5 - The larger N# divisor produced lower stats for the AOC-SCbkg versus the IPC-SCbkg.

6 - Area of Concern (AOC), Inner Perimeter Counties (IPC) around SRS boundary, Outer Perimeter Counties (OPC) outside of IPC, but within 50 miles of SRS boundary, South Carolina Background (SCbkg).

7 - IPC (Aiken, Allendale, Barnwell), OPC (Bamberg, Edgefield), AOC (IPC plus OPC), SCbkg (all county samples outside 50-mile perimeter of SRS boundary).

8 - Table 1 statistics are on a county unit basis and area basis.

9 - 8 AOC detections of tritium in EV were only in the IPC versus 2 SCbkg detections.

10 - Since there are not any OPC tritium detections, the SCbkg detections may not be of SRS origin.

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Table 2. EV Gamma (pCi/g) Detections in SRS Perimeter Counties/Areas and SCbkg, 2012

County Basis Sample Statistics							Radionuclide Averages Comparison				
AKN (IPC)	Avg	SD	Median	Max	D#	N#	Be-7	K-40	Pb-212	Pb-214	Cs-137
Be-7	3.604	4.326	1.747	8.548	3	32	3.604				
K-40	5.468	6.069	3.737	34.610	29	32		5.468			
Pb-212	1.018	0.697	1.018	1.511	2	32			1.018		
Pb-214	1.155	2.316	0.240	7.221	9	32				1.155	
Cs-137	0.160	0.068	0.152	0.285	7	32					0.160
BWL (IPC)	Avg	SD	Median	Max	D#	N#	Be-7	K-40	Pb-212	Pb-214	Cs-137
Be-7	3.526	0.378	3.526	3.793	2	47	3.526				
K-40	4.478	4.666	3.285	32.200	44	47		4.478			
Pb-212	0.398	0.377	0.398	0.665	2	47			0.398		
Pb-214	0.472	0.403	0.288	1.642	13	47				0.472	
Cs-137	1.228	1.799	0.679	8.240	21	47					1.228
ALD (IPC)	Avg	SD	Median	Max	D#	N#	Be-7	K-40	Pb-212	Pb-214	Cs-137
Be-7	<MDA	NA	<MDA	<MDA	0	3	<MDA				
K-40	2.805	1.801	2.412	4.770	3	3		2.805			
Pb-212	<MDA	NA	<MDA	<MDA	0	3			<MDA		
Pb-214	0.413	0.036	0.413	0.439	2	3				0.413	
Cs-137	1.618	0.867	1.618	2.231	2	3					1.618
EDF (OPC)	Avg	SD	Median	Max	D#	N#	Be-7	K-40	Pb-212	Pb-214	Cs-137
Be-7	<MDA	NA	<MDA	<MDA	0	4	<MDA				
K-40	4.566	2.536	3.707	8.264	4	4		4.566			
Pb-212	<MDA	NA	<MDA	<MDA	0	4			<MDA		
Pb-214	0.666	0.454	0.666	0.987	2	4				0.666	
Cs-137	<MDA	NA	<MDA	<MDA	0	4					<MDA
BMB (OPC)	Avg	SD	Median	Max	D#	N#	Be-7	K-40	Pb-212	Pb-214	Cs-137
Be-7	<MDA	NA	<MDA	<MDA	0	4	<MDA				
K-40	3.548	0.732	3.943	3.998	3	4		3.548			
Pb-212	<MDA	NA	<MDA	<MDA	0	4			<MDA		
Pb-214	0.192	NA	0.192	0.192	1	4				0.192	
Cs-137	0.935	0.258	0.935	1.117	2	4					0.935
Inner Perimeter County (IPC) Area Sample Basis						Area of Concern (AOC) Area Sample Basis					
IPC	Be-7	K-40	Pb-212	Pb-214	Cs-137	AOC	Be-7	K-40	Pb-212	Pb-214	Cs-137
Avg	3.572	4.789	0.708	0.723	1.005	Avg	3.572	4.734	0.708	0.700	1.000
SD	3.065	5.168	0.581	1.438	1.579	SD	3.065	4.973	0.581	1.359	1.528
Median	3.258	3.391	0.595	0.284	0.428	Median	3.258	3.397	0.595	0.288	0.444
Maximum	8.548	34.610	1.511	7.221	8.240	Maximum	8.548	34.610	1.511	7.221	8.240
D#	5	76	4	24	30	D#	5	83	4	27	32
Outer Perimeter County (OPC) Average Detections						AOC-SCbkg	Be-7	K-40	Pb-212	Pb-214	Cs-137
OPC	Be-7	K-40	Pb-212	Pb-214	Cs-137	Avg	1.941	<SCbkg	0.450	0.351	0.706
Avg	<MDA	4.130	<MDA	0.508	0.935	Median	1.627	<SCbkg	0.337	-0.028	0.243
SD	NA	1.921	NA	0.422	0.258	Maximum	5.978	<SCbkg	1.190	6.672	7.555
Median	<MDA	3.943	<MDA	0.346	0.935	IPC-SCbkg	Be-7	K-40	Pb-212	Pb-214	Cs-137
Maximum	<MDA	8.264	<MDA	0.987	1.117	Avg	1.941	<SCbkg	0.450	0.375	0.711
D#	0	7	0	3	2	Median	1.627	<SCbkg	0.337	-0.032	0.227
SCbkg	Be-7	K-40	Pb-212	Pb-214	Cs-137	Maximum	5.978	<SCbkg	1.190	6.672	7.555
Avg	1.631	5.627	0.258	0.349	0.294	OPC-SCbkg	Be-7	K-40	Pb-212	Pb-214	Cs-137
SD	1.327	2.770	0.090	0.147	0.273	Avg	<SCbkg	<SCbkg	<SCbkg	0.160	0.641
Median	1.631	5.313	0.258	0.315	0.201	Median	<SCbkg	<SCbkg	<SCbkg	0.030	0.734
Maximum	2.570	11.180	0.321	0.549	0.685	Maximum	<SCbkg	<SCbkg	<SCbkg	0.438	0.432
D#	2	17	2	4	4	82 IPC, 8 OPC, or 90 AOC sample total					
N#	17	17	17	17	17	17 SCbkg samples					

Notes:
1 - Statistics are based on detections >MDA only. EV designation includes fungi. Sample statistics are on county and area basis.
2 - Compare IPC, OPC, and SCbkg area statistics. The area with the highest value for each radionuclide is underlined.
Be-7 and Pb-212 are highest for all statistics in the IPC.
Pb-214 and Cs-137 are highest in the IPC for average and maximum. The medians are highest in the OPC.
K-40 maximum is highest in the IPC, and average and median are highest in the SCbkg.
All maximums are highest in the IPC only, and the IPC dominates most high statistics.
The main radionuclide of concern, Cs-137, has the lowest statistics in the SCbkg.
3 - The AOC is higher than the SCbkg for all statistics except the K-40 average and median.
4 - The frequency (D#/N#) of detections was highest in the IPC for all 5 radionuclides.
5 - Aiken County had highest averages for Be-7, K-40, Pb-212, and Pb-214,and Allendale County was highest for Cs-137.
7 - Conclusion is that area statistical trends indicate SRS as a potential source contributor to concentrations.

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Table 3. EV Type/Species Specific Average Detection Comparison in AOC versus SCbkg

Fungi Mushroom Types	**AOC**		**SCbkg**		**Difference**
	Golden Chanterelle or *Cantharellus cibarius*				**>SCbkg**
Chanterelle Family	**Tritium**	462	<LLD	pCi/L	**462**
of mushrooms	**K-40**	4.074	4.278	pCi/g	<SCbkg
	Pb-214	0.439	<MDA	pCi/g	**0.439**
	Cs-137	1.005	0.124	pCi/g	**0.881**
Polypore Family	**Chicken or *Laetiporus sulphurus***		**Hen-of-the-Woods or *Grifola frondosa***		Difference
of mushrooms	**K-40**	5.170	2.183	pCi/g	**2.987**
	Cs-137	0.124	<MDA	pCi/g	**0.124**
Russula Family	***Lactarius* species**				Difference
of mushrooms	**Tritium**	<LLD	212	pCi/L	<SCbkg
	K-40	1.999	2.556	pCi/g	<SCbkg
	Pb-214	0.290	<MDA	pCi/g	**0.290**
	Cs-137	1.248	0.204	pCi/g	**1.045**
	***Boletus* species**				Difference
Bolete Family	**Tritium**	344	<LLD	pCi/L	**344**
of mushrooms	**K-40**	4.444	4.120	pCi/g	**0.324**
	Pb-212	0.132	<MDA	pCi/g	<SCbkg
	Pb-214	0.293	0.549	pCi/g	<SCbkg
	Cs-137	1.143	0.089	pCi/g	**1.054**
Green Plant Types	**Other Samples, Tritium Only**				Difference
lettuce	**Tritium**	217	<LLD	pCi/L	**217**
collards	**Tritium**	240	233	pCi/L	**7**
mustards	**Tritium**	<LLD	<LLD	pCi/L	<LLD
pokeberry leaf	**Tritium**	276	<LLD	pCi/L	**276**

Notes:
1 - Data comparison for samples having both an AOC and SCbkg sample.
2 - If there was no analysis result >MDA or LLD for a specific AOC and SCbkg type/species, then it was not included.
3 - <LLD or <MDA are treated as zero and the difference is potentially inflated.
4 - Highest Fungi and Green Plant radionuclide is underlined.

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Notes:

1. Bold numbers denote detections.
2. See acronym section for definitions.

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Data Table 1a,b,c,d. Tritium in AOC Green Plants (pCi/L)

Data Table 1a. Edible Domestic and Escapes, Greens and Flowers											
EVPlant	Domestic Mustard		Domestic (D_) Collards			D_Lettuce	Yucca Flower		Bamboo		
ID	EV102	EV111	EV103	EV110	EV161	EV160	EV135	EV139	EV137		
Date	2/16/12	2/21/12	2/16/12	2/21/12	6/5/12	6/5/12	5/8/12	5/9/12	5/8/12		
County	AKN	AKN	AKN	AKN	BWL	BWL	BMB	AKN	BMB		
Tritium	<LLD	<LLD	<LLD	<LLD	**240**	**217**	<LLD	<LLD	<LLD		
U	NA	NA	NA	NA	96	94	NA	NA	NA		
LLD	214	214	214	214	205	205	205	205	205		
Table 1a Statistics...								avg	sd	median	max
Data Table 1b. Edible Wild Greens, Flowers, and Teas								229	16	229	240
EVPlant	Pokeberry Leaf				Mullein	Wild Mustard		PricklyPear	Winged Sumac Drupe		
ID	EV122	EV129	EV128B	EV131	EV121b	EV113	EV121	EV108	EV125BG2	EV190	EV199
Date	3/20/12	4/26/12	4/26/12	4/26/12	3/20/12	2/22/12	3/14/12	2/21/12	3/20/13	8/21/12	10/26/12
County	AKN	BWL	BWL	AKN	AKN	AKN	AKN	AKN	BWL	EDF	BWL
Tritium	<LLD	<LLD	**276**	<LLD	<LLD	<LLD	<LLD	**424**	<LLD	<LLD	<LLD
U	NA	NA	96	NA	NA	NA	NA	106	NA	NA	NA
LLD	220	217	205	205	220	214	220	214	220	213	206
Table 1b Statistics...								avg	sd	median	max
Data Table 1c. Edible Ferns and Bulbs, Roots, Tubers, Rhizomes								350	105	350	424
EVPlant	Fern						D_Radish	D_Turnip Roots			
ID	EV123	EV128a	EV130	EV134	EV136	EV138	EV159	EV112a	EV112b	EV162	
Date	3/20/12	4/26/12	4/26/12	5/8/12	5/8/12	5/8/12	6/5/12	2/21/12	2/21/12	6/5/12	
County	AKN	BWL	BWL	BWL	BMB	BMB	BWL	AKN	AKN	BWL	
Tritium	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	
U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
LLD	220	217	217	205	205	205	213	214	214	205	
Table 1c Statistics...								avg	sd	median	max
Data Table 1d. Edible Wild Fruits and Nuts								<LLD	<LLD	<LLD	<LLD
EVPlant	Plums	Blackberry	Hickory Nuts		Persimmons			Apple-Pear	D_Pear	DeerBerry	Grapes
ID	EV132	EV145	EV167B	EV189	EV173	EV174B	EV188	EV184	EV186	EV194	EV197
Date	5/8/12	5/17/2012	6/14/12	8/21/12	8/8/12	8/8/12	8/21/12	8/14/12	8/15/12	8/24/12	9/11/12
County	AKN	AKN	BWL	EDF	BWL	AKN	EDF	AKN	BWL	BWL	AKN
Tritium	**249**	**224**	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
U	101	98	NA	NA	NA	NA	NA	NA	NA	NA	NA
LLD	217	213	205	213	213	213	213	213	213	213	206
Table 1d Statistics...								avg	sd	median	max
								237	18	237	249

Notes:

1 - Tritium detections occurred in collards, lettuce, pokeberry leaf, prickly pear cactus, hog plums, and wild blackberry.

2 - The maximum tritium detection (424 pCi/L) was <twice the method LLD typical limit (220 pCi/L).

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Data Table 1e,f. Tritium in AOC Fungi (pCi/L)

Data Table 1e. Tritium in Bolete Fungi											
EVPlant	Boletes										
ID	EV150	EV151A	EV151B	EV151C	EV153	EV154	EV155	EV156B	EV158	EV163	EV164
Date	5/29/12	5/29/12	5/29/12	5/29/12	5/29/12	5/29/12	5/30/12	5/30/12	5/30/12	6/14/12	6/14/12
County	BWL	BWL	BWL	BWL	BWL	BWL	AKN	AKN	BWL	AKN	BWL
Tritium	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD
U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LLD	213	213	213	213	213	213	213	213	213	205	205
EVPlant	Boletes										
ID	EV165A	EV166	EV175	EV176	EV177	EV178	EV180	EV183	EV185	EV193	avg
Date	6/14/12	6/14/12	8/14/12	5/17/12	6/15/12	7/7/12	7/14/12	7/23/12	8/15/12	8/24/12	344
County	BWL	BWL	AKN	BMB	BWL	BWL	BWL	BWL	BWL	AKN	median
Tritium	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**344**	<LLD	344
U	NA	NA	NA	NA	NA	NA	NA	NA	102	NA	max
LLD	205	205	213	216	216	216	216	216	213	213	344
Data Table 1f. Tritium in Gilled and Other Fungi											No sd
EVPlant	Oyster		Lactarius				Chanterelles		Coral	RedSulfur	avg
ID	EV120	EV156A	EV152	EV165B	EV182	EV196	EV157	EV195	EV167A	EV192B	462
Date	3/14/12	5/30/12	5/29/12	6/14/12	7/21/12	8/24/12	5/30/12	8/24/12	6/14/12	8/21/12	median
County	AKN	AKN	ALD	BWL	BWL	ALD	EDF	ALD	BWL	AKN	462
Tritium	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**462**	<LLD	<LLD	max
U	NA	NA	NA	NA	NA	NA	NA	104	NA	NA	462
LLD	220	213	213	205	216	206	213	206	205	213	No sd

Notes:
1 - Tritium detections in fungi occurred only in bolete and chanterelle mushrooms.
2 - The maximum tritium detection (462 pCi/L) was barely >two times the typical method LLD limit of 220 pCi/L.

Data Table 2. SCbkg Tritium (pCi/L) in Green Plants and Fungi

EV	Collards		Onion		Mustard	Lettuce	Pokeberry Leaf		Plant Statistics
Field ID	EV141	EV106	EV107	EV140	EV142	EV105	EV143	EV169	Avg
Date	5/10/12	2/19/12	2/19/12	5/10/12	5/10/12	2/19/12	5/10/12	6/15/12	**233**
County	LAU	LAU	LAU	LAU	LAU	LAU	LAU	SAL	Median
Tritium	<LLD	**233**	<LLD	<LLD	<LLD	<LLD	<LLD	<LLD	**233**
U	NA	99	NA	NA	NA	NA	NA	NA	Maximum
LLD	205	214	214	205	205	214	205	205	**233**
EV	Lactarius Mushroom		Chanterelle	Hen of the Woods	Bolete	Fungi Statistics	Green Plant plus Fungi SCbkg Statistics		
Field ID	EV170	EV171A	EV171B	EV187	EV191A	Avg	**Avg**		**SD**
Date	6/15/12	6/15/12	6/15/12	8/20/12	8/21/12	**212**	**223**		**15**
County	SAL	LEX	LEX	LAU	EDF	Median	**Median**		
Tritium	<LLD	**212**	<LLD	<LLD	<LLD	**212**	**223**		
U	NA	94	NA	NA	NA	Maximum	**Maximum**		
LLD	205	205	205	213	213	**212**	**233**		

Notes:
1 - Tritium detections occurred in collards and lactarius mushrooms barely above the sample run LLD, typically 200 pCi/L.
2 - This tritium had to come from an atmospheric deposition at these locations.

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Data Table 3a,b. Edible Fungi Gamma (pCi/g) Detections in the AOC and SCbkg, 2012

Data Table 3a. Edible Non-Gilled Fungi Other Than Bolete Gamma (pCi/g) Detections in the AOC and SCbkg, 2012

Area	IPC			OPC	*SCbkg*	IPC	*SCbkg*	Fungi Type Comparison		Table -
Type	Lichen		Chanterelles			Chicken	Hen-of-the-Woods	Gilled	*Non-Gilled*	All Gilled plus
Field ID	Ev200b	EV114	EV195	EV157	EV171b	EV192b	EV187	Fungi	*& Not Bolete*	All Non-gilled
Date	10/26/12	3/8/12	8/24/12	5/30/12	6/15/12	8/21/12	8/20/12	AOC Avgs	AOC Avgs	SCbkg Avgs
County	BWL	AKN	ALD	EDF	LEX	AKN	LAU	Be-7		
Be-7	<MDA	**8.548**	<MDA	<MDA	<MDA	<MDA	<MDA	**1.747**	**8.548**	<MDA
Be-7 C.I.	NA	1.526	NA	NA	NA	NA	NA			
Be-7 MDA	3.024	1.169	2.094	0.616	0.880	1.920	1.600	K-40		
K-40	<MDA	<MDA	**4.770**	**3.377**	**4.278**	**5.170**	**2.183**	**6.1855**	**4.439**	**3.138**
K-40 C.I.	NA	NA	0.828	0.627	0.708	0.802	0.655			
K-40 MDA	3.372	0.790	0.326	0.216	0.271	0.311	0.318	Pb-212		
Pb-212	<MDA	**1.511**	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	**1.511**	<MDA
Pb-212 C.I.	NA	0.221	NA	NA	NA	NA	NA			
Pb-212 MDA	0.350	0.181	0.102	0.056	0.065	0.102	0.101	Pb-214		
Pb-214	**1.642**	**1.502**	**0.439**	<MDA	<MDA	<MDA	**0.215**	**0.286**	**1.194**	**0.382**
Pb-214 C.I.	0.320	0.230	0.091	NA	NA	NA	0.094			
Pb-214 MDA	0.335	0.204	0.099	0.078	0.092	0.111	0.095	Cs-137		
Cs-137	<MDA	<MDA	**1.005**	<MDA	**0.124**	<MDA	<MDA	**0.687**	**1.005**	**0.294**
Cs-137 C.I.	NA	NA	0.103	NA	0.049	NA	NA	See Data Table 3c for		
Cs-137 MDA	0.143	0.110	0.046	0.026	0.038	0.048	0.043	Bolete Mushroom Data		

Data Table 3b. Edible Gilled Fungi Gamma (pCi/g) Detections in the AOC and SCbkg, 2012

Area	IPC				*SCbkg*		IPC			
Type	Lactarius						Oysters		Honey	A.campestrus
Field ID	EV152a	EV196	EV177b	EV165b	EV170	EV171a	EV120	EV156a	EV119	EV175
Date	5/29/12	8/24/12	7/21/12	6/14/12	6/15/12	6/15/12	3/14/12	5/30/12	3/8/12	7/14/12
County	ALD	ALD	BWL	BWL	SAL	LEX	AKN	AKN	AKN	BWL
Be-7	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	**1.747**	<MDA
Be-7 C.I.	NA	NA	NA	NA	NA	NA	NA	NA	0.620	NA
Be-7 MDA	0.895	1.915	0.756	0.748	0.987	0.567	0.221	0.780	0.569	0.600
K-40	**1.233**	**2.412**	**2.346**	**2.003**	**2.992**	**2.119**	**3.051**	**1.842**	**34.610**	**1.987**
K-40 C.I.	0.662	0.677	0.633	0.499	0.654	0.416	0.433	0.548	2.569	0.541
K-40 MDA	0.301	0.339	0.318	0.259	0.309	0.189	0.179	0.292	0.402	0.278
Pb-214	<MDA	**0.388**	**0.191**	<MDA	<MDA	<MDA	<MDA	<MDA	**0.280**	<MDA
Pb-214 C.I.	NA	0.104	0.072	NA	NA	NA	NA	NA	0.090	NA
Pb-214 MDA	0.106	0.101	0.078	0.094	0.104	0.060	0.052	0.090	0.098	0.077
Cs-137	<MDA	**2.231**	**0.432**	**1.081**	**0.685**	**0.278**	<MDA	**0.160**	**0.116**	**0.105**
Cs-137 C.I.	NA	0.190	0.070	0.099	0.075	0.038	NA	0.039	0.056	0.034
Cs-137 MDA	0.054	0.045	0.035	0.033	0.040	0.027	0.023	0.032	0.049	0.032

Notes:
1 - All other gamma analysis results were <MDA. See appendix 1a for gamma radionuclide list and abbreviations.
2 - Gammas analyzed included Be-7, Na-22, K-40, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Cs-137, Ce-144, Eu-152, Eu-154, Eu-155, Ra-226, Ac-228, U/Th-238, Pb-212, Pb-214, and Am-241.
3 - Underlined values are the highest for that radionuclide in the SCbkg.
4 - The fungi AOC averages were all higher than the SCbkg averages.
5 - See Table 3c for edible bolete mushroom data.
6 - Subtract the specific fungi type SCbkg for the most applicable result greater than SCbkg.
7 - Use all SCbkg average for subtraction of general fungi radionuclide results greater than SCbkg.
8 - Note that the honey mushroom K-40 detection is an outlier that inflates the average for gilled fungi.
9 - Data Table 3c bolete results can be compared to gilled plus other non-gilled & non-bolete fungi.
10- Non-gilled is pored, smooth surfaced, and toothed spore bearing fungi. Pored includes bolete mushrooms and polypores.

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Data Table 3c. Edible Fungi Gamma (pCi/g) Detections in the AOC and SCbkg Bolete Mushrooms, 2012

Area	IPC												
Type	Bolete species												
Field ID	**EV150**	**EV151a**	**EV151b**	**EV151c**	**EV153**	**EV154**	**EV158**	**EV164**	**EV165a**	**EV166**	**EV174b**	**EV174b2**	**EV178a**
Date	5/29/12	5/29/12	5/29/12	5/29/12	5/29/12	5/29/12	5/30/12	6/14/12	6/14/12	6/14/12	7/7/12	7/7/12	7/23/12
County	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**
K-40 Activity	**5.088**	**4.260**	**4.563**	**3.360**	**4.417**	**2.699**	**2.626**	**2.104**	**2.864**	**3.159**	**4.671**	**3.563**	**3.397**
K-40 C.I.	0.704	0.668	0.743	0.726	0.714	0.571	0.944	0.455	0.518	0.542	0.695	0.598	0.696
K-40 MDA	0.266	0.265	0.300	0.300	0.293	0.212	0.458	0.239	0.238	0.250	0.237	0.285	0.368
Pb-212 Activity	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	**0.132**	<MDA	**0.216**	<MDA
Pb-212 C.I.	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.062	NA	0.086	NA
Pb-212 MDA	0.052	0.061	0.072	0.063	0.063	0.057	0.112	0.069	0.073	0.062	0.063	0.083	0.072
Cs-137 Activity	<MDA	<MDA	<MDA	**0.127**	<MDA	**0.111**	**0.250**	**1.934**	**0.455**	**0.260**	**1.090**	**0.965**	**0.423**
Cs-137 C.I.	NA	NA	NA	0.042	NA	0.039	0.072	0.158	0.057	0.044	0.097	0.098	0.061
Cs-137 MDA	0.033	0.033	0.037	0.037	0.036	0.029	0.050	0.028	0.033	0.031	0.037	0.037	0.038
Area	IPC											*SCbkg*	**IPC**
Type	Bolete species												**Radionuclide**
Field ID	**EV178b**	**EV176**	**EV177a**	**EV185**	**EV198**	**EV173**	**EV155**	**EV156b**	**EV163**	**EV192a**	**EV193**	**EV191**	**Average/**
Date	7/23/12	7/15/12	7/21/12	8/15/12	10/11/12	6/15/12	5/30/12	5/30/12	6/14/12	8/21/12	8/24/12	8/21/12	**Median/**
County	**BWL**	**BWL**	**BWL**	**BWL**	**BWL**	**BMB**	**AKN**	**AKN**	**AKN**	**AKN**	**AKN**	**EDF**	**Maximum**
K-40 Activity	**1.665**	**1.886**	**2.476**	**3.210**	**32.200**	**2.704**	**3.038**	**2.667**	**2.546**	**3.712**	**3.792**	**4.120**	**4.444/**
K-40 C.I.	0.507	0.638	0.701	0.675	2.755	0.589	0.617	0.613	0.546	0.745	0.647	0.753	**3.185/**
K-40 MDA	0.242	0.397	0.410	0.335	0.657	0.305	0.285	0.244	0.295	0.380	0.341	0.375	**32.200**
Pb-214 Activity	<MDA	<MDA	<MDA	**0.288**	**0.558**	**0.192**	<MDA	<MDA	<MDA	<MDA	**0.209**	**0.549**	**0.312/**
Pb-214 C.I.	NA	NA	NA	0.090	0.206	0.056	NA	NA	NA	NA	0.080	0.093	**0.248/**
Pb-214 MDA	0.060	0.079	0.114	0.099	0.212	0.064	0.093	0.087	0.105	0.113	0.089	0.098	**0.558**
Cs-137 Activity	**0.679**	**0.122**	**2.576**	**2.704**	**8.240**	<MDA	**0.080**	<MDA	**0.152**	**0.285**	**0.122**	**0.089**	**1.143/**
Cs-137 C.I.	0.073	0.047	0.198	0.221	0.642	NA	0.037	NA	0.034	0.061	0.057	0.035	**0.354/**
Cs-137 MDA	0.036	0.038	0.048	0.042	0.097	0.037	0.037	0.036	0.039	0.044	0.041	0.044	**8.240**

Notes:

1 - All other gamma analysis results were <MDA.

2 - Gammas analyzed included Be-7, Na-22, K-40, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Cs-137, Ce-144, Eu-152, Eu-154, Eu-155, Ra-226, Ac-228, U/Th-238, Pb-212, Pb-214, and Am-241.

3 - The IPC Pb-212 average and median (0.174 pCi/g), and maximum (0.216 pCi/g) are not shown in the table. Pb-212 was not found in the SCbkg sample.

4 - The IPC average, median, and maximums for all K-40, Pb-214, and Cs-137 are summarized in the table. All three were highest in concentration in the EV198 sample.

5 - The SCbkg was highest only for the Pb-214 average (single sample) versus the IPC average (24 samples).

6 - Compare with Data Table 3a,b for general fungi type results (bolete, gilled, and non-bolete non-gilled).

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Data Table 4. SCbkg Gamma (pCi/g) in Green Plants

ID	**EV105**	**EV106**	**EV141**	**EV142**	**EV143**	**EV149**	**EV169**	**EV125BG2**
Date	2/19/12	2/19/12	5/10/12	5/10/12	5/10/12	5/22/12	6/15/12	3/24/12
Type EV	**Lettuce**	**Collards**		**Mustard**	**Pokeberry Leaf**			
County	**LAU**	**LAU**	**LAU**	**LAU**	**LAU**	**EDF**	**SAL**	**LAU**
Be-7	<MDA	**0.693**	<MDA	<MDA	<MDA	<MDA	**2.570**	<MDA
Be-7 C. I.	NA	0.308	NA	NA	NA	NA	1.086	NA
Be-7 MDA	0.428	0.304	1.000	2.051	1.676	1.315	0.864	0.244
K-40	**8.390**	**5.776**	**7.074**	**8.108**	**7.903**	**11.180**	**9.980**	**5.877**
K-40 C. I.	0.868	0.667	0.824	1.283	1.290	1.279	0.925	0.607
K-40 MDA	0.294	0.242	0.317	0.714	0.517	0.432	0.282	0.219
Pb-212	<MDA	<MDA	<MDA	**0.321**	<MDA	<MDA	<MDA	<MDA
Pb-212 C. I.	NA	NA	NA	0.157	NA	NA	NA	NA
Pb-212 MDA	0.072	0.063	0.091	0.146	0.154	0.090	0.080	0.048
Pb-214	<MDA	<MDA	<MDA	<MDA	<MDA	**0.364**	<MDA	<MDA
Pb-214 C. I.	NA	NA	NA	NA	NA	0.091	NA	NA
Pb-214 MDA	0.088	0.074	0.105	0.207	0.180	0.091	0.090	0.053
ID	**EV140**	**EV107**	**EV125BG**	**EV148**				
Date	5/10/12	2/19/12	3/24/12	5/22/12				
Type EV	**Onion**		**Fern**	**Pecans**	**Green Plant SCbkg Statistics**			
County	**LAU**	**LAU**	**LAU**	**EDF**	**Avg**	**SD**	**Median**	**Maximum**
Be-7	<MDA	<MDA	<MDA	<MDA	**1.631**	1.327	**1.631**	**2.570**
Be-7 C. I.	NA	NA	NA	NA				
Be-7 MDA	0.979	0.285	0.857	2.332				
K-40	**2.366**	**3.428**	**5.313**	**4.577**	**6.664**	2.606	**6.476**	**11.180**
K-40 C. I.	0.651	0.464	1.379	1.457				
K-40 MDA	0.315	0.213	0.786	0.601				
Pb-212	<MDA	**0.194**	<MDA	<MDA	**0.258**	0.090	**0.258**	**0.321**
Pb-212 C. I.	NA	0.040	NA	NA				
Pb-212 MDA	0.094	0.041	0.168	0.187				
Pb-214	<MDA	**0.267**	<MDA	<MDA	**0.315**	0.069	**0.315**	**0.364**
Pb-214 C. I.	NA	0.053	NA	NA				
Pb-214 MDA	0.104	0.044	0.169	0.227				

Notes:

1 - All other gamma analysis results were <MDA.

2 - Gammas analyzed included Be-7, Na-22, K-40, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Cs-137, Ce-144, Eu-152, Eu-154, Eu-155, Ra-226, Ac-228, U/Th-238, Pb-212, Pb-214, and Am-241.

3 - No Cs-137 detection in SCbkg for green plants except in ferns and one Deerberry sample (see Data Table 6).

4 - Twelve SCbkg green plant samples plus 5 fungi. See Tables 3a,b and 3c for fungi SCbkgs.

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Data Tables 5a,b,c,d,e. All Green Plant Gamma (pCi/g) Detections (except ferns), 2012

Data Table 5a. All Domestic Green Plant Leafy Greens and Spice											
ID	EV101a	EV111	EV102	EV160	EV103	EV110	EV161	EV112a	EV162L	EV101b	D. Leafy
Date	1/27/12	2/21/12	2/16/12	6/5/12	2/16/12	2/21/12	6/5/12	2/21/12	6/5/12	1/27/12	Avg/
Type EV	Rosemary	Mustard		Lettuce	Collards			Turnip		Garlic	Median/
County	BWL	AKN	AKN	BWL	AKN	AKN	BWL	AKN	BWL	BWL	Maximum
Be-7	**3.258**	**0.516**	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	**1.887**
Be-7 C. I.	1.437	0.244	NA	NA	NA	NA	NA	NA	NA	NA	**1.887**
Be-7 MDA	1.071	0.271	0.339	1.189	0.343	0.368	1.843	0.240	1.325	0.418	**3.258**
K-40	**3.384**	**3.916**	<MDA	**2.902**	<MDA	**3.029**	**3.759**	**3.654**	**3.000**	**2.617**	**3.283**
K-40 C. I.	1.079	0.492	NA	0.800	NA	0.487	1.348	0.447	0.902	0.464	**3.207**
K-40 MDA	0.556	0.181	0.380	0.374	0.320	0.233	0.588	0.173	0.455	0.213	**3.916**

Data Table 5b. All Wild Leafy Green Plant											Wild
ID	EV108	EV121	EV113	EV115	EV121b	EV122	EV116	EV128b	EV129	EV131	Leafy
Date	2/21/12	3/14/12	2/22/12	3/8/12	3/20/12	3/20/12	3/8/12	4/26/12	4/26/12	4/26/12	Avg/
Type EV	Cactus	Wild Mustard		Mullein		Pokeberry					Median/
County	AKN	AKN	AKN	AKN	AKN	AKN	AKN	BWL	BWL	AKN	Maximum
K-40	**3.255**	**6.208**	**4.948**	**8.578**	**7.245**	**6.303**	**7.066**	**5.645**	**8.137**	**8.964**	**6.635**
K-40 C. I.	0.466	0.752	0.593	1.620	0.805	0.711	0.702	0.628	1.007	0.823	**6.685**
K-40 MDA	0.173	0.268	0.199	0.759	0.338	0.234	0.202	0.235	0.309	0.209	**8.964**
Pb-214	**0.108**	<MDA	<MDA	**0.535**	<MDA	<MDA	**0.091**	<MDA	<MDA	<MDA	**0.245**
Pb-214 C. I.	0.046	NA	NA	0.164	NA	NA	0.042	NA	NA	NA	**0.108**
Pb-214 MDA	0.043	0.078	0.066	0.216	0.093	0.079	0.046	0.071	0.128	0.076	**0.535**

Data Table 5c. All Wild Green Plant Bulbs, Roots, Shoots, Tuber, Rhizomes								Data Table 5d. Flowers			
ID	EV162R	EV112b	EV159	EV124	EV126	EV137	Root & Shoot		EV139	Ev127b	Flower
Date	6/5/12	2/21/12	6/5/12	3/20/12	3/27/12	5/8/12	Avg/		5/9/12	7/25/12	Avg/
Type EV	Turnip		Radish	Cattail		Bamboo	Median/		Yucca	Thistle	Median/
County	BWL	AKN	BWL	AKN	BWL	BMB	Maximum		AKN	BWL	Maximum
K-40	**2.630**	**3.267**	**2.780**	**11.040**	**5.909**	**3.943**	**4.928**		**1.803**	**7.023**	**4.413**
K-40 C. I.	0.510	0.462	0.669	2.541	2.164	0.576	**3.605**		0.451	0.813	**4.413**
K-40 MDA	0.261	0.226	0.308	1.353	1.241	0.260	**11.040**		0.218	0.300	**7.023**
Pb-212	<MDA	<MDA	<MDA	**0.525**	**0.665**	<MDA	**0.595**		<MDA	<MDA	<MDA
Pb-212 C. I.	NA	NA	NA	0.228	0.242	NA	**0.595**		NA	NA	<MDA
Pb-212 MDA	0.073	0.052	0.095	0.256	0.230	0.071	**0.665**		0.062	0.083	<MDA
Pb-214	<MDA	<MDA	**0.256**	**7.221**	**0.783**	<MDA	**2.753**		<MDA	<MDA	<MDA
Pb-214 C. I.	NA	NA	0.078	0.456	0.290	NA	**0.783**		NA	NA	<MDA
Pb-214 MDA	0.084	0.059	0.093	0.313	0.287	0.079	**7.221**		0.070	0.096	<MDA

Data Table 5e. All Domestic (D) and Wild (W) Fruit of Green Plants (GP)											
ID	EV186	EV132	EV133	EV125	EV145	EV194					Fruit
Date	8/15/12	5/8/12	5/8/12	3/20/12	5/17/12	**8/24/12**					Avg/
Type EV	(D) Pear	Plum	Rose Hips	SumacDrupe	Blackberry	Deerberry					Median/
County	BWL	AKN	BWL	BWL	AKN	BWL					Maximum
K-40	**1.744**	**3.778**	**2.518**	**7.230**	**1.379**	**1.933**					**3.097**
K-40 C. I.	0.392	0.663	0.562	1.505	0.630	0.449					**2.226**
K-40 MDA	0.173	0.326	0.313	0.885	0.283	0.261					**7.230**
Pb-214	<MDA	<MDA	<MDA	<MDA	<MDA	**0.598**					**0.598**
Pb-214 C. I.	NA	NA	NA	NA	NA	0.075					**0.598**
Pb-214 MDA	0.065	0.097	0.095	0.226	0.104	0.065					**0.598**
Cs-137	<MDA	<MDA	<MDA	<MDA	<MDA	**0.059**					**0.059**
Cs-137 C.I.	NA	NA	NA	NA	NA	0.023					**0.059**
Cs-137 MDA	0.025	0.040	0.103	0.103	0.044	0.028					**0.059**

Notes:

1 - All other gamma analysis results were <MDA.

2 - Gammas analyzed included Be-7, Na-22, K-40, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Cs-137, Ce-144, Eu-152, Eu-154, Eu-155, Ra-226, Ac-228, U/Th-238, Pb-212, Pb-214, and Am-241.

3 - The underlined values are highest for that radionuclide.

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Data Table 6. Edible Fern Gamma (pCi/g) Detections in the AOC

ID	EV123	EV127	EV128a	EV130	EV138	EV134	EV136	AOC D#s	EV125BG
Date	3/20/12	3/27/12	4/26/12	4/26/12	5/8/12	5/8/12	5/8/12	avg	3/24/12
Type EV	**Fern**	**Fern**	**Fern**	**Fern**	**Fern**	**Fern**	**Fern**	sd	**Fern**
County	**AKN**	**BWL**	**BWL**	**BWL**	**BMB**	**BWL**	**BMB**	median	**SCbkg**
K-40	**4.697**	**7.180**	**7.406**	<MDA	<MDA	**4.220**	**3.998**	**5.500**	**5.313**
K-40 C. I.	0.888	1.182	1.515	NA	NA	1.655	1.759	**1.658**	1.379
K-40 MDA	0.452	0.534	0.750	1.084	1.154	0.992	0.835	**4.697**	0.786
Pb-214	**0.240**	**0.406**	<MDA	<MDA	<MDA	<MDA	<MDA	**0.323**	<MDA
Pb-214 C. I.	0.087	0.141	NA	NA	NA	NA	NA	**0.117**	NA
Pb-214 MDA	0.107	0.133	0.248	0.340	0.355	0.345	0.255	**0.323**	0.169
Cs-137	**0.205**	**1.298**	<MDA	<MDA	**1.117**	**1.946**	**0.752**	**1.064**	<MDA
Cs-137 C. I.	0.061	0.143	NA	NA	0.219	0.229	0.150	**0.646**	NA
Cs-137 MDA	0.054	0.067	0.093	0.149	0.157	0.116	0.117	**1.117**	0.089

Notes:
1 - All other gamma analysis results were <MDA.
2 - Gammas analyzed included Be-7, Na-22, K-40, Mn-54, Co-58, Co-60, Zn-65, Y-88, Zr-95, Ru-103, Sb-125, I-131, Cs-134, Cs-137, Ce-144, Eu-152, Eu-154, Eu-155, Ra-226, Ac-228, U/Th-238, Pb-212, Pb-214, and Am-241.
3 - The non-NORM Cs-137 is radioactive fallout frequently detected in edible ferns (can replace potassium).

Data Table 7. Total Strontium in Green Plants and Fungi

Sr Results	**AOC**							**AOC D#s**	**SCbkg**
County	BWL	AKN	BWL	BWL	AKN	BWL	BWL	**Statistics**	LEX
Edible Plant	bolete	bolete	persimmons	persimmons	boletes	boletes	D. pears	**avg**	lactarius
Field ID	Ev151	EV163	EV180	EV181	EV183	EV185	EV186	**sd**	EV171
Collection Date	5/29/12	6/14/12	8/8/12	8/8/12	8/14/12	8/15/12	8/15/12	**median**	6/15/12
Total Sr (pCi/g)	0.000358	0.0118	0.00833	**0.0566**	0.0157	-0.00526	**0.0328**	**0.0447**	0.00292
CSU	0.0122	0.0135	0.0127	0.0239	0.0156	0.0132	0.0173	0.0168	0.0114
MDA	0.026	0.0262	0.0256	0.0224	0.0295	0.0285	0.024	0.0447	0.0241

Notes:
1 - Values below the MDA are questionable and not reportable as detections.
2 - Species specific SCbkgs are needed to improve the AOC comparison.
3 - SCbkg <MDA and cannot be subtrated from other results. EV181 and EV186 results are also >SCbkg result and MDA.

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Notes:
See Acronym section for all abbreviations and definitions.

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Summary Statistics Table 1. Tritium (pCi/L) in EV Types/Species, 2012

All EV Samples	Avg	SD	Median	Max	N#	D#	Type
Tritium in AOC	304	95	262	462	72	8	EV
Blackberries, wild	224	NA	224	224	1	1	WP
Cactus, prickly pear, wild	424	NA	424	424	1	1	WP
Collards, domestic	240	NA	240	240	3	1	DA
Lettuce, domestic	217	NA	217	217	1	1	DA
Plums, wild hog	249	NA	249	249	1	1	WP
Pokeberry leaf, wild	276	NA	276	276	4	1	WP
Bolete, mushroom	344	NA	344	344	21	1	FG
Chanterelles, mushroom	462	NA	462	462	2	1	FG
Apple-Pear, fruit	<LLD	NA	<LLD	<LLD	1	0	DP
Bamboo, shoots	<LLD	NA	<LLD	<LLD	1	0	WP
DeerBerry, berries	<LLD	NA	<LLD	<LLD	1	0	WP
Fern, fiddlehead	<LLD	NA	<LLD	<LLD	6	0	WP
Grapes, wild	<LLD	NA	<LLD	<LLD	1	0	WP
Hickory nuts, wild	<LLD	NA	<LLD	<LLD	2	0	WP
Mustards, domestic (2A) & wild (2P)	<LLD	NA	<LLD	<LLD	4	0	DA&WP
Mullein, wild	<LLD	NA	<LLD	<LLD	1	0	WP
Pear, domestic	<LLD	NA	<LLD	<LLD	1	0	DP
Persimmons, wild	<LLD	NA	<LLD	<LLD	3	0	WP
Radish root, domestic	<LLD	NA	<LLD	<LLD	1	0	DA
Sumac, winged, drupes	<LLD	NA	<LLD	<LLD	3	0	WP
Turnips, root & leaf, domestic	<LLD	NA	<LLD	<LLD	3	0	DA
Yucca, wildflower	<LLD	NA	<LLD	<LLD	2	0	WP
Coral, mushroom	<LLD	NA	<LLD	<LLD	1	0	FG
Lactarius, mushroom	<LLD	NA	<LLD	<LLD	4	0	FG
Oyster, mushroom	<LLD	NA	<LLD	<LLD	2	0	FG
RedSulfur/Chicken, mushroom	<LLD	NA	<LLD	<LLD	1	0	FG
Tritium in SCbkg	223	15	223	223	13	2	EV
Collards, domestic	233	NA	233	233	8	1	DA
Lactarius, mushroom	212	NA	212	212	5	1	FG

Notes:

1- The frequency of tritium detections in AOC EV is low (8/72).

2 - The detected tritium activity concentration is generally less than twice the LLD typical limit (2 x 220 pCi/L).

3 - The EV types with the highest tritium detections occurred in the flood zones.

4 - The greatest tritium exposure for EV appears to come from the liquid pathway versus the atmospheric.

5 - Wild type EV maximum tritium detection was higher than domestic.

6 - Fungi maximum tritium detection was higher than green plant.

7 - WP = wild perennial, DA = domestic annual, DP = domestic perennial, EV= edible vegetation, FG=fungi

7.0 Summary Statistics

2012 Radiological Monitoring of Edible Vegetation

Summary Statistics Table 2. Tritium (pCi/L) in Edible Vegetation (Includes Fungi), 2012

Area of Concern (AOC)						South Carolina Background (SCbkg)					
Avg	SD	Median	Max	N#	D#	Avg	SD	Median	Max	N#	D#
All EV tritium (includes fungi)											
304	95	**262**	462	72	8	**223**	15	**233**	**233**	13	2
All EV tritium (excludes fungi)											
272	77	**245**	424	41	6	**233**	NA	**233**	**233**	8	1
Fungi EV tritium											
403	83	**403**	**462**	31	2	**212**	NA	**212**	**212**	5	1
All Domestic EV tritium (no fungi)											
229	16	**229**	**240**	11	2	**233**	NA	**233**	**233**	5	1
All Wild EV tritiium (no fungi)											
293	90	**262**	**424**	30	4	<LLD	NA	<LLD	<LLD	3	0
Leafy EV tritium (no fungi)											
289	93	**258**	**424**	24	4	**233**	NA	**233**	**233**	6	1
Bulb/Tuber/Root tritium (no fungi)											
<LLD	NA	<LLD	<LLD	2	0	<LLD	NA	<LLD	<LLD	2	0
Fruit EV tritium (no fungi)											
237	18	**237**	**249**	14	2	NA				0	0

Tritium in AOC minus SCbkg				
EV TYPES	Avg	Median	Max	Difference Statistics Greater Than SCbkg
All EV	**81**	**29**	**229**	Annuals, perennials, woody vines, shrubs, trees, and fungi.
All EV (no fungi)	**39**	**12**	**191**	Fungi not included with green EV.
Fungi	**191**	**191**	**250**	Wild edible mushrooms and lichen.
All Domestic	<SCbkg	<SCbkg	**7**	Generally small annual plants with small absorptive surface areas.
All Wild	**293**	**262**	**424**	Generally perennial tree or shrubs with large absorptive surface areas.
Leafy/Flowers	**56**	**25**	**191**	Annuals or perennials of generally small absorptive surface area.
Bulb/Tuber/Root	<SCbkg	<SCbkg	<SCbkg	Small annual underground structures with small absorptive surface area.
Fruit	**237**	**237**	**249**	Trees and shrubs of relatively large aborptive areas.

Notes:

1 - The AOC is the study area and had no tritium detection activity concentrations of concern.

2 - Domestic and/or leafy categories were mostly annuals with relatively small absorptive surface area and shallow roots.

3 - Wild EV & fruit categories were mostly woody perennials with relatively large absorptive surface areas (canopy and root).

4 - The order of tritium difference maximums in categories is wild, fruit, fungi, leafy, underground structures (bulb,tuber,root), and domestic.

