HEALTH PHYSICS REGIONAL MONITORING

Semiannual Report,
January through June 1959

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November 1959

E. I. du Pont de Nemours and Company
Explosives Department - Atomic Energy Division
Savannah River Plant

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Contents

Abstract

Radioactivity in the Plant environs from Plant operations and from bomb fallout was detected during this six-month period.

The six-month average concentration of nonvolatile beta activity released from the Reactor Areas to Plant streams, and from weapons test debris in air, was the highest observed to date.

Introduction

Under a program established by the Du Pont Company in June 1951, the Savannah River Plant site and surrounding region are systematically monitored for radioactivity. The regional monitoring program accumulates information that is useful both as a measure of the effectiveness of Plant controls and as an authoritative record of environmental conditions. This report, covering the period from January through June 1959 is one of a series of reports concerning the regional monitoring program.

Data Reporting

Survey data were averaged for the six-month period and compared with the previous six-month averages ("Health Physics Regional Monitoring Semiannual Report," DPSPU 59-11-23, August 1959). In reporting data, "Avg" or "Total" refers to the average or total for this six-month report period, while "Prev Avg" or "Prev Total" refers to the average or total for the preceding six-month period. Unless otherwise specified, "Max" refers to the greatest concentration observed in a single sample collected during the report period.

Sensitivity and Standard Deviation of Laboratory Analyses

Sensitivity of laboratory analyses refers to the minimum amount of radioactivity that can be detected by the procedure. It is based on statistical counting errors (90% confidence level) and is influenced by sample size, counter efficiency and counter background. No self-absorption corrections have been applied.

The standard deviations, calculated from spike recovery values, are applicable to the six-month averages of data in this report.

Analysis	Sample	Sensitivity	Standard Deviation, %	Spike Value
Alpha	Water	$0.45 \pm 0.14 \times 10^{-3}$ d/m/ml	11	100×10^{-3} d/m/ml
	Mud	0.45 ± 0.14 d/mg	-	-
	Vegetation	0.23 ± 0.07 d/m/g	-	-
	Air	$0.035 \pm 0.011 \times 10^{-14}$ μc/cc	-	-
Beta	Water	$7.1 \pm 0.6 \times 10^{-15}$ c/ml	-	-
	Mud	$7.1 \pm 0.6 \times 10^{-12}$ c/g	-	-
	Vegetation	$3.6 \pm 0.3 \times 10^{-12}$ c/g	-	-
	Biological Specimens	$3.6 \pm 0.3 \times 10^{-12}$ c/g*	-	-
	Air	$1.2 \pm 0.1 \times 10^{-14}$ μc/cc	-	-
TBP Extraction	Water	$0.64 \pm 0.20 \times 10^{-3}$ d/m/ml	16	100×10^{-3} d/m/ml
	Mud	0.61 ± 0.19 d/m/g	17	100 d/m/g
	Vegetation	0.059 ± 0.018 d/mg	19	10 d/m/g
Radioiodine	Water	$12.0 \pm 0.9 \times 10^{-15}$ c/ml	10	300×10^{-15} c/ml
	Vegetation	$1.3 \pm 0.1 \times 10^{-12}$ c/g	14	20×10^{-12} c/g
	Air	$3.3 \pm 0.2 \times 10^{-14}$ μc/cc	-	-
	Milk	$150 \pm 10 \times 10^{-15}$ c/ml	26	3000×10^{-15} c/ml
Tritium	Water	$4.5 \pm 0.6 \times 10^{-12}$ c/ml	3	2500×10^{-12} c/ml
Radiocesium	Water	$3.6 \pm 0.4 \times 10^{-15}$ c/ml	20	400×10^{-15} c/ml
Radiostrontium	Water	$3.6 \pm 0.4 \times 10^{-15}$ c/ml	8	400×10^{-15} c/ml

* Approximate average, there was a wide variation in sample size analyzed.

Summary

RADIOACTIVITY RELEASED BY PLANT OPERATIONS. Radioactivity released to the environment as a result of Plant operations included approximately 0.3 curie alpha, 790 curies nonvolatile beta, and 76 curies radioiodine. Approximately 98,000 curies tritium were released by the 100-Area stacks and water effluents.

Fuel element failures contributed considerably to the nonvolatile beta discharged from the reactor disassembly basins. Of the radioactivity associated with the fuel element failures 90% was Np-239; the greatest releases occurred during discharges of entire reactor loads subsequent to fuel element failures. The largest single-incident release was from C Area during March, when approximately 150 curies of nonvolatile beta (primarily Np-239) were discharged to Four Mile Creek. Radiostrontium was readily detectable in the stream after the incident. Nonvolatile beta and tritium releases due to 100-Area discharges were detectable in the Savannah River at the Highway 301 crossing; it was estimated that the Plant contributed 21 curies nonvolatile beta and 42,000 curies tritium to the flow of radioactivity at this location during the six-month period.

Nonvolatile beta activity was detectable in fish collected from Par Pond, Lower Three Runs, Steel Creek, Four Mile Creek and the Savannah River. Maximum concentrations of 3080×10^{-12} c/g in bone and 985×10^{-12} c/g in flesh were detected in fish collected from Lower Three Runs, but concentrations in specimens collected from the Savannah River remained quite low.

Releases of alpha and nonvolatile beta radioactivity from the 200 Areas increased due to resumption of Purex process operations in F Area, and were coincidental with construction work in the H-Area canyon facilities. Processing of short-cooled material caused an increase in radioiodine releases from H Area. The F-Area radioiodine release was greater than expected because of a low decontamination factor across the process.

No significant concentration of Plant-released alpha or nonvolatile beta radioactivity was detected in samples of air, vegetation or rainwater. Radioiodine concentrations near F and H Areas increased slightly, while the decrease of bomb fallout produced lower concentrations at other on-Plant and off-Plant locations. Radioactivity from H-Area seepage basins was detected in ground water a few feet from Four Mile Creek. Practically all of the radioactivity was due to isotopes of strontium and yttrium.

BOMB FALLOUT. Although no announced nuclear weapons tests have occurred since October 1958, concentrations of radioactive debris remained high through most of the report period. The average concentration of filterable beta activity in air (650×10^{-14} μc/cc) was the highest six-month average ever recorded at SRP. Deposition of nonvolatile beta on the Plant site during the report period was estimated to be 240 curies. Since the debris was rather old, the apparent half life of the radioactivity was fairly long, and ranged from 50 to greater than 100 days.

Nonvolatile beta from weapons test debris was detectable in samples of air, vegetation, rainwater, and stream water.

Survey Results

Radioactivity Released by Plant Operations

100 AREAS

The major sources of liquid waste from the 100 Areas were: (1) deionized water from reactor thermal shields, and (2) disassembly basin water. In L, K, and C Areas the thermal shield was purged at rates of 1 to 6 gpm to prevent accumulation of corrosion products; the deionized water was recirculated with no purging in R and P Areas during this report period. Disassembly basin water was purged at rates of 1000 to 2000 gpm, except during periods of abnormally high concentrations of radioactivity in the basins. Both sources of waste were diluted by spent cooling water, normally discharged at rates of approximately 150,000 gpm; however, cooling water flows were reduced during charge-discharge shutdowns.

There was a twofold increase in nonvolatile beta releases from the thermal shield, due primarily to Na-24 and other short-lived induced activities. L Area contributed 63 of the total 106 curies released by the purging of thermal shield water during the report period.

Nonvolatile beta releases from disassembly basins increased by a factor of 4 as a result of fuel element failures which occurred during the report period. The largest releases occurred during discharges of entire reactor loads subsequent to fuel element failures. Greater than 90% of the radioactive releases associated with fuel element failures was attributed to Np-239. As a result of leakage through the emergency basin stop logs,[1] Sr-90, Cs-134 and Cs-137 continued to be released from R Area.

A summary of the nonvolatile beta released from the 100 Areas to Plant streams is shown in the following table.