7.0 Summary Statistics
2012 Radiological Monitoring of Edible Vegetation

Summary Statistics Table 3. AOC and SCbkg EV Gamma (pCi/g) in Food Use Categories, 2012

AOC							AOC - category SCbkg		
Fruit	**Avg**	SD	**Median**	**Max**	D#	N#	**Avg**	**Median**	**Max**
K-40	3.924	2.415	3.082	9.132	15	16	<SCbkg	<SCbkg	4.555
Pb-214	0.442	0.299	0.346	0.987	7	16	0.442	0.346	0.987
Cs-137	0.059	NA	0.059	0.059	1	16	0.059	0.059	0.059
Leafy	**Avg**	SD	**Median**	**Max**	D#	N#	**Avg**	**Median**	**Max**
Be-7	2.522	1.758	3.258	3.793	3	34	0.891	1.627	1.223
K-40	5.144	2.266	4.220	11.040	31	34	<SCbkg	<SCbkg	<SCbkg
Pb-212	0.595	0.099	0.595	0.665	2	34	0.274	0.274	0.344
Pb-214	1.094	2.308	0.246	7.221	9	34	0.730	<SCbkg	6.857
Cs-137	1.042	0.581	1.025	1.946	6	34	1.042	1.946	1.946
Root	**Avg**	SD	**Median**	**Max**	D#	N#	**Avg**	**Median**	**Max**
K-40	2.824	0.305	2.705	3.267	4	4	<SCbkg	<SCbkg	<SCbkg
Pb-214	0.256	NA	0.256	0.256	1	4	<SCbkg	<SCbkg	<SCbkg
All_EV	**Avg**	SD	**Median**	**Max**	D#	N#	**Avg**	**Median**	**Max**
Be-7	3.572	3.065	3.258	8.548	5	90	1.941	1.627	5.978
K-40	4.734	4.973	3.397	34.610	83	90	<SCbkg	<SCbkg	23.430
Pb-212	0.708	0.581	0.595	1.511	4	90	0.450	0.337	1.190
Pb-214	0.700	1.359	0.288	7.221	27	90	0.351	<SCbkg	6.672
Cs-137	1.000	1.528	0.444	8.240	32	90	0.706	0.243	7.555
All_Green Plant	**Avg**	SD	**Median**	**Max**	D#	N#	**Avg**	**Median**	**Max**
Be-7	2.522	1.758	3.258	3.793	3	54	0.891	1.627	1.223
K-40	4.595	2.306	3.778	11.040	49	54	<SCbkg	<SCbkg	<SCbkg
Pb-212	0.595	0.099	0.595	0.665	2	54	0.337	0.337	0.344
Pb-214	0.776	1.679	0.256	7.221	17	54	0.461	<SCbkg	6.857
Cs-137	0.909	0.600	0.949	1.946	8	54	0.909	0.748	1.946
Fungi	**Avg**	SD	**Median**	**Max**	D#	N#	**Avg**	**Median**	**Max**
Be-7	5.148	4.809	5.148	8.548	2	36	5.148	5.148	8.548
K-40	4.880	7.316	3.045	34.610	34	36	1.741	0.053	30.332
Pb-212	0.821	0.975	0.821	1.511	2	36	0.821	0.821	1.511
Pb-214	0.569	0.543	0.338	1.642	10	36	0.187	<SCbkg	1.093
Cs-137	1.031	1.742	0.354	8.240	24	36	0.737	0.153	7.555
SCbkgs									
Fruit	**Avg**	SD	**Median**	**Max**	D#	N#			
K-40	4.577	NA	4.577	4.577	1	1			
Leafy	**Avg**	SD	**Median**	**Max**	D#	N#			
Be-7	1.631	1.327	1.631	2.570	2	9			
K-40	7.733	1.972	7.903	11.180	9	9			
Pb-212	0.321	NA	0.321	0.321	1	9			
Pb-214	0.364	NA	0.364	0.364	1	9			
Root	**Avg**	SD	**Median**	**Max**	D#	N#			
K-40	2.897	0.751	2.897	3.428	2	2			
Pb-212	0.194	NA	0.194	0.194	1	2			
Pb-214	0.267	NA	0.267	0.267	1	2			
All_EV	**Avg**	SD	**Median**	**Max**	D#	N#			
Be-7	1.631	1.327	1.631	2.570	2	17			
K-40	5.627	2.770	5.313	11.180	17	17			
Pb-212	0.258	0.090	0.258	0.321	2	17			
Pb-214	0.349	0.147	0.315	0.549	4	17			
Cs-137	0.294	0.273	0.201	0.685	4	17			
Green Plants Only									
All_Green	**Avg**	SD	**Median**	**Max**	D#	N#			
Be-7	1.631	1.327	1.631	2.570	2	12			
K-40	6.664	2.606	6.476	11.180	12	12			
Pb-212	0.258	0.090	0.258	0.321	2	12			
Pb-214	0.315	0.069	0.315	0.364	2	12			
Fungi Only									
Fungi	**Avg**	SD	**Median**	**Max**	D#	N#			
K-40	3.138	1.029	2.992	4.278	5	5			
Pb-214	0.382	0.236	0.382	0.549	2	5			
Cs-137	0.294	0.273	0.201	0.685	4	5			

Notes: Underlined value is highest in area, AOC or SCbkg. Some are in many categories and most specific is underlined.
1 - Highest AOC Be-7, K-40, and Pb-212 statistics occurred in fungi except for the K-40 median in leafy green ferns.
2 - Ferns also were the dominant factor in the Pb-214 and Cs-137 higher statistics except for the fungi maximum in Cs-137.
3 - Highest SCbkg Pb-214 and Cs-137 occurred in fungi possibly due to only one fern background sample.
4 - Highest SCbkg Be-7, Pb-212, and Pb-214 occurred in leafy greens mostly from garden samples.
5 - This trend reversed after SCbkg subtraction with Be-7, K-40, and Pb-212 highest in fungi.
6 - Leafy greens dominated the Pb-214 and Cs-137 after SCbkg subtraction due to ferns in AOC.
7 - Cs-137 in fungi had the highest maximum after SCbkg subtraction possibly due to a bioconcentration factor.

7.0 Summary Statistics

2012 Radiological Monitoring of Edible Vegetation

Summary Statistics Table 4a,b. Gamma (pCi/g) in All EV With and Without Fungi, 2012

Table 4a. Gamma Statistics Summary Table for All EV Including Fungi

Radionuclides	AOC - 90 samples						SCbkg - 17 samples					
pCi/g	Avg	SD	Median	Max	D#	D_freq	Avg	SD	Median	Max	D#	D_freq
Be-7 Activity	3.572	3.065	3.258	8.548	5	0.056	1.631	1.327	1.631	2.570	2	0.118
K-40 Activity	4.734	4.973	3.397	34.610	83	0.922	5.627	2.770	5.313	11.180	17	1.000
Pb-212 Activity	0.708	0.581	0.595	1.511	4	0.044	0.258	0.090	0.258	0.321	2	0.118
Pb-214 Activity	0.700	1.359	0.288	7.221	27	0.300	0.349	0.147	0.315	0.549	4	0.235
Cs-137 Activity	1.000	1.528	0.444	8.240	32	0.356	0.294	0.273	0.201	0.685	4	0.235

Study Areas	AOC-SCbkg			
pCi/g	Avgs	Medians	MAX	
Be-7 Activity	1.941	1.627	5.978	Be-7 in fern, fungi, lichen, and rosemary
K-40 Activity	<SCbkg	<SCbkg	23.430	Only the maximum for K-40 was higher in the AOC.
Pb-212 Activity	0.450	0.337	1.190	Pb-212 in lichen, catail, and fungi.
Pb-214 Activity	0.351	<SCbkg	6.672	AOC low median indicates most Pb-214 numbers are near SCbkg.
Cs-137 Activity	0.706	0.243	7.555	Cs-137 occurred in fungi, ferns, and wild berries.

Table 4b. All EV excluding Fungi

Radionuclides	AOC - 54 samples						SCbkg - 12 samples					
pCi/g	Avg	SD	Median	Max	D#	D_Freq	Avg	SD	Median	Max	D#	D_Freq
Be-7 Activity	2.522	1.758	3.258	3.793	3	0.057	1.631	1.327	1.631	2.570	2	0.167
K-40 Activity	4.655	2.350	3.847	11.040	48	0.906	6.664	2.606	6.476	11.180	12	1.000
Pb-212 Activity	0.595	0.099	0.595	0.665	2	0.038	0.258	0.090	0.258	0.321	2	0.167
Pb-214 Activity	0.811	1.728	0.301	7.221	16	0.302	0.315	0.069	0.315	0.364	2	0.167
Cs-137 Activity	0.901	0.647	0.932	1.946	7	0.132	<MDA	<MDA	<MDA	0.000	0	0.000

Study Areas	AOC-SCbkg			
pCi/g	Avgs	Medians	MAX	
Be-7 Activity	0.891	1.627	1.223	Be-7 in fern and rosemary
K-40 Activity	<SCbkg	<SCbkg	<SCbkg	SCbkg K-40 was higher than the AOC.
Pb-212 Activity	0.337	0.337	0.344	Pb-212 in cattail.
Pb-214 Activity	0.496	<SCbkg	6.857	AOC low median indicates most Pb-214 numbers are near SCbkg.
Cs-137 Activity	0.901	0.932	1.946	Cs-137 occurred in ferns and wild berries.

Notes:

1 - D_Freq is the detection frequency out of the total number of sample type, AOC or SCbkg.

Summary Statistics Table 5. Gamma (pCi/g) in Fungi, 2012

Only Fungi

Radionuclides	AOC - 36 samples						SCbkg - 5 samples					
pCi/g	Avg	SD	Median	Max	Count	D_Freq	Avg	SD	Median	Max	Count	D_Freq
Be-7 Activity	5.148	4.809	5.148	8.548	2	0.054	<MDA	NA	<MDA	<MDA	0	0.000
K-40 Activity	4.842	7.211	3.051	34.610	35	0.946	3.138	1.029	2.992	4.278	5	1.000
Pb-212 Activity	0.821	0.975	0.821	1.511	2	0.054	<MDA	NA	<MDA	<MDA	0	0.000
Pb-214 Activity	0.537	0.526	0.288	1.642	11	0.297	0.382	0.236	0.382	0.549	2	0.400
Cs-137 Activity	1.028	1.706	0.423	8.240	25	0.676	0.294	0.273	0.201	0.685	4	0.800

Study Areas	AOC-SCbkg			
pCi/g	Avg	Median	MAX	
Be-7 Activity	5.148	5.148	8.548	Occurred in lichen and honey mushrooms.
K-40 Activity	1.704	0.059	30.332	K-40 is not generally found in lichens.
Pb-212 Activity	0.821	0.821	1.511	Occurred in lichen and bolete fungi.
Pb-214 Activity	0.155	<SCbkg	1.093	AOC low median indicates most Pb-214 numbers are near SCbkg.
Cs-137 Activity	0.734	0.222	7.555	Cs-137 and Pb-214 were found in most types of fungi collected.

7.0 Summary Statistics
2012 Radiological Monitoring of Edible Vegetation

Summary Statistics Table 6ab. Gamma (pCi/g) in Domestic and Wild EV, 2012

Table 6a. Gamma in Wild EV (no fungi)

Radionuclides	AOC - 41 samples						SCbkg - 5 samples					
pCi/g	Avg	SD	Median	Max	Count	Sum	Avg	SD	Median	Max	Count	Sum
Be-7 Activity	3.793	NA	3.793	3.793	1	3.793	2.570	NA	2.570	2.570	1	2.570
K-40 Activity	5.187	2.477	4.632	11.040	36	186.748	8.051	2.538	7.903	11.180	5	40.253
Pb-212 Activity	0.595	0.099	0.595	0.665	2	1.189	<MDA	NA	<MDA	<MDA	0	0.000
Pb-214 Activity	0.849	1.782	0.346	7.221	15	12.728	0.364	NA	0.364	0.364	1	0.364
Cs-137 Activity	0.901	0.647	0.932	1.946	7	6.310	<MDA	NA	<MDA	<MDA	0	0.000

Study Areas	AOC-SCbkg		
pCi/g	Avg	Median	MAX
Be-7 Activity	1.223	1.223	1.223
K-40 Activity	<SCbkg	<SCbkg	<SCbkg
Pb-212 Activity	0.595	0.595	0.665
Pb-214 Activity	0.485	<SCbkg	6.857
Cs-137 Activity	0.901	0.932	1.946

Wild EV tends to be perennials and not fertilized.

Be-7 in mustard and ferns.
K-40 is found in nearly all samples.
Pb-212 in cattails. Pb-214 in cactus, mullein, pokeberry, fern, cattails, grapes, nuts, winged sumac drupes, deerberry, and persimmons,
Cs-137 in ferns and deerberry,

Table 6b. Gamma in Domestic EV (no fungi)

Radionuclides	AOC - 14 samples						SCbkg - 7 samples					
pCi/g	Avg	SD	Median	Max	Count	D_Freq	Avg	SD	Median	Max	Count	D_Freq
Be-7 Activity	1.887	1.939	1.887	3.258	2	0.143	0.693	NA	0.693	0.693	1	0.143
K-40 Activity	3.057	0.599	3.015	3.916	12	0.857	5.674	2.326	5.776	8.390	7	1.000
Pb-214 Activity	0.256	NA	0.256	0.256	1	0.071	0.267	NA	0.267	0.267	1	0.143

Study Areas	AOC-SCbkg		
pCi/g	Avg	Median	MAX
Be-7 Activity	1.194	1.194	2.565
K-40 Activity	<SCbkg	<SCbkg	<SCbkg
Pb-214 Activity	<SCbkg	<SCbkg	<SCbkg

Domestic EV tends to be annuals heavily influenced by fertilizers, which differ in application rates by soil region types.
Be-7 in Mustard & Rosemary is the only radionuclide>SCbkg in Domestic EV.

7.0 Summary Statistics
2012 Radiological Monitoring of Edible Vegetation

Summary Statistics Table 7a,b,c. Green Plant Gamma Detections, 2012

Summary Statistics Table 7a. All Leafy EV Gamma (no fungi), 2012										
Radionuclide	AOC - 31 samples					SCbkg - 9 samples				
pCi/g	Avg	SD	Median	Max	D#	Avg	SD	Median	Max	D#
Be-7	2.522	1.758	3.258	3.793	3	1.631	1.327	1.631	2.570	2
K-40	5.125	1.993	4.566	8.964	27	7.733	1.972	7.903	11.180	9
Pb-212	<MDA	NA	<MDA	0.000	0	0.321	NA	0.321	0.321	1
Pb-214	0.315	0.195	0.246	0.577	7	0.364	NA	0.364	0.364	1
Cs-137	1.042	0.581	1.025	1.946	6	<MDA	NA	<MDA	0.000	0
Study Areas	AOC-SCbkg			D# Frequency		AOC N#	SCbkg N#			
pCi/g	Avgs	Medians	MAX	AOC	SCbkg					
Be-7	0.891	1.627	1.223	0.100	0.222	30	9			
K-40	<MDA	<MDA	<MDA	0.900	1.000	30	9			
Pb-212	<MDA	<MDA	<MDA	0.000	0.111	30	9			
Pb-214	<MDA	<MDA	0.213	0.233	0.111	30	9			
Cs-137	1.042	0.581	1.025	0.200	0.000	30	9			

Summary Statistics Table 7b. Bulb/Tuber/Root/Rhizome, 2012										
Radionuclide	AOC - 6 samples					SCbkg - 2 samples				
pCi/g	Avg	SD	Median	Max	D#	Avg	SD	Median	Max	D#
K-40	4.707	3.347	3.024	11.040	6	2.897	0.751	2.897	3.428	2
Pb-212	0.595	0.099	0.595	0.665	2	0.194	NA	0.194	0.194	1
Pb-214	2.753	3.878	0.783	7.221	3	0.267	NA	0.267	0.267	1
Study Areas	AOC-SCbkg			D# Frequency		AOC N#	SCbkg N#			
pCi/g	Avgs	Medians	MAX	AOC	SCbkg					
K-40	1.810	0.127	7.612	1.000	1.000	6	2			
Pb-212	0.400	0.400	0.470	0.333	0.500	6	2			
Pb-214	2.487	0.517	6.955	0.500	0.500	6	2	Ferns, mustard, rosemary.		

Summary Statistics Table 7c. Edible Fruit of Green Vegetation, 2012										
Radionuclide	AOC - 17 samples					SCbkg - 1 sample				
pCi/g	Avg	SD	Median	Max	D#	Avg	SD	Median	Max	D#
K-40 Activity	3.836	2.360	2.950	9.132	16	4.577	NA	4.577	4.577	1
Pb-214 Activity	0.442	0.299	0.346	0.987	7	<MDA	NA	<MDA	<MDA	0
Cs-137 Activity	0.059	NA	0.059	0.059	1	<MDA	NA	<MDA	0.000	0
Study Areas	AOC-SCbkg			D# Frequency		AOC N#	SCbkg N#			
pCi/g	Avgs	Medians	MAX	AOC	SCbkg					
K-40 Activity	<MDA	<MDA	4.555	0.941	1.000	17	1			
Pb-214 Activity	0.442	0.346	0.987	0.412	0.000	17	1			
Cs-137 Activity	0.059	0.059	0.059	0.059	0.000	17	1			

LIST OF ACRONYMS

AKN	Aiken County
ALD	Allendale County
ANL	Argonne National Laboratory
AOC	Area of Concern or study area. Includes the IPC and OPC.
BMB	Bamberg County
BWL	Barnwell County
CAL	Calhoun County
CDC	Centers for Disease Control
D#	The number of detections for a particular radionuclide.
DIL	Derived Intervention Level
DOE	Department of Energy
DOE-SR	Department of Energy - Savannah River
EDF	Edgefield County
EQC	Environmental Quality Control
ESOP	Environmental Surveillance and Oversight Program
EV	Edible Vegetation
GA	Georgia
HMP	Hampton County
IAEA	International Atomic Energy Agency
IPC	Inner Perimeter of Counties around and adjacent to the DOE-SRS boundary.
LAU	Laurens County
LEX	Lexington County
LLD	Lower Limit of Detection
LLNL	Lawrence Livermore National Laboratory
MCM	McCormick County
MDA	Minimum Detectable Activity
N#	The number of samples with any detections.
NORM	Naturally Occurring Radioactive Material
OPC	The Outer Perimeter of Counties adjacent to and outside of the IPC and SRS
ORG	Orangeburg County
SAL	Saluda County
SC	South Carolina
SCbkg	South Carolina background or outside of a 50-mile perimeter around an SRS center point
SCDHEC	South Carolina Department of Health and Environmental Control
SD	Standard Deviation
SRS	Savannah River Site
SRNS	Savannah River Nuclear Solutions
SRSHES	Savannah River Site Health Effects Subcommittee
TEF	Tritium Extraction Facility
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USFDA	United States Food and Drug Administration
USGS	United States Geological Survey

VEGP	Vogtle Electric Generating Plant
WSRC	Washington Savannah River Company (formerly Westinghouse Savannah River Company)

UNITS OF MEASURE

Activity or radioactivity is the number of atoms disintegrating per unit time (CDC 2009).

g/ml	grams per milliliter
ml/L	milliliter per liter
pCi/g	pico curies per gram
pCi/L	pico curies per liter
±	Plus or minus. Refers to one standard deviation unless otherwise stated.

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APPENDIX

Appendix Table 1a.

Radioisotope	Abbreviation
Actinium-228	Ac-228
Americium-241	Am-241
Antimony-125	Sb-125
Beryllium-7	Be-7
Carbon-14	C-14
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-129	I-129
Iodine-131	I-131
Lead-212	Pb-212
Lead-214	Pb-214
Manganese-54	Mn-54
Potassim-40	K-40
Radium-226	Ra-226
Ruthenium-103	Ru-103
Sodium-22	Na-22
Sulfur-35	S-35
Thorium-234	Th-234
Ytrium-88	Y-88
Zinc-65	Zn-65
Zirconium-95	Zr-95

Appendix Table 1 b. International Atomic Energy Agency Radionuclides Guidelines for Food

Radionuclides in Foods		Guideline Levels	
Radionuclides	Units	kBq/kg	pCi/g
Pu-238, Pu-239, Pu-240, Am-241		1	0.27
Sr-90, Ru-106, I-129, I-131, U-235		100	2.7
S-35, Co-60, Sr-89, Ru-103, Cs-134, Cs-137, Ce-144, Ir-192		1000	27
H-3, C-14, Tc-99		10000	270

Appendix Table 1c.

USFDA Derived Intervention Levels (DILS) for Each Radionuclide Group for Food in Domestic Commerce and Food Offered for Import		Guideline Levels	
Radionuclide Group	Units	Bq/kg	pCi/g
Strontium-90		160	4.32
Iodine-131		170	4.59
Cesium-134 + Cesium-137		1200	32.4
Plutonium-238 + Plutonium-239 + Am-241		2	0.054
Ruthenium-103 + Ruthenium-106		$((C_3/6800) + (C_6/450)) < 1$	

Notes:

1 - For spices use a dilution factor of 10.

2 - C3 and C6 refer to concentrations of Ru-103 and Ru-106.

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2012 Radiological Monitoring of Dairy Milk

Environmental Surveillance and Oversight Program

97MK007
Crystal Robertson, Project Manager
January 01, 2012 - December 31, 2012

Midlands EQC Region – Aiken
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South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

Operations at the Savannah River Site (SRS) have resulted in the potential for radiological constituents to be released to the surrounding environment. Milk from dairies around the SRS is routinely analyzed for levels of radioactivity that could impact human health. This project provides radiological monitoring of milk from selected dairies within a 50-mile radius of the SRS in South Carolina (SC). This project provides analytical data for trending and comparison to published Department of Energy-Savannah River (DOE-SR) data. The 50-mile radius also allows the South Carolina Department of Health and Environmental Control (SCDHEC) to use the data in this report to compare the potential dose from milk consumption to the potential dose calculated by DOE-SR.

Consumption of milk products containing radioactive materials can be a major human exposure pathway. When an atmospheric release occurs, radionuclides can be deposited on pastures and ingested by grazing dairy animals. The animals would then release a portion of the radioactivity into the milk that is consumed by humans (CDC 2001). Radionuclides could also enter the milk exposure pathway by irrigation of a pasture with groundwater containing radioactive materials or uptake by plants from soil containing radioactive materials. Radioactive strontium is a calcium analogue and may show a tendency to accumulate in bones and teeth (Kathren 1984).

Plants and animals assimilate different radioisotopes based on the chemistry and not on the radioactive nature of the components. Cesium-137 (Cs-137) is less readily taken up by plant roots than strontium-90 (Sr-90), but the opposite is true for direct absorption from foliar (leaf) deposits. Cesium-137 is transferred rapidly from pasture grass to the muscles of animals. Strontium-90 can bioconcentrate in bones when there is a deficiency of calcium in the diet of the individual. This pathway is of particular importance in the case of infants and children because they are more likely to drink large quantities of milk and they are actively developing bones and teeth (Kathren 1984). Iodine-131 (I-131) is rapidly transferred to milk and accumulates in the thyroid of humans. Cobalt-60 (Co-60) is unlikely to accumulate in the environment, but if consumed, depending on the individual's health, it can be absorbed in the blood and tissues before it is slowly eliminated (USEPA 2002a). Tritium (H-3) is a radioisotope of hydrogen that produces beta particles, and therefore, can impact anything containing water or hydrocarbons. Tritium exists naturally in the environment**,** and its volatility quickly achieves equilibrium in the environment and the body (Larson 1958).

Historically tritium has been the main product of operations at SRS, produced as a nuclear weapon enhancement component. The majority of tritium released was in the production reactors and separation areas (CDC 2001). Milk tritium contributions come not only from atmospheric depositions, but from food sources and also groundwater wells. Over 99% of tritium occurs as tritiated water and groundwater. Background groundwater monitoring wells have tritium contributions (atomic legacy source likely) that are higher than the range found in milk (SCDHEC 2003). Tritium averages are lower in milk because of plant uptake factors, intrinsic transfer factors, bioelimination factors, and the variation in distributions of atmospheric depositions.

The gamma-emitting radionuclides I-131, Cs-137, and Co-60 are man-made radioactive elements that can impact public health and were all products of SRS activities. These radionuclides were produced by fission in reactor fuels, and they were primarily released in surface streams in the 1960s or into the atmosphere in the separation areas (CDC 2001; WSRC 1998). Most of the Co-60 contamination came exclusively from SRS between 1968 to 1984 when Co-60 was used as a heat source for a thermoelectric generator (WSRC 1998).

Strontium is present around the world due to nuclear weapons atmospheric testing in the 1950s and 1960s (CDC 2001). Since strontium has slow fallout from the atmosphere and a 29-year half-life, it is still present in the environment; however, concentrations are low and continue to decrease over time (USEPA 2002b; Larson 1958). SRS operations have also released strontium into the environment through normal site operations and equipment failure. Strontium was a product of fission in SRS reactors, and was subsequently released in the F-area and H-area (WSRC 1998).

During 2012, DOE-SR collected samples from six dairy locations in SC and Georgia (GA) (Table 1). DOE-SR milk samples are collected quarterly within a 25-mile radius of SRS. Only four of the dairies that DOE-SR sampled are located in SC and the remaining two are located in GA (SRNS 2013). SCDHEC's Environmental Surveillance and Oversight Program (ESOP) collected milk at five dairy locations within South Carolina to provide an independent source of data on radionuclide concentrations of concern in milk (Table 1). Of the five SCDHEC locations, three of them are within a 50-mile perimeter of an SRS center point and two are background locations beyond the 50-mile perimeter. One 2011 sample location was dropped from the project in 2012 due to the lack of available milk from a goat dairy.

SCDHEC personnel collected unpasteurized milk samples on a quarterly basis in 2012. All milk samples from each quarter were analyzed for tritium, strontium-89/90 (Sr-89/90), and select gamma-emitting radionuclides, specifically I-131, Cs-137, and Co-60. SCDHEC analyzes samples for total strontium (Sr-89/90), instead of just Sr-90, due to preferred laboratory techniques. In order to provide a conservative result, it is assumed the total strontium detected is in the form of Sr-90.

SCDHEC did not detect tritium in any of the 20 milk samples collected during 2012. Gamma emitting radionuclides also were not detected by SCDHEC in 2012. Strontium-89/90 was detected in two samples collected in 2012. One of the detections was from a perimeter location within 50 miles of an SRS center point, and the other was a background location outside of that area (Section 6.0, 2012 Strontium Milk Data table). The source of the strontium is likely due to historical atmospheric nuclear weapons testing. Strontium has a half-life of 29 years and slow long-term fallout properties, taking an estimated 7-10 years for half of the Sr-90 formed in a blast to gradually settle to the earth's surface (Larson 1958). None of the Sr-89/90 detections in 2012 exceeded the United States Environmental Protection Agency (USEPA) drinking water Maximum Contaminant Level (MCL) of 8 picocuries per liter (pCi/L) for Sr-90 (USEPA 2002b).

DOE-SR detected tritium in 11 of 24 milk samples collected in 2012, including at least one detection at each location. Seven of these detections were in samples from SC dairies. Like SCDHEC, DOE-SR did not detect any gamma emitting radionuclides in 2012. DOE-SR had 11 detections of Sr-89/90 in 24 milk samples; six from SC dairies (SRNS 2013).

During 2012, concentrations of radionuclides of concern in milk did not deviate from historically expected levels as measured by DOE-SR and SCDHEC. SCDHEC will continue to monitor milk for radionuclides that have the potential to impact human health.

2.0 RESULTS AND DISCUSSION

Tritium Results

No SCDHEC milk sample collected during 2012 exhibited tritium activity above the Lower Limit of Detection (LLD) (Section 6.0, Data). This was consistent with the 2011 results, where no milk sample exhibited tritium activity above the LLD as well (SCDHEC 2012). Figure 1 of Section 5.0 illustrates average tritium detections for the last ten years. All tritium detections have been below the USEPA drinking water MCL of 20,000 pCi/L for tritium. DOE-SR detected tritium in 11 of 24 milk samples for 2012. Seven of these detections were from dairies in SC. The maximum activity was 489 (± 88.0) pCi/L in a sample from a SC dairy (SRNS 2013). Summary statistics for tritium are not given due to the lack of numerical data. The tritium results for all milk samples collected by SCDHEC are given in Section 6.0. These past radionuclide contributions to milk may come from the SRS, other nuclear facilities, and legacy contamination from the cold war period (CDC 2001).

Gamma-Emitting Radionuclides Results

SCDHEC analyzed for I-131, Cs-137, and Co-60 in all milk samples collected in 2012. All analytical results for these radionuclides were below the sample Minimum Detectable Activity (MDA), and can be found in Section 6.0. These results are consistent with past gamma results. Iodine-131 has not been detected since last year's perturbation that occurred shortly after the March 11, 2011, meltdown at the Fukushima Dai-ichi Nuclear Power Station in Japan (SCDHEC 2012). No summary statistics were calculated for these radionuclides due to a lack of numerical data. DOE-SR did not detect gamma emitting radionuclides in any of the 24 milk samples collected in 2012 (SRNS 2013).

Strontium-89/90 Results

Milk samples were collected quarterly in 2012 for Sr-89/90 analysis (Section 6.0). Two out of 20 SCDHEC milk samples collected in 2012 exhibited strontium activities above the MDA, including one detection in a background sample. The range for these detections was 0.45 pCi/L to 0.59 pCi/L, with the minimum detection from a background location in Bowman, SC, and the maximum detection from Leesville, SC. These detections averaged 0.52 (± 0.10) pCi/L for the year (Section 7.0). This average is a slight decrease from 2011, when the strontium average was 0.80 (± 0.34) pCi/L (SCDHEC 2011). Figure 2 (Section 5.0) shows the trend for SCDHEC strontium detections for the last ten years. The averages used in Figure 2 are calculated using only detections; therefore, some averages may actually be the result of a single detection in one sample. All results below the MDA are left out of the summary statistics. All strontium averages have been below the USEPA established MCL of 8 pCi/L for Sr-90 since testing initiated in 1998 (USEPA 2002b). DOE-SR detected Sr-90 in 11 of 24 samples collected in 2012. Six of the 11 detections were in samples from SC dairies. The maximum activity was 1.59 (± 0.312) pCi/L from a dairy in SC (SRNS 2013).

Summary statistics for the background and perimeter locations are in Section 7.0.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The DOE-SR uses all analytical results to compute averages, including results below the Minimum Detectable Concentration (MDC), which is based on the analysis method and comparable to SCDHEC's MDA and LLD. For a more conservative approach, SCDHEC uses only results above the MDA or LLD to compute averages. This does not affect the general data trend; however, numeric statistics may diverge significantly. Consequently, dairy milk analytical data comparisons between SCDHEC and DOE-SR were not conducted.

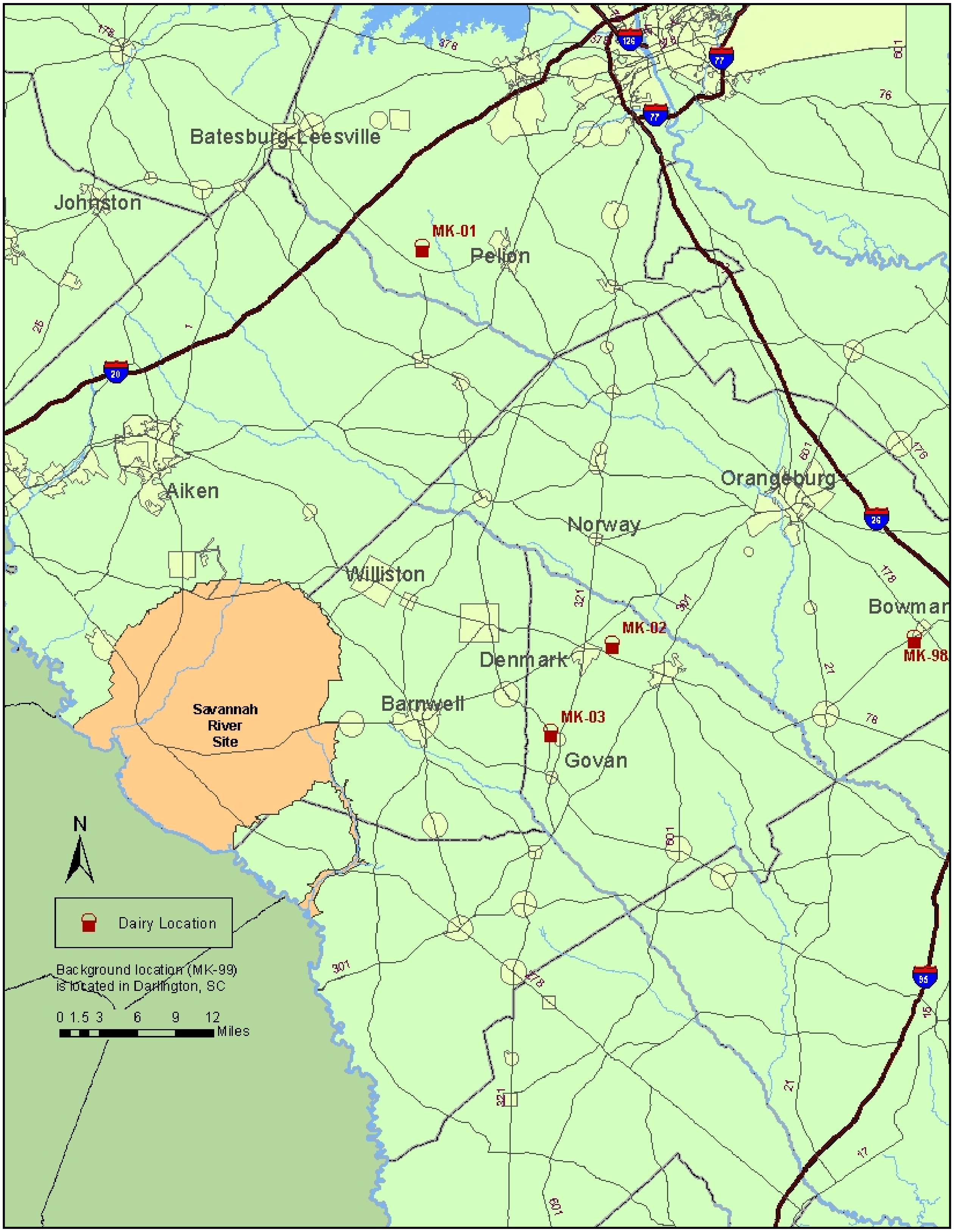
Sampling results for 2012 show a continued trend of decreasing detections of tritium in milk samples. As shown in Section 5.0 Figure 1, tritium has not been detected in any SCDHEC milk sample since 2008 when there was only one detection. Gamma results also continue a trend of non-detections since 2004, with the exception of the I-131 perturbation in 2011. Samples collected after the 2011 occurrence show that I-131 returned to the typically expected results and has not been detected since; however, SCDHEC will continue monitoring for any changes. The 2012 Sr-89/90 results show a slight decreasing trend. The statistical analysis shows that Sr-89/90 concentrations in SRS perimeter samples were slightly more than the concentration in background samples. This is true for various measures of central tendency, including the average and the median. An evaluation of average concentrations by sampling location is included in Section 7.0.

A large portion of the radiological activity observed in milk samples can be attributed to fallout from past nuclear testing. Also, radionuclides within soil and plants can potentially be redistributed as a result of farming practices and prescribed burns. SCDHEC will continue to monitor tritium, gamma-emitting radionuclides, and strontium in milk to ensure the safety of milk consumption by the public.

The dairies in the ESOP South Carolina study area and background locations appear to be stable with no indication of closing in the foreseeable future. ESOP has had no indication of any new dairies opening within the study area. Additional dairy sources will be added to the network if and when they become available.

4.0 Map

Map 1. 2012 SCDHEC Radiological Monitoring Locations for Dairy Milk



5.0 Tables and Figures

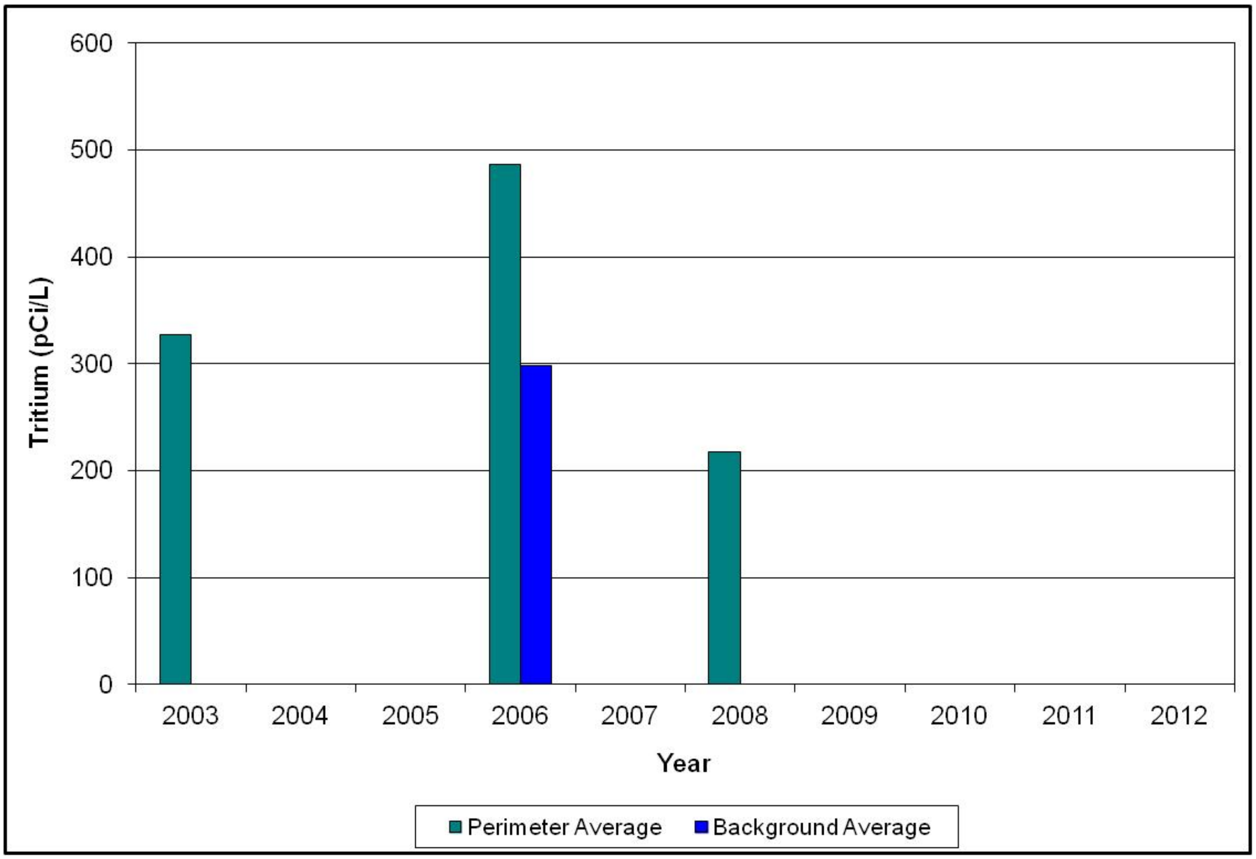
Radiological Monitoring of Dairy Milk

Table 1. 2012 SCDHEC and DOE-SR Dairy Milk Sampling Locations

SCDHEC Cow Dairy Locations	DOE-SR Cow Dairy Locations
Leesville, SC, MK-01	Barnwell: SC Dairy
Denmark, SC, MK-02	Denmark: SC
Govan, SC, MK-03	Ehrhardt Road: Govan: SC Dairy
Bowman, SC*, MK-98	HWY 23 Girard: GA Dairy
Darlington, SC*, MK-99	Hwy 23: McBean GA Dairy
	Partridge Rd: Govan: SC Dairy

*Background Locations

Figure 1. Average Tritium Detections in SCDHEC Milk, 2003-2012

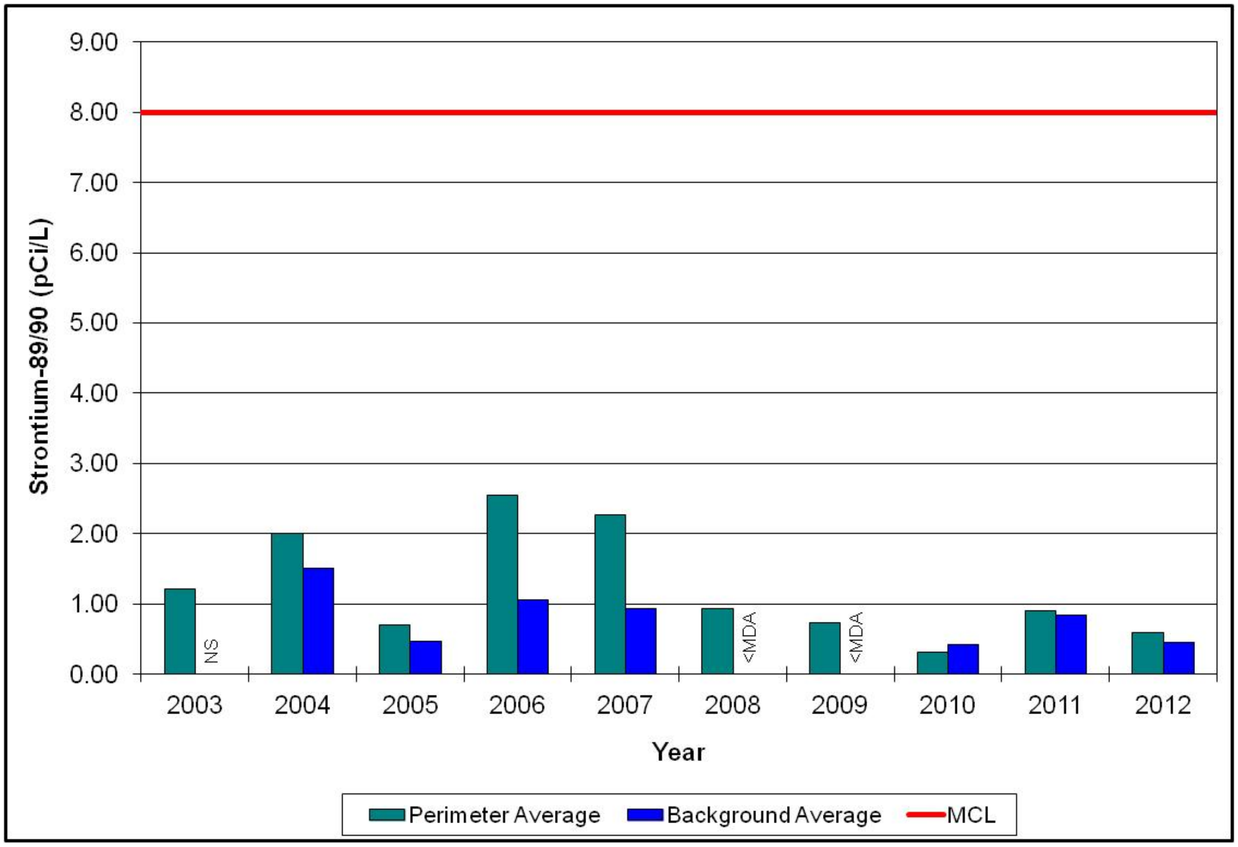


Average detections are well below the USEPA MCL of 20,000 pCi/L for drinking water.
No detections above the LLD were observed in 2004, 2005, 2007, 2009, 2010, 2011 and 2012.
Some averages may be based on a single detection.

Tables and Figures

Radiological Monitoring of Dairy Milk

Figure 2. Strontium-89/90 Detection Averages, 2003-2012



Average detections are below the USEPA MCL of 8.0 pCi/L for drinking water.
Background locations were not sampled (NS) in 2003.
Some averages may be based on a single detection.

6.0 Data

Radiological Monitoring of Dairy Milk

2012 Tritium And Gamma-Emitting Milk Data 9

2012 Strontium Milk Data 11

Notes:

1. LLD - Lower Limit of Detection
2. MDA - Minimum Detectable Activity
3. SC - South Carolina
4. NA - Not Applicable
5. * Indicates a background sampling location

Radiological Monitoring Of Dairy Milk Data

2012 Tritium and Gamma-emitting Milk Data

Sample Location		MK-01 Leesville, SC			
Collection Date		2/1/2012	5/8/2012	7/30/2012	11/28/2012
Radionuclides:	Tritium (pCi/L)	<LLD	<LLD	<LLD	<LLD
	+/- 2 sigma	NA	NA	NA	NA
	LLD	202	200	206	216
	Co-60 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	2.22	2.59	3.21	3.62
	I-131 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	9.75	10.1	3.26	10.9
	Cs-137 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	2.70	2.70	3.39	3.86

Sample Location		MK-02 Denmark, SC			
Collection Date		1/31/2012	5/9/2012	8/1/2012	11/27/2012
Radionuclides:	Tritium (pCi/L)	<LLD	<LLD	<LLD	<LLD
	+/- 2 sigma	NA	NA	NA	NA
	LLD	202	201	207	208
	Co-60 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	2.57	2.50	2.72	3.66
	I-131 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	11.8	14.6	5.68	7.11
	Cs-137 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	3.11	2.69	2.96	4.08

Sample Location		MK-03 Govan, SC			
Collection Date		1/31/2012	5/9/2012	8/1/2012	11/27/2012
Radionuclides:	Tritium (pCi/L)	<LLD	<LLD	<LLD	<LLD
	+/- 2 sigma	NA	NA	NA	NA
	LLD	202	199	207	209
	Co-60 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	2.58	3.26	2.52	3.59
	I-131 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	MA	NA	NA
	MDA	12.1	18.0	5.03	8.19
	Cs-137 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	3.32	3.53	2.92	3.72

Radiological Monitoring of Dairy Milk Data

2012 Tritium and Gamma-emitting Milk Data

Sample Location		MK-98 Bowman, SC*			
Collection Date		1/31/2012	5/9/2012	7/30/2012	11/28/2012
Radionuclides:	Tritium (pCi/L)	<LLD	<LLD	<LLD	<LLD
	+/- 2 sigma	NA	NA	NA	NA
	LLD	202	204	208	208
	Co-60 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	3.20	3.43	2.47	4.18
	I-131 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	14.9	15.2	3.82	12.0
	Cs-137 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	3.96	4.11	2.98	4.12

Sample Location		MK-99 Darlington, SC*			
Collection Date		2/1/2012	5/8/2012	7/30/2012	11/28/2012
Radionuclides:	Tritium (pCi/L)	<LLD	<LLD	<LLD	<LLD
	+/- 2 sigma	NA	NA	NA	NA
	LLD	202	201	207	211
	Co-60 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	2.61	2.46	2.17	3.54
	I-131 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	11.9	10.5	4.52	11.5
	Cs-137 (pCi/L)	<MDA	<MDA	<MDA	<MDA
	+/- 2 sigma	NA	NA	NA	NA
	MDA	3.18	2.69	2.47	3.53

Radiological Monitoring of Dairy Milk Data

2012 Strontium Milk Data

Sample Location	MK-01 Leesville, SC			
Collection Date	2/1/2012	5/8/2012	7/30/2012	11/28/2012
Sr - 89/90 (pCi/L)	<MDA	**0.594**	<MDA	<MDA
+/- 2 sigma	NA	0.233	NA	NA
MDA	0.436	0.411	1.08	0.389

Sample Location	MK-02 Denmark, SC			
Collection Date	1/31/2012	5/9/2012	8/1/2012	11/27/2012
Sr - 89/90 (pCi/L)	<MDA	<MDA	<MDA	<MDA
+/- 2 sigma	NA	NA	NA	NA
MDA	0.397	0.388	1.17	0.399

Sample Location	MK-03 Govan, SC			
Collection Date	1/31/2012	5/9/2012	8/1/2012	11/27/2012
Sr - 89/90 (pCi/L)	<MDA	<MDA	<MDA	<MDA
+/- 2 sigma	NA	NA	NA	NA
MDA	0.382	0.391	1.03	0.365

Sample Location	MK-98 Bowman, SC*			
Collection Date	1/31/2012	5/9/2012	7/30/2012	11/28/2012
Sr - 89/90 (pCi/L)	<MDA	**0.451**	<MDA	<MDA
+/- 2 sigma	NA	0.175	NA	NA
MDA	0.356	0.284	1.33	0.365

Sample Location	MK-99 Darlington, SC*			
Collection Date	2/1/2012	5/8/2012	7/30/2012	11/28/2012
Sr - 89/90 (pCi/L)	<MDA	<MDA	<MDA	<MDA
+/- 2 sigma	NA	NA	NA	NA
MDA	0.342	0.395	1.22	0.409

7.0 Summary Statistics

Radiological Monitoring of Dairy Milk Data

2012 Strontium Summary Statistics For All Milk Sample Detections..13

2012 Strontium Summary Statistics Comparison of Perimeter And Background Locations............13

Notes:

1. N - Number of detections used for statistical analysis
2. TN - Total Number of samples including non-detections
3. Avg - Average
4. St Dev - Standard Deviation
5. Min - Minimum
6. Max - Maximum
7. <MDA - All samples below the Minimum Detectable Activity
8. NA - Not Applicable

Radiological Monitoring of Dairy Milk Data

2012 Strontium Summary Statistics for all Milk Sample Detections

Radionuclide:		Total Strontium					
Statistical Analysis:		**N (TN)**	**Avg**	**St Dev**	**Median**	**Min**	**Max**
All Sample Locations	**MK-01***	1 (4)	0.59	NA	0.59	NA	NA
	MK-02	0 (4)	<MDA	NA	NA	NA	NA
	MK-03	0 (4)	<MDA	NA	NA	NA	NA
	MK-98*	1 (4)	0.45	NA	0.45	NA	NA
	MK-99	0 (4)	<MDA	NA	NA	NA	NA
Yearly Average			0.52				
Standard Deviation			0.10				
Median			0.52				

Radionuclide:		Total Strontium					
Statistical Analysis:		**N (TN)**	**Avg**	**St Dev**	**Median**	**Min**	**Max**
Perimeter System Number:	**MK-01***	1 (4)	0.59	NA	0.59	NA	NA
	MK-02	0 (4)	<MDA	NA	NA	NA	NA
	MK-03	0 (4)	<MDA	NA	NA	NA	NA
Yearly Average of Detectable Sr-89/90*			0.59				
Standard Deviation			NA				
Median*			0.59				

Radionuclide:		Total Strontium					
Statistical Analysis:		**N (TN)**	**Avg**	**St Dev**	**Median**	**Min**	**Max**
Background System Number:	**MK-98***	1 (4)	0.45	NA	0.45	NA	NA
	MK-99	0 (4)	<MDA	NA	NA	NA	NA
Yearly Average of Detectable Sr-89/90*			0.45				
Standard Deviation			NA				
Median*			0.45				

Units are in picocuries per liter (pCi/L)
* Based on a single detection

2012 Strontium Summary Statistics Comparison of Perimeter and Background Locations

	Perimeter Locations (<50 Miles)			Background Locations (>50 Miles)			Perimeter minus Background	
	Avg*	**St Dev**	**Median***	**Avg***	**St Dev**	**Median***	**Average**	**Median**
Total Strontium	0.59	NA	0.59	0.45	NA	0.45	0.14	0.14

Units are in picocuries per liter (pCi/L)
* Based on a single detection

LIST OF ACRONYMS

Cs-137	Cesium-137
Co-60	Cobalt-60
DOE-SR	Department of Energy – Savannah River
ESOP	Environmental Surveillance and Oversight Program
GA	Georgia
H-3	Tritium
I-131	Iodine-131
LLD	Lower Limit of Detection
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
SC	South Carolina
SCDHEC	South Carolina Department of Health and Environmental Control
Sr-89/90	Strontium-89/90
Sr-90	Strontium-90
SRS	Savannah River Site
USEPA	United States Environmental Protection Agency

Units of Measure

pCi/L	picocuries per liter
±	plus or minus 2 standard deviations unless otherwise noted

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Section 4 2012 Biological Monitoring

Chapter 11 Radiological Monitoring of Fish Associated with the Savannah River Site

Chapter 12 Radiological Game Animal Monitoring Adjacent to SRS

2012 Fish Monitoring Associated with the Savannah River Site

Environmental Surveillance and Oversight Program

96FM001
Jeffrey Joyner, Project Manager
January 1, 2012 – December 31, 2012

Midlands EQC Region - Aiken
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D H E C
PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

The Department of Energy-Savannah River (DOE-SR) has historically monitored the uptake of radionuclides in fish. However, DOE-SR reported results were not routinely evaluated by an independent monitoring source. Because of the size, scope, and complexity of the activities at the Savannah River Site (SRS), the Environmental Surveillance and Oversight Program (ESOP) of the South Carolina Department of Health and Environmental Control (SCDHEC) was tasked with providing a non-regulatory independent monitoring and surveillance program at the SRS.