	Nonvolatile Beta Released in Thermal Shield Water, curies					
Area →	R	P	L	K	C	Total for All Areas
Total	*	*	63	35	8	106
Previous Total	12	1	26	4	6	49

* No purging.

	Nonvolatile Beta Released in Disassembly Basin Water, curies					
Area →	R	P	L	K	C	Total for All Areas
Total	134	56	138	93	258	679
Previous Total	89	25	20	10	9	153

Alpha activity discharged in 100-Area effluent streams was estimated to be approximately 0.3 curie, due almost entirely to naturally occurring radioactivity in cooling water.

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[1] From the experimental fuel element failure in November 1957. For details of the incident, see DPSP 58-25-17.

Tritium discharge to 100-Area effluent streams by entrainment of moderator on fuel elements during discharge operations totaled approximately 19,000 curies, as compared to the discharge of 15,000 curies during the previous six-month period.

Tritium released by moderator losses through 100-Area stacks totaled 79,000 curies, as compared to the release of 52,000 curies during the previous report period.

200 AREAS

Increases in stack released radioactivity from both chemical separations facilities were observed during this report period. Spills and construction work in H-Area canyon in March resulted in a release of 1.4 curies nonvolatile beta. Resumption of Purex process operations in F Area during the last half of the report period resulted in an increase in releases of both nonvolatile beta and alpha emitters. Radioiodine releases from H Area totaled 13 curies in January and 19 curies in February. These releases resulted from the processing of shorter-cooled material and from the operation of the caustic scrubber without caustic. A radioiodine release of 25 curies during June from F Area represented the maximum monthly release from the 200-Area stacks; the maximum daily release was 2.7 curies from F Area on June 9. Radioiodine release from F Area was higher than anticipated due to a low decontamination factor as compared with previous operations.

The 200-Area stack releases for the period are summarized in the following table.

	Stack-Released Radioactivity			
	F Area		H Area	
	Total	Prev Total	Total	Prev Total
Nonvolatile Beta, mc				
$Ru^{103,106}$	904	131	1810	211
$Sr^{89,90}$	16	5	24	14
Rare Earths	177	71	283	151
Cs^{137}	22	6	30	6
$Zr\text{-}Nb^{95}$	195	42	190	81
Total →	1314	255	2337	463
Alpha, mc	14*	8	2	1
I-131, c	42	-	34	11

* 65% Pu-239.

300 AREA

Estimated release of natural (unenriched) uranium from 300 Area to Tims Branch was 73 pounds (23 mc) as compared to 60 pounds (19 mc) during the previous six-month period.

700 AREA

Releases of radioactivity from the Building 773-A (Savannah River Laboratory) stacks during April May, and June included 6.2 mc of nonvolatile beta activity and 6.2 μc of alpha activity, as determined by chemical analyses. Air filter samples prior to April were counted in Building 773-A, but the alpha activity release was less than sensitivity (0.18 μc/day) and the nonvolatile beta activity release was obscured by the release of 197 mc I-131. Tritium released during the report period totaled approximately 2500 curies.

Bomb Fallout

The average concentration of filterable beta in air for the six-month period (650×10^{-14}) was the highest ever recorded. Except for occasional decreases due to rainfall, concentrations of filterable beta in air were continually high until May, as shown in figure 1. Although filterable beta increased, the number of discrete radioactive particles detected in air by radioautograph decreased. This anomoly was attributed to a large number of particles too small to be clearly defined by radioautograph as all radioautographs showed a general darkening over the entire area. These particles, in the atmosphere at very high altitudes and slowly settling to the earth's surface, are the results of fallout of long half life materials from weapons tests. Of the particles collected during the six-month period, 162 of the most radioactive particles were counted with GM counters. The average beta activity was 175 d/m per particle, with a maximum of 400 d/m in a particle collected at the Aiken Airport during the week ending January 27. Half life of the radioactivity in the 400 d/m particle was greater than 100 days.

Gamma pulse height analysis of air filters collected during the report period indicated the presence of $Zr\text{-}Nb^{95}$, $Ru^{103,106}$ and $Ce^{141,144}$. A gamma-ray spectrograph of filters collected on May 26 is shown in figure 2.

Absence of radioiodine in weapons tests debris was reflected in decreased concentrations of this isotope in air at the stations distant from the 200 Areas, while the effect of increased stack releases could be observed on the H-Area vegetation.

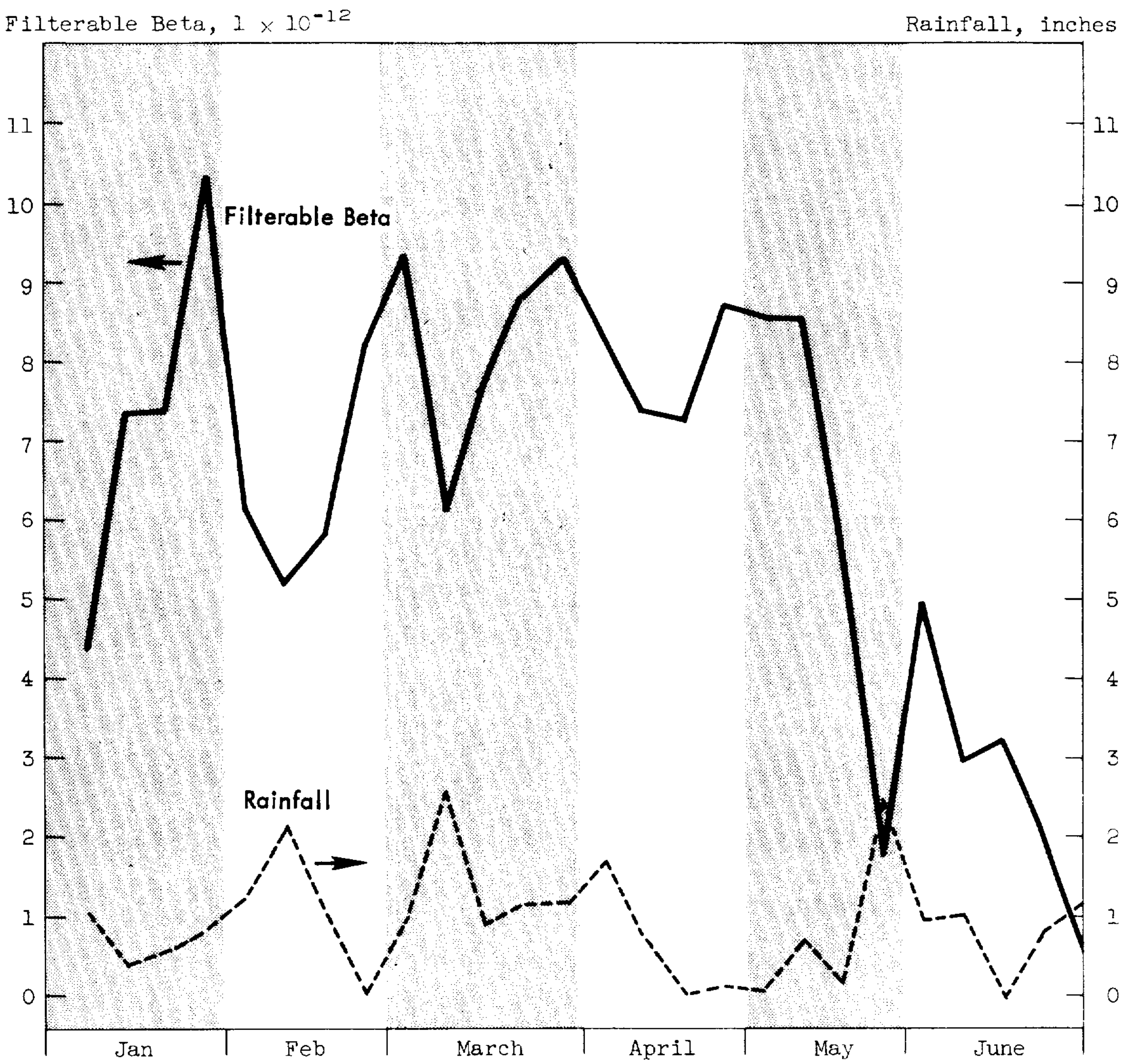

Figure 1. Effects of Rainfall on Concentrations of Filterable Beta in Air

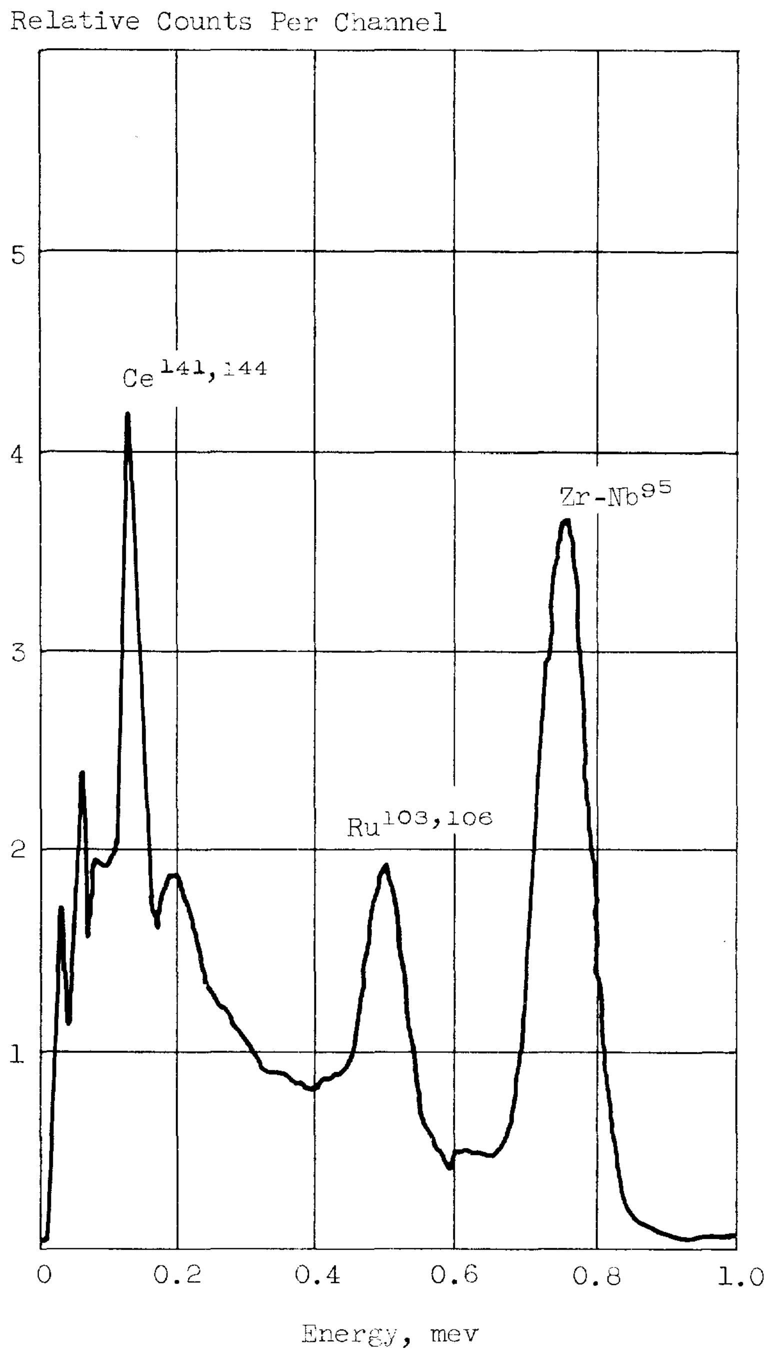

Figure 2. Gamma-Ray Spectrograph of Air Filter Collected May 26, 1959

Radioactivity in the Atmosphere

Air samples were collected weekly from 15 air monitoring stations as shown in figure 3.

Radioactivity in the atmosphere was determined by:

- Counting 369 two-inch-diameter air filters for alpha and beta activity.
- Chemically analyzing 374 two-inch-diameter silver nitrate impregnated air filters for radioiodine.
- Counting the number of particles collected on 345 eight-inch by ten-inch air filters.

Results of these samples are shown in the following table.

Atmospheric Radioactivity

	Alpha, 1×10^{-14} μc/cc*			Filterable Beta, 1×10^{-14} μc/cc*			Radioactive Particles, particles/1000 M^3			Radioiodine, 1×10^{-14} μc/cc		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
F Area	0.3	0.2	0.1	1000	700	430	280	66	100	100	24	22
H Area	.3	.2	.2	1200	730	490	150	54	110	150	29	28
300/700 Area	.4	.2	.2	1300	760	670	270	67	150	13	7	31
Talatha Gatehouse	.3	.1	.2	1200	660	620	230	56	140	18	8	24
Williston Gatehouse	.2	.1	.2	1100	760	600	130	45	110	21	7	25
Dunbarton Fire Tower	.3	.2	.2	1100	680	600	140	45	130	54	12	26
400 Area	.3	.2	.2	1400	850	550	240	56	160	21	6	12
Aiken Airport	.3	.2	.2	1300	720	600	210	48	160	21	6	22
Allendale	.5	.2	.2	1200	700	580	250	60	150	17	6	19
Waynesboro	.3	.2	.2	1000	610	520	190	51	130	14	5	24
Langley	.2	.1	.2	1000	460	380	97	26	-	12	5	9
Williston	.3	.1	.2	1200	600	530	93	29	-	16	6	18
Barnwell	.1	.1	.1	880	430	320	69	24	-	41	6	12
Sardis	.2	.1	.1	730	430	390	97	22	-	16	5	12
Bush Field	0.2	0.1	0.2	1200	650	420	64	27	-	23	5	15

* Three days were allowed for decay of radon and thoron daughters.