ESOP conducts fish monitoring for radionuclide activity in an effort to determine the magnitude, extent, and trends of radionuclide levels. ESOP also conducts fish monitoring for mercury and selected metals levels. Radiocesium, released from 1954-1975, has been reported by DOE-SR as one of the most significant radionuclides related to human exposure (WSRC 1997). At SRS, the majority of liquid releases of cesium-137 (Cs-137) were due to leaking fuel rods in the 1950s and 1960s. Fuel rods were stored in basins, and Cs-137 was released to SRS streams when the basins were purged. In the early 1970s, physical and administrative controls were implemented to control the releases of most fission and activation products. During subsequent years, tritium, which cannot be filtered from effluent streams, became more significant than cesium (WSRC 1999).

Largemouth bass (*Micropterus salmoides)* and catfish (*Ameiurus catus* or *Ictalurus punctatus*) were collected from nine sample locations on the Savannah River, and a background station established on the Combahee River between Colleton and Charleston counties. Studies have shown these species bioaccumulate measurable amounts of radionuclides (Cummins 1994; USEPA 2000). Red drum (*Sciaenops ocellatus*) and striped mullet (*Cynoscion nebulosus***)** were collected near Savannah, Georgia. Sunfish (Family: Centrarchidae) were collected from nine locations along the Savannah River. Sunfish will be collected on a five-year rotation. Stations sampled in 2012 are shown in Map 1 Section 4.0, and location descriptions can be found in the Monitoring of Fish in the Savannah River Quality Assurance Project Plan, (SCDHEC 2011).

Fish were collected using boat-mounted electrofishing equipment. Samples were collected at five stations where creeks from the SRS meet the Savannah River (Upper Three runs Creek SV-2011, Beaver Dam Creek SV-2013, Fourmile Branch SV-2015, Steel Creek SV-2017, and Lower Three Runs Creek SV-2020). Samples were also collected from the Combahee River as a background location (MD-117), one Savannah River station upstream of the SRS, New Savannah Bluff Lock and Dam (NSBLD SV-2028), and four stations downstream of the SRS (Highway 301 SV-118, Stokes Bluff SV-355, Highway 17 fresh water SV-2090, and Highway 17 saltwater SV-2091). All these locations are accessible to the public. Five fish of each species were collected at each sample location. Analysis of a portion of the fillets from each fish for mercury and selected metals was initiated in 2010. The remainder of the edible fillets for each species was combined into homogeneous composites for radionuclide analyses. Edible composites were analyzed for gamma-emitting isotopes and tritium. Non-edible composites consisting of spine, ribs, and tails were analyzed for strontium. Detailed procedures can be found in the Quality Assurance Project Plan (SCDHEC 2011). Strontium collects in the scales and bones of fish, and may build up in your bones if you eat these fish. Strontium ingestion can be reduced strontium by removing scales and bones before cooking the fish. Strontium can also be reduced by eating smaller fish or smaller amounts of fish.

Three locations did not produce samples with detectable tritium activity in 2012: the background location on the Combahee River, NSBLD, and Beaver Dam Creek. All other locations adjacent to and downstream of SRS exhibited detectable tritium activity. Five locations did not exhibit Cs-137 activity: Fourmile Branch, Highway 301, Stokes Bluff, and the Combahee River. Activities of strontium-89,90 (Sr-89,90) were reported from all locations.

The DOE-SR also conducts fish monitoring to assess the environmental effects of current and historical releases of radionuclides. SCDHEC data were compared to DOE-SR reported results. Dissimilarities in these results could be attributed to the natural variation (e.g. fish age and size) of radionuclide levels. Although there are differences between reported values, the data is consistent with historically reported data. In the past, samples have been collected and split between SCDHEC and DOE-SR for analyses, and no great variations in the data results were found. This would potentially rule out methodology differences and substantiate that differences result from the variability in samples analyzed by the two programs.

Independent monitoring of radionuclides and metals in Savannah River fish will continue along with the comparison of the DOE-SR Radiological Fish Monitoring data. The information provided will assist in advising, informing, and protecting the people at risk, and in comparing current and historical data.

2.0 RESULTS AND DISCUSSION

Fish collections were conducted from March through October of 2012. Five fish of each species were caught at all river locations. Largemouth bass and channel catfish were collected from all Savannah River locations and the Combahee River background site. Sunfish were collected from nine Savannah River locations. Five red drum and five stripped mullet were collected from the saltwater location.

A total of 155 fish were collected. Forty-four composites were processed in 2012. The SCDHEC Midlands EQC Region-Aiken's tritium laboratory analyzed aliquots from all edible samples. Edible samples were sent to the SCDHEC Radiological Environmental Monitoring Division in Columbia, South Carolina for radiological analysis of gamma-emitting radionuclides. The non-edible bone portions samples were sent to Eberline Services for strontium analysis. Graphic presentations of 2012 and 2008-2012 activity levels of tritium, Cs-137, and Sr-89,90 are reported in Section 5.0. Activity levels of Cs-137 for all samples and SCDHEC historical trending data from 2008–2012 are reported in Section 6.0. Summary statistics are presented in Section 7.0. Tritium results represent the activity level in the water distilled from the fish tissue. Cesium and strontium results represent the activity level in the wet sample itself. A more in-depth understanding on how these radionuclides may impact human health can be found in the 2012 Critical Pathway Dose Report.

Tritium Results

Tritium is a naturally occurring radioisotope, although in very low concentrations (USEPA 2007). Sources of man-made tritium include nuclear reactors and government weapons production plants. Tritium releases at SRS include both atmospheric and liquid contributions (SRNS 2013).

Although the United States Environmental Protection Agency (USEPA) has not established a Maximum Contaminant Level (MCL) for tritium in solid media (e.g. fish or vegetation), water is removed from the fish tissue and analyzed for tritium. The USEPA has set the MCL for drinking water at 20,000 picocuries per liter (pCi/L) (USEPA 2008).

Activity levels of tritium were analyzed in 31 edible composites. Seven of the nine freshwater stations exhibited detectable tritium activity in 2012 (Section 5.0, Figure 1a). The saltwater sampling location (SV-2091) produced detections in both species sampled. The Combahee River background location did not produce tritium activity. The uppermost Savannah River location near the NSBLD (SV-2028), and the location near Beaver Dam Creek (SV-2013), had no detectable tritium activity.

Seven of nine bass samples from the Savannah River exhibited detectable tritium activity, with an average of 382 (± 235) pCi/L. The composite from the Stokes Bluff location (SV-355) had the highest reported tritium activity, 852 pCi/L. Four of the nine Savannah River catfish samples exhibited tritium activity, with an average of 311 (± 47) pCi/L. The highest tritium level observed in the catfish composites, 332 pCi/L, was from Steel Creek. Four of the nine Savannah River sunfish samples exhibited tritium activity, with an average of 1962 (± 2674) pCi/L. The highest tritium level observed in the sunfish composites, 5944 pCi/L was from the Fourmile Branch location (SV-2015).

With the exception of the Beaver Dam Creek location, samples from downstream of SRS exhibited little tritium activity in 2012. The 2012 data are generally similar to SCDHEC historically reported data (Section 5.0, Figures 1b and 1c; SCDHEC 2011). Although results can be quite variable between years, tritium levels tend to be highest at locations adjacent to SRS (creek mouth stations) and decrease with distance downstream. Tritium has been detected upstream of SRS only occasionally, and at low levels.

Gamma Results

The naturally occurring isotope of potassium-40 (K-40) was detected from all stations where gamma samples were collected in 2012. The lead isotopes Pb-212 and Pb-214 were also detected, but not from all locations. Because these are naturally occurring isotopes, the results will not be discussed in this report.

Cesium-137 is a man-made fission product, and was a constituent of air and water releases on SRS, mainly from F- and H-Areas. Liquid releases also occurred from the production reactors as a result of leaking fuel elements in the 1950s and 1960s, and reactor basin purges were discharged to SRS streams, including Fourmile Branch, Steel Creek, and Lower Three Runs (WSRC 1999).

Activity levels of Cs-137 were analyzed in 31 edible portions of bass, catfish, red drum, mullet and sunfish composites. The Fourmile Branch, Hwy. 301, Stokes Bluff, the Hwy. 17 fresh and saltwater and the Combahee locations did not exhibit Cs-137 activity in any sample.

Three of nine edible bass composites from Savannah River locations exhibited detectable levels of Cs-137, ranging from 0.08 to 0.32 pCi/g, with an average of 0.24 (± 0.14) pCi/g (Section 5.0, Figure 2a). The samples from Upper Three Runs and the Beaver Dam Creek location had the highest (0.32 pCi/g) reported activity level. Cesium-137 levels reported above the Minimum Detectible Activity (MDA) were observed in edible bass composites from two-creek mouth locations adjacent to SRS and the upstream location of the SRS.

Two of nine edible catfish composites exhibited detectable levels of Cs-137, ranging from 0.05 to 0.06 pCi/g, with an average of 0.055 (± 0.007) pCi/g (Section 5.0, Figure 2a). Cs-137 was not detected in sunfish composites in 2012.

Strontium Results

Strontium-89 and -90 are present around the world as a result of fallout from past atmospheric nuclear weapons tests (MII 2008). Strontium at the SRS predominantly originated in the fuel and targets irradiated in the nuclear materials production reactors (WSRC 1992). A large portion the strontium released from the SRS were released to site streams and transported to the Savannah River. Strontium-90 behaves like calcium in the body, and tends to deposit in bone and bone marrow. Internal exposure is linked to several forms of cancer (USEPA 2007).

The 31 non-edible bone composites were analyzed for Sr-89,90. All locations produced detectable strontium activity, including the background station (Section 5.0, Figure 3a). Sr-89,90 levels reported are for wet results, from analysis of whole fish composites. Averages noted below are for Savannah River freshwater species only, excluding the Combahee River location.

Levels of Sr-89,90, in bass, ranged from 0.040 to 0.130 pCi/g, with an average of 0.079 (± 0.041) pCi/g. The samples from the NSBLD, Beaver Dam Creek, and Steel Creek locations had the highest activity level. Strontium levels in catfish samples ranged from 0.040 to 0.130 pCi/g, with an average of 0.070 (± 0.027) pCi/g. The Beaver Dam creek location exhibited the highest activity. Strontium levels in sunfish samples ranged from 0.060 to 0.180 pCi/g, with an average of 0.109 (± 0.038) pCi/g. The Beaver Dam creek location exhibited the highest activity.

Section 5.0, Figures 3b and 3c show historically reported SCDHEC data for Sr-89,90 (SCDHEC 2011). The data from 2008-2012 represents calculated wet results using a dry/wet conversion ratio from the actual dry analyses. The 2008, 2009, and 2010 data were reported as wet results by the contract laboratory that year.

Mercury and Metals Analyses

In 2011, SCDHEC initiated analysis of edible fish samples for mercury and selected metals. In 2012, a total of 31 composites were analyzed. The metals (antimony, arsenic, cadmium, and manganese) were selected for concerns from consumption and analysis for direct comparison to DOE-SR data. Samples were also analyzed for chromium, copper, lead, nickel, and zinc.

Mercury is a naturally occurring element that is found in air, water and soil. It exists in several forms: elemental or metallic mercury, inorganic mercury compounds, and organic mercury compounds. Although small amounts of mercury were released to the SRS environment from site operations, the majority of mercury contamination is a result of atmospheric fallout from coal-burning power plants. Coal-burning power plants are the largest human-caused source of mercury emissions to the air in the United States, accounting for over 50 percent of all domestic human-caused mercury emissions (USEPA 2010).

Mercury in the air eventually settles into water or onto land where it can be washed into water. Once deposited, certain microorganisms can change it into methylmercury, a highly toxic form that builds up in fish, shellfish and animals that eat fish. Fish and shellfish are the main sources of methylmercury exposure to humans. Methylmercury builds up more in some types of fish and shellfish than others. The levels of methylmercury in fish and shellfish depend on what they eat, how long they live, and how high they are in the food chain.

Mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages. Research shows that most people's fish consumption does not cause a health concern. However, it has been demonstrated that high levels of methylmercury in the bloodstream of unborn babies and young children may harm the developing nervous system, making the child less able to think and learn (USEPA 2010).

Mercury was detected in fish, primarily bass, from all locations (Section 6.0). Composites from the background location on the Combahee River exhibited detectable mercury in both bass and catfish.

Mercury was detected in bass composite samples from all nine Savannah River locations, ranging from 0.11 to 0.66 milligrams per kilogram (mg/kg), with an average of 0.36 (± 0.20) mg/kg (Section 5.0, Figure 4).

Mercury was only detected from one catfish composite (0.11 mg/kg) from the Highway 17 fresh water location (Section 5.0, Figure 4).

Mercury was only detected from one sunfish composite (0.22 mg/kg) from the lower three runs location (Section 5.0, Figure 4).

The following metals were not detected in any samples in 2012: arsenic, antimony, cadmium, chromium, lead, and nickel. Manganese was detected in 16 composites. Copper was detected in 27 composites. Zinc was detected in all 31 composites analyzed.

SCDHEC and DOE-SR Data Comparison

SCDHEC bass and catfish data collected for this project in 2012 were compared to DOE-SR reported information (SRNS 2013). Data comparison summaries are located in Section 6.0. One difference between the two programs is that ESOP analyzes one composite type from each species for each location, whereas the DOE-SR program analyzes three composite types per location. Therefore, a single composite for an ESOP location was compared to the average of the three DOE-SR composites reported. Differences in averages of DOE-SR and ESOP data could be attributed to the fact that DOE-SR uses results below the MDC when calculating averages whereas ESOP only uses detects.

ESOP largemouth bass samples from seven locations and DOE-SR bass samples from nine locations exhibited tritium activity. ESOP detected tritium in catfish samples from five sites, DOE-SR from six. ESOP largemouth bass samples from three locations and DOR-SR bass samples from six locations exhibited Cesium-137 activity. Cesium-137 results for edible bass and catfish from ESOP and DOE-SR were less than 1.00 pCi/g. Strontium-89, 90 was detected at all locations by both programs, although all values were less than 1.00 pCi/g. (SRNS 2013).

Average results of tritium, Cs-137, and Sr-89,90 analyses were used for direct comparisons of data between the two programs. Averages were calculated using only detections, including separate DOE-SR composite analyses. For tritium in bass and catfish, DOE-SR results are reported in pCi/g and ESOP data is reported in pCi/L; therefore, no direct comparisons can be made. For Cs-137 in bass samples, DOE-SR results were within two standard deviation of the ESOP results. For Cs-137 in catfish samples, DOE-SR results were within five standard deviations of the ESOP results, although it is noteworthy that most samples were below the minimum detectable concentration. DOE-SR and ESOP results for bass and catfish were five standard deviations apart for Sr-89,90, but the detections were at very low levels. DOE-SR had a Sr-89/90 average of 0.04 pCi/g and ESOP had a Sr-89/90 average of 0.08 pCi/g for catfish. Both DOE-SR and ESOP had a average of 0.08 pCi/g for bass.

Mercury was the only metal detected by both programs, DOE-SR results were within one standard deviation of the ESOP results. Although sample sizes from each program were different average mercury concentrations for both organizations were essentially the same for catfish and largemouth bass samples.

3.0 CONCLUSIONS AND RECOMMENDATIONS

A review of SCDHEC data indicates that DOE-SR operations have impacted fish. Higher levels of radionuclides are found in Savannah River fish collected adjacent to and downstream of SRS compared to upstream. Previous studies have shown that tritium and cesium in the SRS environment from historical and continuing releases can be manifested in the SRS biota (Cummins 1994; WSRC 1997). Fish from background locations tend not to exhibit detectable levels of man-made radionuclides, except for Sr-89,90, which is present worldwide from past nuclear weapons testing (USEPA 2007).

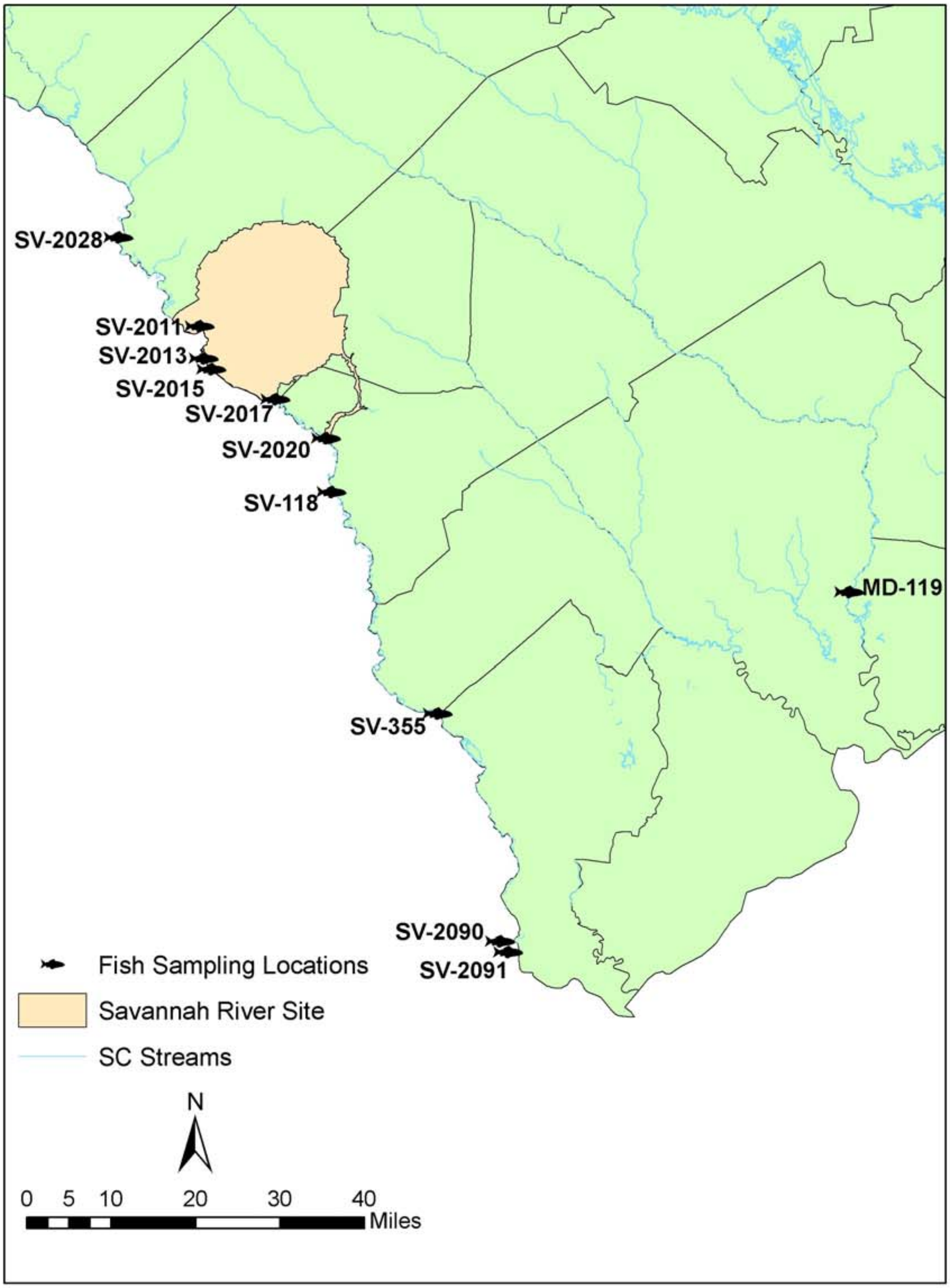
SCDHEC project data was compared to DOE-SR reported information (SRNS 2013). Based on standard deviations, tritium, Cs-137, Sr-89,90, and mercury data were generally similar,12 and at or near the minimum detectable concentration (MDC). Differences in results could be due to the natural variation (e.g. fish age and size) of contaminant levels in individual fish. Both programs detected Sr-89,90, and mercury at all locations.

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 radionuclide levels, their extent, and trends. This data will allow SCDHEC to better advise, inform, and protect those people at risk. Although Cs-137 and Sr-89,90 are found in some Savannah River fish, the levels are low and have decreased over time. If the public follows the SCDHEC mercury advisories for consumption of fish from the river, the health risk from these radioactive elements is very low (SCDHEC 2010b). 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.

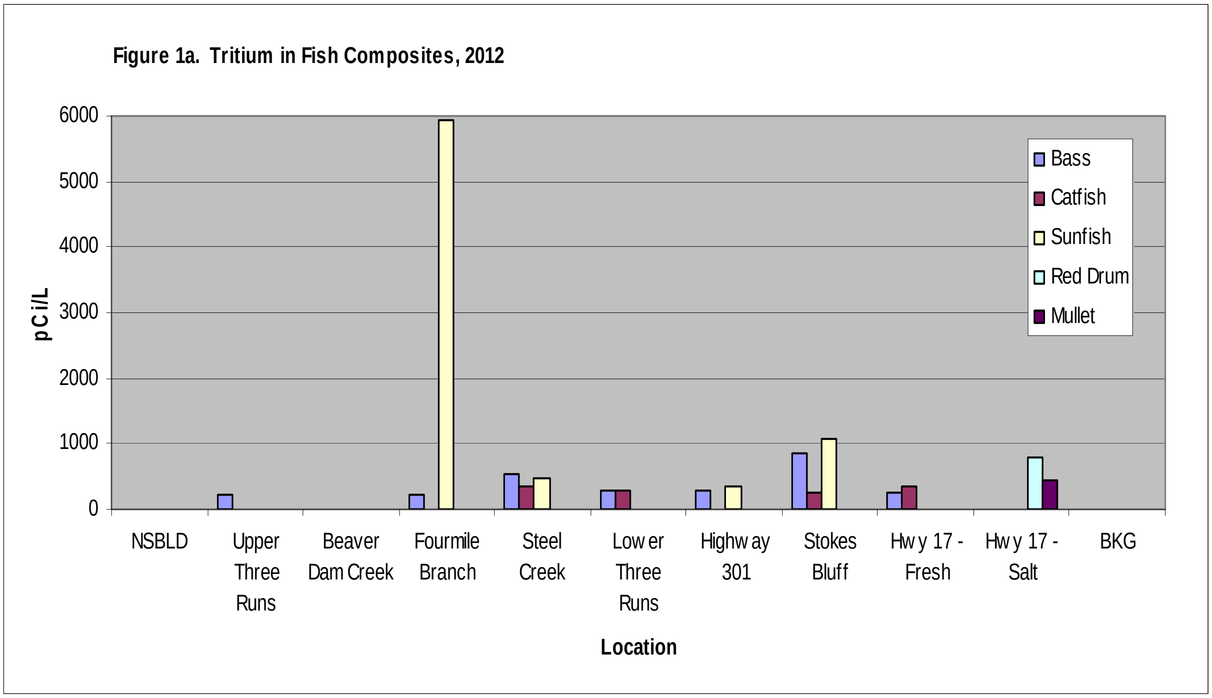
Future analyses of the target species will continue to include mercury and selected metals. This will augment the existing data on Savannah River fish, provide information for human health assessment, and provide another basis for comparison of results with DOE-SR data.

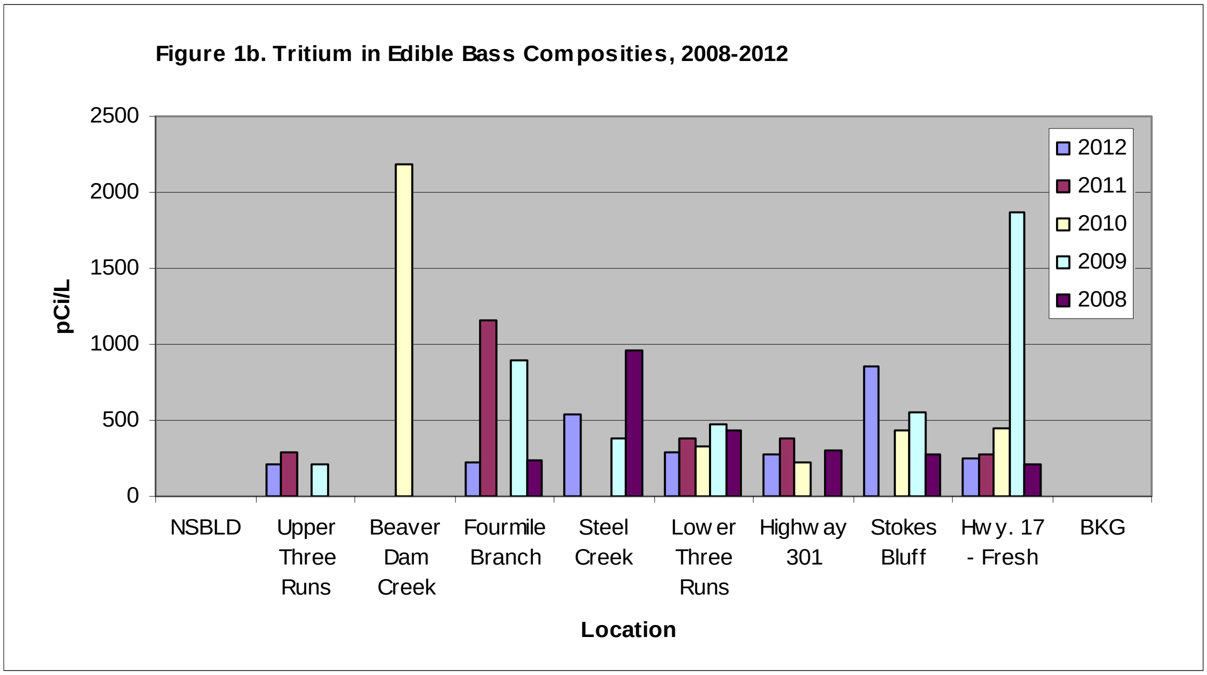
4.0 Fish Monitoring Associated with the Savannah River Site

Map 1. ESOP Fish Sampling Locations, 2012



5.0 Tables and Figures
Fish Monitoring Associated with the Savannah River Site





Tables and Figures
Fish Monitoring Associated with the Savannah River Site

Figure 1c. Tritium in Edible Catfish Composites, 2008-2012

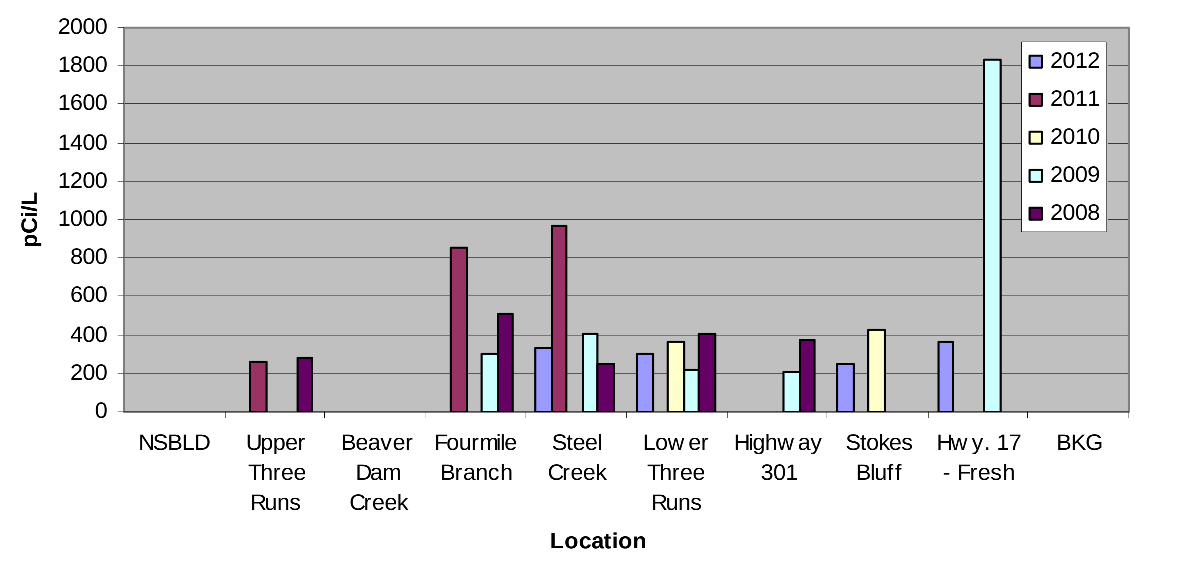
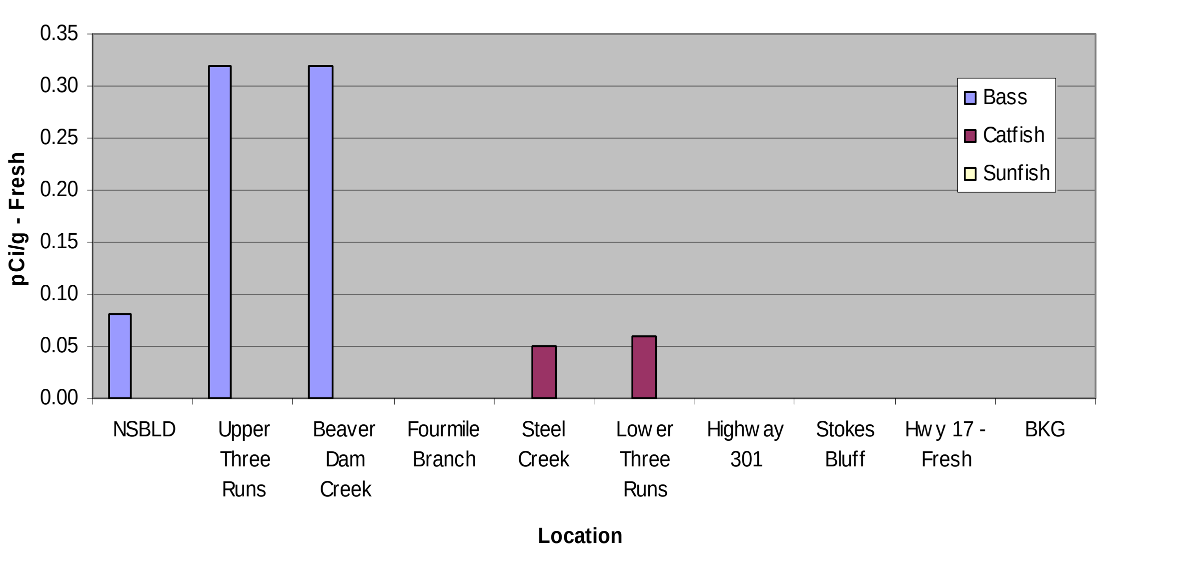
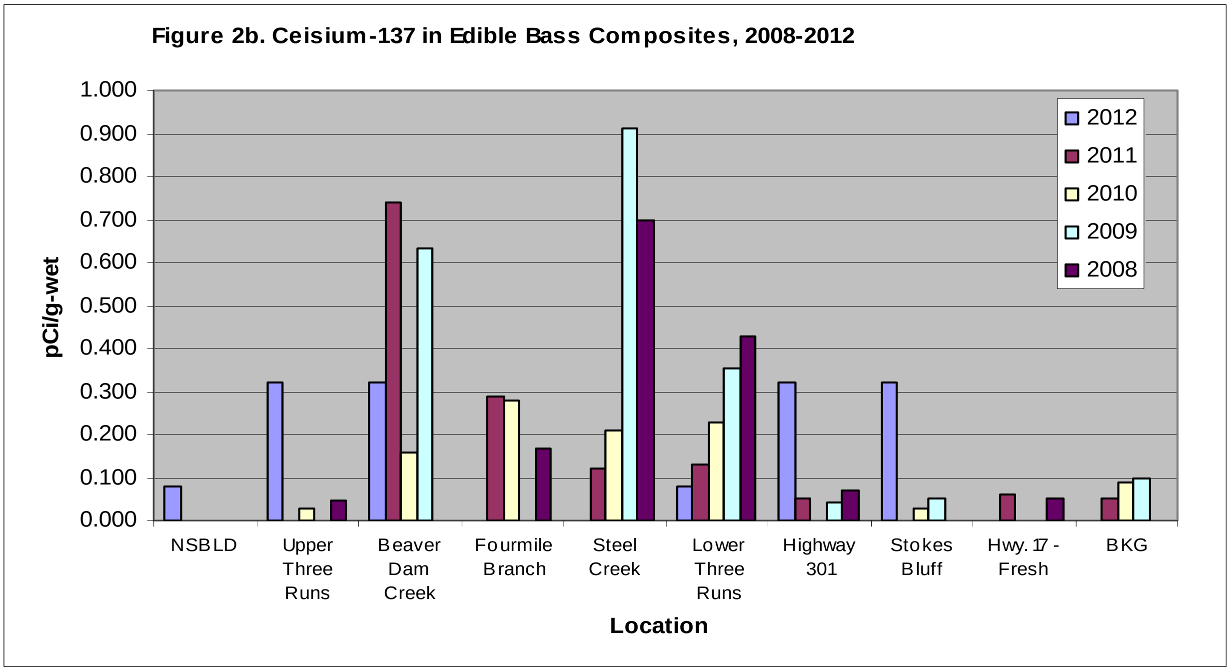
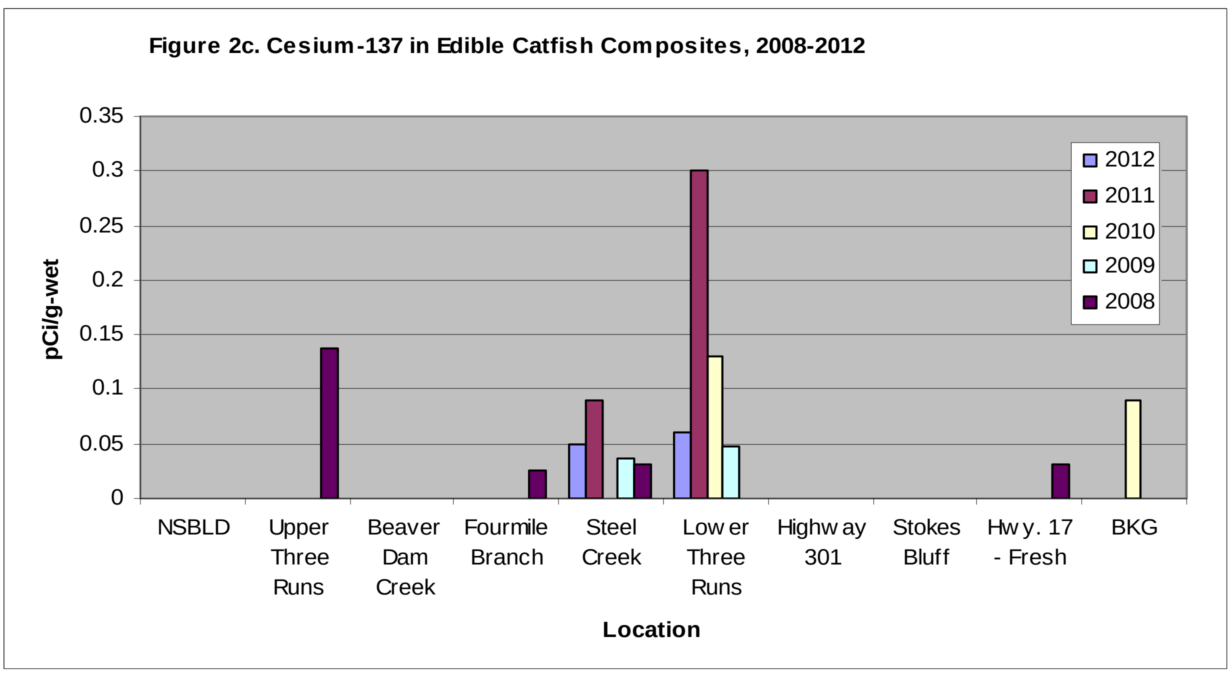


Figure 2a. Cesium-137 in Fish Composites, 2012



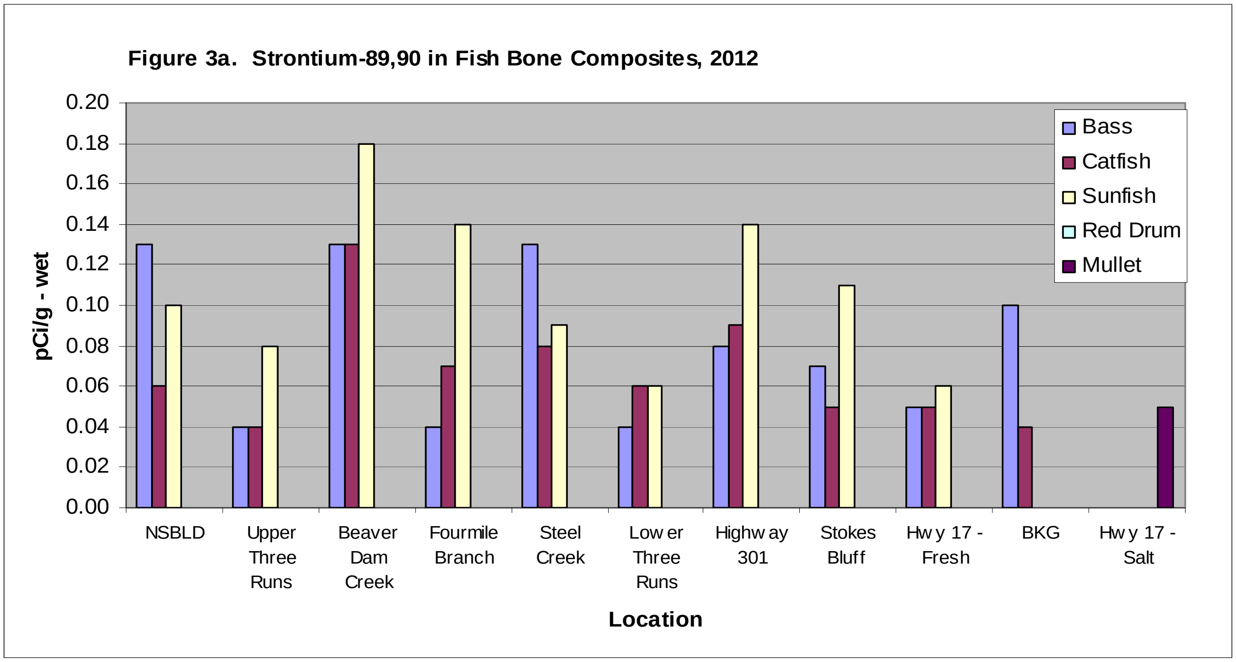
Tables and Figures
Fish Monitoring Associated with the Savannah River Site

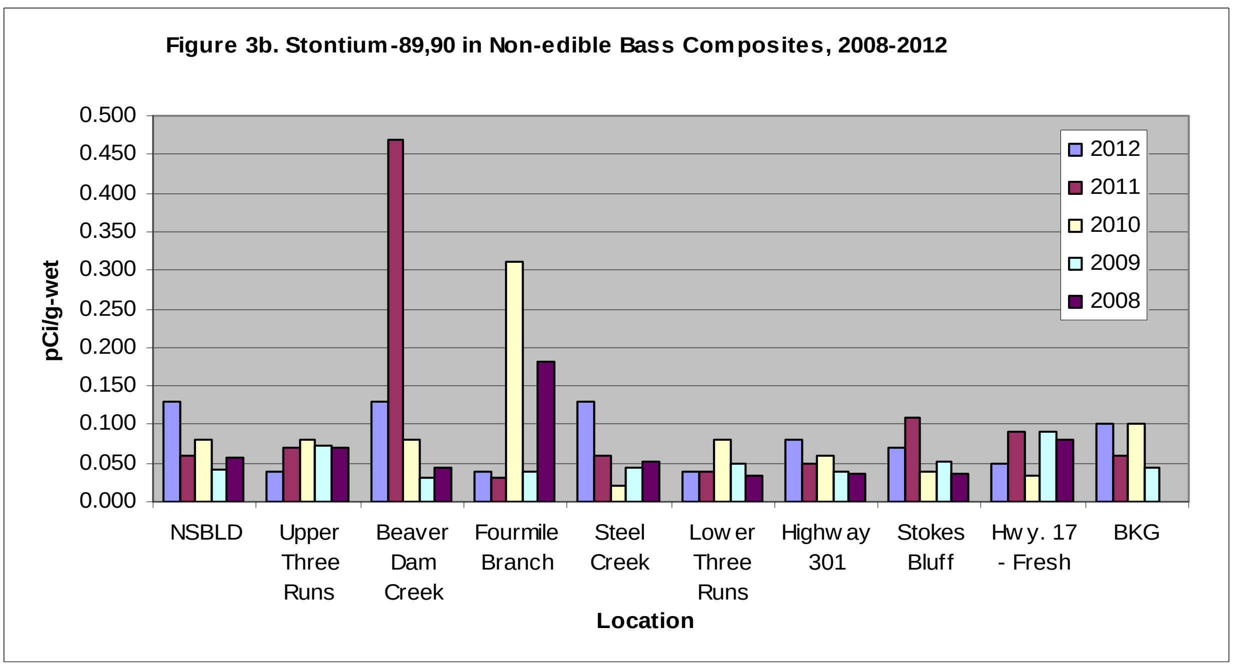




Note: Sampling at the Edisto River location started in 2009

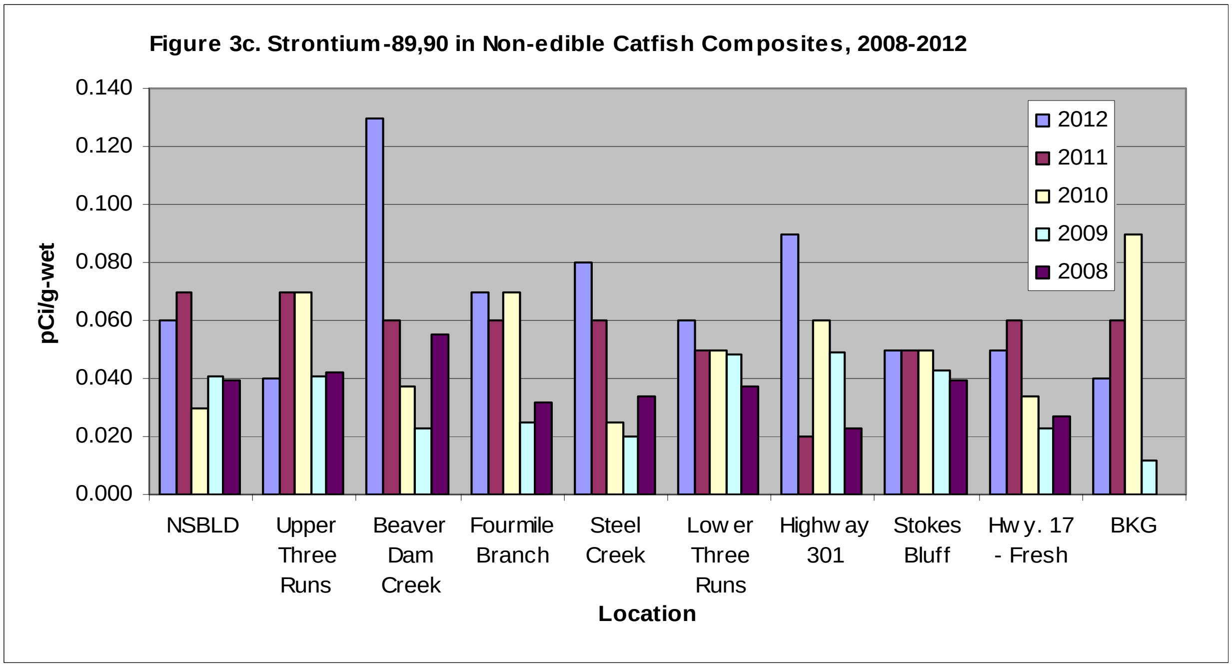
Tables and Figures
Fish Monitoring Associated with the Savannah River Site



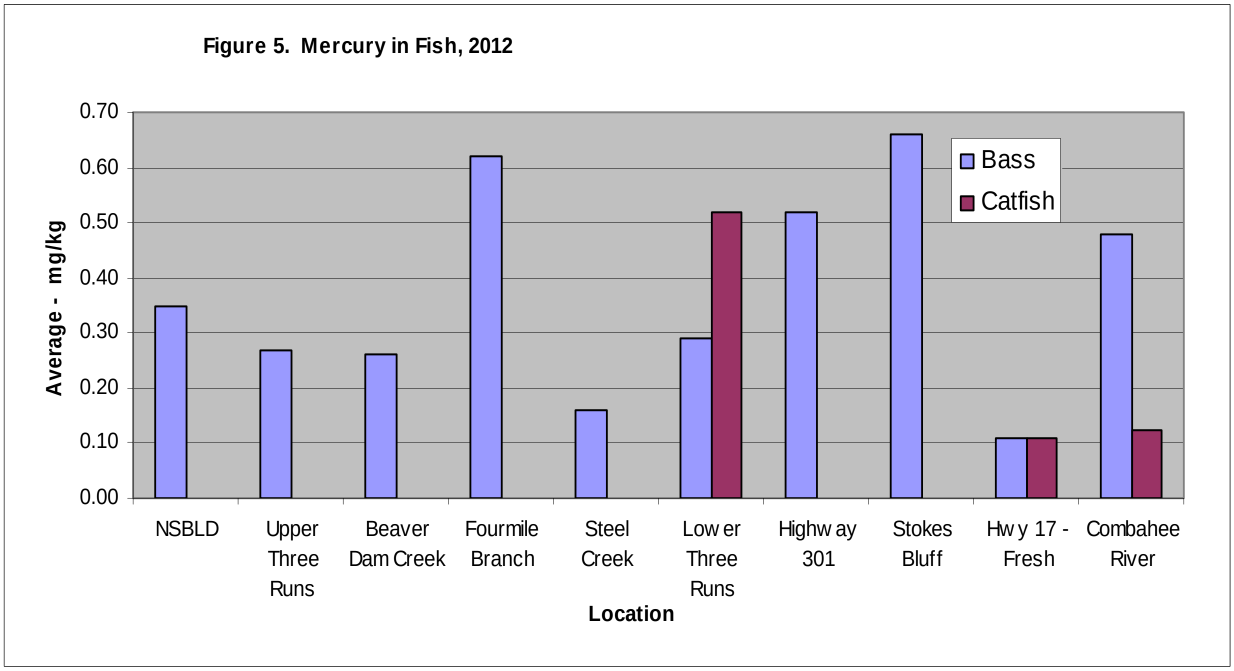


Note: Hwy. 17 not analyzed in 2007

Tables and Figures
Fish Monitoring Associated with the Savannah River Site



Note: Hwy. 17 not analyzed in 2007



6.0 Data

Fish Monitoring Associated with the Savannah River Site

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Notes:

1. FM denotes Fish Monitoring project
2. LLD - Lower Limit of Detection
3. NA – Not Applicable
4. MDA - Minimum Detectable Activity
5. Hwy. 301 - Savannah River at U.S. Highway 301
6. Hwy. 17 - Savannah River at U.S. Highway 17

Fish Monitoring Data
2012 Tritium Data

Edible Samples	Location Description	Analyte	Collection Date	Result (pCi/L) in Extracted Water
New Sav. Bluff	FMSV-2028A	Tritium Activity	2/29/2012	<LLD
Lock & Dam	FMSV-2028A	Tritium Confidence Interval	2/29/2012	NA
Bass	FMSV-2028A	Tritium LLD	2/29/2012	212
New Sav. Bluff	FMSV-2028C	Tritium Activity	2/29/2012	<LLD
Lock & Dam	FMSV-2028C	Tritium Confidence Interval	2/29/2012	NA
Catfish	FMSV-2028C	Tritium LLD	2/29/2012	212
New Sav. Bluff	FMSV-2028E	Tritium Activity	11/15/2012	<LLD
Lock & Dam	FMSV-2028E	Tritium Confidence Interval	11/15/2012	NA
Sunfish	FMSV-2028E	Tritium LLD	11/15/2012	210
Upper	FMSV-2011A	Tritium Activity	3/7/2012	216
Three Runs	FMSV-2011A	Tritium Confidence Interval	3/7/2012	97
Bass	FMSV-2011A	Tritium LLD	7/7/2012	212
Upper	FMSV-2011C	Tritium Activity	3/7/2012	<LLD
Three Runs	FMSV-2011C	Tritium Confidence Interval	3/7/2012	NA
Catfish	FMSV-2011C	Tritium LLD	7/7/2012	212
Upper	FMSV-2011E	Tritium Activity	3/7/2012	<LLD
Three Runs	FMSV-2011E	Tritium Confidence Interval	3/7/2012	NA
Sunfish	FMSV-2011E	Tritium LLD	3/7/2012	210
Beaver	FMSV-2013A	Tritium Activity	3/7/2012	<LLD
Dam Creek	FMSV-2013A	Tritium Confidence Interval	3/7/2012	NA
Bass	FMSV-2013A	Tritium LLD	3/7/2012	210
Beaver	FMSV-2013C	Tritium Activity	3/7/2012	<LLD
Dam Creek	FMSV-2013C	Tritium Confidence Interval	3/7/2012	NA
Catfish	FMSV-2013C	Tritium LLD	3/7/2012	212
Beaver	FMSV-2013E	Tritium Activity	3/7/2012	<LLD
Dam Creek	FMSV-2013E	Tritium Confidence Interval	3/7/2012	NA
Sunfish	FMSV-2013E	Tritium LLD	3/7/2012	210
Fourmile	FMSV-2015A	Tritium Activity	3/19/2012	230
Branch	FMSV-2015A	Tritium Confidence Interval	3/19/2012	97
Bass	FMSV-2015A	Tritium LLD	3/19/2012	212
Fourmile	FMSV-2015C	Tritium Activity	3/19/2012	<LLD
Branch	FMSV-2015C	Tritium Confidence Interval	3/19/2012	NA
Catfish	FMSV-2015C	Tritium LLD	3/19/2012	212
Fourmile	FMSV-2015E	Tritium Activity	3/19/2012	5944
Branch	FMSV-2015E	Tritium Confidence Interval	3/19/2012	222
Sunfish	FMSV-2015E	Tritium LLD	3/19/2012	210

Fish Monitoring Data
2012 Tritium Data

Edible Samples	Location Description	Analyte	Collection Date	Result (pCi/L) in Extracted Water
Steel	FMSV-2017A	Tritium Activity	3/13/2012	544
Creek	FMSV-2017A	Tritium Confidence Interval	3/13/2012	108
Bass	FMSV-2017A	Tritium LLD	3/13/2012	212
Steel	FMSV-2017C	Tritium Activity	3/13/2012	332
Creek	FMSV-2017C	Tritium Confidence Interval	3/13/2012	101
Catfish	FMSV-2017C	Tritium LLD	3/13/2012	212
Steel	FMSV-2017E	Tritium Activity	3/13/2012	462
Creek	FMSV-2017E	Tritium Confidence Interval	3/13/2012	104
Sunfish	FMSV-2017E	Tritium LLD	3/13/2012	210
Lower	FMSV-2020A	Tritium Activity	3/19/2012	296
Three Runs	FMSV-2020A	Tritium Confidence Interval	3/19/2012	100
Bass	FMSV-2020A	Tritium LLD	3/19/2012	212
Lower	FMSV-2020C	Tritium Activity	3/19/2012	297
Three Runs	FMSV-2020C	Tritium Confidence Interval	3/19/2012	100
Catfish	FMSV-2020C	Tritium LLD	3/19/2012	212
Lower	FMSV-2020E	Tritium Activity	3/19/2012	<LLD
Three Runs	FMSV-2020E	Tritium Confidence Interval	3/19/2012	NA
Sunfish	FMSV-2020E	Tritium LLD	3/19/2012	212
Hwy. 301	FMSV-118A	Tritium Activity	5/9/2012	281
Bass	FMSV-118A	Tritium Confidence Interval	5/9/2012	88
	FMSV-118A	Tritium LLD	5/9/2012	212
Hwy. 301	FMSV-118C	Tritium Activity	5/9/2012	<LLD
Catfish	FMSV-118C	Tritium Confidence Interval	5/9/2012	NA
	FMSV-118C	Tritium LLD	5/9/2012	212
Hwy. 301	FMSV-118E	Tritium Activity	5/9/2012	360
Sunfish	FMSV-118E	Tritium Confidence Interval	5/9/2012	99
	FMSV-118E	Tritium LLD	5/9/2012	210
Stokes	FMSV-355A	Tritium Activity	5/1/2012	852
Bluff	FMSV-355A	Tritium Confidence Interval	5/1/2012	117
Bass	FMSV-355A	Tritium LLD	5/1/2012	211
Stokes	FMSV-355C	Tritium Activity	5/1/2012	252
Bluff	FMSV-355C	Tritium Confidence Interval	5/1/2012	98
Catfish	FMSV-355C	Tritium LLD	5/1/2012	211
Stokes	FMSV-355E	Tritium Activity	5/1/2012	1081
Bluff	FMSV-355E	Tritium Confidence Interval	5/1/2012	124
Sunfish	FMSV-355E	Tritium LLD	5/1/2012	210

Fish Monitoring Data
2012 Tritium Data

Edible Samples	Location Description	Analyte	Collection Date	Result (pCi/L) in Extracted Water
Hwy. 17	FMSV-2090A	Tritium Activity	7/11/2012	252
Freshwater	FMSV-2090A	Tritium Confidence Interval	7/11/2012	96
Bass	FMSV-2090A	Tritium LLD	7/11/2012	203
Hwy. 17	FMSV-2090C	Tritium Activity	7/11/2012	362
Freshwater	FMSV-2090C	Tritium Confidence Interval	7/11/2012	100
Catfish	FMSV-2090C	Tritium LLD	7/11/2012	203
Hwy. 17	FMSV-2090E	Tritium Activity	7/11/2012	Lab
Freshwater	FMSV-2090E	Tritium Confidence Interval	7/11/2012	Error
Sunfish	FMSV-2090E	Tritium LLD	7/11/2012	
Hwy. 17	FMSV-2091A	Tritium Activity	7/11/2012	805
Saltwater	FMSV-2091A	Tritium Confidence Interval	7/11/2012	115
Red drum	FMSV-2091A	Tritium LLD	7/11/2012	203
Hwy. 17	FMSV-2091E	Tritium Activity	7/11/2012	428
Saltwater	FMSV-2091E	Tritium Confidence Interval	7/11/2012	102
Mullet	FMSV-2091E	Tritium LLD	7/11/2012	203
Combahee	FMSV-119A	Tritium Activity	10/15/2012	<LLD
River	FMSV-119A	Tritium Confidence Interval	10/15/2012	NA
Bass	FMSV-119A	Tritium LLD	10/15/2012	210
Combahee	FMSV-119C	Tritium Activity	10/15/2012	<LLD
River	FMSV-119C	Tritium Confidence Interval	10/15/2012	NA
Catfish	FMSV-119C	Tritium LLD	10/15/2012	210

Fish Monitoring Data
2012 Cs-137 Data

Edible Samples	Location Description	Analyte	Collection Date	Result (pCi/g) Fresh Weight
New Sav. Bluff	FMSV-2028A	Cs-137 Activity	2/29/2012	0.08
Lock & Dam	FMSV-2028A	Cs-137 Confidence Interval	2/29/2012	0.03
Bass	FMSV-2028A	Cs-137 MDA	2/29/2012	0.02
New Sav. Bluff	FMSV-2028C	Cs-137 Activity	2/29/2012	<MDA
Lock & Dam	FMSV-2028C	Cs-137 Confidence Interval	2/29/2012	NA
Catfish	FMSV-2028C	Cs-137 MDA	2/29/2012	0.03
New Sav. Bluff	FMSV-2028E	Cs-137 Activity	2/29/2012	<MDA
Lock & Dam	FMSV-2028E	Cs-137 Confidence Interval	2/29/2012	NA
Sun Fish	FMSV-2028E	Cs-137 MDA	2/29/2012	0.03
Upper	FMSV-2011A	Cs-137 Activity	3/7/2012	0.32
Three Runs	FMSV-2011A	Cs-137 Confidence Interval	3/7/2012	0.05
Bass	FMSV-2011A	Cs-137 MDA	3/7/2012	0.02
Upper	FMSV-2011C	Cs-137 Activity	3/7/2012	<MDA
Three Runs	FMSV-2011C	Cs-137 Confidence Interval	3/7/2012	NA
Catfish	FMSV-2011C	Cs-137 MDA	3/7/2012	0.03
Upper	FMSV-2011E	Cs-137 Activity	3/7/2012	<MDA
Three Runs	FMSV-2011E	Cs-137 Confidence Interval	3/7/2012	NA
Sun Fish	FMSV-2011E	Cs-137 MDA	3/7/2012	0.03
Beaver	FMSV-2013A	Cs-137 Activity	11/20/2012	0.32
Dam Creek	FMSV-2013A	Cs-137 Confidence Interval	3/7/2012	0.04
Bass	FMSV-2013A	Cs-137 MDA	3/7/2012	0.02
Beaver	FMSV-2013C	Cs-137 Activity	3/7/2012	<MDA
Dam Creek	FMSV-2013C	Cs-137 Confidence Interval	3/7/2012	NA
Catfish	FMSV-2013C	Cs-137 MDA	3/7/2012	0.03
Beaver	FMSV-2013E	Cs-137 Activity	3/7/2012	<MDA
Dam Creek	FMSV-2013E	Cs-137 Confidence Interval	3/7/2012	NA
Sun Fish	FMSV-2013E	Cs-137 MDA	3/7/2012	0.03
Fourmile	FMSV-2015A	Cs-137 Activity	3/19/2012	<MDA
Branch	FMSV-2015A	Cs-137 Confidence Interval	3/19/2012	NA
Bass	FMSV-2015A	Cs-137 MDA	3/19/2012	0.02
Fourmile	FMSV-2015C	Cs-137 Activity	3/19/2012	<MDA
Branch	FMSV-2015C	Cs-137 Confidence Interval	3/19/2012	NA
Catfish	FMSV-2015C	Cs-137 MDA	3/19/2012	0.02
Fourmile	FMSV-2015E	Cs-137 Activity	3/19/2012	<MDA
Branch	FMSV-2015E	Cs-137 Confidence Interval	3/19/2012	NA
Sun Fish	FMSV-2015E	Cs-137 MDA	3/19/2012	0.03

Fish Monitoring Data
2012 Cs-137 Data

Edible Samples	Location Description	Analyte	Collection Date	Result (pCi/g) Fresh Weight
Steel	FMSV-2017A	Cs-137 Activity	3/13/2012	<MDA
Creek	FMSV-2017A	Cs-137 Confidence Interval	3/13/2012	NA
Bass	FMSV-2017A	Cs-137 MDA	3/13/2012	0.02
Steel	FMSV-2017C	Cs-137 Activity	3/13/2012	0.05
Creek	FMSV-2017C	Cs-137 Confidence Interval	3/13/2012	0.02
Catfish	FMSV-2017C	Cs-137 MDA	3/13/2012	0.02
Steel	FMSV-2017E	Cs-137 Activity	3/13/2012	<MDA
Creek	FMSV-2017E	Cs-137 Confidence Interval	3/13/2012	NA
Sun Fish	FMSV-2017E	Cs-137 MDA	3/13/2012	0.02
Lower	FMSV-2020A	Cs-137 Activity	3/19/2012	<MDA
Three Runs	FMSV-2020A	Cs-137 Confidence Interval	3/19/2012	NA
Bass	FMSV-2020A	Cs-137 MDA	3/19/2012	0.02
Lower	FMSV-2020C	Cs-137 Activity	3/19/2012	0.06
Three Runs	FMSV-2020C	Cs-137 Confidence Interval	3/19/2012	0.03
Catfish	FMSV-2020C	Cs-137 MDA	3/19/2012	0.02
Lower	FMSV-2020E	Cs-137 Activity	3/19/2012	<MDA
Three Runs	FMSV-2020E	Cs-137 Confidence Interval	3/19/2012	NA
Sun Fish	FMSV-2020E	Cs-137 MDA	3/19/2012	0.03
Hwy. 301	FMSV-118A	Cs-137 Activity	5/9/2012	<MDA
Bass	FMSV-118A	Cs-137 Confidence Interval	5/9/2012	NA
	FMSV-118A	Cs-137 MDA	5/9/2012	0.02
Hwy. 301	FMSV-118C	Cs-137 Activity	5/9/2012	<MDA
Catfish	FMSV-118C	Cs-137 Confidence Interval	5/9/2012	NA
	FMSV-118C	Cs-137 MDA	5/9/2012	0.02
Hwy. 301	FMSV-118E	Cs-137 Activity	5/9/2012	<MDA
Sun Fish	FMSV-118E	Cs-137 Confidence Interval	5/9/2012	NA
	FMSV-118E	Cs-137 MDA	5/9/2012	0.02
Stokes	FMSV-355A	Cs-137 Activity	5/1/2012	<MDA
Bluff	FMSV-355A	Cs-137 Confidence Interval	5/1/2012	NA
Bass	FMSV-355A	Cs-137 MDA	5/1/2012	0.03
Stokes	FMSV-355C	Cs-137 Activity	5/1/2012	<MDA
Bluff	FMSV-355C	Cs-137 Confidence Interval	5/1/2012	NA
Catfish	FMSV-355C	Cs-137 MDA	5/1/2012	0.02
Stokes	FMSV-355E	Cs-137 Activity	5/1/2012	<MDA
Bluff	FMSV-355E	Cs-137 Confidence Interval	5/1/2012	NA
Sun Fish	FMSV-355E	Cs-137 MDA	5/1/2012	0.03

Fish Monitoring Data
2012 Cs-137 Data

Edible Samples	Location Description	Analyte	Collection Date	Result (pCi/g) Fresh Weight
Hwy. 17	FMSV-2090A	Cs-137 Activity	7/9/2012	<MDA
Freshwater	FMSV-2090A	Cs-137 Confidence Interval	7/9/2012	NA
Bass	FMSV-2090A	Cs-137 MDA	7/9/2012	0.03
Hwy. 17	FMSV-2090C	Cs-137 Activity	7/9/2012	<MDA
Freshwater	FMSV-2090C	Cs-137 Confidence Interval	7/9/2012	NA
Catfish	FMSV-2090C	Cs-137 MDA	7/9/2012	0.02
Hwy. 17	FMSV-2090E	Cs-137 Activity	7/9/2012	<MDA
Freshwater	FMSV-2090E	Cs-137 Confidence Interval	7/9/2012	NA
Sun Fish	FMSV-2090E	Cs-137 MDA	7/9/2012	0.02
Combahee	FMSV 117A	Cs-137 Activity	10/10/2012	<MDA
River	FMSV 117A	Cs-137 Confidence Interval	10/10/2012	NA
Bass	FMSV 117A	Cs-137 MDA	10/10/2012	0.02
Combahee	FMSV 117C	Cs-137 Activity	10/10/2012	<MDA
River	FMSV 117C	Cs-137 Confidence Interval	10/10/2012	NA
Catfish	FMSV 117C	Cs-137 MDA	10/10/2012	0.03
Hwy. 17	FMSV-2091A	Cs-137 Activity	7/9/2012	<MDA
Saltwater	FMSV-2091A	Cs-137 Confidence Interval	7/9/2012	NA
Red drum	FMSV-2091A	Cs-137 MDA	7/9/2012	0.02
Hwy. 17	FMSV-2091C	Cs-137 Activity	7/9/2012	<MDA
Saltwater	FMSV-2091C	Cs-137 Confidence Interval	7/9/2012	NA
Mullet	FMSV-2091C	Cs-137 MDA	7/9/2012	0.03

Fish Monitoring Data
2012 Strontium Data

Non-edible Samples	Location Description	Analyte	Collection Date	Result (pCi/g) Fresh Weight
New Sav. Bluff	FMSV-2028B	Strontium-89,90	2/29/2012	0.13
Lock & Dam	FMSV-2028B	Strontium Uncertainty	2/29/2012	0.01
Bass	FMSV-2028B	Strontium MDA	2/29/2012	0.02
New Sav. Bluff	FMSV-2028D	Strontium-89,90	2/29/2012	0.06
Lock & Dam	FMSV-2028D	Strontium Uncertainty	2/29/2012	0.01
Catfish	FMSV-2028D	Strontium MDA	2/29/2012	0.02
New Sav. Bluff	FMSV-2028F	Strontium-89,90	2/29/2012	0.10
Lock & Dam	FMSV-2028F	Strontium Uncertainty	2/29/2012	0.02
Sun Fish	FMSV-2028F	Strontium MDA	2/29/2012	0.04
Upper	FMSV-2011B	Strontium-89,90	3/7/2012	0.04
Three Runs	FMSV-2011B	Strontium Uncertainty	3/7/2012	0.01
Bass	FMSV-2011B	Strontium MDA	3/7/2012	0.03
Upper	FMSV-2011D	Strontium-89,90	3/7/2012	0.04
Three Runs	FMSV-2011D	Strontium Uncertainty	3/7/2012	0.01
Catfish	FMSV-2011D	Strontium MDA	3/7/2012	0.03
Upper	FMSV-2011F	Strontium-89,90	3/7/2012	0.08
Three Runs	FMSV-2011F	Strontium Uncertainty	3/7/2012	0.01
Sun Fish	FMSV-2011F	Strontium MDA	3/7/2012	0.03
Beaver	FMSV-2013B	Strontium-89,90	11/20/2012	0.13
Dam Creek	FMSV-2013B	Strontium Uncertainty	11/20/2012	0.01
Bass	FMSV-2013B	Strontium MDA	11/20/2012	0.02
Beaver	FMSV-2013D	Strontium-89,90	3/7/2012	0.13
Dam Creek	FMSV-2013D	Strontium Uncertainty	3/7/2012	0.01
Catfish	FMSV-2013D	Strontium MDA	3/7/2012	0.02
Beaver	FMSV-2013F	Strontium-89,90	3/7/2012	0.18
Dam Creek	FMSV-2013F	Strontium Uncertainty	3/7/2012	0.01
Sun Fish	FMSV-2013F	Strontium MDA	3/7/2012	0.02
Fourmile	FMSV-2015B	Strontium-89,90	3/13/2012	0.04
Branch	FMSV-2015B	Strontium Uncertainty	3/13/2012	0.01
Bass	FMSV-2015B	Strontium MDA	3/13/2012	0.02
Fourmile	FMSV-2015D	Strontium-89,90	3/13/2012	0.07
Branch	FMSV-2015D	Strontium Uncertainty	3/13/2012	0.01
Catfish	FMSV-2015D	Strontium MDA	3/13/2012	0.03
Fourmile	FMSV-2015F	Strontium-89,90	3/13/2012	0.14
Branch	FMSV-2015F	Strontium Uncertainty	3/13/2012	0.01
Sun Fish	FMSV-2015F	Strontium MDA	3/13/2012	0.02

Monitoring Data
2012 Strontium Data

Non-edible Samples	Location Description	Analyte	Collection Date	Result (pCi/g) Fresh Weight
Steel Creek Bass	FMSV-2017B	Strontium-89,90	3/12/2012	0.13
	FMSV-2017B	Strontium Uncertainty	3/12/2012	0.01
	FMSV-2017B	Strontium MDA	3/12/2012	0.02
Steel Creek Catfish	FMSV-2017D	Strontium-89,90	5/9/2012	0.08
	FMSV-2017D	Strontium Uncertainty	5/9/2012	0.01
	FMSV-2017D	Strontium MDA	5/9/2012	0.02
Steel Creek Sun Fish	FMSV-2017F	Strontium-89,90	3/12/2012	0.09
	FMSV-2017F	Strontium Uncertainty	3/12/2012	0.01
	FMSV-2017F	Strontium MDA	3/12/2012	0.02
Lower Three Runs Bass	FMSV-2020B	Strontium-89,90	3/19/2012	0.04
	FMSV-2020B	Strontium Uncertainty	3/19/2012	0.01
	FMSV-2020B	Strontium MDA	3/19/2012	0.03
Lower Three Runs Catfish	FMSV-2020D	Strontium-89,90	3/19/2012	0.06
	FMSV-2020D	Strontium Uncertainty	3/19/2012	0.01
	FMSV-2020D	Strontium MDA	3/19/2012	0.03
Lower Three Runs Sun Fish	FMSV-2020F	Strontium-89,90	3/19/2012	0.08
	FMSV-2020F	Strontium Uncertainty	3/19/2012	0.01
	FMSV-2020F	Strontium MDA	3/19/2012	0.02
Hwy. 301 Bass	FMSV-118B	Strontium-89,90	5/9/2012	0.08
	FMSV-118B	Strontium Uncertainty	5/9/2012	0.01
	FMSV-118B	Strontium MDA	5/9/2012	0.02
Hwy. 301 Catfish	FMSV-118D	Strontium-89,90	5/9/2012	0.09
	FMSV-118D	Strontium Uncertainty	5/9/2012	0.01
	FMSV-118D	Strontium MDA	5/9/2012	0.03
Hwy. 301 Sun Fish	FMSV-118F	Strontium-89,90	5/9/2012	0.14
	FMSV-118F	Strontium Uncertainty	5/9/2012	0.01
	FMSV-118F	Strontium MDA	5/9/2012	0.02
Stokes Bluff Bass	FMSV-355B	Strontium-89,90	5/1/2012	0.07
	FMSV-355B	Strontium Uncertainty	5/1/2012	0.01
	FMSV-355B	Strontium MDA	5/1/2012	0.01
Stokes Bluff Catfish	FMSV-355D	Strontium-89,90	5/1/2012	0.05
	FMSV-355D	Strontium Uncertainty	5/1/2012	0.01
	FMSV-355D	Strontium MDA	5/1/2012	0.01
Stokes Bluff Sun Fish	FMSV-355F	Strontium-89,90	5/1/2012	0.11
	FMSV-355F	Strontium Uncertainty	5/1/2012	0.01
	FMSV-355F	Strontium MDA	5/1/2012	0.03

Fish Monitoring Data
2012 Strontium Data

Non-edible Samples	Location Description	Analyte	Collection Date	Result (pCi/g) Fresh Weight
Hwy. 17	FMSV-2090B	Strontium-89,90	7/9/2012	0.05
Freshwater	FMSV-2090B	Strontium Uncertainty	7/9/2012	0.01
Bass	FMSV-2090B	Strontium MDA	7/9/2012	0.02
Hwy. 17	FMSV-2090D	Strontium-89,90	7/9/2012	0.05
Freshwater	FMSV-2090D	Strontium Uncertainty	7/9/2012	0.01
Catfish	FMSV-2090D	Strontium MDA	7/9/2012	0.02
Hwy. 17	FMSV-2090F	Strontium-89,90	7/9/2012	0.06
Freshwater	FMSV-2090F	Strontium Uncertainty	7/9/2012	0.01
Sun Fish	FMSV-2090F	Strontium MDA	7/9/2012	0.02
Combahee	FMMD-119B	Strontium-89,90	10/10/2012	0.10
River	FMMD-119B	Strontium Uncertainty	10/10/2012	0.01
Bass	FMMD-119B	Strontium MDA	10/10/2012	0.02
Combahee	FMMD-119D	Strontium-89,90	10/10/2012	0.04
River	FMMD-119D	Strontium Uncertainty	10/10/2012	0.01
Catfish	FMMD-119D	Strontium MDA	10/10/2012	0.02
Hwy. 17	FMSV-2091H	Strontium-89,90	7/9/2012	<MDA
Saltwater	FMSV-2091H	Strontium Uncertainty	7/9/2012	NA
Red drum	FMSV-2091H	Strontium MDA	7/9/2012	0.03
Hwy. 17	FMSV-2091J	Strontium-89,90	7/9/2012	0.05
Saltwater	FMSV-2091J	Strontium Uncertainty	7/9/2012	0.01
Mullet	FMSV-2091J	Strontium MDA	7/9/2012	0.02

Fish Monitoring Data
SCDHEC Historical Radiological Data, 2008-2012

Year	**Sample Location**		NSBLD	UTR	BDC	FMB	STC
	Sample Station		SV-2028	SV-2011	SV-2013	SV-2015	SV-2017
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Bass	Bass	Bass	Bass	Bass
2012	Radionuclide	Tritium (pCi/L)	ND	216	ND	230	544
2011			ND	384	ND	1162	ND
2010			NS	ND	2187	ND	ND
2009			ND	209	ND	893	383
2008			ND	ND	ND	240	954

Year	**Sample Location**		LTR	Hwy. 301	Stokes	Hwy. 17	Background
	Sample Station		SV-2020	SV-118	SV-355	SV-2090	MD-119
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Bass	Bass	Bass	Bass	Bass
2012	Radionuclide	Tritium (pCi/L)	296	281	852	252	ND
2011			383	380	ND	270	ND
2010			329	218	434	447	ND
2009			468	ND	550	1870	ND
2008			436	301	279	215	NS

Year	**Sample Location**		NSBLD	UTR	BDC	FMB	STC
	Sample Station		SV-2028	SV-2011	SV-2013	SV-2015	SV-2017
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Bass	Bass	Bass	Bass	Bass
2012	Radionuclide	Cs-137 (pCi/g wet)	0.080	0.320	0.320	ND	ND
2011			ND	ND	0.740	0.290	0.120
2010			ND	0.03	0.160	0.28	0.210
2009			ND	ND	0.634	ND	0.910
2008			ND	0.047	ND	0.167	0.700

Year	**Sample Location**		LTR	Hwy. 301	Stokes	Hwy. 17	Background
	Sample Station		SV-2020	SV-118	SV-355	SV-2090	MD-119
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Bass	Bass	Bass	Bass	Bass
2012	Radionuclide	Cs-137 (pCi/g wet)	0.080	0.320	0.320	ND	ND
2011			0.130	0.050	ND	0.060	0.050
2010			0.230	ND	0.030	ND	0.090
2009			0.353	0.041	0.053	ND	0.097
2008			0.427	0.071	ND	0.050	NS

Notes:
ND - Non-Detect
NA - Not Analyzed
NS - Not Sampled
NR - Not Reported
NSBLD - New Sav. Bluff Lock & Dam
UTR - Upper Three Runs
BDC - Beaver Dam Creek
FMB - Fourmile Branch
STC - Steel Creek
LTR - Lower Three Runs
Stokes - Stokes Bluff
2008 - 2011 Background samples were collected on Edisto River
2012 Background samples were collected on the Combahee River

Fish Monitoring Data
SCDHEC Historical Radiological Data, 2008-2012

Year	Sample Location		NSBLD	UTR	BDC	FMB	STC
	Sample Station		SV-2028	SV-2011	SV-2013	SV-2015	SV-2017
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Catfish	Catfish	Catfish	Catfish	Catfish
2012	Radionuclide	Tritium (pCi/L)	ND	ND	ND	ND	332
2011			ND	259	NS	856	967
2010			NS	ND	ND	NS	NS
2009			ND	ND	ND	298	405
2008			ND	278	ND	507	247

Year	Sample Location		LTR	Hwy. 301	Stokes	Hwy. 17	Background
	Sample Station		SV-2020	SV-118	SV-355	SV-2090	MD-119
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Catfish	Catfish	Catfish	Catfish	Bass
2012	Radionuclide	Tritium (pCi/L)	297	ND	252	362	ND
2011			ND	ND	ND	ND	ND
2010			363	ND	427	ND	ND
2009			216	205	ND	1832	ND
2008			406	373	ND	ND	NS

Year	Sample Location		NSBLD	UTR	BDC	FMB	STC
	Sample Station		SV-2028	SV-2011	SV-2013	SV-2015	SV-2017
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Catfish	Catfish	Catfish	Catfish	Catfish
2012	Radionuclide	Cs-137 (pCi/g wet)	ND	ND	ND	ND	0.05
2011			ND	ND	ND	ND	0.090
2010			ND	ND	ND	ND	ND
2009			ND	ND	ND	ND	0.036
2008			ND	0.138	ND	0.026	0.032

Year	Sample Location		LTR	Hwy. 301	Stokes	Hwy. 17	Background
	Sample Station		SV-2020	SV-118	SV-355	SV-2090	MD-119
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Catfish	Catfish	Catfish	Catfish	Catfish
2012	Radionuclide	Cs-137 (pCi/g wet)	0.06	ND	ND	ND	ND
2011			0.300	ND	ND	ND	ND
2010			0.130	ND	ND	ND	0.090
2009			0.048	ND	ND	ND	ND
2008			ND	ND	ND	0.032	NS

Notes:
ND - Non-Detect — NSBLD - New Sav. Bluff Lock & Dam — STC - Steel Creek
NA - Not Analyzed — UTR - Upper Three Runs — LTR - Lower Three Runs
NS - Not Sampled — BDC - Beaver Dam Creek — Stokes - Stokes Bluff
NR - Not Reported — FMB - Fourmile Branch
2008 - 2011 Background samples were collected on Edisto River
2012 Background samples were collected on the Combahee River

Fish Monitoring Data
SCDHEC Historical Radiological Data, 2008-2012

Year	Sample Location		NSBLD	UTR	BDC	FMB	STC
	Sample Station		SV-2028	SV-2011	SV-2013	SV-2015	SV-2017
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Catfish	Catfish	Catfish	Catfish	Catfish
2012	Radionuclide	Tritium (pCi/L)	ND	259	NS	856	967
2011			NS	ND	ND	NS	NS
2010			ND	ND	ND	298	405
2009			ND	278	ND	507	247
2008			ND	ND	233	2,010	1,120

Year	Sample Location		LTR	Hwy. 301	Stokes	Hwy. 17	Edisto R.
	Sample Station		SV-2020	SV-118	SV-355	SV-2090	MD-119
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Catfish	Catfish	Catfish	Catfish	Bass
2012	Radionuclide	Tritium (pCi/L)	ND	ND	ND	ND	ND
2011			363	ND	427	ND	ND
2010			216	205	ND	1832	ND
2009			406	373	ND	ND	NS
2008			484	621	396	273	NS

Year	Sample Location		NSBLD	UTR	BDC	FMB	STC
	Sample Station		SV-2028	SV-2011	SV-2013	SV-2015	SV-2017
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Catfish	Catfish	Catfish	Catfish	Catfish
2012	Radionuclide	Cs-137 (pCi/g wet)	ND	ND	ND	ND	0.090
2011			ND	ND	ND	ND	ND
2010			ND	ND	ND	ND	0.036
2009			ND	0.138	ND	0.026	0.032
2008			0.041	ND	ND	0.342	0.075

Year	Sample Location		LTR	Hwy. 301	Stokes	Hwy. 17	Edisto R.
	Sample Station		SV-2020	SV-118	SV-355	SV-2090	MD-119
	Sample Cut		Edible	Edible	Edible	Edible	Edible
	Species		Catfish	Catfish	Catfish	Catfish	Catfish
2012	Radionuclide	Cs-137 (pCi/g wet)	0.300	ND	ND	ND	ND
2011			0.130	ND	ND	ND	0.090
2010			0.048	ND	ND	ND	ND
2009			ND	ND	ND	0.032	NS
2008			0.053	ND	0.028	0.035	NS

Notes:
ND - Non-Detect
NA - Not Analyzed
NS - Not Sampled
NR - Not Reported

NSBLD - New Sav. Bluff Lock & Dam
UTR - Upper Three Runs
BDC - Beaver Dam Creek
FMB - Fourmile Branch

STC - Steel Creek
LTR - Lower Three Runs
Stokes - Stokes Bluff
Edisto R. - Edisto River

Fish Monitoring Data
SCDHEC Historical Radiological Data, 2008-2012

Year	Sample Location		NSBLD	UTR	BDC	FMB	STC
	Sample Station		SV-2028	SV-2011	SV-2013	SV-2015	SV-2017
	Sample Cut		Non-Edible	Non-Edible	Non-Edible	Non-Edible	Non-Edible
	Species		Catfish	Catfish	Catfish	Catfish	Catfish
2012	Radionuclide	Sr-89,90 (pCi/g Wet)	0.060	0.040	0.130	0.070	0.080
2011			0.070	0.070	0.060	0.060	0.060
2010			0.030	0.070	0.037	0.070	0.025
2009			0.041	0.041	0.023	0.025	0.020
2008			0.039	0.042	0.055	0.032	0.034

Year	Sample Location		LTR	Hwy. 301	Stokes	Hwy. 17	Background
	Sample Station		SV-2020	SV-118	SV-355	SV-2090	MD-119
	Sample Cut		Non-Edible	Non-Edible	Non-Edible	Non-Edible	Non-edible
	Species		Catfish	Catfish	Catfish	Catfish	Catfish
2012	Radionuclide	Sr-89,90 (pCi/g Wet)	0.06	0.09	0.05	0.05	0.04
2011			0.050	0.020	0.050	0.060	0.060
2010			0.050	0.060	0.050	0.034	0.090
2009			0.048	0.049	0.043	0.023	0.012
2008			0.037	0.023	0.039	0.027	NS

Year	Sample Location		NSBLD	UTR	BDC	FMB	STC
	Sample Station		SV-2028	SV-2011	SV-2013	SV-2015	SV-2017
	Sample Cut		Non-Edible	Non-Edible	Non-Edible	Non-Edible	Non-edible
	Species		Bass	Bass	Bass	Bass	Bass
2012	Radionuclide	Sr-89,90 (pCi/g Wet)	0.130	0.040	0.130	0.040	0.130
2011			0.060	0.070	0.470	0.030	0.060
2010			0.080	0.080	0.080	0.310	0.022
2009			0.041	0.072	0.032	0.038	0.045
2008			0.056	0.069	0.044	0.182	0.053

Year	Sample Location		LTR	Hwy. 301	Stokes	Hwy. 17	Background
	Sample Station		SV-2020	SV-118	SV-355	SV-2090	MD-119
	Sample Cut		Non-Edible	Non-Edible	Non-Edible	Non-Edible	Non-edible
	Species		Bass	Bass	Bass	Bass	Bass
2012	Radionuclide	Sr-89,90 (pCi/g Wet)	0.040	0.080	0.070	0.050	0.100
2011			0.040	0.050	0.110	0.090	0.060
2010			0.080	0.060	0.040	0.033	0.100
2009			0.050	0.040	0.051	0.091	0.044
2008			0.034	0.035	0.036	0.080	NS

Notes:
ND - Non-Detect
NA - Not Analyzed
NS - Not Sampled
NR - Not Reported
NSBLD - New Sav. Bluff Lock & Dam
UTR - Upper Three Runs
BDC - Beaver Dam Creek
FMB - Fourmile Branch
STC - Steel Creek
LTR - Lower Three Runs
Stokes - Stokes Bluff
2008 - 2011 Background samples were collected on Edisto River
2012 Background samples were collected on the Combahee River

Fish Monitoring Data
SCDHEC Historical Radiological Data, 2008-2012

Year	**Sample Location**		Hwy. 17	Hwy. 17
	Sample Station		SV-2091	SV-2091
	Sample Cut		Edible	Edible
	Species		Red drum	Mullet
2012	Radionuclide	Tritium (pCi/L)	805	428
2011			228	1191
2010			300	221
2009			378	414
2008			ND	ND

Year	**Sample Location**		Hwy. 17	Hwy. 17
	Sample Station		SV-2091	SV-2091
	Sample Cut		Edible	Edible
	Species		Red drum	Mullet
2012	Radionuclide	Cs-137 (pCi/g wet)	ND	ND
2011			ND	ND
2010			ND	ND
2009			ND	ND
2008			ND	ND

Year	**Sample Location**		Hwy. 17	Hwy. 17
	Sample Station		SV-2091	SV-2091
	Sample Cut		Non-edible	Non-edible
	Species		Red drum	Mullet
2012	Radionuclide	Sr-89,90 (pCi/g Wet)	ND	0.050
2011			0.020	ND
2010			0.140	0.009
2009			0.017	0.004
2008			0.010	ND

Notes: ND - Non-Detect

Fish Monitoring Data
2012 Mercury Data

Edible Composites	Location Description	Analyte	Collection Date	Result (mg/kg)
New Sav. Bluff Lock & Dam Bass	FMSV-2028A	Mercury in Fish	3/29/2012	0.35
New Sav. Bluff Lock & Dam Catfish	FMSV-2028C	Mercury in Fish	6/28/2011	<0.10
Upper Three Runs Bass	FMSV-2011A	Mercury in Fish	3/21/2011	0.27
Upper Three Runs Catfish	FMSV-2011C	Mercury in Fish	3/21/2011	<0.10
Beaver Dam Creek Bass	FMSV-2013A	Mercury in Fish	3/21/2011	0.26
Beaver Dam Creek Catfish	FMSV-2013C	Mercury in Fish	3/21/2011	<0.10
Fourmile Branch Bass	FMSV-2015A	Mercury in Fish	3/29/2011	0.62
Fourmile Branch Catfish	FMSV-2015C	Mercury in Fish	4/18/2011	<0.10
Steel Creek Bass	FMSV-2017A	Mercury in Fish	3/29/2011	0.16
Steel Creek Catfish	FMSV-2017C	Mercury in Fish	3/29/2011	<0.10

Fish Monitoring Data
2012 Mercury Data

Edible Composites	Location Description	Analyte	Collection Date	Result (mg/kg)
Lower Three Runs Bass	FMSV-2020A	Mercury in Fish	4/20/2011	0.29
Lower Three Runs Catfish	FMSV-2020C	Mercury in Fish	4/20/2011	0.52
Hwy. 301 Bass	FMSV-118A	Mercury in Fish	5/3/2011	0.52
Hwy. 301 Catfish	FMSV-118C	Mercury in Fish	5/3/2011	<0.10
Stokes Bluff Bass	FMSV-355A	Mercury in Fish	5/5/2011	0.66
Stokes Bluff Catfish	FMSV-355C	Mercury in Fish	5/5/2011	<0.10
Hwy. 17 Bass	FMSV-2090A	Mercury in Fish	6/14/2011	0.11
Hwy. 17 Catfish	FMSV-2090C	Mercury in Fish	6/14/2011	0.11
Hwy. 17 Red Drum	FMSV-2091A	Mercury in Fish	6/14/2011	<0.10
Hwy. 17 Flounder	FMSV-2091C	Mercury in Fish	6/14/2011	<0.10

Fish Monitoring Data
2012 Mercury Data

Edible Composites	Location Description	Analyte	Collection Date	Result (mg/kg)
Combahee River Bass	FMMD-117A	Mercury in Fish	10/15/2011	0.65
Combahee River Bass	FMMD-117C	Mercury in Fish	10/15/2011	<0.10

Fish Monitoring Data
2012 SCDHEC and DOE-SR Data Comparison

Table 1
Tritium Activity Levels in Edible Bass

Location	Agency	# of samples	Result
NSBLD	ESOP	1	<LLD
	DOE-SR	3	0.07
Upper Three Runs	ESOP	1	246
	DOE-SR	3	0.15
Beaver Dam Creek	ESOP	1	<LLD
	DOE-SR	3	0.13
Fourmile Branch	ESOP	1	230
	DOE-SR	3	0.14
Steel Creek	ESOP	1	544
	DOE-SR	3	0.10
Lower Three Runs	ESOP	1	296
	DOE-SR	3	0.13
Hwy. 301	ESOP	1	281
	DOE-SR	3	0.09
Stokes Bluff	ESOP	1	852
	DOE-SR	3	0.11
Hwy. 17	ESOP	1	252
	DOE-SR	3	<MDC
Average[2]	ESOP	7	386
	DOE-SR	8	0.12
Standard Deviation[2]	ESOP	7	232
	DOE-SR	8	0.03

Table 2
Tritium Activity Levels in Edible Catfish

Location	Agency	# of samples	Result
NSBLD	ESOP	1	<LLD
	DOE-SR	3	<MDC
Upper Three Runs	ESOP	1	<LLD
	DOE-SR	3	0.11
Beaver Dam Creek	ESOP	1	<LLD
	DOE-SR	3	0.09
Fourmile Branch	ESOP	1	<LLD
	DOE-SR	3	0.08
Steel Creek	ESOP	1	332
	DOE-SR	3	0.11
Lower Three Runs	ESOP	1	297
	DOE-SR	3	0.19
Hwy. 301	ESOP	1	<LLD
	DOE-SR	3	<MDC
Stokes Bluff	ESOP	1	252
	DOE-SR	3	0.09
Hwy. 17	ESOP	1	362
	DOE-SR	3	<MDC
Average[2]	ESOP	4	311
	DOE-SR	6	0.11
Standard Deviation[2]	ESOP	3	47
	DOE-SR	6	0.04

Notes:
ESOP Data is reported in pCi/L
DOE-SR Data is reprted in pCi/G
DOE-SR data from SRNS 2013
DOE-SR results are averages
[2]Calculated using detections only

Fish Monitoring Data
2012 SCDHEC and DOE-SR Data Comparison

Table 3 Cesium-137 Activity Levels in Edible Bass pCi/g			
Location	Agency	# of samples	Result
NSBLD	ESOP	1	0.08
	DOE-SR	3	<MDC
Upper Three Runs	ESOP	1	0.32
	DOE-SR	3	0.06
Beaver Dam Creek	ESOP	1	0.32
	DOE-SR	3	0.06
Fourmile Branch	ESOP	1	<MDA
	DOE-SR	3	0.17
Steel Creek	ESOP	1	<MDA
	DOE-SR	3	0.07
Lower Three Runs	ESOP	1	<MDA
	DOE-SR	3	0.08
Hwy. 301	ESOP	1	<MDA
	DOE-SR	3	0.03
Stokes Bluff	ESOP	1	<MDA
	DOE-SR	3	<MDC
Hwy. 17	ESOP	1	<MDA
	DOE-SR	3	<MDC
Average[2]	ESOP	3	0.24
	DOE-SR	6	0.06
Standard Deviation[2]	ESOP	3	0.14
	DOE-SR	6	0.05

Table 4 Cesium-137 Activity Levels in Edible Catfish pCi/g			
Location	Agency	# of samples	Result
NSBLD	ESOP	1	<MDA
	DOE-SR	3	0.03
Upper Three Runs	ESOP	1	<MDA
	DOE-SR	3	0.10
Beaver Dam Creek	ESOP	1	<MDA
	DOE-SR	3	0.02
Fourmile Branch	ESOP	1	<MDA
	DOE-SR	3	0.03
Steel Creek	ESOP	1	0.05
	DOE-SR	3	0.03
Lower Three Runs	ESOP	1	0.06
	DOE-SR	3	0.04
Hwy. 301	ESOP	1	<MDA
	DOE-SR	3	<MDC
Stokes Bluff	ESOP	1	<MDA
	DOE-SR	3	<MDC
Hwy. 17	ESOP	1	<MDA
	DOE-SR	3	0.03
Average[2]	ESOP	2	0.06
	DOE-SR	7	0.04
Standard Deviation[2]	ESOP	2	0.01
	DOE-SR	7	0.03

Notes: DOE-SR data from SRNS 2013
DOE-SR results are averages
[2]Calculated using detections only

Fish Monitoring
2012 SCDHEC and DOE-SR Data Comparison

Table 5
Strontium-89,90 Activity Levels in Non-edible Bass
pCi/g

Location	Agency	# of samples	Result
NSBLD	ESOP	1	0.13
	DOE-SR	3	0.10
Upper Three Runs	ESOP	1	0.04
	DOE-SR	3	0.08
Beaver Dam Creek	ESOP	1	0.13
	DOE-SR	3	0.11
Fourmile Branch	ESOP	1	0.04
	DOE-SR	3	0.06
Steel Creek	ESOP	1	0.13
	DOE-SR	3	0.05
Lower Three Runs	ESOP	1	0.04
	DOE-SR	3	0.06
Hwy. 301	ESOP	1	0.08
	DOE-SR	3	0.10
Stokes Bluff	ESOP	1	0.07
	DOE-SR	3	0.11
Hwy. 17	ESOP	1	0.05
	DOE-SR	3	0.07
Average[2]	ESOP	9	0.08
	DOE-SR	9	0.08
Standard Deviation[2]	ESOP	9	0.04
	DOE-SR	9	0.02

Table 6
Strontium-89,90 Activity Levels in Non-edible Catfish
pCi/g

Location	Agency	# of samples	Result
NSBLD	ESOP	1	0.06
	DOE-SR	3	0.03
Upper Three Runs	ESOP	1	0.04
	DOE-SR	3	0.06
Beaver Dam Creek	ESOP	1	0.18
	DOE-SR	3	0.03
Fourmile Branch	ESOP	1	0.07
	DOE-SR	3	0.05
Steel Creek	ESOP	1	0.08
	DOE-SR	3	0.04
Lower Three Runs	ESOP	1	0.06
	DOE-SR	3	0.06
Hwy. 301	ESOP	1	0.09
	DOE-SR	3	0.05
Stokes Bluff	ESOP	1	0.05
	DOE-SR	3	0.05
Hwy. 17	ESOP	1	0.05
	DOE-SR	3	0.02
Average[2]	ESOP	9	0.08
	DOE-SR	9	0.04
Standard Deviation[2]	ESOP	9	0.04
	DOE-SR	9	0.01

Notes: DOE-SR data from SRNS 2013
DOE-SR results are averages
[2]Calculated using detections only

Fish Monitoring Data
2012 SCDHEC and DOE-SR Data Comparison

Table 7 Mercury Levels in Edible Bass mg/kg			
Location	Agency	# of samples	Result
NSBLD	ESOP	1	0.35
	DOE-SR	1	0.24
Upper Three Runs	ESOP	1	0.27
	DOE-SR	1	0.27
Beaver Dam Creek	ESOP	1	0.26
	DOE-SR	1	0.28
Fourmile Branch	ESOP	1	0.62
	DOE-SR	1	0.29
Steel Creek	ESOP	1	0.16
	DOE-SR	1	0.34
Lower Three Runs	ESOP	1	0.29
	DOE-SR	1	0.29
Hwy. 301	ESOP	1	0.52
	DOE-SR	1	0.30
Stokes Bluff	ESOP	1	0.66
	DOE-SR	1	0.66
Hwy. 17	ESOP	1	0.11
	DOE-SR	1	0.16
Average[2]	ESOP	9	0.36
	DOE-SR	9	0.31
Standard Deviation[2]	ESOP	9	0.22
	DOE-SR	9	0.14

Table 8 Mercury Levels in Edible Catfish mg/kg			
Location	Agency	# of samples	Result
NSBLD	ESOP	1	<PQL
	DOE-SR	1	0.03
Upper Three Runs	ESOP	1	<PQL
	DOE-SR	1	0.21
Beaver Dam Creek	ESOP	1	<PQL
	DOE-SR	1	0.11
Fourmile Branch	ESOP	1	<PQL
	DOE-SR	1	0.12
Steel Creek	ESOP	1	<PQL
	DOE-SR	1	0.18
Lower Three Runs	ESOP	1	<PQL
	DOE-SR	1	0.11
Hwy. 301	ESOP	1	<PQL
	DOE-SR	1	0.10
Stokes Bluff	ESOP	1	<PQL
	DOE-SR	1	0.22
Hwy. 17	ESOP	1	0.11
	DOE-SR	1	0.20
Average[2]	ESOP	9	0.11
	DOE-SR	9	0.14
Standard Deviation[2]	ESOP	9	NA
	DOE-SR	9	0.06

Notes:
DOE-SR data from SRNS 2013
[2]Calculated using detections only
PQL - Practical Quantitation Limit
mg/kg - milligrams per kilogram
DOE-SR results converted from ug/g (microgram per gram)

7.0 Summary Statistics

Fish Monitoring Associated with the Savannah River Site

2012 Fish Monitoring Summary Statistics..36

Notes:
1. N - denotes number of samples
2. ND – denotes non-detections
2. Tritium results (pCi/L) represent the activity level in water distilled from the fish tissue.
3. Cs-137 results (pCi/g) represent the activity level in natural fish tissue.
4. Strontium results (pCi/g) represent the activity level in an aliquot of wet fish tissue.

2012 Fish Monitoring Summary Statistics

Tritium Levels (pCi/L) in Savannah River Fish, 2012

Edible	N (ND)	Average	Standard Deviation	Median	Maximum	Minimum
Bass	7 (2)	382	235	281	852	216
Catfish	5 (5)	311	47	315	362	252

Non-detections (ND) excluded from computations
Tritium reported as activity in the water extracted from tissue

Cesium-137 Levels (pCi/g - Wet) in Savannah River Fish, 2012

Edible	N (ND)	Average	Standard Deviation	Median	Maximum	Minimum
Bass	3 (6)	0.24	0.14	0.32	0.32	0.08
Catfish	2 (7)	0.06	0.01	0.06	0.06	0.05

Non-detections (ND) excluded from computations

Strontium-89,90 Levels (pCi/g - Wet) in Savannah River Fish, 2012

Non-edible	N (ND)	Average	Standard Deviation	Median	Maximum	Minimum
Bass	9 (0)	0.08	0.04	0.07	0.13	0.04
Catfish	9 (0)	0.07	0.03	0.06	0.13	0.04

Mercury Levels (mg/kg) in Savannah River Fish, 2012

Edible	N (ND)	Average	Standard Deviation	Median	Maximum	Minimum
Bass	9 (0)	0.36	0.20	0.39	0.10	0.84
Catfish	9 (8)	0.11	NA	NA	0.11	0.11

Non-detections (ND) excluded from computations

List of Acronyms

BDC	Beaver Dam Creek
DOE-SR	Department of Energy-Savannah River
ESOP	Environmental Surveillance and Oversight Program
FMB	Fourmile Branch
Hwy. 17	United States Highway 17
LLD	Lower Limit of Detection
LTR	Lower Three Runs creek
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
NSBLD	New Savannah Bluff Lock & Dam
SCDHEC	South Carolina Department of Health and Environmental Control
SRS	Savannah River Site
STC	Steel Creek
STOKES	Stokes Bluff Landing
Hwy. 301	United States Highway 301
USEPA	United States Environmental Protection Agency
UTR	Upper Three Runs creek

Units of Measure

mg/kg	milligrams/kilogram
pCi/g	picocuries/gram
pCi/L	picocuries/liter
±	plus or minus (one standard deviation unless stated otherwise)

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2012 Game Animal Radiological Monitoring Adjacent to SRS

Environmental Surveillance and Oversight Program

98GA001
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January 01, 2012 - December 31, 2012

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D H E C
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South Carolina Department of Health and Environmental Control

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1.0 PROJECT SUMMARY

Since the initiation of nuclear testing, concern has grown over the accumulation of radionuclides in the environment. The Savannah River Site (SRS) has historically been a nuclear weapons material production, separation, and research facility located along the Savannah River within Aiken, Allendale, and Barnwell counties in South Carolina. The operation of production reactors, waste storage sites, and other nuclear facilities at SRS has resulted in the release of cesium-137 (Cs-137) to the environment for the past 50 years. Routine operations at the SRS have released Cs-137 to the regional environment surrounding the 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, separation areas, liquid waste facilities, solid waste disposal facility, central shops, heavy water rework facility, and the Savannah River National Laboratory. A number of other facilities handled material containing Cs-137, but releases, if any, are not documented (Till et al 2001). As part of the environmental monitoring program, the Department of Energy - Savannah River (DOE-SR) investigates a variety of mammalian species for the presence of contaminants. White-tailed deer and feral hogs have shown the highest potential of the mammalian species for a human exposure pathway from Cs-137 (Haselow 1991).

DOE-SR has annual hunts open to members of the general public to control the site's deer and feral hog population and to reduce animal/vehicle accidents. Before any animal is released to a hunter, SRS personnel monitor Cs-137 levels for exposure limit considerations to ensure established administrative dose limits are not exceeded. DOE-SR does not collect game animal samples within the South Carolina Department of Health and Environmental Control (SCDHEC) study area, and off-site hunter doses are based on DOE-SR models. Therefore, no direct comparisons could be made between SCDHEC and DOE-SR data. The SCDHEC Critical Pathway Dose report addresses dose based on collected samples and is compared to DOE-SR modeled dose for off-site hunters.

The precise ranging behavior of individual deer and hogs on the SRS is unknown. White-tailed deer and feral hogs have access to a number of contaminated areas on the SRS and are a vector for the redistribution of contaminants, primarily Cs-137, to off-site locations. Typical home range for adult white-tailed deer is 2.67 square miles. (Vanderhoof 1993) A five-mile study area was established based on a typical white-tailed deer upper limit home range to ensure that potentialy contaminated deer residing at or near the SRS boundry would be included in the sample set. Consumption of these wildlife species can result in the transfer of contaminants to humans. Cesium-137 is of concern because of the 30 year half-life, its availability to game animals, and associated health risk to humans. (Haselow 1991).

Cesium-137 is readily incorporated into the human body because of its similarity to potassium-40 (K-40) in physiological processes (Davis 1963). Cesium-137 concentrates in animal skeletal muscles, that are selectively consumed by hunters (Brisbin et al. 1975). Cesium-137 emits both beta and gamma radiation, contributing to both internal and external radiation exposure, which may be associated with gastrointestinal, genetic, hematopoietic, and central nervous system damage (Bond et al. 1965). Because of these concerns, Cs-137 will be the only isotope discussed in this report.

The Environmental Surveillance and Oversight Program (ESOP) of the SCDHEC conducts independent non-regulatory oversight of game animal monitoring activities within a five-mile study area around the SRS. The game animal project addresses concerns of potentially contaminated white-tailed deer and feral hogs migrating off the SRS and can provide valuable information concerning the potential off-site exposure to Cs-137 by analyzing samples collected off-site. SCDHEC analyzed muscle tissue collected in 2012 for Cs-137 from 38 deer and seven hogs collected from area hunters via hunting clubs, plantations, and Crackerneck Wildlife Management Area within a five-mile study area adjacent to the SRS (Section 4.0, Map 1). Additionally, 25 deer tissue samples were collected and analyzed from a background location 85 miles southeast of the SRS in Jasper County, South Carolina. Sample size, location, and collection dates were dependent on the participating hunters.

2.0 RESULTS AND DISCUSSION

Cesium-137

Cesium-137 and the naturally occurring isotopes K-40 and lead-214 (Pb-214) were the only isotopes detected in game samples collected in 2012. Naturally occurring isotopes will not be discussed in this report. Cesium-137 concentrations from deer collected in the SRS perimeter study area are shown in (Section 5.0, Figure 2). Analytical results are listed under each zone in Section 6.0.

Cesium-137 activities from the 38 SCDHEC perimeter deer samples ranged from < Minimum Detectible Activity (MDA) to 2.29 pCi/g, with an average of 0.66 (± 0.65) pCi/g (Section 7.0). Cesium-137 activities from the seven SCDHEC perimeter hog samples ranged from 0.42 to 3.86 pCi/g with an average of 1.87 (± 1.77) pCi/g (Section 7.0). All SCDHEC hunt zone averages were within one standard deviation of the overall perimeter average. Results from the 25 background samples (Section 6.0) ranged from 0.04 pCi/g to 0.45 pCi/g, with an average of 0.24 (± 0.10) pCi/g.

SCDHEC and DOE-SR Data Comparison

DOE-SR reported an approximate field measurement range of 1.00 pCi/g to 12.6 pCi/g with an field gross average average of 1.27 pCi/g from 543 deer and 1.22 pCi/g from 100 feral hogs harvested on the SRS in 2012 (SRNS 2013). The DOE-SR field average was within one standard deviation of the SCDHEC perimeter average. Average perimeter, background, and DOE-SR on-site Cs-137 levels for the past five years (Section 7.0) are indicated in Section 5.0, Figure 1. The five-year Cs-137 averages between SCDHEC and DOE-SR may differ for various reasons. The DOE-SR data is acquired in the field by using a portable sodium iodide detector while SCDHEC data are analytical results. Also, the SCDHEC data presents a challenge for direct comparisons to DOE-SR data because the perimeter area is heavily baited. Therefore, the uptake of Cs-137 by these animals will be reduced based on the increased K-40 levels in the corn from fertilizers (Heckman 1992).

3.0 CONCLUSIONS AND RECOMMENDATIONS

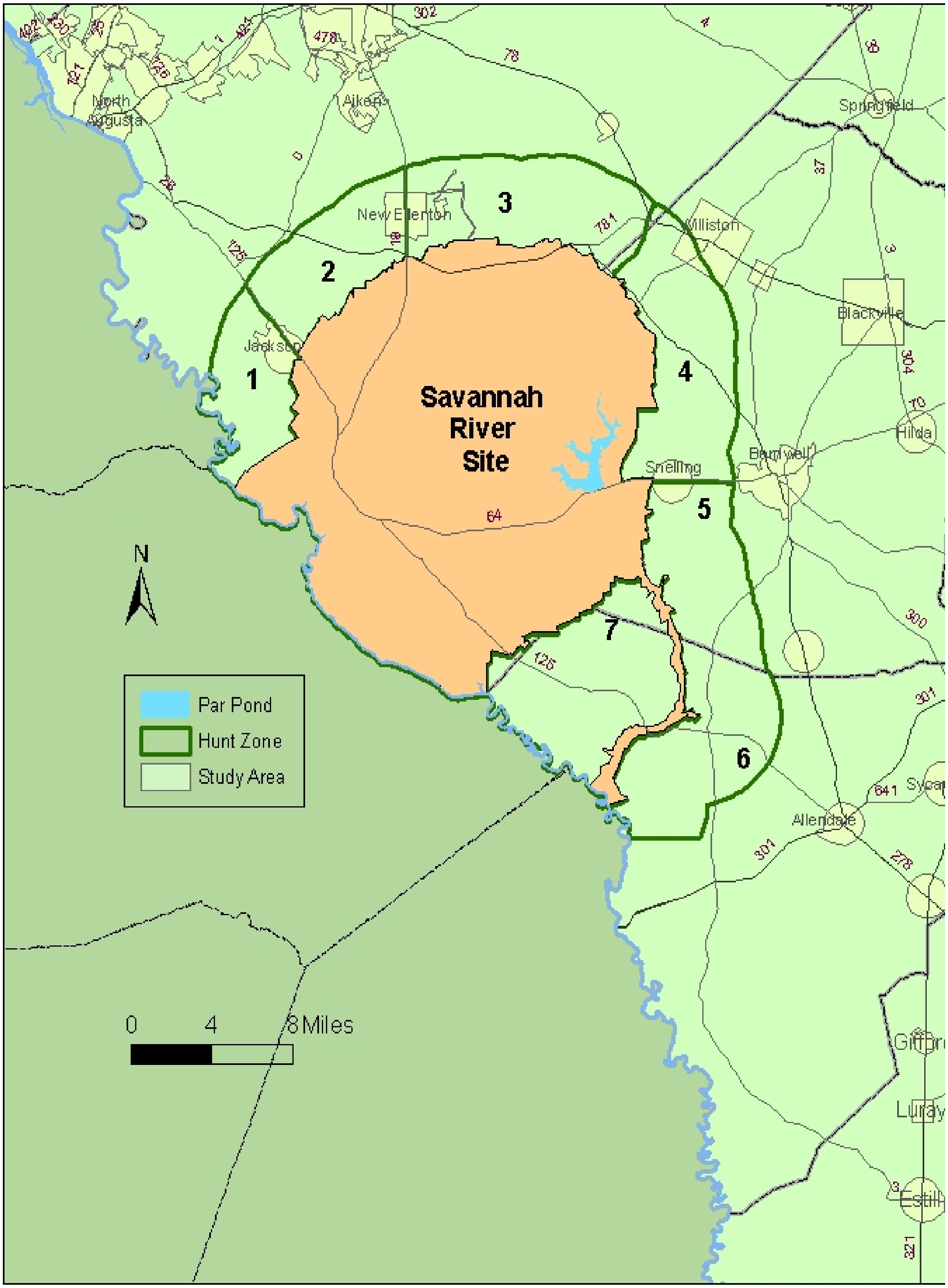
Historic SRS operations released known Cs-137 contamination to Steel Creek, Par Pond, and Lower Three Runs, their floodplains, and the Savannah River swamp (Till et al 2001), all of which impact hunt zones four, five, six and seven (Section 4.0, Map 1). Although a portion of Cs-137 was deposited on the SRS from site operations, levels found in the study area and background location are likely results of above ground nuclear weapons testing (Haselow 1991). DOE-SR does not collect game animal samples within the SCDHEC study area, and off-site hunter doses are based on DOE-SR models from animals collected on SRS. Further research may be needed to help determine why elevated Cs-137 activities are found in other hunt units.

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). The differences in average activities (Section 5.0, Figure 1) are possibly a combination of one or more of the above factors. 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 ESOP Critical Pathway Dose report for a better understanding of the contamination found in game versus other food sources.

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

4.0 Game Animal Radiological Monitoring Adjacent to SRS

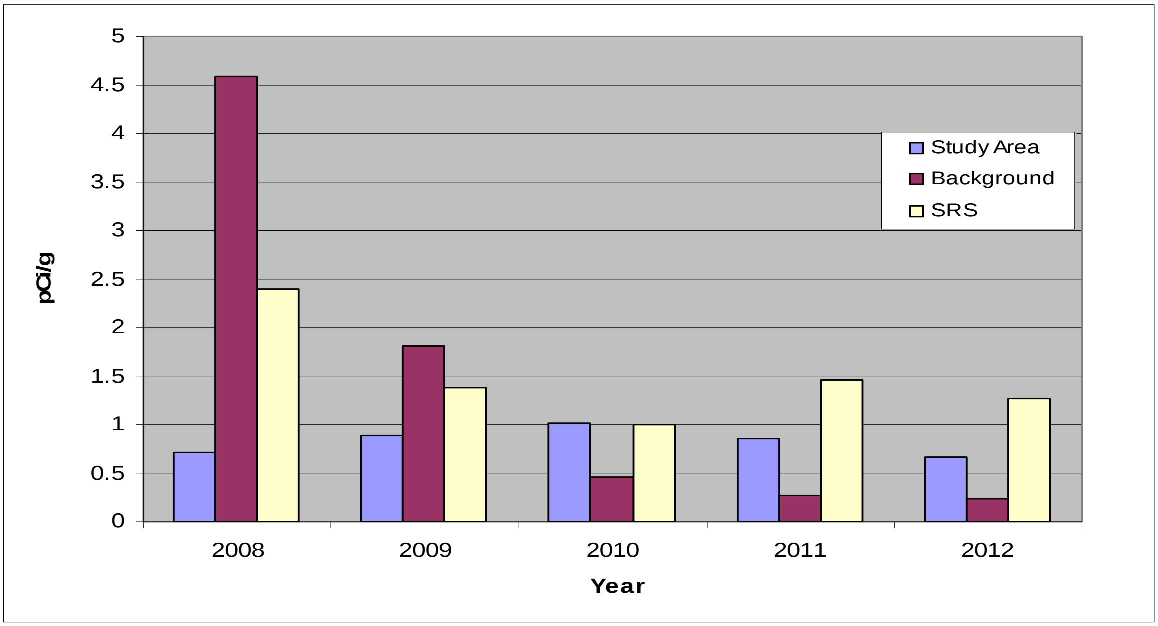
Map 1. ESOP Hunt Zones Adjacent to SRS, 2012



5.0 Tables and Figures

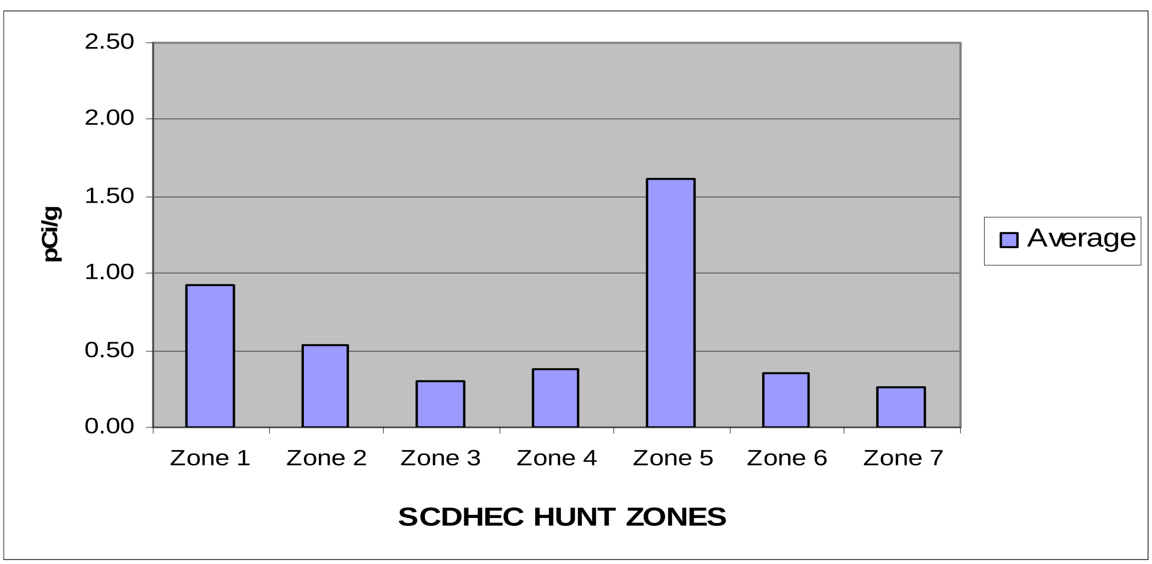
Game Animal Radiological Monitoring Adjacent to SRS

Figure 1. Average Cs-137 Concentration In Deer, 2008-2012



Background Locations
2008 - 2009 - Carolina Sandhills National Wildlife Refuge
2010 - 2011 - Bamberg County
2012 - Pinckney Island National Wildlife Refuge

Figure 2. SCDHEC Hunt Zone Average Cs-137 Concentration In Deer, 2012



6.0 Data

Game Animal Radiological Monitoring Adjacent to SRS

2012 Perimeter Cs-137 Data 7

2012 Background Data 9

Notes:
1. MDA - Minimum Detectable Activity
2. Sig - Sigma

Game Animal Radiological Monitoring Adjacent to SRS Project Data

2012 Perimeter Cs-137 Data

Sample Location		Zone-1	Zone-1	Zone-1	Zone-1	Zone-1
Sample Date		10/21/2012	10/21/2012	10/21/2012	10/21/2012	10/21/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Buck	Buck	Buck	Buck	Buck
Weight	Pounds	130	150	175	110	125
Cesium-137	(pCi/g) wet	1.30	0.10	2.05	<MDA	0.79
Uncertainty	(+/- 2sig)	0.11	0.02	0.15	NA	0.07
MDA	(pCi/g) wet	0.03	0.02	0.02	0.02	0.02

Sample Location		Zone-1	Zone-1	Zone-1
Sample Date		10/21/2012	10/21/2012	10/21/2012
Species		Deer	Deer	Deer
Sex		Doe	Buck	Doe
Weight	Pounds	95	120	105
Cesium-137	(pCi/g) wet	0.18	<MDA	1.17
Uncertainty	(+/- 2sig)	0.03	NA	0.09
MDA	(pCi/g) wet	0.02	0.02	0.02

Sample Location		Zone-2	Zone-2	Zone-2	Zone-2	Zone-2
Sample Date		9/4/2012	9/4/2012	9/4/2012	9/7/2012	10/1/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Buck	Buck	Buck	Doe	Doe
Weight	Pounds	145	125	135	100	95
Cesium-137	(pCi/g) wet	1.34	0.07	1.00	0.16	0.08
Uncertainty	(+/- 2sig)	0.11	0.02	0.09	0.03	0.02
MDA	(pCi/g) wet	0.02	0.02	0.02	0.02	0.02

Sample Location		Zone-3	Zone-3	Zone-3	Zone-3	Zone-3
Sample Date		9/4/2012	9/4/2012	9/4/2012	10/5/2012	10/11/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Buck	Buck	Buck	Buck	Buck
Weight	Pounds	150	145	155	125	150
Cesium-137	(pCi/g) wet	0.07	0.41	0.76	0.35	0.05
Uncertainty	(+/- 2sig)	0.02	0.04	0.07	0.04	0.02
MDA	(pCi/g) wet	0.02	0.02	0.02	0.02	0.02

Sample Location		Zone-3	Zone-4	Zone-4	Zone-4
Sample Date		10/11/2012	3/1/2012	3/1/2012	3/1/2012
Species		Deer	Hog	Hog	Hog
Sex		Buck	Boar	Sow	Sow
Weight	Pounds	160	140	145	155
Cesium-137	(pCi/g) wet	0.16	3.86	3.84	3.56
Uncertainty	(+/- 2sig)	0.03	0.34	0.34	0.31
MDA	(pCi/g) wet	0.02	0.02	0.02	0.01

Game Animal Radiological Monitoring Adjacent to SRS Project Data

2012 Perimeter Cs-137 Data

Sample Location		**Zone-4**	**Zone-4**	**Zone-4**	**Zone-4**	**Zone-4**
Sample Date		9/4/2012	10/5/2012	10/5/2012	10/11/2012	10/11/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Buck	Doe	Doe	Buck	Buck
Weight	Pounds	130	110	130	190	200
Cesium-137	(pCi/g) wet	0.20	0.33	0.54	0.78	0.06
Uncertainty	(+/- 2sig)	0.03	0.03	0.05	0.07	0.02
MDA	(pCi/g) wet	0.02	0.02	0.02	0.02	0.02

Sample Location		**Zone-5**	**Zone-5**	**Zone-5**	**Zone-5**	**Zone-5**
Sample Date		11/29/2012	11/29/2012	11/29/2012	11/29/2012	11/29/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Buck	Buck	Buck	Doe	Buck
Weight	Pounds	130	150	180	100	115
Cesium-137	(pCi/g) wet	0.33	2.29	1.64	2.16	1.63
Uncertainty	(+/- 2sig)	0.05	0.22	0.16	0.21	0.16
MDA	(pCi/g) wet	0.02	0.03	0.03	0.03	0.02

Sample Location		**Zone-5**	**Zone-5**	**Zone-5**	**Zone-5**
Sample Date		10/17/2012	3/11/2012	3/11/2012	3/11/2012
Species		Hog	Hog	Hog	Hog
Sex		Boar	Boar	Sow	Sow
Weight	Pounds	255	65	55	85
Cesium-137	(pCi/g) wet	0.92	0.42	0.69	0.56
Uncertainty	(+/- 2sig)	0.09	0.05	0.07	0.06
MDA	(pCi/g) wet	0.02	0.02	0.02	0.02

Sample Location		**Zone-6**	**Zone-6**	**Zone-6**	**Zone-6**	**Zone-6**
Sample Date		9/29/2012	9/29/2012	10/8/2012	10/11/2012	10/13/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Doe	Doe	Buck	Doe	Buck
Weight	Pounds	110	105	90	115	135
Cesium-137	(pCi/g) wet	0.50	0.30	0.63	0.25	0.05
Uncertainty	(+/- 2sig)	0.05	0.04	0.07	0.03	0.02
MDA	(pCi/g) wet	0.01	0.02	0.03	0.02	0.02

Sample Location		**Zone-7**	**Zone-7**	**Zone-7**	**Zone-7**
Sample Date		10/11/2012	10/11/2012	10/13/2012	12/5/2012
Species		Deer	Deer	Deer	Deer
Sex		Buck	Buck	Buck	Buck
Weight	Pounds	155	135	115	115
Cesium-137	(pCi/g) wet	0.11	<MDA	0.26	0.40
Uncertainty	(+/- 2sig)	0.03	NA	0.03	0.05
MDA	(pCi/g) wet	0.02	0.02	0.02	0.02

Game Animal Radiological Monitoring Adjacent to SRS Project Data

2012 Background Cs-137 Data

Sample Location		**Background**	**Background**	**Background**	**Background**	**Background**
Sample Date		11/9/2012	11/9/2012	11/9/2012	11/9/2012	11/9/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Buck	Doe	Buck	Buck	Doe
Weight	Pounds	95	65	110	105	90
Cesium-137	(pCi/g) wet	0.24	0.09	0.29	0.34	0.28
Uncertainty	(+/- 2sig)	0.03	0.03	0.04	0.04	0.04
MDA	(pCi/g) wet	0.02	0.03	0.02	0.02	0.02

Sample Location		**Background**	**Background**	**Background**	**Background**	**Background**
Sample Date		11/9/2012	11/9/2012	11/9/2012	11/9/2012	11/9/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Buck	Buck	Buck	Buck	Doe
Weight	Pounds	100	130	110	85	70
Cesium-137	(pCi/g) wet	0.15	0.15	0.15	0.26	0.13
Uncertainty	(+/- 2sig)	0.03	0.03	0.03	0.04	0.02
MDA	(pCi/g) wet	0.02	0.02	0.02	0.03	0.02

Sample Location		**Background**	**Background**	**Background**	**Background**	**Background**
Sample Date		11/9/2012	11/9/2012	11/9/2012	11/9/2012	11/9/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Doe	Buck	Doe	Doe	Buck
Weight	Pounds	90	120	95	110	130
Cesium-137	(pCi/g) wet	0.04	0.23	0.45	0.37	0.28
Uncertainty	(+/- 2sig)	0.02	0.03	0.06	0.04	0.04
MDA	(pCi/g) wet	0.02	0.02	0.03	0.03	0.02

Sample Location		**Background**	**Background**	**Background**	**Background**	**Background**
Sample Date		11/9/2012	11/9/2012	11/9/2012	11/9/2012	11/9/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Doe	Buck	Doe	Buck	Doe
Weight	Pounds	75	100	90	85	120
Cesium-137	(pCi/g) wet	0.28	0.15	0.19	0.20	0.21
Uncertainty	(+/- 2sig)	0.04	0.03	0.03	0.03	0.03
MDA	(pCi/g) wet	0.02	0.02	0.02	0.02	0.02

Sample Location		**Background**	**Background**	**Background**	**Background**	**Background**
Sample Date		11/9/2012	11/9/2012	11/9/2012	11/9/2012	11/9/2012
Species		Deer	Deer	Deer	Deer	Deer
Sex		Buck	Doe	Buck	Buck	Buck
Weight	Pounds	90	120	80	90	100
Cesium-137	(pCi/g) wet	0.28	0.35	0.19	0.37	0.42
Uncertainty	(+/- 2sig)	0.03	0.04	0.04	0.04	0.05
MDA	(pCi/g) wet	0.03	0.02	0.02	0.02	0.02

7.0 Summary Statistics

Game Animal Radiological Monitoring Adjacent to SRS

2012 Game Animal Radiological Monitoring Statistics 11

Notes:
1. N - Number of Samples
2. Std.Dev. - Standard Deviation
3. Min - Minimum
4. Max - Maximum
5. MDA - Minimum Detectable Activity
6. Average, Std.Dev., and Median calculated using detections only
7. NA - Not Available

Game Animal Radiological Monitoring Adjacent to SRS Summary Statistics

Cs-137 concentration (pCi/g wet weight) in deer and hogs collected in 2012

	N	Average	Std. Dev.	Median	Min.	Max
Study Area Deer	38	0.66	0.65	0.41	<MDA	2.29
Study Area Hogs	7	1.87	1.77	0.78	0.42	3.86
Background Deer	25	0.24	0.10	0.24	0.04	0.45

Cs-137 concentration (pCi/g wet weight) in deer and hogs collected in 2012 SCDHEC Hunt Zones

Hunt Zone	N	Average	Std. Dev.	Median	Min.	Max
Zone 1 Deer	8	0.93	0.74	0.98	<MDA	2.05
Zone 2 Deer	5	0.53	0.60	0.16	0.07	1.34
Zone 3 Deer	6	0.30	0.27	0.26	0.05	0.76
Zone 4 Deer	5	0.38	0.28	0.33	0.06	0.78
Zone 4 Hogs	3	3.75	0.17	3.84	3.56	3.86
Zone 5 Deer	5	1.61	0.78	1.64	0.33	2.29
Zone 5 Hogs	4	0.65	0.21	0.63	0.42	0.92
Zone 6 Deer	5	0.35	0.23	0.30	0.05	0.63
Zone 7 Deer	4	0.26	0.15	0.26	<MDA	0.40

Cs-137 concentration (pCi/g wet weight) in deer and hogs collected from 2008 - 2012

	Year	N	Average	Std.Dev	Median	Min.	Max.
Study Area	2008	51	0.72	0.83	0.38	<MDA	4.60
Background	2008	10	4.59	2.45	4.11	1.91	10.59
SRS	2008	432	2.40	NA	NA	1.00	12.65
Study Area Deer	2009	47	0.89	0.81	0.63	<MDA	3.13
Study Area Hogs	2009	7	0.05	0.01	0.05	<MDA	0.05
Background	2009	12	1.81	0.88	1.58	0.77	3.60
SRS Deer	2009	396	1.38	NA	NA	1.00	9.17
SRS Hogs	2009	78	1.06	NA	NA	1.00	2.78
Study Area Deer	2010	30	1.02	1.93	0.34	<MDA	9.96
Study Area Hogs	2010	4	1.33	1.23	1.26	<MDA	2.49
Background	2010	5	0.46	0.66	0.18	0.05	1.63
SRS Deer	2010	502	1.00	NA	NA	1.00	2.99
SRS Hogs	2010	107	1.00	NA	NA	1.00	2.14
Study Area Deer	2011	54	0.85	1.00	0.34	<MDA	4.31
Study Area Hogs	2011	6	0.51	0.12	0.51	<MDA	0.59
Background	2011	5	0.27	0.11	0.29	0.11	0.40
SRS Deer	2011	564	1.46	NA	NA	1.00	10.50
SRS Hogs	2011	156	1.75	NA	NA	1.00	11.50
Study Area Deer	2012	38	0.66	0.65	0.41	<MDA	2.29
Study Area Hogs	2012	7	1.87	1.77	0.78	0.42	3.86
Background	2012	25	0.24	0.10	0.24	0.04	0.45
SRS Deer	2012	543	1.27	NA	NA	1.00	12.60
SRS Hogs	2012	100	1.22	NA	NA	1.00	4.81
Study Area Deer	2008 -2012	220	0.83	0.14	0.87	< MDA	9.96
Study Area Hogs	2009 -2012	24	0.94	0.82	0.92	<MDA	3.86
Background Deer	2008 -2012	57	1.47	1.86	0.46	0.05	10.59
SRS Deer	2008 -2012	2437	1.50	0.53	1.42	1.00	12.65
SRS Hogs	2009 -2012	441	1.26	0.34	1.06	1.00	10.50

Background Locations
2008 - 2009 Carolina Sandhills National Wildlife Refuge
2010 - 2011 Bamberg County
2012 - Pinckney Island National Wildlife Refuge

LIST OF ACRONYMS

Cs-137	Cesium-137
DOE-SR	Department of Energy–Savannah River
ESOP	Environmental Surveillance and Oversight Program
MDA	Minimum Detectable Activity
Pb-214	Lead-214
K-40	Potassium-40
SCDHEC	South Carolina Department of Health and Environmental Control
SRS	Savannah River Site

UNITS OF MEASURE

pCi/g	picocuries per gram
±	plus or minus (one standard deviation unless stated otherwise)

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Section 5 2012 Critical Pathway / Dose

Chapter 13 Critical Pathway / Dose Report

2012 Critical Pathway Dose Report

Environmental Surveillance and Oversight Program

01DM003 and 01CP001
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January 01, 2012 - December 31, 2012

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1.0 PROJECT SUMMARY

The Environmental Surveillance and Oversight Program (ESOP) of the South Carolina Department of Health and Environmental Control (SCDHEC) monitored the Savannah River Site (SRS) and adjacent areas under an Agreement in Principle with the United States Department of Energy (USDOE). Atmospheric pathway (APW) and liquid pathway (LPW) discharges from the SRS were monitored by the Department of Energy – Savannah River (DOE-SR) contractor Savannah River Nuclear Solutions (SRNS), and Environmental Monitoring Section (EMS). DOE-SR and SCDHEC used data from their monitoring activities to calculate the potential radiation dose in millirem (mrem) to the surrounding public (WSRC 1999-2009, SRNS 2010-13 and SCDHEC 1999-2013). SCDHEC implemented a Radionuclide Dose Calculation Project and a Critical Pathway Project to calculate the potential exposure or dose to the public within 50-miles of an 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. Historical missions and data in previous years reports, primarily the SRS Environmental Reports (WSRCa 1999-2005, WSRCb 2006-2009), the Risk Assessment Corporation report (Till 2001) and the Centers for Disease Control study (CDC 2004) helped to establish the SCDHEC (1999-2013) Critical Pathway Dose Report basis. Radionuclide dose potential exposure to the public was calculated by SCDHEC from radionuclide concentration activities found in various media that may impact the public (Section 5.0). A comparison of similar SCDHEC and DOE-SR media resulted in an evaluation of both programs based on media potential exposure in millirems (Section 2.0). Summary statistics (Section 6.0 tables), and figures (Section 4.0) illustrate the trends and central tendencies in the critical pathway potential dose exposures. The critical pathway dose is now calculated on a non-scenario and individual optional scenario (Section 4.0) basis allowing readers to select media or specific exposures that may have occurred due to their individual lifestyle choices. The non-scenario basis is summarized in Section 4.0, Table 1a, which presents the total dose detected per media in 2012 by SCDHEC. The scenario basis adds up these media totals dependent on whether the scenario individual would or would not be exposed to a given media. For example, the survivalist scenario by definition receives all dose present in all sampled media, whereas the general public receives only the applicable atmospheric (air and domestic vegetation, e.g.) and liquid pathway dose (public water system drinking water), and does not receive the wild-type food dose. Most of the total dose detected comes from the ingestion route through wild game and wild-type vegetation consumption. Any acronyms not defined in the text are defined in the acronyms, units, reference, and appendix lists at the end of this report.

It is important for the reader to note the differences in DOE-SR and SCDHEC critical pathway dose estimations. Some DOE-SR dose calculations use computer models based on estimates of known *releases within the report year* using source term data. SCDHEC annual dose estimates are based solely on field sample data that allow calculation of an average (Avg) exposed individual (AEI) dose per radionuclide per media above background and represents *accumulated dose over several years*. Also, SCDHEC calculates an upper bound of potential dose based on the single highest maximum (MAX) dose per radionuclide per media that may result in exposure throughout the year as if that maximum is somehow stored and used throughout the year. A one time filling of a water cistern with Savannah River water for consumption during a MAX dose event is an example of storage dose for an ingestion potential MAX. The MAX calculation also represents an upper bound estimate of potential accumulated exposure that may not have been detected. The AEI data represents the typical potential dose levels above background. The MAX data represents the extreme data points or one time dose extreme that could occur through exposure storage, if possible. The MAX data is assigned to the maximally exposed individual (MEI) considered by SCDHEC as a survivalist who is exposed to all media maximums as if the MAX exposure occurred throughout the entire year. An alternate possibility existed that all potential exposure was not detected, but was allowed for by the ESOP MAX calculation and any additional DOE-SR release estimates greater than the SCDHEC sample estimates (Section 4.0, Tables 1a and 3). The health of the public and environment are protected when all of these estimates are below established protective dose standards/limits for the various radionuclides and pathways of exposure. The DOE Order 5400.5 dose limits to yearly releases do not apply to accumulated dose in environmental samples. However, they do provide a comparison basis that illustrates environmentally accumulated dose totals over several years are less than the yearly DOE-SR release limits (10 mrem air, 4 mrem liquid, and 100 mrem total for all radionuclides released in a given year) (SRNS 2013).

The 2012 non-scenario media calculations were represented on an AEI basis (average potential dose if exposed to all media sampled) and on a MAX (upper bound) basis of potential exposure per media per radionuclide above the average background (Section 4.0, Table 1a). The non-scenario table (1a) does not assign any result to an exposure scenario. The MAX (19.845 mrem in 2012) basis provides a radiation exposure limit based on the single highest potential dose in media. Exposures on a non-scenario basis should be less than or closer to the AEI media total (3.777 mrem in 2012). Individual exposures may be far less than the AEI total due to temporal factors and the lack of contact by an individual with all media collected.

The SCDHEC plus DOE-SR total (37.444 mrem) for applicable MAX assigned to the MEI is based on the total of the highest possible exposure from environmental media (MAX column, Section 4.0 Table 1a), plus all other dose modeled or detected by DOE-SR that has the potential to impact the public (Section 4.0, Table 3). For example, the SCDHEC dose estimates are only from offsite (off SRS) detected dose and the addition of onsite (on SRS) DOE-SR hunter dose estimates includes most of the total potential dose from all public exposure sources.

Public and survivalist scenarios were developed based on selecting media results from Section 4.0 Table 1a that applied only to those hypothetical scenarios, which represent the minimum and maximum dose potentials from radionuclides accumulated in the media sampled. The media selections per scenario are defined under the 2012 Scenario heading. These SCDHEC scenarios calculate an accumulated dose relative to minimum (Public) and maximum (Survivalist) exposure activities in 2012 (Section 4.0, Table 2) and during a given period:

1) Public scenario - 0.040 mrem in 2012, and averaged 0.080 (± 0.069) mrem with a median of 0.056 mrem during 1999-2012; dose calculations began in 1999 for SCDHEC data.
2) MAX Survivalist scenario – 19.845 mrem in 2012, and averaged 11.778 (± 5.884) mrem with a median of 12.184 mrem during 1999-2012.

The median represents the central tendency of the bulk of the data when sampling is sufficiently large, and the 14 year period of 1999-2012 contains a large amount of data (Gilbert 1987). Even the median may represent an overestimation of the true population central tendency due to measurement and statistical bias originating from the use of detections only. The 2012 Public scenario returned to the typical public dose level (<0.1 mrem) after I-131 detections from the Fukushima Daiichi nuclear facility (ANS 2011) decayed away. Other scenarios provided in the past (e.g., farmer and sportsman) were judged no longer necessary since the reader can now calculate (add up) the exposures for the various media they were exposed to and determine their own unique scenario (see The 2012 Optional Individual Personal Scenario section, page 7) potential dose from Section 4.0, Table 1a. A scenario is a lifestyle that defines which media the individual was exposed to and determines that individual's total dose potential based on only those media sample results.

The SCDHEC radionuclide detected dose that was not naturally occurring radioactive material (nonNORM) had cumulative contributions from 1999 through 2012 (24.827 mrem from cesium-137 (Cs-137), 2.073 mrem from all strontium (mostly Sr-89/90), and 1.281 mrem from tritium (H-3)) (Section 6.0, Table 1). These SCDHEC field collections represent an accumulated dose over the study period (1999-2012) of years and not yearly dose releases, which was the main reason for differences in dose estimates by SCDHEC and DOE-SR (see Dose Critique in Section 2.0). Any correlation between SCDHEC dose data (accumulated environmental dose) and DOE-SR dose data (annual releases) would be due to the dominant radionuclide dose contributors (Cs-137, Sr-90, H-3) to exposure via comparable media.

The following comparisons to DOE-SR annual release limits are not explicitly applicable since dose found in media represents many years of dose accumulation, but the comparison is made to show that even the accumulated dose in the environment is less than the annual DOE-SR standard release limits for the air, liquid, and all-pathway categories (SRNS 2012).
The SCDHEC 2012 conservative estimate for All-Sources AEI exposures from APW (3.13 mrem, mostly Cs-137) and LPW (0.67 mrem, mostly tritium) accumulations were within the respective, 10 mrem and 4 mrem, annual DOE-SR release limits even though these limits do not apply to field samples due to more than one years potential accumulation (Section 4.0, Table 1b).
An upper bound 2012 MEI (excluding NORM detections) accumulated dose potential (37.444 mrem) calculated from the combined data of DOE-SR and SCDHEC was also strictly not applicable to the 100-mrem DOE-SR annual release limit to the public (Section 4.0, Table 3) (SRNS 2012).

Some studies related to the effects of low dose radiation are reviewed by the Office of Biological and Environmental Research (BER), Office of Science, U.S. Department of Energy. Some low dose reference values, included herein, come from the chart developed by Dr. Noele Metting of the DOE Low Dose Radiation Research Program (USDOE 2010). Presently, it is not possible to detect low dose initiated changes in the frequency of cancer in populations.

2.0 RESULTS AND DISCUSSION

The SCDHEC MEI is a subsistence and survivalist type of individual who resides in the downriver swamp 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. Other tables and figures are derived from the Section 5.0 data tables. The 2012 data and dose results are discussed under the following headings in this section: the 2012 non-scenario basis, the 2012 scenario basis, the 2012 individual optional personal scenario, the 2012 added dose basis, the DOE-SR and SCDHEC comparisons, the critical pathways summary, the 1999-2012 statistical summary, and the dose critique. The statistical summary covers the 1999-2012 period, whereas other headings discuss only 2012 data except for critical pathways and some DOE-SR comparisons. Not all media were collected throughout this summary period (1999-2012). See Section 6.0, Summary Statistics Table 2 for the individual media total years of collection.

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

The 2012 Non-Scenario Basis

A non-scenario basis for dose calculations is not limited to any particular pathway(s) 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. The non-scenario Table 1a in Section 4.0 summarized all SCDHEC detections by media on an AEI and MAX detection basis without assigning any result to an exposure scenario. The 2012 non-scenario average media (AEI basis) results above background were added to past years results to establish the 1999-2012 media statistics summary tables in section 6.0. The 2012 non-scenario media calculations were represented on an AEI and MAX basis per media above their respective media radionuclide average backgrounds (Section 4.0, Table 1a). The MAX 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 (MEI) continued throughout the year (Section 5.0 Data). If the individual did not store the media at the location, date, and time of ESOP sample collection, and achieve a full year's exposure to that media, then the the MAX estimate represents a potentially gross overestimate (upper bound based on data exteme). The AEI dose column is a conservative estimate (overestimate) based on maximum consumption rates (MCR column in data tables) that the individual may change for their individual scenario as a refined estimate of exposure (see The 2012 Optional Individual Personal Scenario section, page 7).

The two scenarios used only the non-scenario media results from Section 4.0, Table 1a that applied to the hypothetical person's exposure. The optional personal scenario shows how an individual can select only the media exposure data that applied to them for a personal dose estimate. Thus, the statistics for the non-scenario, scenario, and personal scenario could be very different. Radiation exposures to the single highest detection greater than background from each radionuclide exposure per media were assigned to the SCDHEC MEI. This MEI (19.845 mrem MAX in 2012) basis provides an offsite radiation exposure limit based on the single highest potential dose detections and represents an upper bound potential. However, the true MEI may be higher, since not all dose potential can be collected and measured. This was the reason for calculating the MEI based on the single highest detection per radionuclide per media at protective maximum exposure rates. This MEI dose was due mostly to single maximum food detections (19.560 mrem excluding incidental soil) that were theoretically consumed by one individual (Section 4.0, Table 4). Typical exposures on a non-scenario basis should be less than the AEI media totals in Section 4.0, Table 1a, since a single individual could not be at all locations where and when all maximums occurred and sustain that exposure at a constant rate throughout the year. The MAX dose exposure was remotely possible only if the media containing the MAX dose were somehow stored and used by the MEI over the entire year. The MAX total perimeter dose (the SCDHEC MEI) will always be assigned as the maximum survivalist dose.

Only specific radionuclide (speciated) doses were included in the estimated dose for 2012 (see the Dose Critique section, page 22). The use of detections only in determining AEI dose above background per radionuclide per media; the calculation of dose based on the MAX detection for each radionuclide/media; and conservative consumption references provided a protective dose estimate. Each media radionuclide dose above background, excluding naturally occurring radioactive material (NORM), was considered as part of a different critical pathway lifestyle with contributions through the inhalation, ingestion, and direct exposure routes. There may be a contribution from historical nonNORM to the South Carolina background (SCbkg) and the NORM background is also altered by the presence of historical depositions due to anthropogenic contributions. The typical perimeter average dose exposure greater than background without regard to lifestyle (as if the individual were exposed to all media collected) was represented on an AEI (3.777 mrem) basis (Section 4.0, Table 1a). Refer to the scenario basis for typical potential exposures by lifestyle. The SRS perimeter study area total dose exposure was viewed either on an AEI (3.777 mrem) or MAX detection (19.845 mrem) basis that excludes probable NORM.

The SCDHEC MEI grand total (37.444 mrem) that includes added dose from DOE-SR (17.599 mrem) was based on the total of all SCDHEC MAX (19.845 mrem) detections (Section 4.0, Table 1a, MAX column) plus any additional exposure estimates by DOE-SR (Section 4.0, Table 3). This combined onsite and offsite MEI dose was an improbable dose based on maximums that could potentially be consumed by only one individual. All other individuals would receive the AEI dose or less. Most of this dose came from large game animals. The MEI or MAX dose potential can be received by only one individual, since that individual had to receive the specific dose basis animals and consume all of the edible portion. Two elevated dose bases (AEI and MAX) 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. These dose assignments were discontinued in 2008 and replaced by calculating a MAX dose potential from the single highest detection per radionuclide per media. This was done to allow for the possible storage of dose and consummation or exposure throughout the year.

The All-Sources Dose

The All-Sources dose comes from a DOE-SR reference, which indicates direct annual release dose totals assignable to the atmospheric and liquid pathways (SRNS 2013, Table 6-5). All other dose sources are atypical in that the general public is usually not impacted. Dose measured in an animal is the result of dose releases over more than one year and exposure to more than one source. An All-Sources Dose Upper Bound and a Perimeter Dose total are given in Section 4.0, Table 1b for the SCDHEC AEI and MAX column totals.

The SCDHEC All-Sources Dose Upper Bound totals for the atmospheric (AEI-3.13 mrem and

MAX-18.70 mrem), and liquid (AEI-0.67 mrem and MAX-1.20 mrem) pathways were not the applicable totals because each drinking water source dose would require proportioning of consumption rates or selection of one drinking water source when there was more than one drinking water potential source (Section 4.0, Table 1b). Therefore, only one drinking water source, the highest media dose for the survivalist MAX and the highest public water system (PWS) dose for the public, was used as the sole source for the entire year. The All-Sources Upper Bound dose total was not an achievable dose based on temporal and location conflicts; a 100 % consumption factor used for all water sources; and single MAX detections treated as if they occurred at unvarying concentration activities throughout the entire year. The Perimeter Dose MEI (MAX total) was an applicable dose potential estimate (19.845 mrem) that included the single highest media water ingestion dose plus ingestion potential for swimming at the most contaminated location (Section 4.0, Table 1a).

The Perimeter Dose

Since only one drinking water maximum could be added to the final perimeter dose total, the highest AEI dose source (0.015 mrem) was used at 100 % (underlined in Section 4.0, Table 1a, DW Ingestion was not potable) instead of proportioning each water source. The AEI air inhalation (0.002 mrem), food ingestion (3.758 mrem), and direct exposure (0.000 mrem) totals were added to the highest drinking water dose (0.015 mrem from rainwater), the swimming ingestion dose (0.002 mrem), and rounded-off dose from to three decimal places to obtain the 2012 Perimeter Dose AEI results (3.777 mrem). The 2012 MAX perimeter dose potential used the same logic resulting in 0.005 mrem for air inhalation, 19.562 mrem for food ingestion, 0.255 mrem for water ingestion at boat landings (BL), 0.022 mrem for a swimming ingestion dose, and 0.003 mrem direct exposure for a total MAX perimeter dose rounded to 19.845 mrem (Section 4.0, Table 1). The theoretical assumption was that a single MEI always received the maximum dose potential despite the high improbability. The AEI and MAX applicable Perimeter Dose totals used only the single highest drinking water source (underlined in Section 4.0, Table 1a) on an AEI and MAX basis, respectively. The highest detections occurred in surface water (SW) and rainwater; these were the basis for dose calculations that assumed riverwater was sterilized by boiling, then used for cooking and drinking at boat landings. Sterilization of water by boiling does not remove dose. Reverse osmosis and ion exchange filtering of drinking water can remove most dose from drinking water (SCDHEC 2001), but not tritium.