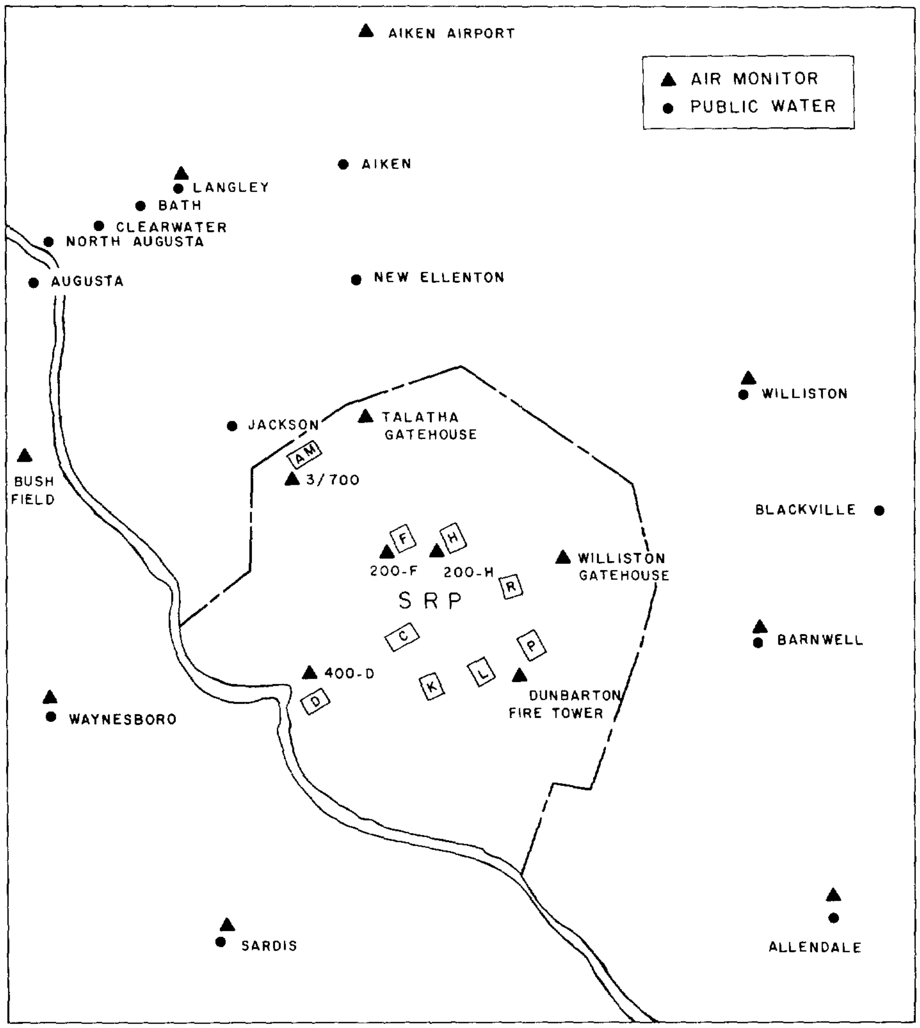

Figure 3. Constant Air Monitoring Stations and Public Water Sampling Locations

PARTICULATE FALLOUT

Adhesive papers were collected weekly and radioautographed. Results from 522 adhesive papers, and the locations from which they were collected are shown in the following table.

Location	Particles/Ft^2/Week		
	Max	Avg	Prev Avg
F Area	20	4	8
F Area (at 1-mile radius)	34	4	8
H Area	14	3	7
H Area (at 1-mile radius)	13	2	6
Burial Ground Fence*	9	2	2

* Papers placed in vertical positions to collect horizontally moving particles.

In March a program was begun to determine the contribution of the 100-Area stacks to airborne radioactivity. Results of radioautographs from 320 adhesive paper samples and the locations from which they were collected are shown in the following table.

Location	Deposition of Radioactive Particles, particles/ft^2/week	
	Max	Avg*
R Area	13	1.5
P Area	18	1.8
K Area	14	1.5
L Area	14	1.4
C Area	22	1.4
On-Plant Air Monitor Locations**	31	1.9
Off-Plant Air Monitor Locations**	22	1.5

* A 16-week average.
** Included for comparison only.

Radioactivity in Rainwater

Location	No. of Samples	Alpha, 1×10^{-3} d/m/ml Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Nonvolatile Beta Avg	Nonvolatile Beta Prev Avg	Radioiodine, 1×10^{-15} c/ml Max	Radioiodine Avg	Radioiodine Prev Avg
F Area	20	8.6	2.3	3.0	780	400	630	90	37	56
H Area	22	4.9	2.2	2.2	1500	580	860	130	39	90
300/700 Area	21	4.4	1.8	2.6	1500	660	880	23	15	87
Talatha Gatehouse	20	3.5	1.1	1.3	940	490	540	29	15	55
Williston Gatehouse	20	6.1	1.7	1.7	770	260	300	46	16	81
Dunbarton Fire Tower	20	3.1	1.1	0.7	500	240	240	27	15	45
400 Area	20	3.2	1.1	1.3	1100	400	590	82	22	120
Aiken Airport	23	6.5	1.7	1.7	1400	600	570	29	15	80
Allendale	20	2.2	1.1	1.3	550	250	250	18	13	54
Waynesboro	20	2.5	1.0	1.4	840	460	540	15	13	130
Langley	23	3.6	1.4	2.6	2500	840	810	23	15	61
Williston	21	2.9	0.8	1.6	1500	590	920	25	14	67
Barnwell	21	1.7	0.6	1.1	1200	580	710	24	15	70
Sardis	21	1.8	0.8	1.6	1200	550	1200	20	14	94
Bush Field	21	1.4	0.8	1.8	1200	600	920	21	13	120

Radioactivity deposited on the Plant site, estimated from results of analyses of rainwater samples and rainfall measurements, is shown in the following table. During weeks when no rain occurred, nonvolatile beta deposition was estimated from radioactivity collected in an open pan of water located near Building 735-A.

	Nonvolatile Beta, c	Radioiodine, c
January	34	2
February	46	4
March	79	3
April	25	<1
May	31	<1
June	22	2
Total →	237	13
Previous Total →	181	15

Radioactivity in Vegetation

There were 514 vegetation samples analyzed for alpha and nonvolatile beta activity, and 764 samples analyzed for radioiodine. Sample locations are shown in figures 4 and 5. Results of analyses are shown in the following table.

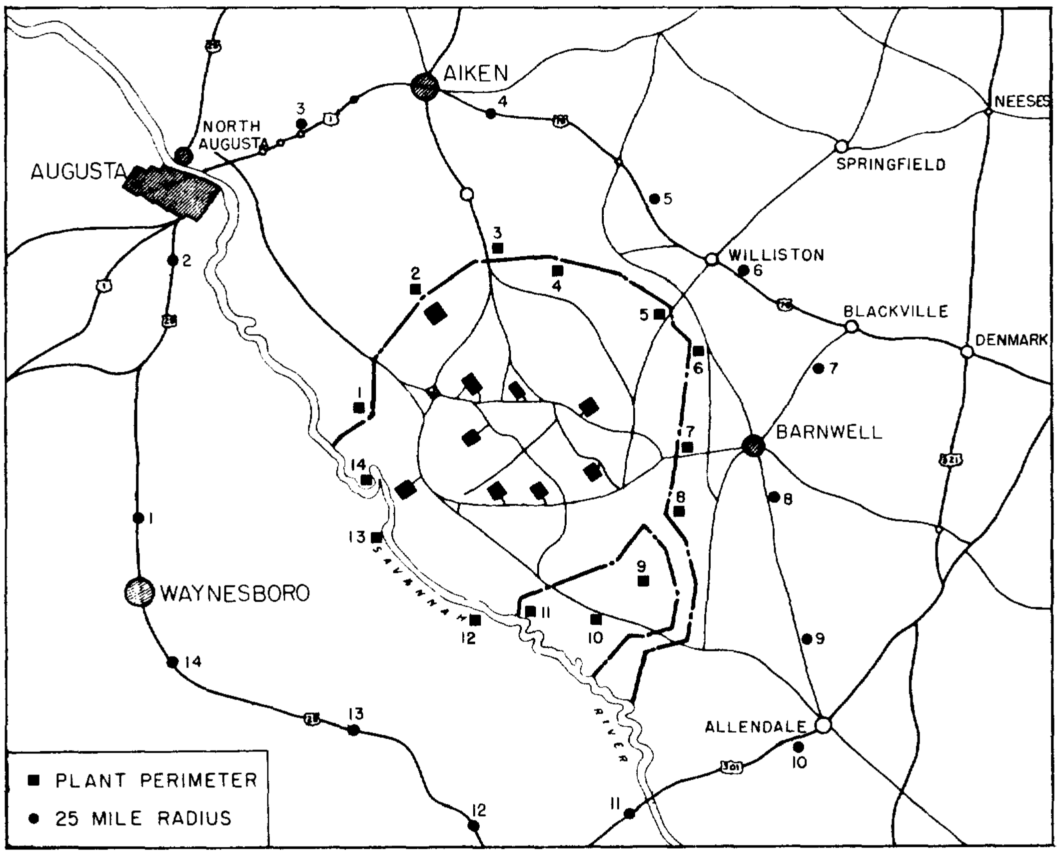

Figure 4. Vegetation Sample Locations

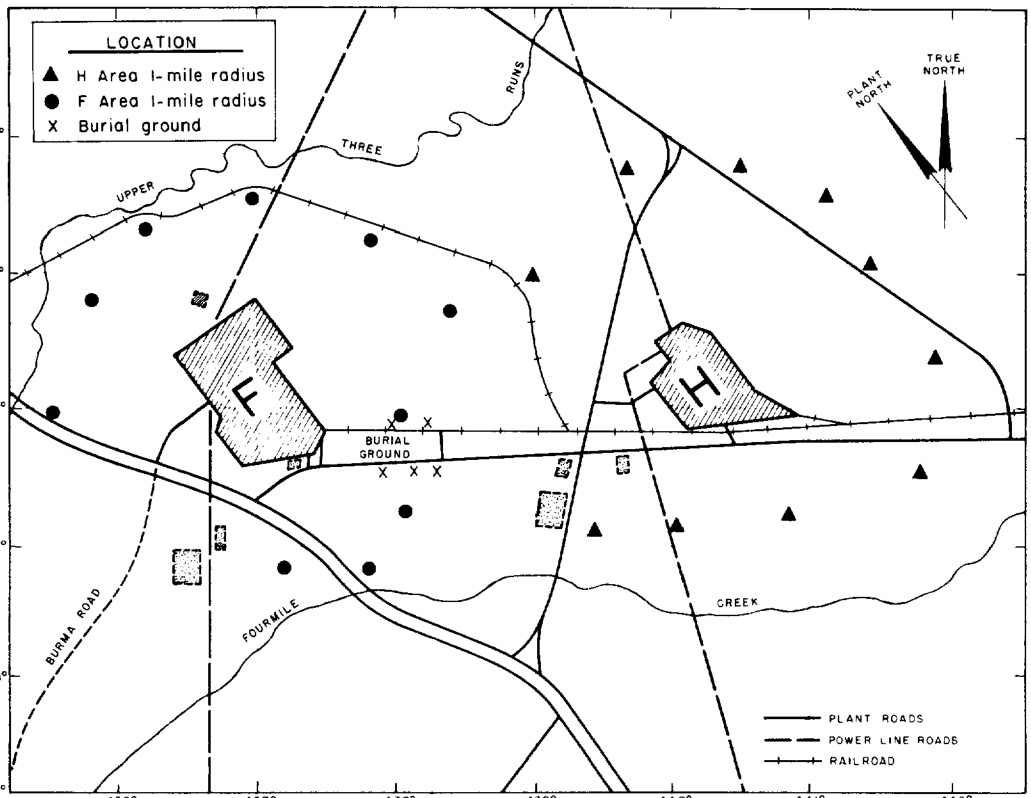

Figure 5. Vegetation Sample Locations in F and H Areas

Location	Alpha, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g			Radioiodine, 1×10^{-12} c/g		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
F Area (at 1-mile radius)	1.2	0.3	0.4	870	260	140	5.4	2.8*	-
H Area (at 1-mile radius)	1.7	.4	.4	971	300	150	41.0	5.4	3.1
Plant Perimeter	1.8	.3	.3	948	255	130	1.8	1.0	2.0
25-Mile Radius	1.0	0.4	0.3	923	346	120	-	-	-

* Average for 14 weeks only (March 25 to June 24).

Radioactivity in Milk

Milk samples were collected weekly from Talatha, Snelling, Aiken, North Augusta, and Langley. Of 126 samples analyzed for radioiodine, the average concentration was less than 170×10^{-15} c/ml.

Environmental Radiation Levels

A summary of 520 readings made with Landsverk L-65 pocket chambers and a modified L-60 electrometer is given in the following table.

Location	Dose Rate, mr/24 hours	
	Avg	Prev Avg*
H Area	0.94	0.81
F Area	.80	.47
R Area	.78	.62
L Area	.77	.55
C Area	.74	.48
P Area	.71	.56
K Area	.69	.52
Aiken Airport	.66	.54
Allendale	.64	.57
400 Area	.63	.48
300/700 Area	.63	.56
TC Area	.61	.40
Waynesboro	.58	.48
Dunbarton Fire Tower	.54	.53
Williston	.54	.36
Williston Gatehouse	.52	.44
Talatha Gatehouse	.49	.46
Bush Field	.41	.39
Barnwell	.39	.27
Sardis	.37	.36
Langley	0.35	0.30

* Two-month average.

Radioactivity in Streams and the Savannah River

Weekly water samples were collected at the stream sampling locations shown in figure 6. During weeks when large variations in stream flow caused difficulties with operation of the continuous samplers, weekly concentrations were determined by averaging results of analyses of daily samples. Mud samples were collected monthly through March, and weekly during the remainder of the report period. Results of analyses of 598 water samples and 322 mud samples are summarized in the following tables.

TIMS BRANCH

Radioactivity in Water

Location	Alpha, 1×10^{-3} d/m/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Avg	Prev Avg
2	150	50	33	230	110	64
3	8000	1500	440	6500	1200	450
4	170	74	40	290	170	84
5	77	41	11	130	76	24

Radioactivity in Mud

Location	TBP Extractable Alpha, d/m/g Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/g Max	Avg	Prev Avg
2	520	240	570	140	81	100
3	830	340	1400	1100	230	300
4	68	45	48	39	23	19
5	96	32	18	70	12	10

Increased concentrations of radioactivity in water at locations 3, 4, and 5 were caused by increased releases of uranium from the 300 Area. Maximum alpha and nonvolatile beta concentrations at location 3 (300-Area effluent) occurred in a sample collected on March 19.

UPPER THREE RUNS

Results of analyses of water and mud samples are shown in the following tables.