The SCDHEC MAX (MEI) non-scenario perimeter total was simply all available dose based on the single highest detections per media at maximum consumption rates for a period of one year (19.845 mrem). The perimeter AEI dose total (the typical available dose) was 3.777 mrem in 2012 and no individual offsite dose potential should exceed the MAX dose total (19.845 mrem) on a non-scenario basis. An exception was the addition of DOE-SR additional dose potential not measured by SCDHEC (mostly from onsite deer) that was included in a combined SCDHEC and DOE-SR MEI estimate. This DOE-SR and SCDHEC combined dose estimate should capture the upper bound for any nondetected dose for the combined onsite plus offsite hunter. A personal scenario different from those described above can be calculated by the reader (see the 2012 Optional Personal Scenario Basis section). Note the 3.777 mrem AEI perimeter dose was approximately half the dose attributable to living in a block house for one year (7.00 mrem, Section 4.0, Figure 2.0), while the 19.845 mrem perimeter MAX dose was less than the NORM dose from living in a brick house (7 mrem/yr) for three years. This AEI dose was less than the NORM dose exposure for people living in the United States (310 mrem) (Section 4.0, Figure 2.0). The authors of a recent study concluded that if there were harmful health effects at or below 100 mrem, they were “certainly very small” (Manzoli 2004). The nonNORM totals for the 2012 AEI (3.777 mrem) and MAX (19.845 mrem) dose estimates (mostly wild food sources) in 2012 (Section 4.0, Table 1a) were less than the 1998 food protective action guideline of 500 mrem committed effective dose equivalent to the whole body or 5000 mrem committed dose equivalent to an individual tissue or organ (USDHHS 1998).

The 2012 Scenario Basis

A scenario is a lifestyle that defines which media the individual encounters and determines that individual’s total dose potential (exposure) based on only the encountered media sample results. The basic scenario results for 1999-2012 are given in Section 4.0, Table 2.0, and are based on AEI data for the public (smallest dose potential). The MAX Survivalist scenario uses all MAX dose based on the single highest radionuclide detections in media (highest potential dose). The alpha-beta dose assumptions are now replaced by observed maximum detections (single highest detections per radionuclide per media) that provide a measured (not assigned) upper bound of potential dose and protective buffer for public dose calculations. See Section 4.0, Table 2.0 for the two SCDHEC scenario results for 2012. Even the AEI totals are very conservative estimates of potential dose and should be greater than any actual or typical dose per individual. The DOE-SR hunter can add onsite dose to the sportsman and survivalist dose, if they kill and eat onsite harvested game animals.

Critical pathway basic scenarios estimate a typical dose potential based on averages for lifestyle activities that resulted in media exposures above background (Section 4.0, Table 2). The MAX Survivalist, defines the upper bound of dose potential for SCDHEC detections in media. The notes below Section 4.0, Table 2.0 explain which data were included in each scenario. The 2012 scenario average results were: 0.040 mrem of potential dose for the general public that uses only public water systems, local milk, and local garden vegetables. One drinking water dose was assigned per scenario, and incidental ingestion of water while swimming was added for the worst case exposure at creek mouths for the survivalist category. The MAX Survivalist Scenario dose (19.845 mrem) was based on the total of all dose detection maximums in the MAX column of Section 4.0 Table 1a except for a limitation to one drinking water source (the highest dose source in that column). The surface water dose at boat landings was highest for the MAX column. The MAX Survivalist dose was equal to the MAX Perimeter dose (19.845 mrem), and was the MEI based on SCDHEC data alone. The reader should not assume that the AEI or MEI dose data applied to them except on an optional individual personal scenario basis (dose adjustment) that is described under the next heading. The scenario statistics given below were due to the inclusion of other media as part of the scenario dose.

The 2012 Optional Individual Personal Scenario

Both AEI and MAX media calculations are categorized into two primary exposure pathways (atmospheric and liquid) that are subdivided into other more specialized exposure routes (inhalation, ingestion, and direct) by media. The overall statistical results discussion is given under the Critical Pathways 2012 Summary heading (page 10) and 1999-2012 Summary

Statistics section (page 11).

The public can estimate their offsite potential dose based on activities that involve exposure to one or more media not covered by the given scenarios. However, their personal scenario dose calculation can not exceed the available dose of 19.845 mrem for offsite (off SRS) MAX exposure or 3.777 mrem for offsite AEI exposure. These AEI and MAX dose totals are summations for all detected dose and any increase above those values represents an error on the part of the individual calculating a personal dose. If a lifestyle is different from one of the given scenarios, each individual can add one or more MAX column media dose detections (Section 4.0, Table 1a) to the perimeter AEI column dose total and subtract the corresponding media AEI column dose to calculate their own maximum dose potential.

For example, a member of the general public who received deer meat for consumption, but did not hunt, may add the deer MAX (6.150 mrem) to the Perimeter AEI Dose total (3.777 mrem) and then subtract the corresponding media AEI dose average for deer (0.630 mrem) to obtain a dose of 9.297 mrem (Section 4.0, Table 1b). Thus, by adding deer meat from the local area to the general diet, the non-scenario dose potential would increase from 3.777 mrem (AEI) to a maximum of 9.297 mrem for the worst-case deer consumption exposure. Alternately, add the difference column (MAX minus AEI) to the total for a revised estimate that includes any selected media MAX value (3.777 plus 5.520 gives 9.297 also). However, the probability is low that this person would receive all the deer meat (may consume more than one deer) from the MEI hunter (2 deer for 1 hunter in 2012) with the highest deer dose, and consume all of the edible portion. This is a specific personal dose potential versus the highest MAX overall offsite dose detections of 19.845 mrem (MEI).

Likewise, if someone consumed wild edible mushrooms in 2012, a MAX of 1.450 mrems could be added, and then subtract the corresponding AEI dose (0.135 mrem) to obtain their potential maximum dose exposure of 5.093 mrem. Alternately, add the difference column (MAX minus AEI) to the total for a revised estimate that includes any selected media MAX value (3.777 plus 1.316 gives 5.093 also). Again, a refined dose may be calculated if your consumption rate is less than 3.65 kg/yr of mushrooms (e.g., if you eat only 454 g/yr of mushrooms, then multiply the AEI and/or MAX result by a reduction factor of 0.454/3.65 to obtain your more refined dose. This dose was found in chanterelle and bolete mushrooms, which tend to bioaccumulate Cs-137. If you did not consume these particular wild-type mushrooms, especially at the locations mentioned in the 2012 SCDHEC Edible Vegetation Report, then your actual dose from mushroom consumption may be near zero mrem. This example points out the fact that if you were not at a specific location when the media was sampled, then you were not actually exposed to that dose. The Dose Critique section (pg 22) points out why the upper bound for most individuals would be less than the median value for individual media and closer to the public dose scenario, if you were never at the locations when detections occurred. Dose calculations do not apply to domestically raised mushrooms grown in protected environments (not sampled).

Also, this individual unique scenario can be further refined by referring to the data calculation tables in Section 5.0 and reducing the dose by a personal consumption or time exposure ratio (the MCR column). For example, if you eat only 5 kg/yr of fish instead of 48.2 kg/yr (the survivalist), then reduce the corresponding dose of concern, say Cs-137 in fish, by a factor of 5/48.2. If this reduction factor was applied to the consumption of 5 kg/yr of bass fish only, the overall bass fish dose above background can be reduced by that same factor (0.5796 mrem x 5/48.2). Then use that dose result in Table 1a for a fish consumption personal scenario. The MEI survivalist consumes the highest dose per radionuclide in fish irrespective of the fish species for the survivalist eats all fish. The 2012 Critical Pathway Dose Report Plan gives further information on why particular dose factors were chosen for inclusion in dose calculation formulas (SCDHEC 2012).

Any dose observed by DOE-SR (onsite deer dose, e.g.) that was not sampled by SCDHEC may also be added to the optional total dose, if applicable to the individual (Section 4.0, Table 3.0). An onsite deer hunter could add 14.5 mrem of potential dose (SRNS 2012, Table 6-4). The grand total for any personal scenario dose calculated from this data cannot exceed the SCDHEC plus DOE-SR upper bound (37.444 mrem) given in Section 4.0 of Table 3.0 (refer to the following 2012 Added Dose Basis section, page 8). This SCDHEC plus DOE-SR dose total is a summation for all detected potential dose and any increase above those values would represent an error on the part of the individual calculating a personal dose. Again, the SCDHEC and/or DOE-SR dose total could be refined, if a particular deer dose was known (measured onsite or offsite). In the absence of individual exposure measurements use the AEI and MAX conservative estimates based on all samples collected.

The SCDHEC AEI dose determination was the most realistic estimate for a typical exposure versus the atypical MAX dose basis, if the individual was exposed to all media listed in Section 4.0, Table 1a. The scenario basis and the individual optional scenario provided an individual estimate based on scenarios or actual media exposure. Also, the scenario medians were potentially more relevant to typical central tendency exposures over the 1999-2012 period versus averages. The individual seeking to calculate their most accurate personal dose estimate should use the Section 4.0 Data Table 1a data, and add up only the relevant radionuclide AEI and/or MAX dose for specific media they encountered within the year.

Additions of the medians from Summary Statistics Table 2 for personal scenarios (using only media encountered) may give the best estimate of a personal exposure potential for the period 1999-2012, and still be protective due to the use of detections only and conservative factors in calculations.

The 2012 Added Dose Basis

Section 4.0, Table 3.0 includes data from Table 6-5 of the SRS Environmental Report that can be added to give a total combined SCDHEC plus DOE-SR onsite and offsite dose potential of 37.444 mrem for the Upper Bound MEI estimate (SRNS 2013). This addition of dose detections other than SCDHEC detections from other environmental programs helped to extend the MEI potential dose limit on a definable basis. The main contributors to this combined onsite and offsite maximum dose estimate were DOE-SR onsite hunter dose (14.5 mrem), and SCDHEC offsite feral hog dose (10.920 mrem) and offsite deer dose (6.15 mrem). The onsite DOE-SR hunter would have to consume 517 pounds of animals harvested onsite in 2012, and the same hunter would also have to receive and consume all of the offsite SCDHEC hunter dose (148.5 pounds of deer and 132.75 pounds of feral hog meat) to achieve just the hunter portion of the maximum dose potential. Thus, the achievement of the maximum available dose potential by the MEI is improbable.

A consumption factor of 3.65 kg/yr was used to calculate dose for edible fungi in 2012 for the avid wild mushroom consumer (Botsch 1999). Therefore, the potential dose above background from consuming wild mushrooms was added for the wild mushroom consumer and the SCDHEC MEI (survivalist). The 2012 edible fungi dose maximum (1.450 mrem) was well below the 1998 food protective action guideline of 500 mrem to the whole body (USDHHS 1998).

Critical Pathways 2012 Summary

All SCDHEC dose detections occurred in one of the following pathways: atmospheric and liquid routes of exposure, and subpathways of food ingestion, air and dust inhalation, direct exposure, public water supply ingestion, and the nonpotable drinking water ingestion. Most of the critical pathways were discussed in detail under the section “DOE-SR and SCDHEC Comparisons”. Percentage comparisons of critical pathways in 2012 denoted their relative importance to overall dose exposure (Section 4.0, Table 1a and Section 5.0, Data). The 1999-2012 Statistics Summary Section 6.0 covered the overall media trends. The AEI data represented the typical yearly dose levels above background. The MAX data represented the extreme data points or one time dose extreme that occurred sometime during the year. The MAX dose was very conservative since it was based on single high detections per radionuclide per media as if they were stored and constantly used throughout the year.

The Atmospheric Pathway 2012 Summary

The SCDHEC 2012 atmospheric pathway contributed dose to the individual through the inhalation of air and resuspended soil, ingestion of food and game, and direct exposure routes. Table 1b Section 4.0 clearly illustrated the dominance of the APW (82.82 % of dose) over the LPW (17.18 % of dose) in 2012 routes of exposure. Section 4.0 Figure 3 illustrated the dominance of the food subpathway (mostly due to wild edible vegetation and wild game) over all other subpathways. It was obvious from Section 4.0, Tables 1a, 3, and 4, and Section 6.0, Summary Tables 2, 3, and 4 that most dose exposure under any scenario was due to food (mostly wild-type) consumption.

The Section 6.0, Summary Statistics Table 1 illustrated that most of the dose exposure in 2012 was due to Cs-137 (3.543 mrem total) in wild game, fish, and edible vegetation that included fungi. Strontium-89/90 was the second highest dose exposure in 2012 (0.204 mrem), and tritium third (0.053 mrem). Tritium occurred in all major pathways (APW and LPW).

The SCDHEC APW All-Sources limit or upper bound (MAX column) for the atmospheric dose accumulated potential in Section 4.0, Table 1b was based on exposure to the single highest media maximum *accumulations* (18.70 mrem APW) with the assumption of all one-time high dose maximums as lasting throughout the year. This was not directly comparable to the DOE-SR *annual* atmospheric dose *release limit*.

The Liquid Pathway 2012 Summary

The SCDHEC 2012 liquid pathway estimated AEI dose to the individual was through the ingestion of fish (0.646 mrem), groundwater (0.000 mrem), surface water (0.023 mrem), public river water supplies (0.009 mrem), swimming ingestion (0.002 mrem), inhalation (0.002 mrem), and direct exposure routes (0.000 mrem) and pathways (Section 4.0, Table 1a). Riverbank sediments were an example of a media that can impact both atmospheric (through inhalation of resuspended dry sediments) and liquid pathways (through ingestion and direct contact), dependent on how the exposure occurred. The LPW contributions to dose exposure were second to those contributing to the APW pathway. A review of the Section 5.0 Data and Section 6.0, Table 1 shows the radionuclide rank order (Cs-137 and Sr-89/90 in fish, and tritium in rainwater, surface water, fish, and drinking water) that occurred in the LPW pathway in 2012.

The Food Pathway

The food pathway was covered under the atmospheric and liquid pathways except for these few additional observations. The annual 2012 SCDHEC AEI food pathway dose order, highest to lowest, for averages was hog, deer, fungi, edible vegetation, fish, and milk. The 1999-2012 period average dose order changed to hog, fish, deer, fungi, edible vegetation, and milk (Section 6.0, Table 2 and Section 5.0, Data). Single high detections can occur in any of the game, fish, or wild fungi and vegetation samples, and cause a reversal of the rank order of media in any year. The 2012 MAX food pathway order was hog, deer, fungi, fish, and edible vegetation. The 1999-2012 period MAX food pathway oder was deer, hog, fish, fungi, and edible vegetation, respectively. Most of this dose was due to Cs-137 and strontium (all calculated as Sr-90) detections in game, fish, and wild edible vegetation including fungi. The food pathway contained all detected radionuclides (Cs-137, Sr-89/90, tritium) contributing to dose exposure. The dominant food categories were MEI Survivalist, MAX Fish&Game, Hunter MEI, AEI Fish&Game, MAX EV (edible vegetation) &Fungi, AEI non-Game, and AEI Fungi. Wild-type edible vegetation was higher than domestic for 2012 and multi-year averages (Section 6.0, Table 4). Section 4.0, Table 4 summarizes the 2012 AEI food category statistics. Game contained the most radionuclide activity potential exposure at 3.476 mrem (92.03%), nongame food was second at 0.146 mrem (3.87 %), and fungi was third at 0.135 mrem (3.57 %) of 2012 annual dose.

1999-2012 Summary Statistics

Section 6.0, Table 1 summarizes radionuclides of concern *potential* dose detections, and Section 6.0 Table 2 summarizes only media dose assigned to the AEI and MAX media calculations. Section 6.0, Tables 3 and 4 break down the primary pathway contributor to dose exposure, i.e., the food pathway, into subpathways and food categories.

The critical pathway basis of comparison for SCDHEC detected dose comes from accumulated releases of radionuclides that were deposited outside of SRS during 1999-2012 and within 50-miles of the SRS center-point. Section 6.0, Table 3 illustrates the dominance of the atmospheric pathway dose (66.88 %) over the liquid pathway (33.12 %) and emphasizes the AEI dose basis (Section 6.0, Tables 2,3,4). The food subpathway (95.64 % of dose) was the dominant route of exposure; the nonpotable drinking water supply was second (2.65 %);, the public water supply pathway, third (1.16 %); the direct exposure pathway, fourth (0.32 %); and the inhalation pathway, fifth (0.23 %).

Section 4.0, Figures 1,2,3 and Section 6.0, Table 3 illustrate the various pathways of dose exposure. The total detected AEI basis critical pathway dose (3.777 mrem) is just slightly greater than half the dose from living in a block house (7.00 mrem) for one year (Section 4.0 Figures 2,3). Figures 4,5,6,7 in Section 4.0 illustrate the media exposure trends via line graphs. These figures clearly illustrate that the various media can change rank order in any given year on an AEI and MAX basis. Summary statistics, especially medians, for multi-year periods are relevant to actual trends and comparison of typical dose exposures from media with large sample numbers. Additions of the medians for the period 1999-2012 from Summary Statistics Table 2 for personal scenarios (using only media encountered) may give the best estimate of a personal exposure trend and still be protective due to the use of detections only and conservative factors in calculations.

Cesium-137 (86.74 % of AEI dose detections) accounted for most accumulated dose detections in all media for the period 1999-2012, and occurred primarily as a result of exposure to wild-type food sources (Section 6.0, Tables 1 and 2). Total strontium (7.24 % of AEI dose) was second, and tritum ingestion (4.48 %) third. All other potential non-NORM radionuclides were less than 1 % of the dose exposure for the period 1999-2012.

Section 6.0, Table 2 offsite hunter MAX (averaged 10.207 ± 9.469 mrem, and median 8.360 mrem) and offsite hunter AEI (averaged 1.002 ± 1.472 mrem, and median 0.210 mrem) summary statistics are only for game animal totals (deer plus hog), and all other statistics in this table are on a single media basis. Contaminated mushrooms may be consumed both by animal and man. At Chernobyl the highest environmental dose rank occurred in individuals who consistently ate wild mushrooms (Botsch 1999). Even though the MAX dose is not achieveable for all media locations, one hunter/survivalist does have the opportunity to attain most of the MEI dose since it is mostly due to wild-type food consumption (Sections 4.0, Table 1a, 4 and Secton 6.0, Tables 2,3, 4). The 2012 MEI dose was based on a hunter MAX dose of one hunter consuming the edible portion of 2 deer and another hunter consuming 2 hogs (7.043 mrem). Thus, the SCDHEC hunter who was not the MEI would receive far less dose on average (AEI), and the typical dose that was not based on extremes of consumption should be closer to the AEI offsite hunter median (0.210 mrem) for numerous nondetections were not part of the dose estimate calculations (Section 6.0, Table 2).

The dominant sources of exposure (wild food) on an AEI or average basis for 1999-2012 were hog (1.215 mrem), fish (0.539 mrem), fungi (0.408 mrem), deer (0.347 mrem), and wild-type edible vegetation (0.184 mrem) (Section 6.0, Table 2). The minor dose sources of exposure on an AEI average basis were milk (0.044 mrem), surface water at boat landings (0.030 mrem), domestic edible vegetation (0.023 mrem), public water systems using river water (0.015 mrem), rainwater (0.011 mrem), public water systems using groundwater (0.007 mrem), and untreated private well represented by Department of Natural Resources Groundwater Wells (DNRGW), and swimming ingestion, soil, and air were all 0.004 mrem each, and sediment exposure was 0.002 mrem.

Section 6.0, Table 2 medians, which reduce the influence of the extremes, should provide the most relevant central tendency for environmental media exposure estimates over the period 1999-2012 due to the large amount of data, and the median is still protective since the statistics are based on detections only (Gilbert 1987). The dominant sources of exposure (wild food) on an AEI median basis were hog (0.970 mrem), fish (0.468 mrem), fungi (0.306 mrem), deer (0.210 mrem), and wild-type edible vegetation (0.152 mrem) (Section 6.0, Table 2). The minor dose sources of exposure on an AEI median basis were surface water at boat landings (0.030 mrem), public water systems using river water (0.013 mrem) and rainwater cisterns (0.013 mrem), domestic vegetation (0.008 mrem), milk (0.004 mrem), air (0.002 mrem), swimming ingestion (0.002 mrem), sediments (0.001 mrem), and all others were < 0.000 mrem.

MAX food (dominant dose) categories change the median order and indicate the dose potential that exists in exposure to extremes. Compare the offsite hunter MAX median dose (8.360 mrem) to the hunter AEI median dose (0.210 mrem). The MAX median order is deer (6.330 mrem), hog (2.120 mrem), fish (1.766 mrem), edible fungi (1.450 mrem), wild-type edible vegetation (0.140 mrem), and milk (0.018 mrem). Notice that deer meat consumption represents the most variable rank in comparisons of AEI to MAX detection statistics.

Section 4.0, Figure 1 illustrates that public and environmental dose exposure can occur through many routes and pathways via atmospheric and liquid releases to various media. Also, many potential cross pathways exist. Section 4.0 Table 6 illustrates the 1999-2012 DOE-SR Percent of Total Dose potential to the MEI for the atmospheric and liquid pathways based on annual releases. The greatest potential dose exists in the inhalation, vegetation, cow milk, domestic meat, and ground pathways *when atypical dose (e.g. sportsman or survivalist dose) is not included*. SCDHEC Section 4.0, Table 7 illustrates that the dominant dose (mrem) exposure for the overall DOE-SR MEI for 1999-2012 on a median basis is from the sportsman pathways (onsite hunter 14.60 mrem, offsite hunter 6.95 mrem, offsite fisherman 0.52 mrem) versus the All-Pathway typical exposures (0.18 mrem). The total potential dose during the 1999-2012 period on a median basis was 22.25 mrem yearly.

SCDHEC data from dose accumulations in all media shows that dose exposure is dominated by the wild food (deer, hog, fish, fungi) pathway for the period 1999-2012 (Section 4.0, Figures 4, 5, 6, 7, 8) (Section 6.0, Table 2 and 4). Wild-type food dominates the dose exposure to the MEI. The SCDHEC recent addition of edible fungi (mushroom MAX dose was 1.450 mrem in 2012) and other edible native plants shifts the emphasis of maximum exposure to include the atypical survivalist who takes advantage of all food sources. Section 4.0, Figure 5 game plus fungi represent bioconcentrators of dose (highest dose media is wild-type food, animal or plant). Figure 6 represents exposure in the liquid pathway (potential as drinking water sources) and Figure 7 indicates other minor pathway dose contributions. Section 4.0, Figure 8 shows the general agreement between DOE-SR and SCDHEC sportsman media, and the overall trend in sportsman media dose (declining). Section 4.0, Figure 9 shows recent dose trends since SCDHEC added the wild edible plant and fungi pathways. The DOE-SR offsite dose model estimate tends to be twice the SCDHEC AEI dose and the onsite hunter dose tracks near the SCDHEC MAX dose. Also, the upper bound median (Max on + offsite) for the combined program dose estimate is 27.33 mrem 2009-2012. DOE-SR did not collect fungi and few wild-type edible vegetation species during 1999-2012. Most of the SCDHEC dose detections in wild-type vegetation came from bolete and chanterelle mushrooms, and woody edible plant sources (not annuals). Annual plants are exposed mostly to seasonally absorbed surface dose. Perennial plants such as shrubs and trees have two or more years of exposure through extensive root and foliage absorptive areas. Long-lived fungi mycelia mats may have even greater absorptive surface for dose accumulations and/or bioconcentrations over many years. This accumulated dose is then passed on to the consumer of those sources. The data seems to indicate that the true MEI is primarily a survivalist who is heavily dependent on sportsman media.

Section 6.0, Table 2 gives individual media statistics for assigned dose to the MEI on an AEI basis without regard to applicability, and the media rows total mrem, averages, and/or medians can be totaled for an individual optional scenario dose estimate for the period 1999-2012. The general non-sportsman public, for example, could total the medians for the most applicable media exposures (public water system river water or PWSRW dose of 0.201 mrem, air 0.057 mrem, domestic vegetation 0.248 mrem, and milk 0.612 mrem) to obtain a 14 year public scenario median exposure above background of 1.118 mrem (nearly the same as a single year of TV cathode ray exposure) (Section 4.0, Figure 2).

The hunter doses given in Section 6.0, Tables 2 and 4 are not scenarios, but merely game category combinations without additional dose from other media that might be applicable to total dose under a scenario. Section 6.0, Table 4 totals and statistics are based only on averages and medians across food categories, but the data came from Table 2. The differences between medians and averages may indicate expected potential ranges for AEI and MAX food media overall. The range estimate may also apply to combined food categories. Consistent future sampling results outside of these ranges may indicate a declining or increasing radionuclide population characterization. The AEI section of Table 4, Section 6.0 can be compared to other dose as well. For example, the 1999-2012 AEI food total dose is 24.203 mrem and is 84.56 % of the total dose from all nonNORM sources (28.623 mrem) detected, which is given in Section 6.0, Table 1. Most of the food dose was due to Cs-137, which was 86.74 % of the radionuclide detections. The detection of Cs-137 in nonfood sources (e.g., water, soil, air) was minor, but included most of the remaining dose, which from Section 4.0 Table 1a was 0.042 mrem (AEI) or 0.339 mrem (MAX).

DOE-SR and SCDHEC 2012 Comparisons

The SCDHEC MEI was a survivalist type of individual that received most of the dose exposure through the wild game and edible wild plant and fungi consumer pathways. The 2012 SCDHEC MEI represented a potential upper bound exposure based on the single highest detections per radionuclide per media. DOE-SR and SCDHEC critical pathways dose are compared within the atmospheric and liquid pathways. Both pathways major contributions occurred through the food pathway and a special section discusses comparisons to the DOE-SR All Pathway category. The DOE-SR All-Pathway MEI dose is limited to the liquid plus airborne pathway annual releases representing the typical low dose exposure potential for the general public downstream of SRS. The SCDHEC MAX dose contributes to the SCDHEC MEI and is compared to the DOE-SR Sportsman, Hunter, and Fisherman doses that represent atypical dose for minority categories (onsite hunter or poacher, e.g.). The following comparisons reveal that the atypical sportsman and edible wild vegetation doses make up the majority of the available dose, while the All Pathway typical exposure for the general population was minor. All typical and atypical potential dose exposures combined represent an upper bound potential dose estimate in the environment for the MEI based on the available data.

The SCDHEC MAX and AEI estimates were inflated (see Dose Critique heading) and represented a potential dose accumulated over several years in environmental samples. The SCDHEC AEI dose was more relevant to actual potential exposure rather than the very low probability MAX total (MEI) dose. DOE-SR dose was compared to SCDHEC dose central tendency ranges (median/average) for periods longer than one year, and within the 2012 year only the low dose (AEI) was listed first followed by the more improbable upperbound (MAX) dose. However, both estimates were conservative. The SCDHEC scenarios (public and MAX survivalist doses) represent limits on a lifestyle basis (0.040 and 19.845 mrem, respectively) (Section 4.0, Table 2). These scenarios can be compared to the DOE-SR ranges for typical versus atypical dose; i.e., All-Pathway dose (0.26 mrem) versus the total of onsite and offsite dose (20.086 mrem) in Table 6-5 of the SRNS 2013 report. SCDHEC and DOE-SR cannot sample all dose available in the environment and the actual dose(s) can exceed the given ranges for typical versus atypical dose. The addition of and comparison to DOE-SR dose estimates may be directly relevant (onsite deer also represented accumulated dose), while other detections may be from yearly release estimates or measurements that do not necessarily result in depositions within the 50-mile study area (backgrounds). Also, some DOE-SR radionuclide releases cannot be measured and DOE-SR must use computer modeling to generate a theoretical exposure based on known releases or other media dose (onsite deer, hog). The DOE-SR dose was potentially inflated due to the treatment of unknown alpha as Pu-239 and unknown beta as Sr-90, since their conversion factors are higher than most other radionuclides.

The DOE-SR All-Pathway (0.26 mrem) and the SCDHEC Public Scenario basis (0.040 mrem) were the most relevant dose estimates that represent a range of potential dose exposure for the general public in 2012. However, potential or available dose does not necessarily imply the individual was exposed to any or all of the dose detections, and many other factors may limit dose uptake, if available. Section 4.0, Tables 6 and 7 indicate relative releases and exposure media based on DOE-SR data. Certain media (wild food, e.g.) are not included in the general public dose, but added to the survivalist dose (includes all dose potential) that represents the atypical maximum offsite and onsite dose. Offsite dose is expected to be less than onsite dose due to dispersion at a distance, if from SRS. If not, historical contributions from past nuclear tests fallout that tracked across South Carolina may still occur at significant levels in some media and contribute to detections.

The overall upperbound potential estimate consists of all dose (differences within the two programs) added together to represent the individual survivalist maximum dose (37.444 mrem) (Section 4.0, Table 3). This SCDHEC 2012 combined dose estimate (37.444 mrem) was greater than the combined averages of DOE-SR committed dose for the MEI sportsman pathways and All Pathway estimates (36.24 mrem) for the period 1999-2012 (Section 4.0, Table 7). This fourteen year total for the four DOE-SR pathways was close to the 2012 DOE-SR and SCDHEC combined average dose (37.444), and indicates along with yearly totals that the two different environmental sampling programs were detecting similar dose. Also, Section 4.0, Figure 9 (for the years 2009-2012) indicates a more recent combined potential dose on a median basis for SCDHEC offsite (14.52 mrem) and DOE-SR onsite (13.45 mrem) dose. The recent four year period upper bound average plus standard deviation (1sd) was 28.392 (± 6.821) mrem with median of 27.331 mrem, which gives a very narrow central tendency range. Section 4.0, Table 7 illustrates the downward trend for the DOE-SR committed sportsman dose exposure toward the medians of 14.60 mrem for the onsite hunter, 6.95 mrem for the offsite hunter, and 0.52 mrem for the offsite fisherman. These DOE-SR pathway estimates were within 1sd of the SCDHEC estimates except for the fisherman, which was slightly over 1sd compared to SCDHEC fish (2.019 ± 1.447 mrem) (Section 6.0, Summary Statistics Table 2).

Section 4.0, Table 5 compares the air, liquid, soil, and food media dose in 2012. The sum of the highest dose potentials across the SCDHEC and DOE-SR programs in these media (21.426 mrem) was higher than the SCDHEC MEI (outer bound estimate) of 19.845 mrem. Again, the closeness of the combined media maximum totals of both programs to the SCDHEC estimate alone indicates a general agreement between programs overall. It is highly improbable that an individual could be at all locations when the maximums exposures were present and maintain all exposures as a constant (stored exposure throughout the year). Thus, these maximum estimates represent available year long exposures without consideration of limiting factors.

Section 4.0, Figures 8 and 9 show the overall trend in dose estimates for comparable exposure media. The recent trend for the 2009-2012 SCDHEC AEI basis offsite and DOE-SR offsite medians tend to limit offsite dose to <5.5 mrem, while the recent SCDHEC MAX offsite dose trend (14.52 mrem median) and the DOE-SR onsite dose trend (13.45 mrem median) were similar (Section 4.0, Figure 9). This recent year (2009-2012) period accumulated dose trend in SCDHEC offsite data (2009-2012) now includes wild edible vegetation with a median of 2.53 mrem for the SCDHEC AEI data versus the DOE-SR offsite dose modeling median of 5.38 mrem (Section 4.0, Figure 9). Compare this to the typical exposure risk from a coast-to-coast airplane flight (2.5 mrem, Section 4.0, Figure 2).

DOE-SR yearly radionuclide releases were not directly comparable to field measurements that included accumulated dose from past releases. Most comparisons were based on Table 6-5 of the Savannah River Site Environmental Report for 2012 (SRNS 2013) and combinations from Table 1a of this report. This comparison assisted in evaluating the 2012 DOE-SR environmental monitoring program and the SCDHEC ESOP environmental monitoring program. The preceding paragraphs indicated similarities in the environmental trends (usually within 1sd) for potential dose exposure despite differences in media and methods. The SCDHEC media dose detections within the study area represented accumulated and decayed dose from all area sources including historical, atomic bomb test fallout, Chernobyl, and domestic nuclear power. No dose detected by SCDHEC was strictly assignable to DOE-SR alone, but was considered of potential DOE-SR origin if within the 50-mile study area and greater than the South Carolina media backgrounds.

Most of the 2012 MEI exposure estimates for SCDHEC and DOE-SR were due primarily to Cs-137 occurrence in bioconcentrators of dose in the sportsman food pathway and not to correlations between annual releases and accumulated detected dose in media (Section 4.0, Table 1a, and SRNS 2013, Table 6-5). The following sections look at the typical radiation exposure routes (air and liquid), and the atypical subpathways (sportsman and wild food), while comparing DOE-SR and SCDHEC dose data. The differences between DOE-SR and SCDHEC dose estimates primarily represent a potential range of dose dependent on lifestyle scenarios of exposure and consumption rates.

SCDHEC and DOE-SR Atmospheric Pathway Comparison

This section refers only to detections of atmospheric depositions that may result in dose exposure for an individual in 2012. Most of the dose was resident in food sources that were found primarily in the atmospheric depositions pathway. SCDHEC dose data was calculated as an AEI above background and as a MAX potential dose (as if the media could somehow be stored and consumed throughout the year). The potential dose to the MEI from SRS atmospheric releases was highest generally northwest to northeast of the site per the SRS Environmental Report for 2012 (SRNS 2013, Data Table 6-21). The highest tritium detections in air (8.815 pCi/m^3) and rainwater (531 pCi/L) in SCDHEC samples were also slightly northeast (NE) and northwest (NW) of the SRS, and the next highest detections occurred due north of the SRS in New Ellenton. The highest Cs-137 detection in edible bolete mushrooms (8.24 pCi/g) occurred NE of the site in Barnwell County (SCDHEC 2012 Data).

The National Emission Standards for Hazardous Air Pollutants (NESHAP) MEI dose for all radionuclide air pollutants (0.0395 mrem plus 0.014 mrem diffuse and fugitive releases) was 0.054 mrem in 2012 for the MEI (SRNS 2013). This was 0.54 % of the 10 mrem/yr DOE Order 5400.5 air pathway standard. The atmospheric pathway contributed accumulated dose to the individual through the inhalation, ingestion, and direct exposure routes. Rainwater contamination from atmospheric releases of tritium (SCDHEC AEI 0.015 mrem, MAX 0.025 mrem) would directly impact water cisterns that used rainwater for drinking water.

Not all SRS dose releases resulted in depositions within the sample area. This was evidenced by the SCDHEC inhalation pathway detections (0.005 mrem MAX) that were far less than the SRS release dose estimate of 0.027 mrem (Section 4.0, Table 1a) (SRNS 2013). This confirms that the DOE-SR atmospheric release estimate was conservative. Atmospheric releases, when deposited outside of the study area are greatly diluted with distance from the originator (dispersion), and by other weather factors. The cumulative dose depositions that contributed to the SCDHEC dose detections in any given year and potential dose releases by DOE-SR (an annual estimate) were not directly comparable. However, the 2012 SCDHEC accumulated air dose (0.005 mrem) was much lower than the DOE yearly air dose limit of 10 mrem. The detected exposure in millirems was a more meaningful indicator of dose to the public versus percentages that establish rank.

Four comparable SCDHEC and DOE-SR media pathway dose results (air, liquid, soil, food) were totaled and compared for 2012 data in Section 4.0, Table 5. SCDHEC detected far less air inhalation dose (0.005 mrem MAX) than the estimated potential dose by DOE-SR releases (0.027 mrem MAXDOSE-SR goat milk pathway). All releases were not detected and were not necessarily deposited within the study area. The air pathway data difference between SCDHEC and DOE-SR was due to dose based primarily on field measurements versus actual atmospheric releases and dose modeling, respectively. Few atmospheric releases resulted in measureable dose detections offsite of SRS within the 50-mile study area perimeter. The DOE-SR pathways most affected by contributions from atmospheric releases (> 1 %) in 2012 were the vegetation (0.012 mrem), inhalation (0.0074 mrem), goat milk (0.0069 mrem), ground (0.003 mrem), meat

(0.0003 mrem), and plume pathways (0.0001 mrem) (Data Table 6-22 MAXDOSE-SR MEI Dose Using Goat Milk Pathway data, SRNS 2013). The SRS 2012 air dose potential was due mostly to tritium (57.08 %), Sr-90 (23.54 %), Cs-137 (5.03 %), Pu-239 (2.91 %), I-129 (2.89 %), and californium-251 (Cf-251, 1.68 %). The first three radionuclides reverse the DOE-SR order and magnitude in SCDHEC 2012 detections of accumulated dose: Cs-137 (93.24 %), Sr-89/90 (5.38 %), and tritium (1.38 %) (Section 6.0, Summary Statistics Table 1).

SCDHEC MAX atmospheric pathway dose detections in 2012 came mostly from the sportsman food (fish, deer, hog), and wild edible mushroom pathways (97.82 % of 19.845 mrem MAX basis), and was 95.61 % of the 3.777 mrem AEI basis (Section 4.0, Table 4) (Section 6.0, Summary Statistics Table 4). Nearly all of this dose was due to food media dose, 19.560 of 19.845 mrem (98.56 %) MAX potential dose in 2012 (Section 4.0, Table 4), and most of that was due to Cs-137 (19.29 of 19.56 mrem or 98.62 % of food dose), Sr-89/90 (0.217 of 19.56 mrem or 1.11 %) and tritium (0.053 of 19.56 mrem or 0.27 %) (Section 5.0, Data). The SCDHEC APW pathway contained 0.147 mrem in vegetables and fruit, and 0.000 mrem in the milk pathway. The DOE-SR airborne dose (0.027 mrem) in 2012 is far less than the atypical hunter dose (14.5 mrem onsite) pathway (SRNS 2013, Table 6-5). The higher accumulated dose in atypical pathways is clear evidence of bioaccumulation of dose (e.g., SCDHEC 0.117 mrem AEI dose in wild edible plants versus 0.001 mrem in soil and sediments). The observed annual dose release detections would require several years to achieve the dose found in some wild food sources (deer, hog, fish, mushrooms, vegetation) by SCDHEC and DOE-SR in 2012 (SRNS 2013).

The approximate DOE-SR overall media atmospheric dose accumulation (19.467 mrem) was higher than the SCDHEC atmospheric (subtracting fungi for similar media) dose accumulation (18.139 mrem), but nearly the same if fungi was included (19.845 mrem) (SRNS 2013, Table 6-5) (Section 4.0, Table 1a). The theoretical estimates made by DOE-SR for offsite deer (4.04 mrem) were less than the field samples calculated by SCDHEC on a MAX basis (6.15 mrem) (Section 4.0, Table 1a). However, the DOE-SR theoretical estimates for offsite hogs (0.90 mrem) were much less than that observed by SCDHEC on a MAX basis (10.92 mrem) and AEI basis (2.20 mrem). The offsite hunter DOE-SR model that includes deer and hogs is summarized in Secton 4.0, Table 7 for the period 1999-2012. The committed dose for the offsite hunter averages 8.19 ± 5.30 mrem (1sd) with a median of 6.95 mrem over the fourteen year period (Section 6.0, Summary Statistics Table 2). This is within the first standard deviation of the SCDHEC offsite hunter average of 10.207 ± 9.469 mrem with a median of 8.36 mrem (Section 4.0, Table 7). Thus, the DOE-SR offsite theoretical estimate of dose in deer plus hogs based on onsite modeling does appear more accurate than that for deer or hog alone.

Any close agreement of the MEI calculations between the two monitoring programs was due primarily to Cs-137 occurrence in bioconcentrators of dose in the sportsman food pathway, and to tritium in the Savannah River water supply pathway, and not to a correlation between releases and detected dose in media. Despite bioaccumulation over several years versus annual release estimates, both environmental program estimate totals added together indicated that the upper bound of the combined MEIs (37.444 mrem) in 2012 was far less than the 100-mrem (not applicable except on an annual release basis) DOE-SR Order 5400.5 dose release standard. Accumulated dose over several years was primarily dependent on the higher energy of radiation and longer half-life radionuclides (Cs-137 and Sr-90) versus tritium (lowest beta energy) (Baum

2009). Comparisons to DOE-SR annual dose release limits are not strictly applicable, but serve to illustrate that accumulated dose in the environment is less than any single years DOE-SR allowed dose release.

SCDHEC detected sportsman soil exposure dose (0.003 mrem) based on riverbank and forest soils was far less than the estimated DOE-SR swamp soil dose (2.94 mrem) (Section 4.0, Table 1a) (SRNS 2013, Table 6-5). Again, some DOE-SR calculations were based on an annual dose potential from releases, whereas SCDHEC data results measured accumulated dose in sampled media (not directly comparable). However, note that SCDHEC accumulated dose estimates were less than the annual release estimates of DOE-SR, which indicated that most of the dose releases either stayed on SRS or were carried far away by weather atmospherics and dispersed.

The SCDHEC order of MAX detected radionuclide dose in the 2012 atmospheric pathway excluding assigned NORM was: Cs-137 in hogs (10.920 mrem), Cs-137 in deer (6.150 mrem), Cs-137 in fungi (1.450 mrem), Sr-89/90 in wild fruit (0.1129 mrem), tritium in air (0.005 mrem), and tritium in wild-type fruit (0.004 mrem) and 0.003 mrem tritium in soils (Section 5.0, Data). Differences in observed dose were potentially influenced by weather deposition, location, and temporal factors. The SCDHEC MAX dose from the atmospheric pathway (16.923 mrem/yr) was approximately the same as living in a block house for two years (7 mrem/yr) and taking one coast-to-coast flight (2.5 mrem) (Section 4.0, Figure 2). The DOE-SR MAX dose order was Cs-137 in deer and hogs with a maximum hunter dose of 14.5 mrem onsite and 4.04 mrem offsite, vegetation (0.012 mrem), goat milk (0.0069 mrem), inhalation (0.007 mrem), ground (0.003 mrem), and domestic meat (0.0003 mrem) (SRNS 2013, Table 6-5 and Data Table 6-22).

SCDHEC only monitors offsite dose, and SCDHEC terrestrial food samples did not include an onsite (within SRS boundary) hunter dose to compare with DOE-SR (14.5 mrem Table 6-5, SRNS 2013). Thus, it was necessary to add the DOE-SR onsite hunter dose to SCDHEC offsite dose for a total potential dose estimate (37.444 mrem, Section 4.0, Table 3). DOE-SR and SCDHEC data together indicated that animals with large body mass and vegetation with large absorptive surface areas (leaf canopy, root system, or fungi mycelia mat) tended to contain the highest dose for particular radionuclides (Cs-137, e.g.) (Section 5.0, Data).

A comparison of atmospheric plus sportsman dose maximums (air, soil, and food pathways) in similar media that were monitored by both DOE-SR and SCDHEC programs gave totals of 5.376 mrem and 18.117 mrem, respectively (Section 4.0, Table 5). The sportsman scenario includes fish (covered under the liquid pathway), but most sportsman dose was related to the atmospheric pathway (Section 4.0, Table 1a). The main differences between the two program estimates were due to consumption rates, backgrounds, and offsite deer plus hog dose modeling estimates by DOE-SR. SCDHEC offsite deer and hog dose was measured, whereas DOE-SR offsite deer and hog dose was a hypothetical calculation based on onsite measurements. The higher SCDHEC offsite animal dose may be due to contamination from onsite territory cross-over feeding, and may point to a potential problem with the DOE-SR deer and hog offsite modeling estimate. The SCDHEC Crackerneck area deer results seem to confirm potential crossover feeding within the Upper Three Runs area (see the SCDHEC Game Report). The SCDHEC Bamberg deer background dose was 0.24 mrem in 2012. Some previous years higher backgrounds (McBee area) may be due to natural factors such as: the abundance of mushrooms consumed (bioconcentrators of Cs-137) by deer during the high background years, legacy spot depositions of Cs-137 in the area by fallout from nuclear weapons testing primarily in the 1950-1970 period, or a variation in weather patterns that affected atmospheric depositions at a distance from potential sources.

Section 4.0, Figure 8 shows a general decreasing dose trend in onsite deer and hunter dose down to the 2006 year when the yearly dose stabilized around 15 mrem of median dose. This may indicate that maximums in the early years deer meat Cs-137 activity were a result of the legacy dose local maximums and their respective decay rates. The DOE-SR 1999-2012 committed onsite MEI sportsman dose (onsite hunter) averaged 27.33 mrem of the total dose average of 36.24 mrem or 75.41 % of the fourteen year period dose. The offsite hunter averaged 22.61 % (8.19 of 36.24) of the dose in the same period (Section 4.0, Table 7). The 1999-2012 SCDHEC offsite MEI sportsman averaged 76.22 % (132.696 of 174.106 mrem) of the potential dose, which correlates closely to the DOE-SR onsite dose (75.41%) (Section 6.0, Summary Statistics Table 2). Even the 1999-2012 SCDHEC AEI basis sportsman was 51.46 % of total dose (13.022 of 25.304 mrem). This seems to indicate that offsite and onsite deer or hogs share the same territory and resident dose within both habitat areas. Approximately 72.19 % (14.50/20.086 mrem x 100%) of the DOE-SR 2012 atmospheric dose in Table 6-5 came primarily from the sportsman hunter subpathway within the atmospheric pathway (SRNS 2013). The SCDHEC hunter subpathway within the 2012 atmospheric pathway accumulated MAX dose that was 86.02 % (17.07/19.845 mrem x 100 %) of the detected dose within the atmospheric pathway (Section 4.0, Table 1a). Thus, DOE-SR and SCDHEC agree that most of the MEI dose comes from the atmospheric pathway.

The SCDHEC combined deer plus hog Max dose (17.07 mrem) was greater than the DOE-SR onsite hunter (14.5 mrem). Deer and hogs harvested near the SRS could contain contamination from onsite travel and food consumption within the SRS. Dose accumulations in offsite fungi (1.450 mrem Max) were near DOE-SR hog (0.90 mrem) and deer (1.10 mrem) dose consumption levels (Section 4.0, Table 1a) (SRNS 2013, Table 6-5). This may reflect contributions from fungi consumption to both hog and deer diets. DOE-SR did not collect fungi on or off the SRS, therefore program comparisons of Cs-137 in fungi were not possible.

SCDHEC and DOE-SR Liquid Pathway Comparison

The SCDHEC PWS drinking water maximum detection for public exposure was 0.033 mrem, but averaged only 0.009 mrem (Savannah River water). The DOE-SR maximum drinking water dose that includes the Vogtle Electric Generating Plant (VEGP) contributions was 0.044 mrem, and the maximum for DOE-SR alone was 0.025 mrem (SRNS 2013). About 46 % of this dose was due to tritium at the Savannah, Chelsea, and Purrysburg downriver locations. Both atypical and typical liquid pathway exposures were well below the 4 mrem/yr DOE 5400.5 drinking water pathway annual release standard (SRNS 2013). Rainwater SCDHEC MAX dose (0.025 mrem in 2012) was less than the Savannah River public water supply (PWS) MAX drinking water exposure (0.033 mrem), and far less than the exposure from using Savannah River water in cooking food at boat landings near SRS (0.255 mrem MAX) (Section 4.0, Table 1a).

The SCDHEC fish dose MAX value was 0.893 mrem and the AEI was 0.646 mrem (Section 4.0, Table 1a). The DOE-SR total offsite fisherman dose plus creekmouth fisherman was 0.382

mrem (0.166 plus 0.22, respectively) (SRNS 2013, Table 6-5). SCDHEC determined the fish dose based on the sum of the highest dose per radionuclide in all fish and not per fish species, since the survivalist was assumed to eat all fish. Most of the difference between DOE-SR and SCDHEC was a consumption factor of 48.2 kg/yr for the SCDHEC survivalist versus 24 kg/yr for the DOE-SR typical fisherman. These different estimates represent a range of potential dose (0.38 to 0.89 mrem) that applies to the fisherman according to lifestyle scenario choices (typical sportsman versus atypical survivalist). The SCDHEC MAX liquid pathway dose potential (1.169 mrem) was due primarily to Cs-137 in bass fish (0.771 mrem), and H-3 in nonpotable Savannah River water (0.255 mrem), and Sr-89/90 in catfish (0.052 mrem) (Section 5.0, Data Tables). The SCDHEC AEI liquid dose (0.663 mrem) applied to the average potential exposure versus the highly improbable MAX exposure based on the single highest (1.169 mrem) detection (Section 4.0, Table 1b). The DOE-SR fish dose maximum of 0.386 mrem and the SCDHEC fish dose estimates (0.646 mrem AEI to 0.893 mrem MAX) compared to the maximum dose in Savannah River water (0.255 mrem Cs-137) indicate that yearly dose releases are building up in fish (also mostly due to Cs-137). Ingestion or dose uptake resulting in bioconcentration of Cs-137 in fish was the dominant route of exposure to the public via the food pathway that was of liquid pathway origin. The SCDHEC 2012 MAX dose total for the liquid pathway (1.17 mrem/yr) was less than that from a single coast-to-coast airplane flight (2.50 mrem/yr) (Section 4.0, Table 1b and Figure 2).

The DOE-SR potential dose contributions via a theoretical irrigation (0.13 mrem) pathway (vegetable 0.11 mrem, milk 0.018 mrem, meat 0.0053 mrem) were higher than the typical liquid (0.11 mrem) pathway (fish 0.068 mrem, water 0.032 mrem, shoreline 0.0005, and swimming and boating 0.000009 mrem) (SRNS 2013). The main liquid dose release contributors were Cs-137 (57 %), tritium (15 %), unknown alpha (7 %), U-234 and U-238 (4 % each), I-129 (3 %), nonvolatile beta (2 %), and Sr-90 (1 %), and the rest were all <1 % each (SRNS 2013, Data Tables 6-12 and 6-16). The DOE-SR liquid releases percent of dose potential in 2012 was 68 % for fish consumption, 31 % for water consumption, and <1 % for the shoreline, swimming, and boating.

All-Pathway SCDHEC and DOE-SR Comparison

The DOE-SR MEI All-Pathway dose including irrigation yearly dose (0.26 mrem) basically represented combining typical exposures from the airborne and liquid pathways for the general public who were not subject to increased exposure from atypical activities. DOE-SR (0.127 mrem) and SCDHEC (0.038 mrem) detected comparable dose in the basic air inhalation and liquid ingestion dose pathways. DOE-SR added 0.13 mrem for a theoretical irrigation pathway. The consumption of PWS water at downstream locations was <0.04 mrem for both DOE-SR and SCDHEC data. The irrigation pathway gave the highest DOE-SR potential dose to food media: vegetable (0.11 mrem), milk (0.018 mrem), and domestic meat (0.005 mrem) for a total of 0.138 mrem (SRNS 2013, Data Table 6-16). The SCDHEC liquid consumption plus air inhalation MAX (MEI) potential dose in 2013 was 1.204 mrem (1.169 mrem liquid plus 0.035 air), and was less than that received from taking one coast-to-coast flight (2.5 mrem) (Section 4.0 Figure 2). The DOE-SR All-Pathway potential has not exceeded 0.28 mrem in the last fourteen years and has an overall downward trend since 1999 except for the irrigation pathway, which was added in 2011 (SCDHEC Section 4.0, Table 7, DOE-SR Data Table 6-16).

The SCDHEC and DOE-SR Comparison Summary

The combined SCDHEC and DOE-SR MEI dose potential (37.45 mrem) confirmed that any scenario or individual was not exposed to a dose greater than the DOE-SR annual dose limit of 100 mrem/yr., especially since this total represented accumulated dose over many years and not just one year. DOE-SR monitored individual hunters on the SRS to ensure that they did not exceed the DOE 100 mrem annual release standard or the 30 mrem per year administrative limit for game animals (SRNS 2013). Both SCDHEC (17.07 mrem offsite Max) and DOE-SR (14.5 onsite and 4.94 mrem offsite) game animal samples were under this onsite DOE-SR 30 mrem/yr limit (Section 4.0, Table 1a) (SRNS 2013, Table 6-5). Large offsite game animals may roam onto the SRS and be exposed to onsite dose and vice versa, which appears possible for many SCDHEC buck deer samples were harvested near SRS. Section 4.0, Table 7 gives DOE-SR dose totals and percentages for the major dose routes, 1999-2012. Onsite hunter was highest at 382.67 mrem of committed dose over fourteen years (75.41 % of dose), offsite hunter second at 114.72 mrem (22.61 %), offsite fisherman third at 7.63 mrem (1.50 %), and All Pathway fourth at 2.41 (0.48 %) of total dose to the MEI and Sportsman pathways. SCDHEC did not have an onsite hunter dose, and only the offsite dose data can be compared. This changes the DOE-SR committed dose ranking on an offsite basis to: offsite hunter first at 114.72 mrem (91.95 %), offsite fisherman second at 7.63 mrem (6.11 %), and All Pathway third at 2.41 mrem (1.93 %) of total dose to the MEI and Sportsman pathways. The 1999-2012 SCDHEC Max offsite deer plus hog hunter total was first at 132.695 mrem (76.22 %), offsite fisherman second at 28.261 (16.23 %), and other nongame ingestion at 13.15 mrem (7.55 %).

Dose Critique

The median may be a more applicable reference for deciding the true central tendency in environmental data when media sample numbers are relatively large in size and based on detections only (Gilbert 1987). Random sampling in most SCDHEC media revealed that the environmental data detections are asymmetric and skewed to the left (most detections are low and near the origin) and the median of the population probably tends to be larger than the *true* mean. Most sampling resulted in less than minimum detectable activity (<MDA) determinations and were not included in the above statistics that used detections only. The use of detections only in statistics was protective, and biases the central tendency high, which was the primary basis for concluding that the median was probably closer to the true central tendency.

The DOE-SR study area shows a gradual downward exposure trend due to inactive SRS reactors, and radioactive decay and dispersal processes. This trend can change based on new DOE-SR missions or outside influences from global atmospheric sources.
All dose was summarized by average, standard deviation, and median. The median may be a better indicator of the central tendency in environmental media dose compared to average dose for large sample numbers due to:

1) the decrease in the central tendency for the bulk of the data without extremes;
2) the added conservancy present in selected dose factors;
3) the addition of dose based on single highest detections such as hog and deer worst-case game animal consumption;
4) the use of “detections only” for statistical analyses when many sample results were less than the detection limit;

5) the assignment of the higher dose to dual radionuclide determinations (e.g., the assignment of dose based on Sr-90 when the detection is for Sr-89/90 or total strontium);
6) the use of 0.00 mrem as background subtraction for <MDA data averages;
7) the influence or potential of false positives (WSRC 2003a).
8) and while the median does represent the bulk of the data, the application of statistical methods for eliminating extremes without an assignable cause does not preclude the variation in the natural environment.

The NORM averages and maximums were not included in the dose estimates since this dose was part of the 310-mrem expected NORM for the study area. The yearly dose averages greater than background were based on SCDHEC detections only and are inflated since most sample results were <MDA. The MDA values are below typical South Carolina background detections and would not add dose to the MEI. 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 consideration of the SCDHEC 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 was excessive and 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 achieveable by the MEI due to the unlikely 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 worst case deer, hog, and edible plant and mushrooms could approach the MEI dose if these contaminated media were stored and consumed over the entire year. The SCDHEC 2007 Critical Pathway Dose Report noted that 38.50 % of the dose was assigned and represented a potential dose overestimate that may in fact be NORM detections (alpha and beta). Also, only 44.25 % of the detected dose above background was potentially from SRS, if all NORM potentials were excluded. The SCDHEC dose calculations since then were still protective due to the use of detections only in determining dose, the calculation of a maximum dose for the MEI based on a single maximum detection for each radionuclide/media, and the use of very conservative consumption rates.

The AEI was given prominence as protective for general dose considerations, and the reader should be aware that the AEI dose estimate was conservative or biased high due to the use of ‘detections only’ in calculations and the use of very conservative consumption rates for the SCDHEC AEI. For example, the omission of <MDA assignments from calculations would raise any calculated number to a higher value. Alternatively, <MDA actually represents an undetermined low number that may be zero or any number up to the given MDA value for that analysis. All detected dose above background was assigned either to the AEI, MAX (the MEI), or NORM dose dependent on assignable cause that was based on knowledge of environmental sources, media, and locations (Section 4.0, Tables 1a,b and Section 5.0, Data). For example, the potential NORM dose for resuspended soils was not assignable as farmer inhalation unless detected by air samplers (see atmospheric pathway section). The SCDHEC MEI was primarily a sportsman scenario because most potential dose was found in game animals and fish. However,

the wild edible mushroom and plant consumer potential dose would add significant additional dose to the survivalist. The wild edible vegetation dose exposure was higher compared to domestic edible vegetation (Section 6.0, Table 4). The MEI by definition would consume all media maximum activity/radionuclide/media and defined a limit of potential dose based on detections only. This was done since SCDHEC sampling was limited and did not necessarily include the true yearly MEI exposure (due to undetected dose and/or dose accumulations) for the exceptional individual who may receive the MEI dose resident in the 50-mile perimeter study area. Thus, the dose limiting factors were biased high to be protective of the public and the environment, but realistic or limiting in that only measured radionuclides were used in calculations.

Specific radionuclide (speciated) doses were used in the estimated dose for 2012 except for the dose assignments of total strontium as Sr-90. The use of detections only, the calculation of dose based on a single maximum for each radionuclide/media, and high consumption levels, provide an elevated dose basis that is protective without the inclusion of screening value assumptions for alpha and beta. SCDHEC field detection dose accumulations from 1999 through 2012 and DOE-SR yearly releases were not directly comparable and yet the potential MEIs calculated from both programs were close primarily due to the dominance of Cs-137 in the wild food pathway.

This project used dose instead of risk so that direct comparisons of dose magnitude can be made with similar media data published in the SRS Environmental Reports. Both the United States Environmental Protection Agency (USEPA) and SCDHEC use risk calculations when determining clean-up levels at Comprehensive Environmental Resource Compensation and Liability Act (CERCLA) and Resource Conservation Recovery Act (RCRA) sites. DOE-SR modeled radionuclide releases for a particular year were not directly comparable to SCDHEC yearly-detected dose in some media due to accumulation or biomagnification factors that may have occurred during 1999-2012.

3.0 CONCLUSIONS AND RECOMMENDATIONS

A very conservative estimate by SCDHEC of the average DOE-SR perimeter accumulated dose potential above background was only 3.777 mrem in 2012 (Section 4.0, Table 1a). The dose to the general public that did not consume wild food was 0.040 mrem in 2012 and averaged 0.080 (±0.069 mrem) with a median of 0.056 mrem during 1999-2012 (Section 4.0, Table 2). The median was viewed as the best representation of the central tendency over the period 1999-2012, and was still a protective estimate (see Dose Critique Section).

The survivalist MEI scenario should include all potential dose as a worst-case dose exposure. The SCDHEC MEI survivalist was a sportsman and a wild plant and mushroom consumer (new in 2008) who received a maximum dose of 19.845 mrem in 2012, and for the period 1999-2012, averaged 11.778 (±5.884) mrem, with a median of 12.184 mrem. The SCDHEC MEI (MAX) dose estimate represents an upper bound of all SCDHEC detected dose potential and is not potentially achievable unless all dose maximums could somehow be stored and maintained as a constant exposure throughout the year. Only one individual could receive this dose, since most of the dose required that individual to consume all of the edible portion from the specific animals used as the dose basis. The AEI dose (3.777 mrem in 2012) basis should apply to the rest of the population on an average potential basis and still be protective when based on detections only.

Since even the AEI dose basis was protective and inflated, the median dose may represent the typical individual who did not consume the animals containing the maximum dose. This AEI dose for the period 1999-2012 averaged 0.080 (±0.069) mrem, with a median of 0.056 mrem. The MEI central tendency dose (median basis) for 1999-2012 was 12.184 mrem. The SCDHEC MEI potential dose was based on the single highest detections/radionuclide/media in 2012 that included edible fungi, and was less than the dose typically received by living in a block house for three years (7 mrem/yr) (Section 4.0, Figure 2). Additional dose added primarily from DOE-SR onsite estimates for sportsmen increased the combined onsite and offsite dose potential to 37.45 mrem for the combined MEI. This improbable combined MEI potential accumulated dose was less than the DOE-SR 100-mrem annual dose release standard to the public in 2012 despite contributions from other years dose and bioaccumulations (Section 4.0, Table 3). Most of the dose in the DOE-SR and SCDHEC estimates was due primarily to the occurrence of Cs-137 in bioconcentrators of dose in the sportsman and wild-type edible vegetation food pathways.

The SCDHEC 2012 All-Pathway MAX dose estimates relative to the All-Pathway DOE standard atmospheric (0.005 mrem from air inhalation) and liquid (0.255 mrem from surface water ingestion at boat landings) pathways, excluding the atypical dose pathways, were less than the respective 10 mrem and 4 mrem DOE Order 5400.5 limits (Section 4.0, Table 1) despite dose additions from other years inherent in field collected media. The DOE limits apply only to yearly DOE releases and not to dose accumulated in the environment and are not applicable to SCDHEC field detections. However, it is important to note that even the environmental accumulations over several years have not reached the DOE annual limits even when on a maximum detection basis instead of a yearly average. The All-Pathway DOE atmospheric and liquid estimates for the general public exclude atypical dose (game e.g.), which was captured under the total MEI estimate for comparison to the DOE defined dose limit for all annual dose releases to the public (100 mrem/yr).

The SCDHEC Critical Pathway estimates included atypical dose, which was primarily due to Cs-137 exposure from ingested game animals. Inhalation was 0.06 % of the AEI dose to the critical pathway, ingestion was 99.48 % food and 0.45 % water, and direct exposure was 0.01 % in 2012 (Section 4.0, Table 1a). The primary critical pathways for dose exposure were via atmospheric and liquid dose that was eventually ingested directly or indirectly from wild-type food sources. The 1999-2012 statistics reduce sampling selection variations and gives a more accurate characterization of the central tendency potential in critical pathway dose (25.30 mrem of dose over a 14 year period) (Section 6.0, Table 2). The dose accumulations in the major critical pathways were atmospheric (66.88 % or 16.92 mrem), and liquid (33.12 % or 8.38 mrem) (Section 6.0, Table 3). The observed potential dose for this 14 year period (25.30 mrem) can be broken down into the following subpathways: food ingestion (95.64 % or 24.20 mrem, primarily wild-type food), nonpotable drinking water ingestion (2.65 % or 0.67 mrem, primarily from boiling water at Savannah River boat landings), public water supplies using Savannah River water (1.16 % or 0.29 mrem), direct exposure to soils and sediments (0.32 % or 0.08 mrem, primarily at Savannah River boat landings), and direct inhalation (0.23 % or 0.06 mrem). These exposures were well below all applicable limits.

The 2012 primary radionuclide dose contributors were Cs-137 (93.24 % or 3.543 mrem) followed by contributions from strontium species (5.38 % or 0.204 mrem), and tritium (1.38 % or 0.053 mrem) (Section 4.0, Table 1). Percentages and rankings can vary widely on a yearly basis due to sampling limitation selections, but the overall period statistics and percentages include all data and characterize the radionuclide populations more accurately (Section 6.0, Data Tables). Radionuclide rankings for all nonNORM detections during the period 1999-2012 without regard to applicability were Cs-137 86.74 %, Sr species 7.24 %, and tritium 4.48 %.

ESOP has increased sampling near the perimeter of SRS and in closer proximity to SRS tank farms, and basins and seepage areas to ensure an early warning for any contaminant making its way to the SRS streams. New media sampling will be added in the future, if project re-evaluation indicates a need. Edible fungi sampling was started in 2008 to address the concern for Cs-137 bioconcentration in edible mushrooms, and a wider variety of wild edible vegetation sources, including aquatics, was added in 2012.

Potential atmospheric and liquid release concerns that may play a relatively larger role in the dose to the surrounding public in the future may include the following:

1) releases of americium-241 (Am-241), plutonium and uranium radionuclides from the Mixed Oxide Fuel Fabrication Facility (MFFF) through the air and surface water environmental mediums (Compagnie Generale des Martieres Nucleaires or COGEMA, Duke, Stone, & Webster 1998);
2) a high concentration of tritium predicted by computer models migrating from the Old Radioactive Waste Burial Ground (ORWBG) to Upper Three Runs (WSRC 2001) and/or the Savannah River;
3) and radionuclides such as carbon-14 (C-14), iodine-129 (I-129), neptunium-237 (Np-237) and technetium-99 (Tc-99) may be an ORWBG contaminant to monitor in the future because of their long half-lives.

These findings indicated that monitoring of the potential accumulations and bioconcentrations of dose should continue, especially within the sportsman food and wild edible food source subpathways, in addition to the primary inhalation, ingestion, and direct exposure routes from the typical atmospheric and liquid pathways. The down-gradient wells, surface water, sediments, plants, and animals should be carefully monitored for any signs of the contaminants that are present at tank farms, basins, and seepage areas. Early detection is paramount to protecting the public and the environment if a release to offsite streams or groundwater occurs. SCDHEC will continue to monitor the SRS and adjacent area for the primary radionuclide contributors to dose potentially associated with DOE-SR operations.

4.0 Tables and Figures
2012 Critical Pathway Dose Report

Table 1a. 2012 SCDHEC Non-Scenario Dose (mrem/yr) Estimates for Pathways, Exposure Routes, and Media

Pathways	Routes	Media	AEI [1]	MAX [2]	MAX minus AEI [3]
APW [4]	Inhalation	Air	0.002	0.005	0.002
APW	Inhalation	Resuspended Soil	0.000	0.000	0.000
LPW [4]	Inhalation	Resuspended Riverbank Sediment	0.000	0.000	0.000
AEI **%**	0.06	**Air Inhalation Totals**	**0.002**	**0.005**	0.003
LPW	Ingestion	Fish [5]	0.646	0.893	0.247
APW	Ingestion	Deer	0.630	6.150	5.520
APW	Ingestion	Hog	2.200	10.920	8.720
APW	Ingestion	Domestic Vegetable/Fruit	0.029	0.029	0.000
APW	Ingestion	Wild Vegetable/Fruit	0.117	0.117	0.000
APW	Ingestion	Milk	0.000	0.000	0.000
APW	Ingestion	Soil	0.000	0.001	0.001
LPW	Ingestion	Riverbank Sediments	0.000	0.000	0.000
APW	Ingestion	Edible Fungi	0.135	1.450	1.316
AEI **%**	99.48	**Food Ingestion Dose Totals**	**3.758**	**19.562**	15.804
LPW	Ingestion	PWS River Water	0.009	0.033	0.024
LPW	Ingestion	PWS Wells	0.000	0.000	0.000
LPW	Ingestion	DNR GW Wells	0.000	0.000	0.000
LPW	Ingestion	SR Water at Boat Landings	0.014	0.255	0.241
APW	Ingestion	Rainwater	0.015	0.025	0.010
LPW	Ingestion	Swimming Ingestion	0.002	0.022	0.019
AEI **%**	0.45	**All DW Ingestion Dose Totals**	**0.040**	**0.334**	0.294
Ingesting Highest Water Source Dose plus Swimming [8]			**0.017**	**0.276**	0.259
APW	Direct	Submersion (Cloud)	NS	NS	NS
APW	Direct	Absorption (Skin)	NS	NS	NS
LPW	Direct	Immersion (Swimming)	0.000	0.000	0.000
LPW	Direct	Sediment Wading (Skin)	0.000	0.000	0.000
APW	Direct	Ground Direct Exposure (Shine)	0.000	0.002	0.000
LPW	Direct	Boating	0.000	0.000	0.000
LPW	Direct	Riverbank (Shine)	0.000	0.000	0.000
LPW	Direct	Swamp Dweller Surface Water Shine	0.000	0.000	0.000
AEI **%**	0.01	**All Direct Exposure Dose Totals**	**0.000**	**0.003**	0.002
All-Sources [6] Dose (Upper Bound of Detections) Totals			3.800	19.903	16.103
Perimeter [7] Dose (Applicable Ingestion Media and Totals Underlined [8])			**3.777**	**19.845**	16.068
See Table 1b for critical pathway summary and notes. <MDA results are assigned as 0.000 mrem.					

Tables and Figures
2012 Critical Pathway Dose Report

Table 1b. 2012 SCDHEC Non-Scenario Dose (mrem/yr) Estimates for Pathways, Exposure Routes, and Media (continued)

Examples of maximum dose substitutions for an AEI media average result.			
Examples of adding	Replace Avg Deer with Max Deer	9.30	3.78 plus difference 5.52
maximums to avg dose	Replace Avg Fish with Max Fish	4.02	3.78 plus difference 0.25
Perimeter[8] Dose Detections Applicable to MEI			
Critical Pathway Summary of MEI Perimeter[8] Dose (mrem)		**AEI[1]**	**MAX[2]**
The Atmospheric Pathway Perimeter Totals (APW)		3.13	18.67
The Liquid Pathway Perimeter Totals (LPW)		0.65	1.17
Perimeter8 Critical Pathways Percent Contributions (%)		**AEI[1]**	**MAX[2]**
Atmospheric (APW) Pathway		*APW%*	*APW%*
Percentage Totals for Perimeter Dose		82.82	94.10
Liquid (LPW) Pathway		*LPW%*	*LPW%*
Percentage Totals for Perimeter Dose		17.18	5.90
All-Sources[6] Dose (Upper Bound of Detections) Detections			
Critical Pathway Summary (mrem)		**AEI[1]**	**MAX[2]**
The Atmospheric Pathway Totals (APW) From All-Sources[6]		3.13	18.70
The Liquid Pathway Totals (LPW) From All-Sources[6]		0.67	1.20
ALL-Sources Critical Pathways Percent Contributions (%)		**AEI[1]**	**MAX[2]**
Atmospheric (APW) Pathway		*APW%*	*APW%*
Percentage Totals for Perimeter Dose From All-Sources		82.32	93.95
Liquid (LPW) Pathway		*LPW%*	*LPW%*
Percentage Totals for Perimeter Dose From All-Sources		17.68	6.05

Table 1 Notes:
1 - AEI is the average radionuclide activity concentrations (dose) above background excluding NORM.
2 - MAX is the single highest (maximum) radionuclide activity concentration (dose) above background excluding NORM.
3 - Difference of values in AEI and MAX (highest single dose) columns.
4 - APW is the atmospheric pathway media and LPW is the liquid pathway media.
5 - Fish dose totals are based on the highest dose detection/radionuclide instead of fish species.
6 - All-sources refers to all detected dose except NORM without qualification as to its' applicability.
7 - Perimeter refers to the study area which is outside of DOE-SR boundaries and within 50-miles of an SRS center-point.
8 - The maximum ingestion rate can only be used with one drinking water (DW) source (highest underlined) plus swimming.
9 - Nonspecific screening level detections of alpha, beta, and beta-gamma were replaced by the MAX estimate.

Table 2. Dose Scenario Estimates

Scenarios in Millirem of Exposure	2012	1999-2012		
Statistics	Avg.	Avg.	SD	Median
Public[1]	**0.040**	**0.080**	**0.069**	**0.056**
Max Survivalist[2]	**19.845**	**11.778**	**5.884**	**12.184**

Notes:
1 – The public who is exposed only to the milk, air, domestic vegetation, and the highest public water supply AEI dose.
2 - The MAX survivalist adds all remaining maximums in place of the AEI dose (started in 2008).
The exception is that only one drinking water maximum can be used. Equals the perimeter MAX dose total.
3 - Scenario results are not directly comparable to non-scenario results due to specified media/scenario,
but the MAX Survivalist receives all of the perimeter nonscenario dose, which is the SCDHEC MEI.
4 - Data and scenario corrections through 2007 include updates for dividing edible vegetation into wild and domestic vegetation dose, and dividing surface soil and river bank sediments into direct and resuspened inhalation dose.
5 - The trend in periodic averages for the public dose scenario is declining.
6 - The maximum survivalist periodic averages fluxuate widely due to high variables in animal dose and more recent additions to that scenario.

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Table 3. 2012 MEI All-Pathway and Survivalist Potential Dose Comparisons to DOE-SR (mrem)

Pathway	Media Comparison Additional Dose	DOE-SR[1]	SCDHEC[2]	Add to SCDHEC[3]
All-Pathway	Liquid (PWS plus Air Table 1) plus Airborne[4]	0.13	0.038	0.089
	Irrigation Pathway[7]	0.13	0.372	0.000
Sportsman	Onsite Hunter	14.50	**NS**	14.500
	Creek Mouth Fish	0.22	0.893	0.000
	Offsite Hog	0.90	10.920	0.000
	Offsite Deer	1.10	6.150	0.000
	Hunter Soil Exposure[5]	2.94	0.002	2.938
	Fisherman Soil Exposure[6]	0.07	0.000	0.072
Mushroom Consumer	Edible Fungi[8]	**NS**	1.450	0.000
Totals	**SCDHEC MEI**	NA	**19.845**	NA
	Total Difference to be added for MEI	NA	**17.599**	**17.599**
	SCDHEC plus DOE-SR MEI Additions[9]	NA	**37.444**	NA

Notes:
1 - DOE-SR data primarily from Table 6-5 (SRNS 2013).
2 - SCDHEC Maximums or single highest detection basis for all media per route of exposure (Table 1).
3 - MEI all-source 2012 dose additions. Some DOE-SR offsite dose is based on computer modeling.
4 - Air inhalation plus LPW water source ingestion (PWS).
5 - APW soil sources were from Creek Plantation (DOE-SR) and other soil and sediment (SCDHEC).
6 - LPW soil and sediment sources (location differences).
7 - Other Highest Irrigation food pathway potentials - milk, vegetable, and surface water ingestion sources
8 - Edible fungi dose from Cs-137 bioconcentration was highest in *Cantharellus* and *Boletus* spp.
9 - Biased high primarily due to single maximums (SCDHEC), assigned dose (DOE-SR), and released dose basis.
Not all released dose is absorbed, and explains why field measurements do not detect all dose released.
On-site Turkey is included in the Onsite Hunter dose.

Table 4. Sportsman versus Nonsportsman Food Group Comparison

2012		**1999-2012 Food Pathway mrem[6]**			
2012 AEI Food Categories or Groups	**Total mrem**	**Media**	**Avg.**	**SD**	**Median**
Sportsman or Game[4]	3.476	Fish,Deer,Hog	0.700	0.456	0.539
Nongame	0.146	All Veg and Milk	0.074	0.042	0.074
Fungi	0.135	Fungi	0.408	0.365	0.306
AEI All-Food Total[1]	**3.757**	**AEI All-Food Group Totals[7]**	**1.182**	NA	**0.919**
Scenario[8]	**Scenario Total**	**Max All-Food Group Totals[7]**	**7.216**	NA	**3.649**
Substitute MAX Deer/Hog for AEI Deer/Hog[2]	18.017	**2012 Food Group[5]**		**MAX**	**% of MEI[3]**
Substitute MAX Fish for AEI Fish[2]	4.024	Fungi Only		1.450	7.307
Substitute MAX Fungi for AEI Fungi[2]	5.093	Sportsman (fish, deer, hog)		17.963	90.517
Substitute MAX Domestic Veg for AEI Veg[2]	3.689	Public (domestic vegetables and milk)		0.029	0.146
Substitute MAX Wild Veg for AEI Veg[2]	3.765	Survivalist (wild vegetation, fungi)		1.567	7.896
All Food MAX Totals[1]				**19.560**	**98.559**

Notes:
1 - The AEI All-Food totals are based on the AEI group values.
2 - Examples of adding highest maximums in place of the AEI value.
3 - Food type % of MEI is on a MAX basis percent of the MAX Perimeter dose (19.845 mrem).
4 - Game animal (deer,hog) consumption in 2012 had greatest effect on food dose followed by fungi, wild vegetation, milk, and domestic vegetation least.
5 - Food dose was 98.559% of the total MEI dose with sportsman media containing the most potential dose (90.517%), survivalist fungi and wild type food second (7.896%), and public domestic food sources (0.146%) were the third pathway contributor.
6 - Collection years vary for some media. See Summary Statistics Table 4 for group category statistics.
7 - Totals of group averages and median values from Section 6.0, Summary Statistics Table 4.
8 - Add Table 1a difference column to AEI total.

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Table 5. Variability in SCDHEC and DOE-SR Media Dose Pathway Maximums, 2012

Environmental Monitors	SCDHEC				DOE-SR[1]			
Pathways - - - - - - -	Air	Liquid	Soil	Food	Air	Liquid	Soil	Food
Media and mrem Dose[2]	Single Highest Dose				DOE-SR MEI			
Water		0.255				0.230		
Inhalation	0.005				0.027			
Combined Soil[3]			0.002				3.012	
Swimming & Boating		0.022				0.000		
Milk (highest cow or goat)				0.000				0.007
Edible Vegetation				0.147				0.110
Creek Mouth Fish				0.893				0.220
Offsite Deer				6.150				1.100
Offsite Hog				10.920				0.900
Media Totals	0.005	0.276	0.002	18.110	0.027	0.230	3.012	2.337
Avg across media	0.005	0.138	0.002	3.622	0.027	0.115	3.012	0.467
SD	NA	0.165	NA	4.803	NA	0.163	NA	0.497
Median across media	0.005	0.138	0.002	0.893	0.027	0.115	3.012	0.220
2010 MEI Comparison	Media				Summary Statistics			
Program Standards (mrem)	Air[6]	Liquid[6]	Soil	Food	Totals(100)	Avg[4]	SD[5]	Median
SCDHEC	0.005	***0.276***	0.002	***18.110***	18.393	**4.598**	9.009	0.140
DOE-SR	***0.027***	0.230	***3.012***	2.337	5.606	**1.401**	1.498	1.283
Combined averages...	0.016	0.253	1.507	10.224	12.000	3.000	NA	0.712
with standard deviation...	0.016	0.033	2.128	11.154	9.042	2.261	NA	NA
Highest % of standard[6]...	**0.270**	**6.903**	***Highest media across programs Total (Italics)***				***21.426***	is <100 mrem

Notes:

1. Used highest DOE-SR MEI estimates from air, liquid, goat, irrigation, and sportsman pathways of the Savannah River Site Environmental Report for 2012, SRNS-STI-2013-00024.
   The sum of highest dose potential across programs in these media (21.426 mrem) is > the SCDHEC MEI of 19.845 mrem.
2. Some media are not directly comparable due to annual release estimates versus field accumulations over several years.
3. The combined soil reflects dose from surface and riverbank soil (SCDHEC), swamp and Steel Creek soils (DOE-SR).
4. Avg is average.
5. SD is standard deviation.
6. Percent (%) of DOE annual air (10 mrem) and liquid (4 mrem) releases using highest program dose.
   Percent of dose is not applicable to accumulated dose over several years.
   The 21.426 mrem total was higher than the outer bound based on SCDHEC maximum potential of 19.845 mrem.
   The combined averages with standard deviation may approximate an expected range of media maximum dose.
7. The SCDHEC single highest dose is based on one MAX detection exposure per media assumed constant throughout the year.
8. An individual could not be at all locations when maximum exposures were present and maintained that exposure as a constant throughout the year. Thus, these maximums represent available exposure without consideration of limiting factor

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Table 6. 1999-2012 DOE-SR Percent of Total Dose to the MEI for Atmospheric and Liquid Releases

MEI from Atmospheric Releases Percent of Total Dose

DOE-SR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Plume	0.1	0.4	0.5	0.2	0.4	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.4
Ground	1.0	1.7	0.7	2.1	1.7	1.6	2.3	6.4	3.8	0.30	3.2	2.7	4.5	11.2
Inhalation	48.3	45.7	42.6	41.0	33.5	43.4	42.7	41.6	41.1	43.20	41.1	47.0	36.3	27.1
Vegetation	44.4	41.9	44.1	44.5	51.9	39.4	40.7	46.3	39.6	39.32	38.7	32.2	42.4	44.2
Cow Milk	4.6	7.3	9.0	9.1	9.6	11.3	10.3	1.5	10.9	12.34	12.2	17.4	16.1	16.1
Meat	1.7	2.9	3.2	3.2	2.9	4.4	4.0	4.3	4.6	4.84	4.7	0.7	0.8	1.1

Cow Milk Pathway % Dose

1999-2012	Avg	SD	Median
Plume	0.1	0.2	0.0
Ground	3.1	2.8	2.2
Inhalation	41.0	5.6	42.1
Vegetation	42.1	4.5	42.1
Cow Milk	10.5	4.4	10.6
Meat	3.1	1.5	3.2

MEI from Liquid Releases Percent of Total Dose

DOE-SR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Fish	61.0	45.8	40.2	42.5	55.4	47.0	59.0	59.0	51.0	43.0	64.0	61.0	72.0	68.0
Water	38.5	53.9	59.5	57.2	44.2	53.0	41.0	41.0	49.0	57.0	36.0	39.0	27.0	31.0
Shoreline	0.4	0.3	0.3	0.3	0.4	<1	<1	<1	<1	<1	<1	<1	<1	<1
Swimming	0.0	0.0	0.0	0.0	0.0	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boating	0.0	0.0	0.0	0.0	0.0	<1	<1	<1	<1	<1	<1	<1	<1	<1

Potential MEI % Dose Liquid Releases

1999-2012	Avg	SD	Median
Fish	54.9	10.1	57.2
Water	44.8	10.3	42.6
Shoreline	0.3	0.1	0.3
Swimming	0.0	0.0	0.0
Boating	0.0	0.0	0.0

Notes:

1 - See the list of acronyms for abbreviation definitions.

2 - Data accumulated from the DOE-SR SRS Environmental Reports for the listed years.

Table 7. 1999-2012 DOE-SR Committed Dose (mrem) for MEI and Sportsman Pathways (DOE-SR)

Path / Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
All Pathway[5]	0.28	0.18	0.18	0.18	0.19	0.15	0.13	0.20	0.10	0.12	0.12	0.11	0.21	0.26
Onsite Hunter[3]	77.00	63.00	14.00	39.50	15.60	70.80	8.80	22.00	9.00	13.00	8.4	12.37	14.7	14.5
Offsite Hunter[4]	9.10	10.10	4.93	16.60	5.60	21.70	8.30	9.60	4.80	8.60	4.44	3.27	3.64	4.04
Offsite Fisherman	0.61	1.18	0.64	0.62	0.66	0.71	0.52	0.52	0.50	0.37	0.38	0.40	0.35	0.17
Total Potential Dose	**86.99**	**74.46**	**19.75**	**56.9**	**22.05**	**93.36**	**17.75**	**32.32**	**14.4**	**22.09**	**13.34**	**16.15**	**18.9**	**18.966**

1999-2012	Onsite Plus Offsite Statistics					Offsite Only Statistics					
Critical Pathways	Avg	SD	Median[6]	Totals	%	Avg	SD	Median[6]	Totals	%	
All Pathway	**0.17**	0.05	**0.18**	2.41	0.475	0.172	0.055	0.18	2.41	1.9318	Measured
Onsite Hunter	**27.33**	24.67	**14.60**	382.67	75.41	NA	NA	NA	NA	NA	Measured
Offsite Hunter	**8.19**	5.30	**6.95**	114.72	22.61	8.194	5.298	6.95	114.72	91.955	Hypothetical
Offsite Fisherman	**0.54**	0.24	**0.52**	7.63	1.503	0.545	0.236	0.52	7.626	6.1127	Measured
Total Potential Dose	**36.24**	**30.26**	**22.25**	507.43	100	**8.911**	**5.589**	**7.65**	**124.76**	**100**	

Notes: Total potential dose never exceeded 100 mrem in any year 1999-2012.

1 - See the list of acronyms for abbreviation definitions.

2 - Data accumulated from the DOE-SR SRS Environmental Reports for the listed years.

3 - The onsite hunter includes turkey, deer, and hog when available.

4 - The offsite hunter includes deer and hog (when available) for this total.

5 - The DOE-SR All-Pathway dose is for the liquid and airborne pathways excluding the sportsman dose.

6 - The median is a better estimate of data central tendency due to large amounts of environmental data, the use of detections only in statistics, and the very conservative consumption factors.

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Figure 1. DOE-SR Critical Pathways and Dose Media

SRS Exposure Pathway

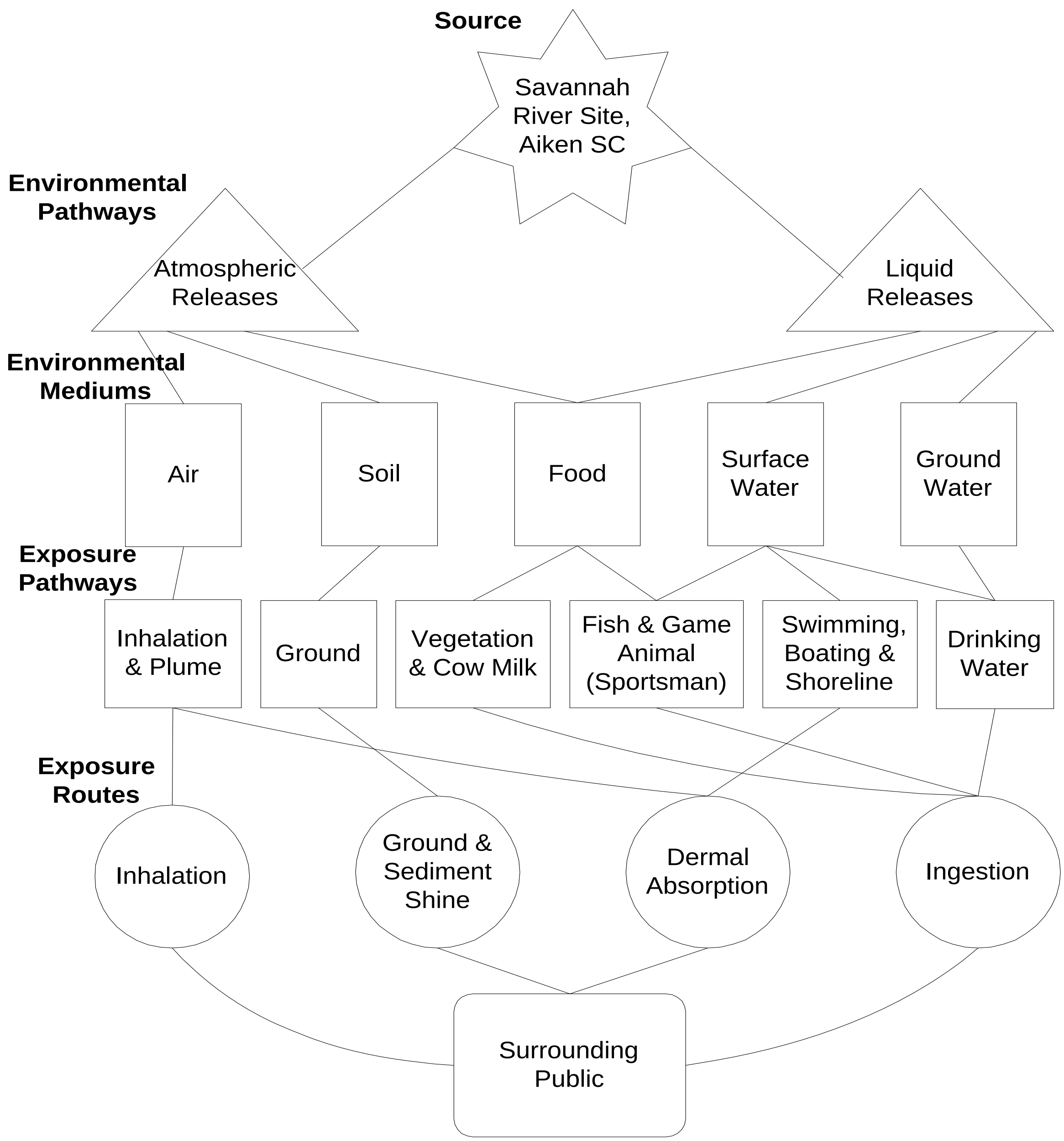

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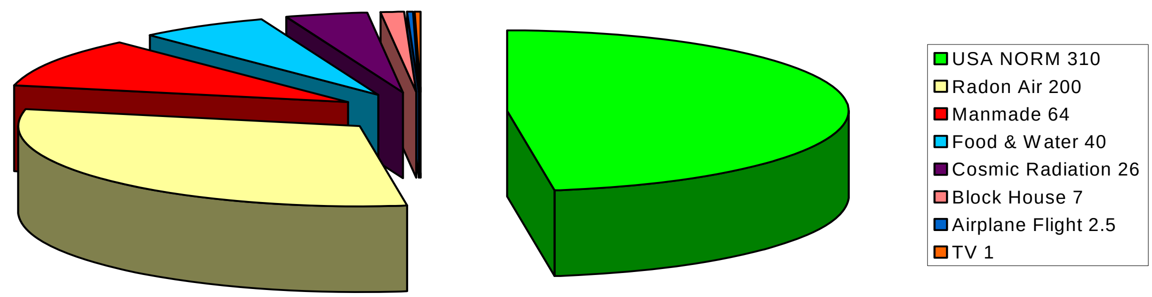
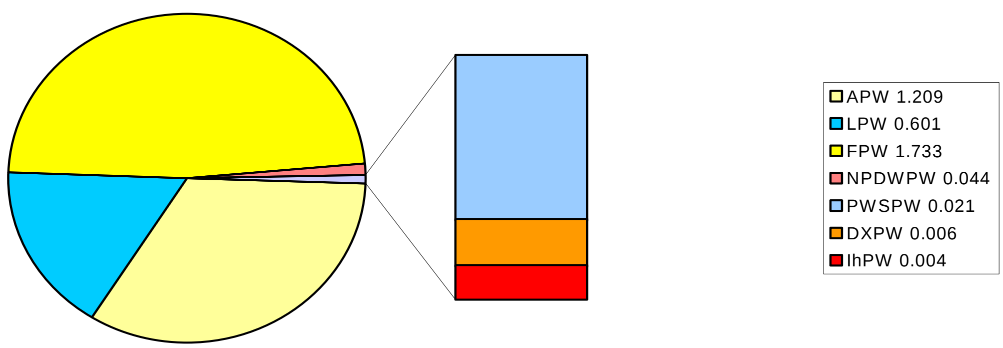
Figure 2. Comparison of Average Dose Exposures (mrem/yr)



Notes:
1 - The average naturally occurring radioactive material (NORM) background dose is 310 mrem in USA.
2 - Pie sections are relative to each other and not to percent of total.

Figure 3. 1999-2012 Critical Pathway Dose (mrem/yr) Average Comparison



Notes: Data from Summary Statistics Table 3, Section 7.0.
1 - These pie sections are relative to each other and not to a total.
2 - There are two major pathways (PW) for radiation exposure, APW (atmospheric pathway) and LPW (liquid pathway). The APW and LPW combined average exposure is less than that from a coast-to-coast airplane flight (Figure 2), and only slightly greater than the FPW (food pathway) exposure. The FPW portion of the APW and LPW is 1.733/1.810 or 95.75 % of the period 1999-2012.
3 - The two major routes of exposure (APW and LPW) can be subdivided into five subpathways for the observed data. The observed potential dose exposure in SCDHEC samples occurred in the following subpathways: FPW (food), IhPW (inhalation), DXPW (direct exposure or shine), PWSPW (public water system pathways), and NPDWPW (nonpotable drinking water pathways). Wild game and wild vegetation is the dominant exposure route for the SCDHEC MEI.
4 - Compare these relative dose levels with the higher NORM exposure levels in Figure 2.

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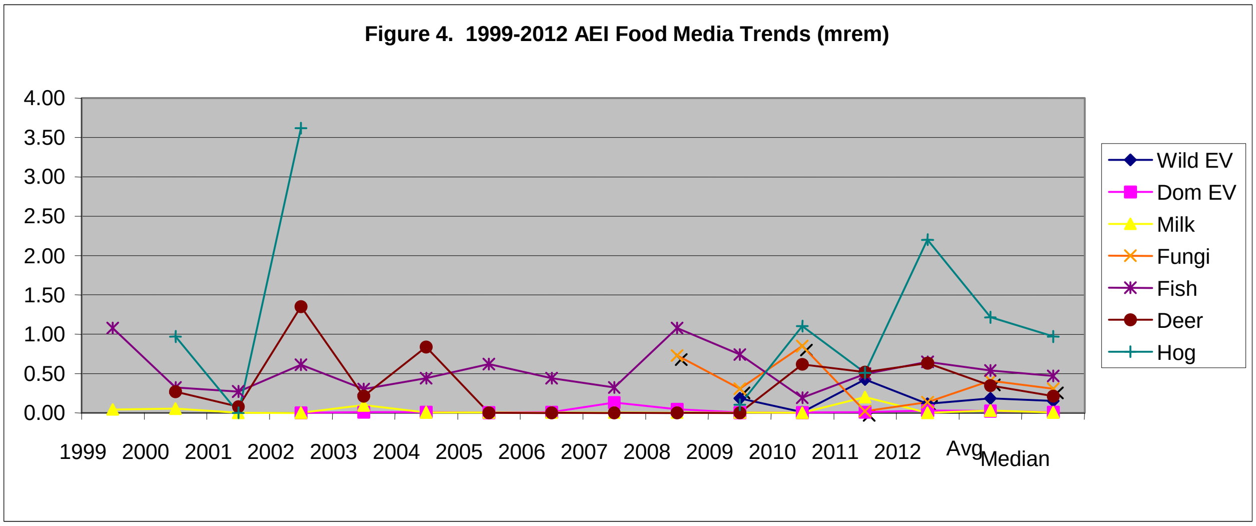
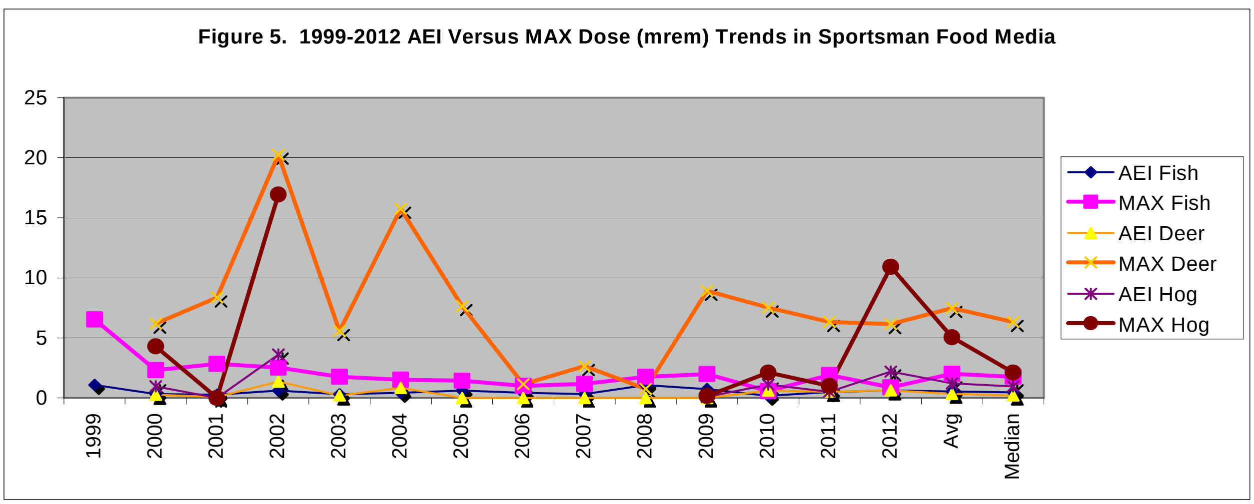


Notes:
1 - The AEI food dose is mostly due to wild-type sources and the central tendency is typically less than 1.5 mrem Avg and 1.0 mrem Median.
2 - Dom EV is domestic edible vegetation.
3 - AEI Median dose (mrem) order: Hog (0.970), fish (0.468), fungi (0.306), deer (0.210), wild EV (0.152), dom EV (0.010), and Milk (0.003).
4 - The median is the best central tendency approximation for large amounts of environmental data (Gilbert 1987).



Notes:
1 - AEI is the average detected dose above a South Carolina background.
2 - MAX is the single highest maximum detected dose as if it occurred throughout the year.
3 - Wild food contains most of the dose exposure and can be stored and used throughout the year.
4 - The potential dose order changes radically when based on a single highest dose.
5 - Compare Max/AEI Median estimates (mrem): Deer 6.33/0.210, Hog 2.12/0.97, and Fish 1.766/0.468.