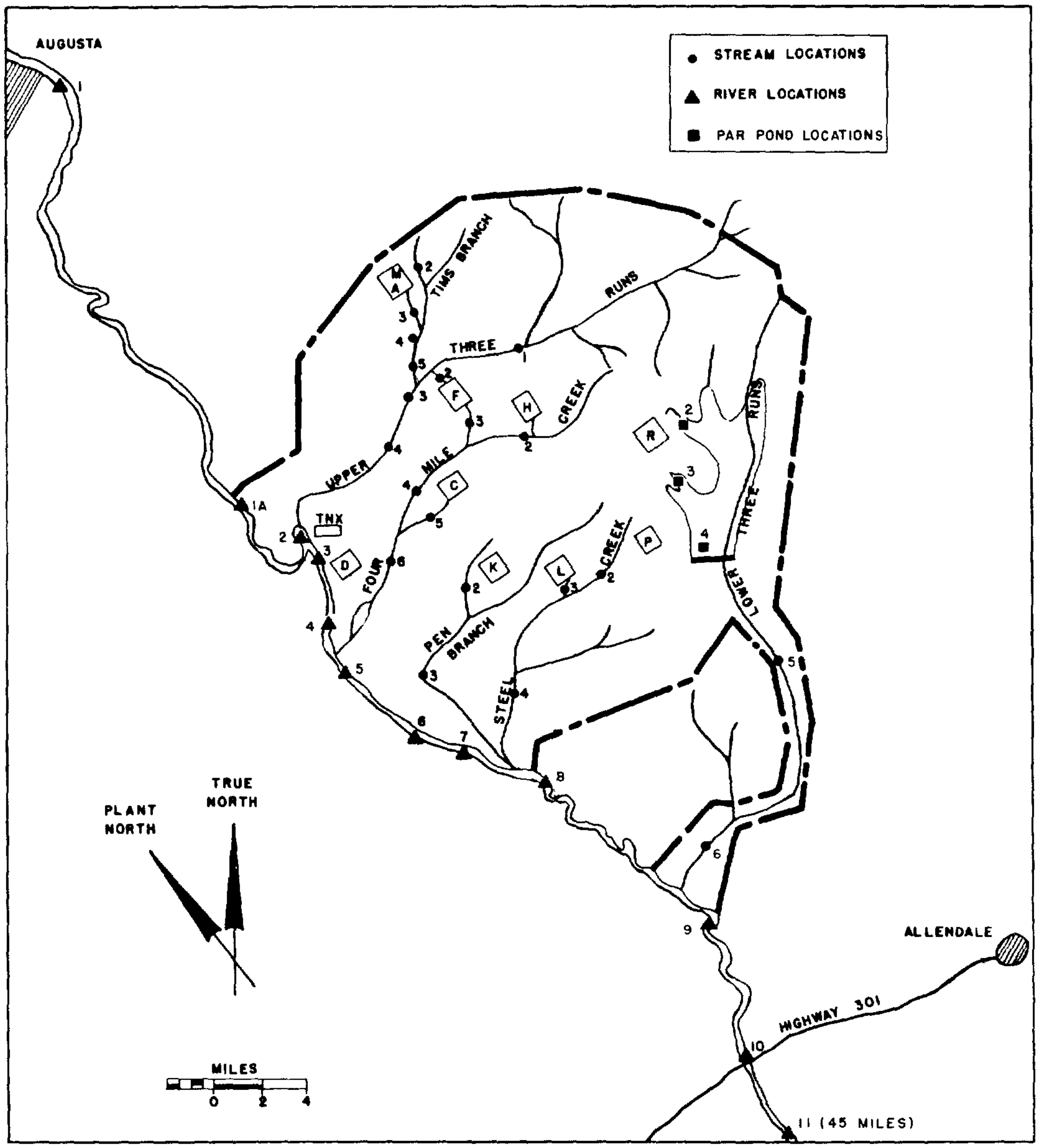

Figure 6. Stream and River Sample Locations

Radioactivity in Water

Location	Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1 (Control)	8	4	5	59	19	24
2	23	6	6	1400	140	71
3	13	8	5	71	26	11
4	8	4	5	96	24	19

Radioactivity in Mud

Location	Alpha, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1 (Control)	2.3	1.1	1.0	18	12	9
2	2.6	1.0	1.4	100	35	27
3	4.0	1.4	2.1	29	10	12
4	3.6	1.4	1.6	47	14	11

Concentrations of radioactivity at location 2 (F-Area storm sewer) were influenced by spills in F Area. Maximum alpha concentration in water occurred in a sample collected on March 12 and was due to natural uranium.

Maximum nonvolatile beta concentration in water occurred in a sample collected on May 7 and was traced to a spill of canyon process waste from Building 211-F.

FOUR MILE CREEK

Analyses of water and mud samples are summarized in the following tables.

Radioactivity in Water

Location	Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	4	3	3	110	53	39
3	8	4	3	300	110	43
4	1	1	1	120	42	28
5	3	2	1	80,000*	7100	260
6	3	1	1	66,000*	4300	110

* Maximum weekly concentrations. Daily samples contained as much as 260,000 $\times 10^{-15}$ c/ml at location 5, and 170,000 $\times 10^{-15}$ c/ml at location 6.

Radioactivity in Mud

Location	Alpha, d/m/g Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/g Max	Avg	Prev Avg
2	1.6	0.9	0.9	12	8	8
3	2.1	1.0	1.2	39	11	8
4	2.0	0.5	0.9	9	7	10
5	4.3	1.1	1.1	140	23	8
6	3.4	1.4	1.3	340	93	49

Concentrations of nonvolatile beta in water at location 3 (F-Area segregated water effluent) increased with the startup of F Area in March; the maximum concentration occurred in a sample collected on May 21. Samples of steam condensate taken from various locations within the F-Area segregated water system indicated possible leakage from dissolver 6.4 and the high activity waste system.

Approximately 80% of the average concentration of nonvolatile beta in water at location 5 (C-Area effluent) was due to samples collected during two weeks of the report period. The high concentrations during these two periods ($80,000 \times 10^{-15}$ c/ml during the week ending March 26, and $72,000 \times 10^{-15}$ c/ml during the week ending May 14) were due to large releases of Np-239 from C Area. Releases of approximately 146 curies during March and 68 curies during May resulted from discharges of the reactor subsequent to fuel element failures. The half life of nonvolatile beta in samples collected from location 5 during the remainder of the report period ranged from 4 days to 100 days, with a weighted average of 15 days.

Water samples collected downstream from C Area contained greater concentrations of radiostrontium than found in any other Plant stream. Results of analysis of samples for specific isotopes are shown in the following table.

Radioactivity in Water

Location	Tritium, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radiostrontium, 1×10^{-15} c/ml Max	Avg	Prev Avg	Radiocesium, 1×10^{-15} c/ml Max	Avg	Prev Avg
5	-	-	-	640	150*	-	610	110*	-
6	3000	190	260	240	40	8	190	14	11

* Three-month average.

Concentrations of radiostrontium and radiocesium at location 6 increased sharply after the March fuel element failures. The average radiostrontium concentration increased from 6×10^{-15} c/ml during the 11 weeks before the March failures to 63×10^{-15} c/ml during the remaining 15 weeks. Similarly, the average radiocesium concentration increased from 5×10^{-15} c/ml to 19×10^{-15} c/ml.

PEN BRANCH

Results of analyses of water and mud samples are shown in the following tables.

Radioactivity in Water

Location	Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	2	1	1	5500	470	320
3	2	1	1	5900	640	260

Radioactivity in Mud

Location	Alpha, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	3.0	1.5	1.1	74	32	29
3	2.3	1.3	1.4	260	80	54

The half life of nonvolatile beta in water samples collected from location 2 ranged from 4 days to 110 days, with a weighted average of 10 days. Even though location 3 is downstream from location 2, intensive sampling revealed that concentrations of nonvolatile beta at location 3 were actually higher than those at location 2. This is believed to have been caused by drainage from some unknown source.

An analysis for specific isotopes follows.

Radioactivity in Water

Location	Tritium, 1×10^{-12} c/ml			Radiostrontium, 1×10^{-15} c/ml			Radiocesium, 1×10^{-15} c/ml		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	-	-	-	190	22*	-	21	5*	-
3	3100	250	87	120	15	13	23	6	7

* Three-month average.

STEEL CREEK

Analyses of water and mud samples are shown in the following tables.

Radioactivity in Water

Location	Alpha, 1×10^{-3} d/m/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Avg	Prev Avg
2	2	1	2	2,400	390	370
3	3	1	1	150,000*	6400	410
4	2	1	1	4,500	300	120

* Daily samples contained as much as $480{,}000 \times 10^{-15}$ c/ml.

Radioactivity in Mud

Location	Alpha, d/m/g Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/g Max	Avg	Prev Avg
2	10.	3.4	3.2	130	60	52
3	1.8	1.3	1.9	93	64	77
4	3.4	1.7	1.7	140	46	43

The half life of nonvolatile beta in water samples collected from location 2 ranged from 4 days to 110 days with a weighted average of 18 days.

The maximum concentration of nonvolatile beta in water at location 3 occurred during the week ending June 4 and accounted for 90% of the six-month average concentration. High concentrations in June resulted from the release of 116 curies nonvolatile beta (primarily Np-239) from L Area during discharge of the reactor subsequent to fuel element failures. Half life of the nonvolatile beta in samples collected during the remainder of the report period ranged from 5 days to 88 days, with a weighted average of 18 days.

An analysis for specific isotopes follows.

Radioactivity in Water

Location	Tritium, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radiostrontium, 1×10^{-15} c/ml Max	Avg	Prev Avg	Radiocesium, 1×10^{-15} c/ml Max	Avg	Prev Avg
2	-	-	-	44	22	9	64	37	18*
4	620	84	56	32	12	8	44	16	12

* Eighteen-week average.

LOWER THREE RUNS AND PAR POND

Analyses of water and mud samples are shown in the following tables.

Radioactivity in Water

Location	Alpha, 1×10^{-3} d/m/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Avg	Prev Avg
2	2	1	1	1100	230	490
3	3	1	1*	240	150	110*
4	2	1*	-	220	140*	-
5	2	1	1	150	110	160
6	2	1	1	120	74	130

* Four-month average.