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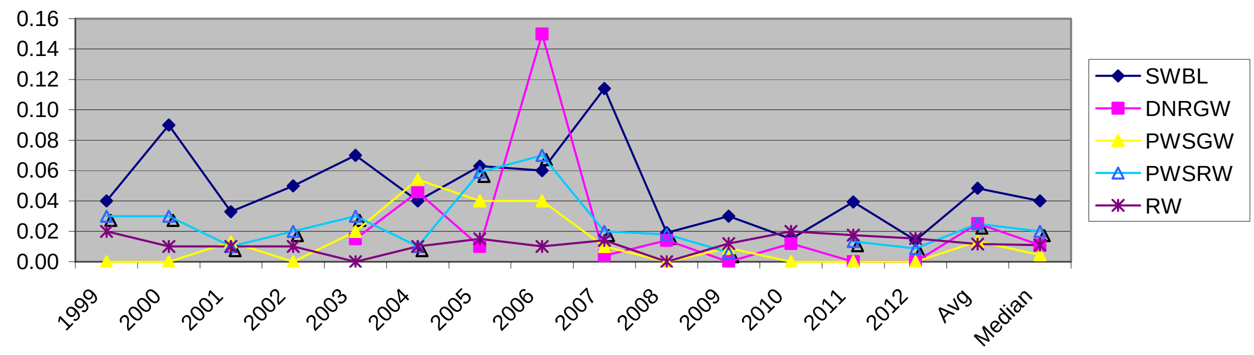
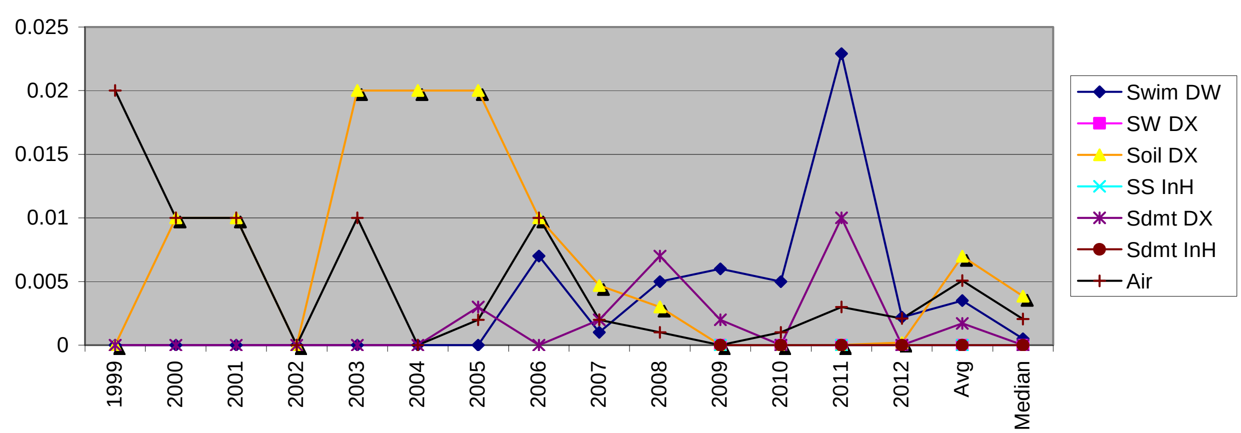
Figure 6. 1999-2012 AEI Dose (mrem) Trends in Water Sources



Notes: AEI Medians (mrem)
1 - SWBL (0.04) is surface water at boat landings.
2 - DNRGW (0.01) is Department of Natural Resources wellwater, and is comparable to private wells.
3 - PWSGW (0.0045) is public water system groundwater sources.
4 - PWSRW (0.02) is public water system riverwater sources.
5 - RW (0.01) is rainwater.
6 - Water source dose, whether potable or nonpotable, is minor compared to wild food sources.

Figure 7. 1999-2012 AEI Trends in Minor Dose Media (mrem)



Notes: AEI Medians (mrem)
1 - Swim DW (0.0005) means incidental drinking water while swimming.
2 - SW DX (0.0000) is direct exposure from surface water.
3 - Soil DX (0.004) is direct exposure from soil.
4 - SS InH (0.0000) is the inhalation of resuspended surface soil.
5 - Sdmt DX (0.0000) is direct exposure from riverbank sediments.
6 - Sdmt InH (0.0000) is the inhalation of resuspended riverbank soil.
7 - Air (0.002) is direct atmospheric inhalation.
8 - Air, soil, sediments, and swimming exposure were less than the E-2 comparative mrem dose level.

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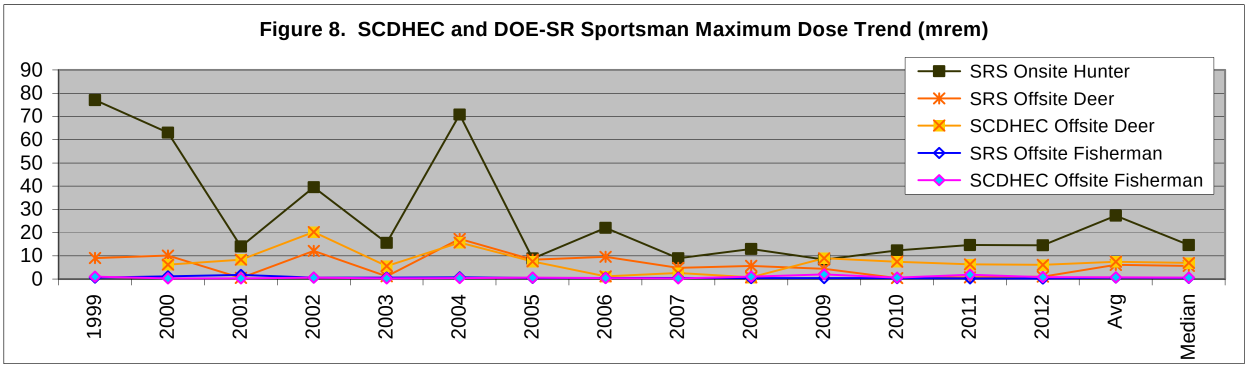
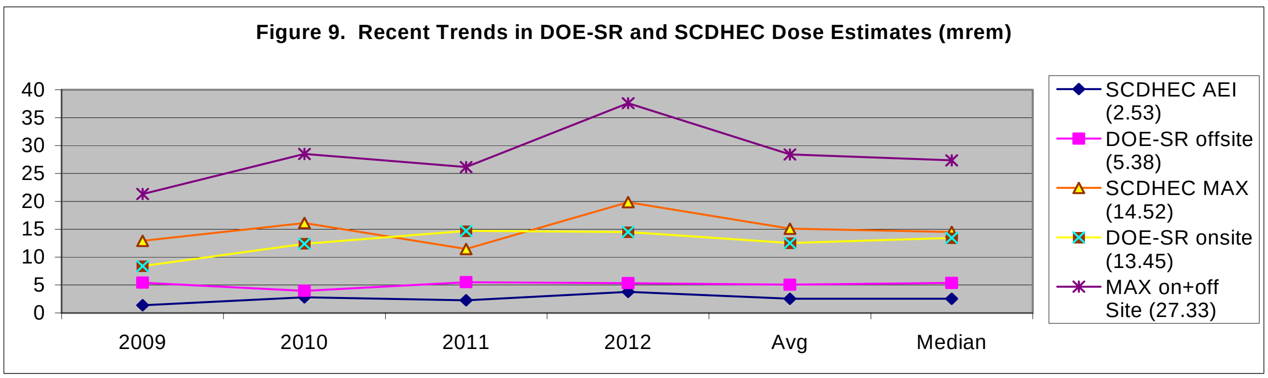


Notes: Medians (mrem) are the best estimate of environmental central tendency due to protective factors in estimates (Dose Critique).
1 - The onsite Max hunter dose median has declined to 14.7 mrem and appears almost flat since 2007.
2 - The offsite deer dose median range estimate is 6.93 mrem (SCDHEC) to 5.7 mrem (DOE-SR).
3 - The offsite fisherman dose median range estimate is 0.58 mrem (SCDHEC) to 0.52 mrem (DOE-SR).
4 - The average versus median shows that variation in extremes in the SRS offsite dose are approaching a low point.



Notes: Comparison updated since the addition of wild edible vegetation and fungi, and medians (mrem) are in parenthesis.
1 - DOE-SR Table 6-4&5 (SRNS 2009-2013) reference doses (DOE-SR offsite and onsite) of annual estimates.
2 - See SCDHEC Table 1a (SCDHEC AEI and MAX) offsite reference doses (SCDHEC 2009-2013) for 2009-2012.
3 - The upper bound of highest offsite plus onsite dose potentials is 28.392 plus or minus 6.821 mrem (SD).
4 - The 2012 combined SCDHEC and DOE-SR dose (37.453 mrem) is within 2sd of dose calculated on the same media basis.
5 - SCDHEC detected offsite AEI dose accumulations are less than the annual DOE-SR offsite estimates..
6 - Note trend in MAX on+off Site dose with a slight increase in overall average dose or extremes.
7 - However, the median, which indicates the environmental central tendency of most data, remains less than the average.

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Notes:

1 – The following “Average Dose” data tables subtract an average background activity from the average activity of the listed radionuclide found in a media.

2 – The “Single Highest Dose” data tables subtract the same average background from the single highest maximum for a particular radionuclide found in a media.

3 – The resultant net activity is multiplied by a consumption rate and dose factors from USEPA FGR sources to obtain the dose result for a particular radionuclide and media source. The 2006 Dose Report and 2007 Critical Pathway Dose plan explain how these calculations result in a dose estimate in millirems per year.

4 – The last column/page gives the resultant dose that was assigned to the maximum exposed individual.

5 – Alpha, beta, and beta-gamma dose is no longer included since these are screening values with assigned dose for calculating an upper bound. The maximum dose from the single highest detected dose per radionuclide per media replaces this upper bound calculation with an actual detected radionuclide factor instead of an assigned substitute factor.

6 – See the list of acronyms, radionuclides, and units for abbreviation definitions.

7 - Section 4.0, Table 1 places the dose from media sources into applicable critical pathway categories. There are many crossover pathways; for example liquid dose can result in both direct exposure to the swimmer and water ingestion. Specific knowledge of the science, radionuclides, media, locations, and supporting media are required to properly assign dose as NORM or nonNORM. Only nonNORM dose is included in these tables.

8 – Calculations by SCDHEC are to three decimal places in millirem determinations and rounded as needed for appropriate comparisons to DOE-SR data.

9 – NORM activity is not included since total (Ttl) yearly NORM detections are far less than the 300 mrem average background.

10 – Edibility of wild plants is based on Porcher (1863, 2001) and fungi on Lincoff (1981).

11 – Data Table abbreviations are defined in the acronym section.

12 – All <MDA results are assigned as 0.000 mrem.

2012 Average Dose Detections in Food Media

Project Media	Radionuclide	AOC Activity	SCbkg Activity	Net Activity	MCR	Dose mrem	Summaries Species Average	Summaries Species Totals	MEI Dose NonNORM Basis
Potential Dose from Fish Ingestion							Average per Isotope	Totals per Isotope	
Fish		pCi/g	pCi/g	pCi/g	kg/yr	mrem			
Bass	**H-3**	**0.382**	0.000	**0.382**	48.2	**0.0012**	Totals per Fish type		
	Cs-137	**0.240**	0.000	**0.240**	48.2	**0.5784**	**H-3**	**H-3**	**0.006**
	Sr-89/90	**0.079**	0.100	0.000	48.2	0.0000	0.002	0.012	
	Bass nonNORM dose average					0.1932	*Bass Total*	*0.580*	
Catfish	**H-3**	**0.311**	0.000	**0.311**	48.2	**0.0010**	**Cs-137**	**Cs-137**	**0.578**
	Cs-137	**0.055**	0.000	**0.055**	48.2	**0.1326**	0.355	0.711	
	Sr-89/90	**0.070**	0.040	**0.030**	48.2	**0.0173**	*Catfish Total*	*0.151*	
	Catfish nonNORM dose average					0.0503	**Sr-89/90**	**Sr-89/90**	**0.062**
Sunfish	**H-3**	**1.962**	0.000	**1.962**	48.2	**0.0061**	0.036	0.108	
	Sr-89/90	**0.107**	0.000	**0.107**	48.2	**0.0617**	*Sunfish Total*	*0.068*	
	Sunfish nonNORM dose average					0.0339			
Mullet	**H-3**	**0.428**	0.000	**0.428**	48.2	**0.0013**			
	Sr-89/90	**0.050**	0.000	**0.050**	48.2	**0.0288**	*Mullet Total*	*0.030*	
	Mullet nonNORM dose average					0.0151			
Red Drum	**H-3**	**0.805**	0.000	**0.805**	48.2	**0.0025**	*Red Drum Total*	*0.002*	
	Average Dose all Fish types (Detections only)					*0.0590*	***All Fish total***	*0.831*	
Potential Dose from Milk Ingestion									**0.000**
Cow		**pCi/L**	**pCi/L**	**pCi/L**	**kg/yr**	**mrem**	**nonNORM in Cow Milk**		
	H-3	<LLD	<LLD	**0.000**	230.0	0.0000			
	Sr-89/90	**0.594**	0.451	**0.143**	230.0	**0.0004**			
	I-131	<MDA	<MDA	**0.000**	230.0	0.0000		**Cow Milk Total**	
	Cow milk nonNORM dose avg					0.0001		0.000	
Avg Potential Dose From Game									**2.830**
Game Animal		**Study Area Avg**		**Bkg Average**		**Annual**	**Avg Basis**	**Game Total**	
Ingestion	**Isotope**	**mrem**		**mrem**		**mrem**	1.415	2.830	
Avg Deer	**Cs-137**	**0.870**		**0.240**		**0.6300**			
Avg Hog	**Cs-137**	**2.200**		0.000		**2.2000**			
	Game Animal nonNORM dose average					1.4150			
Potential Dose from NonNorm in Edible Vegetation									
Edible Vegetation	**Isotope**	**pCi/g**	**pCi/g**	**pCi/g**	**kg/yr**	**mrem**	**Leafy nonNORM Basis**		**0.000**
All Leafy	**H-3**	**0.289**	0.233	**0.056**	73.0	**0.0003**	**Total**	**0.000**	
Leafy Vegetables nonNORM Average						***0.0003***	**Fruit nonNORM Basis**		**0.146**
All Fruit	**H-3**	**0.237**	0.000	**0.237**	276.0	0.0042	**Totals**	**0.146**	
	Sr-89/90	**0.022**	0.000	**0.022**	276.0	0.0710			
Wild Fruit only	**Sr-89/90**	**0.034**	0.000	**0.034**	276.0	**0.1129**	**Use highest dose per radionuclide.**		
	H-3	**0.237**	0.000	**0.237**	276.0	**0.0042**	All fruit tritium detections were		
Domestic Fruit	**Sr-89/90**	**0.009**	0.000	**0.009**	276.0	**0.0291**	in wild types.		
Vegetable fruits nonNORM Average						***0.0376***	**Fungi nonNORM Basis**		
Fungi	**H-3**	**0.403**	0.212	**0.191**	3.65	**0.0000**	**Totals**	**0.135**	**0.135**
Fungi	**Cs-137**	**1.031**	0.294	**0.737**	3.65	**0.1345**			
Fungi nonNORM Average						***0.0673***			
All EV - average by type		0.035	All EV - totals by type			0.2100	**Total nonNORM**		**3.758**

Table notes:

1 - Underlined bolded data is the highest detection per isotope by media type contributing to the stated MEI value.

2 - Fish and edible vegetation total MEI dose is based on adding the highest values per each radionuclide regardless of species.

3 - These edible fungi were not identified to species level. Most boletes are edible and other edible fungi potential dose was added only as a special case representing a minority consumer of wild mushrooms.

4 - <LLD and <MDA are entered as a zero average detection and biases the dose high.

5 - Statistics are based only on detections resultant dose and are biased high as a result.

2012 Single Highest Dose (MAX) Detections in Food Media

Project		AOC	SCbkg	Net	MCR	Dose	Summaries		MEI
Media	Radionuclide	Activity	Activity	Activity		mrem	Species		Dose
Potential Dose from Fish Ingestion							Average	Totals	NonNORM
Fish		pCi/g	pCi/g	pCi/g	kg/yr	mrem	per Isotope		Basis
Bass	H-3	0.852	0.000	0.852	48.2	0.0026	Totals per Fish type		
	Cs-137	0.320	0.000	0.320	48.2	0.7712	H-3	H-3	0.018
	Sr-89/90	0.130	0.100	0.030	48.2	0.0173	0.005	0.026	
	Bass non-NORM dose average					0.2637	*Bass Total*	*0.791*	
Catfish	H-3	0.362	0.000	0.362	48.2	0.0011	Cs-137	Cs-137	0.771
	Cs-137	0.060	0.000	0.060	48.2	0.1446	0.458	0.916	
	Sr-89/90	0.130	0.040	0.090	48.2	0.0519			
	Catfish non-NORM dose average					0.0659	*Catfish Total*	*0.262*	
Sunfish	H-3	5.944	0.000	5.944	48.2	0.0184	Sr-89/90	Sr-89/90	0.104
	Sr-89/90	0.180	0.000	0.180	48.2	0.1038	0.050	0.202	
	Sunfish nonNORM dose average					0.0611	*Sunfish Total*	*0.122*	
Mullet	H-3	0.428	0.000	0.428	48.2	0.0013			
	Sr-89/90	0.050	0.000	0.050	48.2	0.0288			
	Mullet nonNORM dose average					0.0151	*Mullet Total*	*0.030*	
Red Drum	H-3	0.805	0.000	0.805	48.2	0.0025	*Red Drum Total*	*0.002*	
	Average Dose all Fish types (Detections only)					*0.0816*	***All Fish total***	*1.144*	
Potential Dose from Milk Ingestion									0.000
Cow		pCi/L	pCi/L	pCi/L	kg/yr	mrem	H-3	I-131	
	H-3	<LLD	<LLD	0.000	230.0	<LLD	<MDA	<MDA	
	Sr-89/90	0.594	0.451	0.143	230.0	0.0004	Sr-89/90	Cow Total	
	I-131	<MDA	<MDA	0.000	230.0	<MDA	0.000	0.000	
	Cow milk nonNORM dose avg					0.0004			
Potential Dose From Game									17.070
Game Animal		Study Area Average		Bkg Average			Hunter Game MEI Total		
Ingestion		mrem		mrem		mrem	17.070		
MAX Deer	Cs-137	6.390		0.240		6.1500	Based on 4 deer/1 hunter		
MAX Hog	Cs-137	10.920		0.000		10.9200	Based on 2 hogs/1 hunter		
Hunter MEI	Cs-137	Deer & Hog				17.0700	Based on deer+ hog		
Deer & Hog	Game Animal nonNORM dose average					8.5350			
Potential Dose from NonNorm in Edible Vegetation									
Edible Vegetation	Isotope	pCi/g	pCi/g	pCi/g	kg/yr	mrem	Leafy nonNORM Basis		0.001
All Leafy	H-3	0.424	0.233	0.191	73.0	0.0009	Totals	0.001	
Leafy Vegetables nonNORM Average						0.0009	Fruit nonNORM Basis		0.146
All Fruit	H-3	0.249	0.000	0.249	276.0	0.0044	Totals	0.146	
All Fruit	Sr-89/90	0.034	0.000	0.034	276.0	0.1129			
wild fruit only	Sr-89/90	0.034	0.000	0.034	276.0	0.1129			
	H-3	0.249	0.000	0.249	276.0	0.0044	All fruit H-3 detections		
domestic fruit	Sr-89/90	0.009	0.000	0.009	276.0	0.0291	were in wild types.		
Vegetable/Fruits nonNORM Average						0.0587	Fungi nonNORM Basis		1.450
Fungi	H-3	0.462	0.212	0.250	3.7	0.0001	Totals	1.450	
Fungi	Cs-137	8.240	0.294	7.946	3.7	1.4501			
Fungi nonNORM avg						0.7251			
All EV - average by type		0.262	All EV - totals by type			1.5684	Total nonNORM		19.561

Table notes:

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2 - Fish and edible vegetation total MEI dose is based on adding the highest values per each radionuclide regardless of species.

3 - These edible fungi were not identified to species level. Most boletes are edible and other edible fungi potential dose was added only as a special case representing a minority consumer of wild mushrooms.

4 - <LLD and <MDA are entered as a zero average detection and biases dose high.

5 - Statistics are based only on detections resultant dose and are biased high as a result.

2012 Average Dose Detections in Water Media

Project		AOC	SCbkg	Net	MCR	Dose	Exposure Group	MEI
Water	Radionuclide	Activity	Activity	Activity		mrem		Dose
Sources	Radionuclide Ingestion From Surface Water (SW) and Wells							(mrem)
PWSRW(DW)		**pCi/L**	**pCi/L**	**pCi/L**	**L/yr**	**mrem**	**NonNORM in ……**	**0.009**
SW	**H-3**	**464**	278	**186**	730	**0.0087**	**PWSRW(DW)**	
Public Water Supplies (PWS) Drinking Water (DW) from the Savannah River (SR), Augusta Bkg								
Downstream river water near Savannah would be < surface water (SW) values below due to tributary dilutions.								
PWSGW(DW) Ingestion		**pCi/L**	**pCi/L**	**pCi/L**	**L/yr**	**mrem**	**NonNORM in ……**	**0.000**
GW	**H-3**	**253**	329	0	730	0.0000	**PWSGW(DW) Ingestion**	
PWS with Groundwater (GW) Sources used for drinking water (DW), PWS well bkg								
DNRGW		**pCi/L**	**pCi/L**	**pCi/L**	**L/yr**	**mrem**	**NonNORM in ……**	**0.000**
GW	**H-3**	<LLD	<LLD	0	730	0.0000	**DNRGW**	
DNR Monitoring Wells (comparable to local untreated private wells)								
Nonpotable DW		**pCi/L**	**pCi/L**	**pCi/L**	**L/yr**	**mrem**	**NonNORM in ……**	**0.014**
SW	**H-3**	**553**	251	**302**	730	**0.0141**	SW	
Survivalist Ingestion of SR water (drinking or cooking at Savannah River Boat Landings),UTRbkg								
Rainwater	**H-3**	**324**	0	**324**	730	**0.0152**	**NonNORM in ……**	**0.015**
Nonpotable Average Dose Potential from all sources.						0.0146	Rainwater	
Streams and Savannah River Surface Water Samples Excluding PWSRW(DW)								
Surface Water Swimming		**pCi/L**	**pCi/L**	**pCi/L**	**hrs/yr**	**mrem**	**NonNORM in ……**	**0.002**
Ingestion	**H-3**	**4051**	251	**3800**	91	**0.0022**	**SW Swimming**	
Incidental ingestion of water while swimming at Savannah River Site Creek Mouths								
Surface Water Immersion		**pCi/L**	**pCi/L**	**pCi/L**	**hrs/yr**	**mrem**	**NonNORM in ……**	**0.000**
Immersion	**H-3**	**4051**	251	**3800**	91	0.0000	**SW Immersion**	
Direct exposure to the skin while swimming at SRS Creek Mouths.								
Surface Water Shine		**pCi/L**	**pCi/L**	**pCi/L**	**hrs/yr**	**mrem**	**NonNORM in ……**	**0.000**
Boating	**H-3**	**4051**	251	**3800**	192	0.0000	**Surface Water Shine**	
Direct exposure to skin from SRS Creek Mouth Water while Boating or Fishing.								
Surface Water Shine		**pCi/L**	**pCi/L**	**pCi/L**	**hrs/yr**	**mrem**	**NonNORM in ……**	**0.000**
Resident	**H-3**	**4051**	251	**3800**	4380	0.0000	**Surface Water Shine**	
Direct exposure to skin from surface water while living in a boat or swamp house.								
Sediment at Creek Mouths								
Skin Dose - Wading exposure from 1 cm sediment depth.							**NonNORM in ……**	**0.000**
Sediment Dose		**pCi/g**	**pCi/g**	**pCi/g**	**hrs/yr**	**mrem**	**Sediment Dose**	
Creek Mouths	**Cs-137**	**0.390**	0.110	**0.280**	91	0.0000	Foot depression to	
	Pu-238	**0.008**	0.000	**0.008**	91	0.0000	1 cm depth.	
	Pu-239/240	**0.003**	0.000	**0.003**	91	0.0000		
Boat Landings	**Cs-137**	**0.190**	0.200	0.000	91	0.0000		
Avg dose to skin from wading in sediments at creek mouths and landings is <0.000.							**Total nonNORM**	**0.040**

Table notes:

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2 - <LLD and <MDA are entered as a zero average detection and biases dose high.

3 - Statistics are based only on detections resultant dose and are biased high as a result.

2012 Single Highest Dose (MAX) Detections in Water Media

Project Water Sources	Radionuclide	AOC Activity	SCbkg Activity	Net Activity	MCR	Dose mrem	Exposure Group	MEI Dose (mrem)
	Ingestion						Totals	
PWSRW(DW)		**pCi/L**	**pCi/L**	**pCi/L**	**L/yr**	**mrem**	**NonNORM in……**	**0.033**
SW	**H-3**	**975**	278	**697**	730	**0.0326**	**PWSRW(DW)**	
Savannah River Public Water Supplies (PWS) Drinking Water (DW)								
Includes RW from Chelsea, Beaufort Jasper, and City of Savannah minus Jackson boat landing background.								
PWSGW(DW) Ingestion		**pCi/L**	**pCi/L**	**pCi/L**	**L/yr**	**mrem**	**NonNORM in……**	**0.000**
GW	**H-3**	**253**	329	0.000	730	0.0000	**PWSGW(DW) Ingestion**	
Public Water Supplies with Groundwater (GW) Sources used for drinking water (DW)								
PWSGW(DW) Public Water Supplies from Wells.								
DNRGW		**pCi/L**	**pCi/L**	**pCi/L**	**L/yr**	**mrem**	**NonNORM in……**	**0.000**
GW	**H-3**	<LLD	<LLD	0.000	730	0.0000	**DNRGW**	
DNR Monitoring Wells (comparable to local untreated private wells)								
Nonpotable DW		**pCi/L**	**pCi/L**	**pCi/L**	**L/yr**	**mrem**	**NonNORM in……**	**0.255**
SW	**H-3**	**5694**	251	5443	730	**0.2546**	**SW**	
Survivalist ingestionof river water for drinking or cooking at Savannah River Boat Landings								
Rainwater	**H-3**	**531**	0.000	**531**	730	**0.0248**	**NonNORM in……**	**0.025**
Nonpotable Average Dose Potential from Rainwater and Boat Landings.						0.1397	Rainwater	
Streams and Savannah River Surface Water Samples Excluding PWSRW(DW)								
Surface Water Swimming		**pCi/L**	**pCi/L**	**pCi/L**	**hrs/yr**	**mrem**	**NonNORM in……**	**0.021**
Ingestion	**H-3**	**37042**	251	**36791**	91	**0.0215**	**SW Swimming**	
Incidental ingestion of water while swimming at Savannah River Creek Mouths								
Surface Water Immersion		**pCi/L**	**pCi/L**	**pCi/L**	**hrs/yr**	**mrem**	**NonNORM in……**	**0.000**
Immersion	**H-3**	**37042**	251	**36791**	91	0.0000	**SW Immersion**	
Direct exposure to the skin while swimming at SRS Creek Mouths								
Average Dose from Skin Exposure to Creek Water						0.0000		
Surface Water Shine		**pCi/L**	**pCi/L**	**pCi/L**	**hrs/yr**	**mrem**	**NonNORM in……**	**0.000**
Boating	**H-3**	**37042**	251	**5443**	192	0.0000	**Surface Water Shine**	
Direct exposure to skin from SRS Creek Mouth Water while Boating or Fishing								
Surface Water Shine		**pCi/L**	**pCi/L**	**pCi/L**	**hrs/yr**	**mrem**	**NonNORM in……**	**0.000**
Resident	**H-3**	**37042**	251	**36791**	4380	0.0000	**Surface Water Shine**	
Direct exposure to skin from surface water while living in a boat or swamp house.								
Sediment Random plus Nonrandom at Streams and Creek Mouths								
Skin Dose - Wading exposure from 1 cm sediment depth.							**NonNORM in……**	**0.000**
Sediment Dose		**pCi/g**	**pCi/g**	**pCi/g**	**hrs/yr**	**mrem**	**Sediment Dose**	
Creek Mouths	**Cs-137**	**0.691**	0.110	**0.581**	91	0.0001	Foot depression of sediment	
	Pu-238	**0.011**	0.000	**0.011**	91	0.0000	to 1 cm depth.	
	Pu-239/240	**0.004**	0.000	**0.004**	91	0.0000		
Boat Landings	**Cs-137**	**0.327**	0.200	**0.127**	91	0.0000		
Avg dose to skin from wading in sediments at creek mouths and landings is <0.000.							**Total nonNORM (mrem)**	**0.334**

Table notes:

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3 - Statistics are based only on detections resultant dose and are biased high as a result.

2012 Average Dose Detections in Soil and Air Media

Project	Radionuclide	AOC	SCbkg	Net	MCR	Dose	Exposure Group		MEI
Surface		**Activity**	**Activity**	**Activity**		**mrem**	**nonNORM**		**Dose**
Soil									**Total**
Surface Soil & Riverbank Soil Random plus Nonrandom Sample Detections									
Soil Ingestion									
Surface Soil (SS)		**pCi/g**	**pCi/g**	**pCi/g**	**mg/day**	**mrem**	**NonNORM……**		**0.000**
Ingestion	**Cs-137**	**0.140**	0.124	**0.016**	100	**0.0000**	Surface Soil (SS)		
Represents potential dose from ingesting farm soil with plants.							**Avg**	**Totals**	
Surface Soil Ingestion Statistics - All nonNORM dose.							0.000	0.000	
Riverbank Soil (RS)		**pCi/g**	**pCi/g**	**pCi/g**	**mg/day**	mrem	**NonNORM……**		**0.000**
Ingestion	**Cs-137**	**0.221**	0.127	**0.094**	100	**0.0002**	Riverbank Soil (RS)		
Riverbank Soil Ingestion Dose at Boat Landings.							**Avg**	**Totals**	
Riverbank Soil Ingestion Statistics - All nonNORM dose.							0.000	0.000	
Soil Shine									
Surface Soil		**pCi/g**	**pCi/g**	**pCi/g**	**hrs/yr**	**mrem**	**NonNORM……**		**0.000**
Shine	**Cs-137**	**0.140**	0.124	**0.016**	4380	**0.0001**	Surface Soil		
Radionuclide shine or direct exposure from farm soil.							**Avg**	**Totals**	
Surface Soil Direct Exposure Dose Statistics - All nonNORM dose.							0.000	0.000	
Riverbank Soil		**pCi/g**	**pCi/g**	**pCi/g**	**hrs/yr**	**mrem**	**NonNORM……**		**0.000**
Shine	**Cs-137**	**0.221**	0.127	**0.094**	4380	**0.0002**	Riverbank Soil		
Radionuclide shine or direct exposure from riverbanks.							**Avg**	**Totals**	
Riverbank Soil Direct Exposure Dose Statistics - All nonNORM dose.							0.000	0.000	
Atmospheric Inhalation									
Soil Resuspension and Air Inhalation Dose									
Surface Soil Resuspension		**pCi/g**	**pCi/g**	**pCi/g**	**m3/yr**	**mrem**	**NonNORM……**		**0.000**
	Cs-137	**0.140**	0.124	**0.016**	8000	**0.0000**	**Avg**	**Totals**	
Surface Soil Resuspension All Inhalation Avg Dose							0.000	0.000	
Riverbank Soil Resuspension		**pCi/g**	**pCi/g**	**pCi/g**	**m3/yr**	**mrem**	**NonNORM……**		**0.000**
	Cs-137	**0.221**	0.127	**0.094**	8000	**0.0000**	**Avg**	**Totals**	
Riverbank Soil Resuspension All Inhalation Avg Dose							0.000	0.000	
All Soil Resuspension (Surface Soil plus Riverbank)							**0.000**	0.000	
Air Inhalation		**pCi/m3**	**pCi/m3**	**pCi/m3**	**m3/yr**	**mrem**	**NonNORM……**		**0.002**
Inhalation	**H-3**	**4.127**	0.000	**4.127**	8000	**0.0021**	**Avg**	**Totals**	
							0.002	0.002	
Atmospheric inhalation avg		**0.001**	**Atmospheric inhalation total**			**0.0021**	**nonNORM total**		**0.003**

Table notes:

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3 - Statistics are based only on detections resultant dose and are biased high as a result.

2012 Maximum Dose Detections in Soil and Air Media

Project	Radionuclide	AOC	SCbkg	Net	MCR	Dose	Exposure Group		MEI
Surface		Activity	Activity	Activity		mrem	nonNORM		Dose
Soil									Total
Surface Soil & Riverbank Soil Random plus Nonrandom Sample Detections									
Soil Ingestion									
Surface Soil (SS)		pCi/g	pCi/g	pCi/g	mg/day	mrem	NonNORM……		0.001
Ingestion	Cs-137	0.413	0.124	0.289	100	0.0005	Surface Soil (SS)		
Represents potential dose from ingesting farm soil with plants.							Avg	Totals	
Surface Soil Ingestion Statistics - All nonNORM dose.							0.001	0.001	
Riverbank Soil (RS)		pCi/g	pCi/g	pCi/g	mg/day	mrem	NonNORM……		0.000
Ingestion	Cs-137	0.356	0.127	0.229	100	0.0004	Riverbank Soil (RS)		
Riverbank Soil Ingestion Dose at Boat Landings.							Avg	Totals	
Riverbank Soil Ingestion Statistics - All nonNORM dose.							0.000	0.000	
Soil Shine									
Surface Soil		pCi/g	pCi/g	pCi/g	hrs/yr	mrem	NonNORM……		0.002
Shine	Cs-137	0.413	0.124	0.289	4380	0.0018	Surface Soil		
Radionuclide shine or direct exposure from farm soil.							Avg	Totals	
Surface Soil Direct Exposure Dose Statistics - All nonNORM dose.							0.000	0.000	
Riverbank Soil		pCi/g	pCi/g	pCi/g	hrs/yr	mrem	NonNORM……		0.000
Shine	Cs-137	0.356	0.127	0.229	4380	0.0004	Riverbank Soil		
Radionuclide shine or direct exposure from riverbanks.							Avg	Totals	
Riverbank Soil Direct Exposure Dose Statistics - All nonNORM dose.							0.000	0.000	
Atmospheric Inhalation									
Soil Resuspension and Air Inhalation Dose									
Surface Soil Resuspension		pCi/g	pCi/g	pCi/g	m3/yr	mrem	NonNORM……		0.000
	Cs-137	0.413	0.124	0.289	8000	0.0000	Avg	Totals	
Surface Soil Resuspension All Inhalation Avg Dose							0.000	0.000	
Riverbank Soil Resuspension		pCi/g	pCi/g	pCi/g	m3/yr	mrem	NonNORM……		0.000
	Cs-137	0.356	0.127	0.229	8000	0.0000	Avg	Totals	
Riverbank Soil Resuspension All Inhalation Avg Dose							0.000	0.000	
All Soil Resuspension (Surface Soil plus Riverbank)							0.000	0.000	
Air Inhalation		pCi/m3	pCi/m3	pCi/m3	m3/yr	mrem	NonNORM……		0.005
Inhalation	H-3	8.815	0.000	8.815	8000	0.0045	Avg	Totals	
							0.005	0.005	
Atmospheric inhalation avg		0.002	Atmospheric inhalation total			0.0045	nonNORM total		0.008

Table notes:

1 - Underlined data is the highest detection per isotope by media contributing to the stated MEI value.

2 - <LLD and <MDA are entered as a zero average detection and biases dose high.

3 - Statistics are based only on detections resultant dose and are biased high as a result.

6.0 Summary Statistics
2012 Critical Pathway Dose Report

Table 1. Detection (D#) Dose Statistics for Radionuclides of Concern (Milllirems & %)..................45

Table 2. The 1999-2012 AEI Basis Media Statistics & Special MAX Categories of Dose (mrem) 45

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Notes: Refer to the acronym section for definitions.

Summary Statistics
2012 Critical Pathway Dose Report

Summary Statistics Table 1. Detection (D#) Dose Statistics for Radionuclides of Concern (Millirems and Percentages)

1999-2012	mrem	%	avg	sd	median	max	D#
Cs-137	**24.827**	86.74	**0.468**	0.770	**0.265**	**4.770**	49
Sr-89/90	**1.452**	5.07	**0.069**	0.097	**0.023**	**0.350**	21
H-3	**1.281**	4.48	**0.009**	0.013	**0.003**	**0.073**	99
Sr-90	**0.436**	1.52	**0.145**	0.241	**0.009**	**0.424**	3
I-131	**0.202**	0.71	**0.101**	0.143	**0.101**	**0.202**	1
Sr-89	**0.185**	0.65	**0.062**	0.093	**0.014**	**0.169**	3
Eu-155	**0.119**	0.42	**0.060**	0.074	**0.060**	**0.112**	2
Zn-65	**0.073**	0.26	**0.073**	NA	**0.073**	**0.073**	1
Am-241	**0.039**	0.14	**0.020**	0.012	**0.020**	**0.028**	2
Am-243	**0.003**	0.01	**0.003**	NA	**0.003**	**0.003**	1
Zr-95	**0.002**	0.01	**0.002**	NA	**0.002**	**0.002**	1
Pu-239/240	**0.002**	0.01	**0.001**	0.000	**0.001**	**0.001**	2
Pu-238	**0.001**	0.00	**0.001**	NA	**0.001**	**0.001**	1
Tc-99	**0.001**	0.00	**0.000**	0.000	**0.000**	**0.001**	2
Totals	28.623	100.00	1.014	NA	0.574	6.209	188
2012	**mrem**	**%**	**avg**	**sd**	**median**	**max**	**D#**
Cs-137	**3.543**	93.24	**0.591**	0.836	**0.356**	**2.200**	6
Sr-89/90	**0.204**	5.38	**0.051**	0.048	**0.046**	**0.113**	4
H-3	**0.053**	1.38	**0.005**	0.006	**0.002**	**0.015**	7
Totals	3.800	100.00	0.646	0.890	0.404	2.328	17

Notes:
1 - All data is on an AEI basis and statistics are based on detections only.
2 - This table is not directly comparable to other tables for this summary is based on all media dose regardless of applicability
3 - NORM radionuclide detections not of concern (e.g. K-40) are not included in this chart.
4 - D# refers to number of detections and is not the total N# or number of samples, which is far greater.
5 - This table and others include updates of past data and copied rounding errors.

Summary Statistics Table 2. 1999-2012 AEI Basis Media Statistics and Special MAX Cateferies of Dose (mrem)

AEI Media Cateories	2012 Totals	1999-2012	AEI % Basis	Avg.	SD	Median
Surface Water at Boat Landings	0.014	0.413	1.63	**0.030**	0.015	**0.030**
DNRGW	0.000	0.041	0.16	**0.004**	0.007	**0.000**
PWSGW	*0.000*	0.092	0.36	**0.007**	0.012	**0.000**
PWSRW	*0.009*	0.201	0.79	**0.015**	0.009	**0.013**
Rainwater	0.015	0.161	0.63	**0.011**	0.006	**0.013**
Swimming ingestion, Savannah River	0.002	0.056	0.22	**0.004**	0.006	**0.002**
Surface Water Direct Exposure	0.000	0.000	0.00	**0.000**	0.000	**0.000**
Soil	0.000	0.051	0.20	**0.004**	0.005	**0.000**
Surface Soil Resuspension Inhalation	0.000	0.000	0.00	**0.000**	0.000	**0.000**
Sediment Direct Exposure	0.000	0.031	0.12	**0.002**	0.004	**0.001**
Sediment Resuspension Inhalation	0.000	0.000	0.00	**0.000**	0.000	**0.000**
Air	0.002	0.057	0.23	**0.004**	0.008	**0.002**
Wild Vegetation	0.117	0.732	2.89	**0.183**	0.177	**0.152**
Domestic Vegetation	0.029	0.248	0.98	**0.023**	0.039	**0.008**
Milk	0.000	0.612	2.42	**0.044**	0.069	**0.004**
Edible Fungi	0.135	2.039	8.06	**0.408**	0.365	**0.306**
Fish[2]	0.646	7.547	29.82	**0.539**	0.280	**0.468**
Deer[2]	0.630	4.517	17.85	**0.347**	0.421	**0.210**
Hog[2]	2.200	8.505	33.61	**1.215**	1.294	**0.970**
Totals	**3.800**	**25.304**	**100.00**	2.841	NA	2.178
Millirems of Potential Exposure	**2012 Totals**	**1999-2012**	**AEI % check**	**Avg.**	**SD**	**Median**
MAX Deer2	6.150	97.245	55.85	**7.480**	5.409	**6.330**
MAX Hog2	10.920	35.450	20.36	**5.064**	6.467	**2.120**
MAX Fish2	0.893	28.261	16.23	**2.019**	1.447	**1.766**
MAX Fungi	1.450	11.198	6.43	**2.240**	1.896	**1.450**
MAX EV	0.147	1.072	0.62	**0.179**	0.190	**0.140**
MAX Milk	0.000	0.880	0.51	**0.063**	0.103	**0.018**
Totals	**19.560**	**174.106**	**100.00**	17.045	NA	11.824
Millirems of Potential Exposure	**2012 Totals**	**1999-2012**	**% of Totals**	**Avg.**	**SD**	**Median**
Offsite Hunter (deer plus hog) Max Basis	17.070	132.695	76.22	**10.207**	9.469	**8.36**
Offsite Hunter (deer plus hog) AEI	2.830	13.022	51.46	**1.002**	1.472	**0.21**

Notes:
1 - This table includes dose error corrections and updates, and is not directly comparable to Section 4.0 Table 1.
2 - Selections of applicable dose alter totals between tables, e.g., the 2012 dose estimate includes only one water source and small contributions that are not shown round up or down (hidden decimal places).
3 - Ttl yrs means total number of years of data or sample collection results.
4 - MAX basis does not include all media, but does all food, which is 98.559 % of MEI (Section 4.0, Table 4).

Summary Statistics
2012 Critical Pathway Dose Report

Summary Statistics Table 3. 1999-2012 AEI Critical Pathways, Subpathways, and Potential Exposure Summary

AEI Basis Critical Pathways Dose (mrem) Totals 1999-2012		Millirems	% of Total	Avg.	SD	Median
Atmospheric Pathway (APW)[1]		16.923	66.88	1.209	1.465	0.697
Liquid Pathway (LPW)[2]		8.382	33.12	0.601	0.283	0.549
Subpathways	Food or Ingestion (FPW)[3]	24.203	95.64	1.733	1.483	1.409
	Inhalation (IhPW)[4]	0.057	0.23	0.004	0.008	0.002
	Direct Exposure (DXPW)[5]	0.082	0.32	0.006	0.007	0.003
	Public Water Supply (PWSPW)[6]	0.293	1.16	0.021	0.011	0.020
	Nonpotable Drinking Water (NPDWPW)[7]	0.671	2.65	0.044	0.016	0.042

Notes:
1 – APW is the atmospheric pathway inhalation plus deposition dose.
2 – LPW is the liquid pathway or water dose.
3 – FPWis the food subpathway.
4 – IhPW is the inhalation subpathway.
5 – DXPW is the direct exposure subpathway.
6 – PWSPW is the public water systems drinking water subpathway.
7 – NPDWPW is the nonpotable or untreated drinking water subpathway.
8 - Does not include alpha, beta, or beta-gamma since they are nonspecific screening values.

Summary Statistics Table 4. Food Media, AEI and MAX Food Basis Category Comparisons

AEI Food Category Basis Dose Statistics								
Route	Pathway	Media	2012	1999-2012 & AEI% Basis		Avg.	SD	Median
APW	FPW	Wild EV 09-12	0.117	0.732	74.47	0.183	0.177	0.152
APW	FPW	Domestic EV	0.029	0.251	25.53	0.023	0.039	0.008
EV AEI Food Category		Totals & Statistics	0.146	0.983	100.00	0.103	0.1129	0.080
APW	FPW	All EV 02-12	0.146	0.983	4.06	0.103	0.113	0.080
APW	FPW	Milk	0.000	0.612	2.53	0.044	0.069	0.004
APW	FPW	Fungi	0.135	2.039	8.43	0.408	0.365	0.306
LPW	FPW	Fish	0.646	7.547	31.18	0.539	0.280	0.468
APW	FPW	Deer	0.630	4.517	18.66	0.347	0.421	0.210
APW	FPW	Hog	2.200	8.505	35.14	1.215	1.294	0.970
All AEI Food Categories		Totals & Statistics	3.757	24.203	100.00	2.656	NA	2.038
MAX Food Category Basis Dose Statistics								
Route	Pathway	Media	2012	1999-2012 Ttl & AEI% Basis		Avg.	SD	Median
APW	FPW	MAX Deer	6.150	97.245	55.85	7.480	5.409	6.330
APW	FPW	MAX Hog	10.920	35.450	20.36	5.064	6.467	2.120
APW	FPW	MAX Fish	0.893	28.261	16.23	2.019	1.447	1.766
APW	FPW	MAX Fungi	1.450	11.198	6.43	2.240	1.896	1.450
APW	FPW	MAX EV	0.147	1.072	0.62	0.179	0.190	0.140
APW	FPW	MAX Milk	0.000	0.880	0.51	0.063	0.103	0.018
All MAX Food Categories		Totals & Statistics	19.560	174.106	100.00	17.045	NA	11.824
Food Category Combinations Dose Statistics								
AEI Combined Food Categories			2012	1999-2012 & AEI% Basis		Avg.	SD	Median
AEI nonGame (EV,Milk) Food			0.147	1.595	6.59	0.074	0.042	0.074
AEI Fish&Game Food (Fish,Deer,Hog)			3.476	20.569	84.99	0.700	0.456	0.539
Atypical Fungi (Wild Mushroom) Consumer			0.135	2.039	8.43	0.408	0.365	0.306
AEI Totals Across Categories			3.757	24.203	100.00	1.182	NA	0.919
MAX Combined Food Categories			2012	1999-2012	% Basis	Avg.	SD	Median
MAX nonGame (EV,Milk) Food			0.147	1.952	1.12	0.121	0.082	0.079
MAX Fish&Game (Fish,Deer,Hog)			17.963	160.956	92.447	4.855	2.737	2.120
Atypical Fungi (Wild Mushroom) Consumer			1.450	11.198	6.43	2.240	1.896	1.450
MAX Totals Across Categories			19.560	174.106	100.00	7.216	NA	3.649
Special MEI Category Totals			2012	1999-2012	% Basis	Avg.	SD	Median
Hunter MEI (Game-Deer plus Hog)			17.070	132.695	NA	6.272	1.708	4.225
MEI Survivalist MAX All Food Total			19.560	174.106	NA	17.045	NA	11.824

Notes:
1 - Initial food dose is from Summary Statistics Table 2, and rearranged relative to food cateories.
2 - APW (atmospheric depositions or inhalation), LPW (liquid pathway consumption), FPW (Food Pathway)
3 - AEI (average exposed individual basis), MAX (single highest exposure basis),
4 - Food categories are compared on an AEI, MAX, and Special Category basis and statistics are across categories compared,
E.g., Hunter MEI average and standard deviation is for deer plus hog MAX dose, and median relates to deer and hog medians.

LIST OF ACRONYMS

AEI	Average Exposed Individual
ANS	American Nuclear Society
APW	Atmospheric Pathway
AVG	Average
BER	Biological and Environmental Research
CERCLA	Comprehensive Environmental Resource Compensation and Liability Act
COGEMA	Compagnie Generale des Martieres Nucleaires
D#	Detection number
DNRGW	Department of Natural Resources Groundwater Wells
DOE-SR	Department of Energy - Savannah River
DW	Drinking Water
DXPW	Direct Exposure Pathway
EMS	Environmental Monitoring Section
EV	Edible Vegetation
ESOP	Environmental Surveillance and Oversight Program
FPW	Food Pathway
GW	Groundwater (from wells)
InH	Inhalation
IhPW	Inhalation Pathway
LLD	Lower Limit of Detection
LPW	Liquid Pathway
MAX	Single highest maximum detection
MCR	Maximum consumption rate
MDA	Minimum Detectable Activity
MEI	Maximum Exposed Individual
MFFF	Mixed Oxide Fuel Fabrication Facility
N#	Number of Samples
NA	Not Applicable
NESHAP	National Emission Standards for Hazardous Air Pollutants
NORM	Naturally Occurring Radioactive Material
NPDWPW	Nonpotable Drinking Water Pathway
NS	No Sample
ORWBG	Old Radioactive Waste Burial Ground
PWS	Public Water System
PWSGW	Public Water System Groundwater Wells
PWSPW	Public Water System Pathway
PWSRW	Public Water System River Water
RCRA	Resource Conservation Recovery Act
RW	River Water
SCBKG	South Carolina Background
SCDHEC	South Carolina Department of Health and Environmental Control
SD	Standard Deviation
SRS	Savannah River Site
SRNS	Savannah River Nuclear Solutions

SSRS Surface Soil Resuspension
SW Surface Water
SWBL Surface Water at Boat Landings
TLD Thermoluminescent Dosimeter
TV Television cathode ray tube
USDOE United States Department of Energy
USEPA United States Environmental Protection Agency
VEGP Vogtle Electric Generating Plant

UNITS OF MEASURE

hrs/yr hours per year
kg/yr kilograms per year
L/yr liters per year
m^3/yr cubic meters per year
mrem millirem or milliroentgen equivalent man
mg/day milligrams per day
pCi/g picocuries per gram
pCi/L picocuries per liter
pCi/m^3 picocuries per cubic meter

% percent

person-rem/y Person-roentgen equivalent man per year

± plus or minus one standard deviation unless stated otherwise

< less than

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