Radioactivity in Mud

Location	Alpha, d/m/g Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/ml Max	Avg	Prev Avg
2	1.1	0.6	1.9	34	13	174
3	1.0	0.4	-	14	8	-
4	0.5	0.4	-	7	7	-
5	1.3	0.8	0.6	36	11	36
6	1.6	0.6	0.5	20	13	9

Effects of the experimental fuel element failure of November 1957 continued to be observed in the Lower Three Runs - Par Pond system, and samples collected from these locations contained a greater percentage of long-lived isotopes than observed in any other reactor effluent stream. The half life of nonvolatile beta in samples collected from location 2 ranged from 6 days to 500 days, with a weighted average of 57 days.

An analysis of samples for specific isotopes follows.

Location	Tritium, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radiostrontium, 1×10^{-15} c/ml Max	Avg	Prev Avg	Radiocesium, 1×10^{-15} c/ml Max	Avg	Prev Avg
2	180	68	47	92	18	37	410	68	150
3	90	70	-	25	17	-	110	56	-
4	88	70*	-	50	18*	-	78	51*	-
5	-	-	-	36	19	25	85	40	65
6	35	22	23	28	16	28	59	19	38

* Four-month average.

RADIOACTIVITY IN THE SAVANNAH RIVER

Samples of river water were collected once a week at the locations shown in figure 6, except during the period from March 18 through March 31, when rather large quantities of nonvolatile beta were discharged from C Area to Four Mile Creek. During this period, 2 to 4 daily samples were collected each week and the results averaged to give weekly concentrations. Samples from location 10 were collected by a continuous "paddle wheel" type sampler.

Monthly mud samples from locations 1 through 9 and weekly samples from locations 10 and 11 were analyzed for TBP extractable alpha. Weekly mud samples were analyzed for nonvolatile beta, except at locations 1 through 9 where monthly samples were analyzed during the period January through March.

Analyses of 342 water samples for alpha and nonvolatile beta, 119 mud samples for TBP extractable alpha, and 211 mud samples for nonvolatile beta are summarized in the following tables.

Radioactivity in Water

	Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	2	1	1	44	21	14
1A	2	1	1	63	25	15
2	4	2	1	53	23	18
3	2	1	1	52	21	17
4	2	1	1	87	25	19
5	3	1	1	1300*	110	19
6	2	1	1	120*	29	17
7	2	1	1	140*	33	16
8	1	1	1	1600	130	26
9	3	1	1	140	45	26
10	1	1	1	88	29	24
11	2	1	1	97	33	20

* Average of 2 to 4 daily samples. Maximum daily samples were as high as 2600×10^{-15} c/ml at location 5, 210×10^{-15} c/ml at location 6, and 220×10^{-15} c/ml at location 7.

Location	TBP Extractable Alpha, d/m/g Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/g Max	Avg	Prev Avg
1	9	5	6	46	16	18
1A	13	6	-	35	20	22
2	10	6	7	25	13	18
3	14	7	7	40	17	20
4	10	7	10	29	17	18
5	14	6	16	37	20	22
6	12	6	10	38	11	9
7	9	6	6	26	15	21
8	12	5	6	49	25	22
9	11	4	7	40	15	14
10	13	7	7	39	24	20
11	10	3	6	12	8	11

Radioactivity in Mud

Maximum concentrations of nonvolatile beta in water at locations 5, 6, and 7 occurred during the week ending March 31, while the maximum concentration at location 8 occurred in a sample collected on June 1. In each case, the high concentrations resulted from releases of large amounts of Np-239 to Plant streams (Four Mile Creek in March and Steel Creek in June).

Calculations based on river flow rates and concentrations of nonvolatile beta in river water indicated the flow of approximately 72 curies past location 1A and 93 curies past location 10, during the six-month period.

Results of analyses of water samples for specific isotopes are summarized in the following table.

Radioactivity in Water

Location	Tritium, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radiostrontium, 1×10^{-15} c/ml Max	Avg	Prev Avg	Radiocesium, 1×10^{-15} c/ml Max	Avg	Prev Avg
9	-	-	-	16	4	9	9	4	8
10	44	14	10	9	4	9	7	3	8
11	42	10	9	16	5	9	5	3	6

Tritium concentrations observed at location 10 indicated a flow of approximately 42,000 curies past that location during the six-month period.

Radioactivity in Plant Drinking Water

Samples of drinking water were collected monthly from operating areas and quarterly from other domestic water systems. Analyses of 91 samples are summarized in the following table.

Location	Alpha, 1×10^{-3} d/m/ml Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Beta Avg	Beta Prev Avg
Barricade 2*	20	17	23	22	18	18
H Area	15	9	15	28	16	22
TC-1*	14	9	11	21	9	14
F Area	12	8	13	22	13	23
Barricade 4*	9	6	6	7	7	8
Barricade 1*	4	3	3	8	8	8
300/700 Area	7	3	3	13	9	8
400 Area	5	2	2	14	9	9
P Area	3	2	1	7	7	7
Pump House 2*	3	2	1	10	9	7
TNX	2	2	2	14	9	9
L Area	1	1	1	19	11	8
Classification Yards	2	1	2	13	9	8
C Area	1	1	1	12	9	8
K Area	1	1	1	11	9	9
R Area	1	1	1	10	7	9
Central Shops*	1	1	1	8	7	7
Pump House 1*	1	1	1	7	7	7
Barricade 3*	1	1	1	7	7	7
Barricade 5*	1	1	1	7	7	7
Par Pond - Pump House	1	1	-	7	7	-

* Quarterly samples.

Analyses of 88 of the samples in the preceding table showed no detectable tritium concentrations.

Radioactivity in Public Water Supplies

Samples of public drinking water were collected monthly from the 14 surrounding towns shown in figure 3. Analyses of 98 samples collected during the report period are summarized in the following table.

Location	Alpha, 1×10^{-3} d/m/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Avg	Prev Avg
Jackson	11	9	8	13	9	13
Aiken	10	8	4	16	9	7
Bath	5	3	5	10	8	9
Langley	4	3	3	44	17	9
New Ellenton	2	2	2	29	11	10
Williston	2	1	1	9	8	8
North Augusta	1	1	1	17	15	8
Clearwater	1	1	1	24	14	9
Waynesboro	1	1	1	18	12	10
Augusta	1	1	1	14	10	8
Sardis	1	1	1	16	9	8
Barnwell	1	1	1	12	8	8
Allendale	1	1	1	11	8	7
Blackville	1	1	1	8	7	8

Bomb fallout caused increased concentrations of nonvolatile beta activity at all locations which secure water from streams or open reservoirs. These include Aiken, Langley, North Augusta, Clearwater, Waynesboro, and Augusta.

Radioactivity in Ground Water

Ground water was monitored by analyses of water samples collected from drilled, cased wells near F and H Areas (ZW and Z wells) and at the burial ground. Locations of the wells are shown in figures 7 and 8. By "Tri-Carb" analysis, tritium was detected in all groups of wells.

ZW WELLS, F AND H AREAS

Analyses of 58 samples are summarized in the following table.

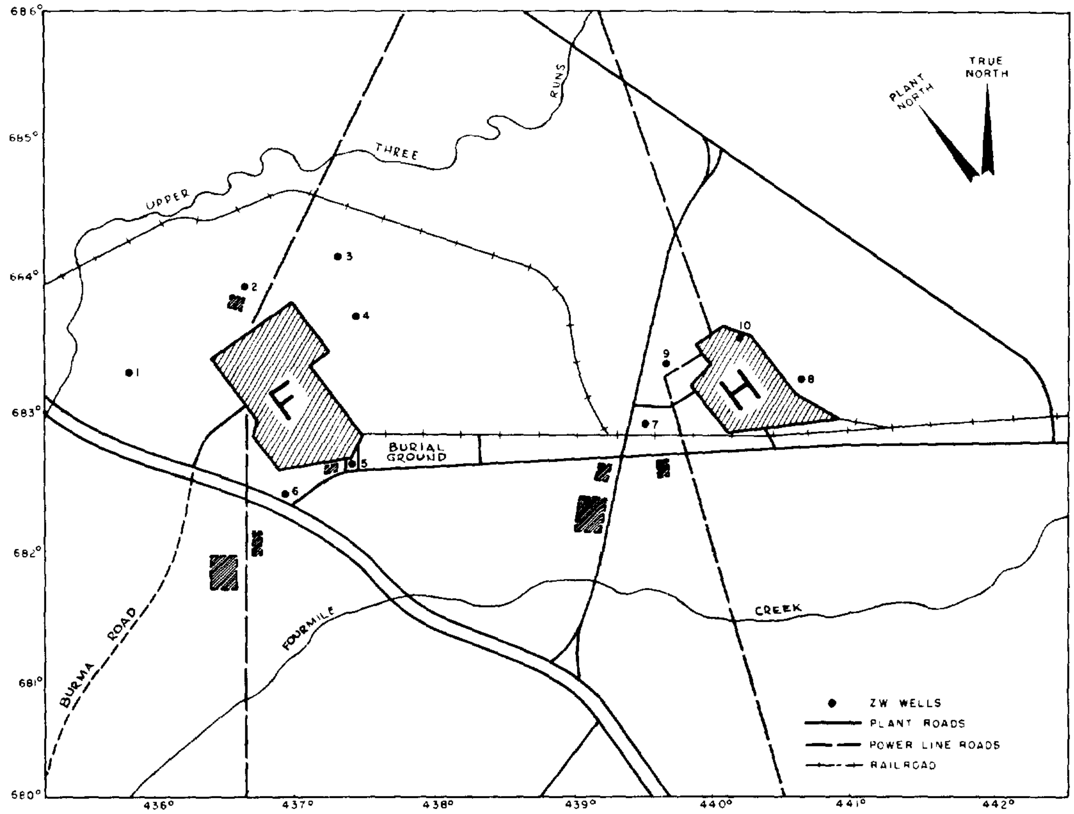

Figure 7. ZW Wells, F and H Areas

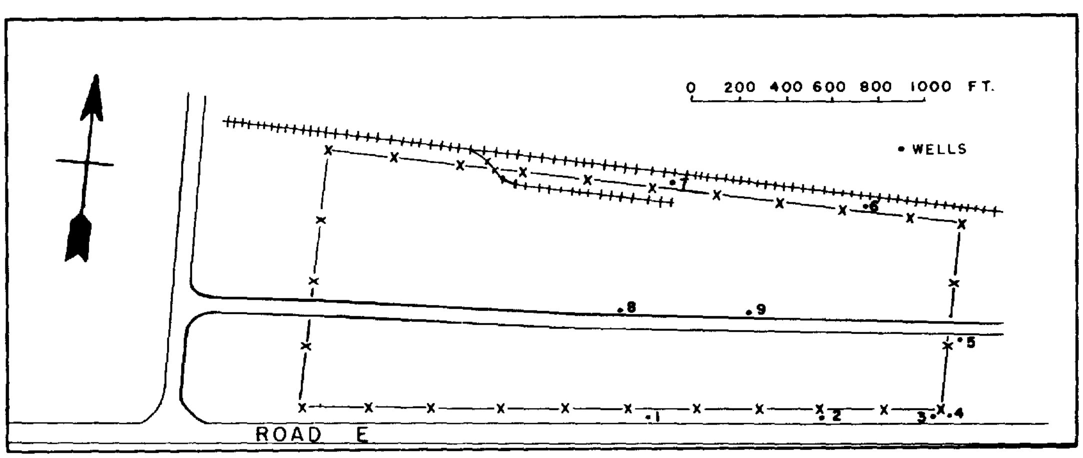

Figure 8. Burial Ground Wells

Location	Depth to Water, ft	Radioactivity in Water: Alpha, 1×10^{-3} d/m/ml Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Beta Avg	Beta Prev Avg
1	84.0 - 86.6	2	1	2	12	9	10
2	83.2 - 84.5	2	2	1	15	10	20
3	59.2 - 60.5	3	2	3	10	8	9
4	33.7 - 36.0	3	3	4	34	12	14
5	49.1 - 50.5	3	2	2	12	8	15
6	49.1 - 50.5	3	2	3	13	9	10
7	5.1 - 9.5	2	1	1	25	12	8
8	4.4 - 4.9	2	1	2	14	10	13
9	35.3 - 39.5	2	1	2	8	8	11
10	49.9 - 53.2	2	2	2	16	9	9

BURIAL GROUND WELLS

Analyses of 63 samples are summarized in the following table.

Location	Radioactivity in Water: Alpha, 1×10^{-3} d/m/ml Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Beta Avg	Beta Prev Avg
1	3	1	1	15	11	11
2	3	2	1	39	14	11
3	1	1	1	14	8	13
4	3	2	2	20	10	16
5	2	1	1	31	14	10
6	1	1	1	17	11	8
7	1	1	1	16	9	9
8	3	2	2	26	13	14
9	2	1	2	13	10	15

Radioactivity in Seepage Basins

100 AREAS

Alpha activity discharged to the 100-Area seepage basins was negligible. Results of analyses of nonvolatile beta discharged to the basins are shown in the following table.

Area →	Nonvolatile Beta Discharged to Seepage Basins, curies: R	P	L	K	C
Total	32	22	-	3	84
Previous Total	26	0.08	-	-	-

R AREA. The R-Area seepage basins and monitoring wells are shown in figure 9.

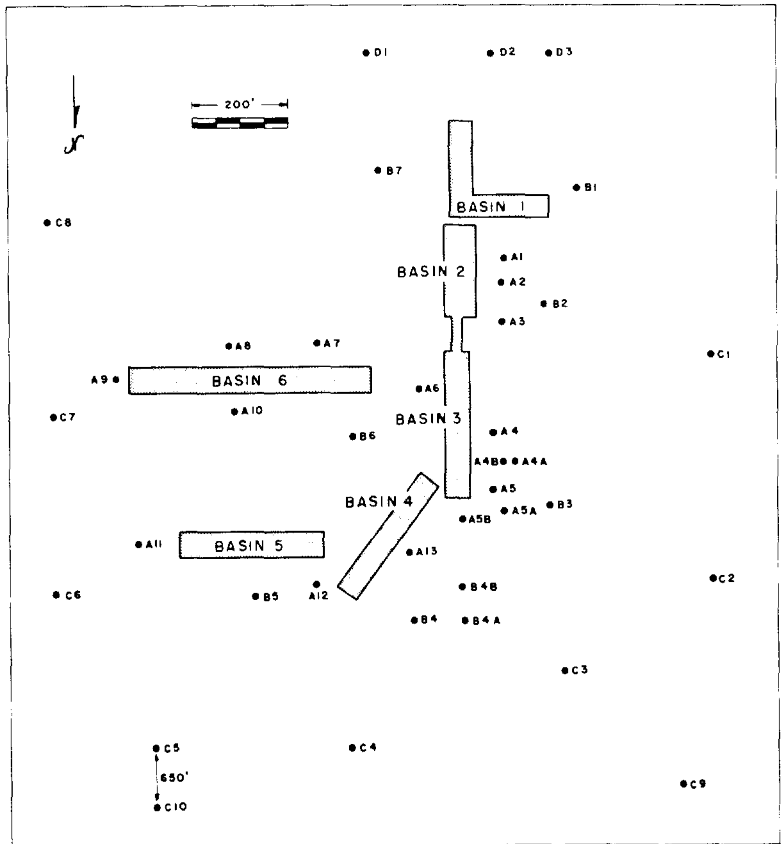

Figure 9. 100-R Seepage Basins and Monitoring Wells

Water was pumped from the emergency basin to the seepage basin system intermittently during the report period to prevent leakage from the emergency basin to the disassembly basin. Of the 32 curies nonvolatile beta released to the basins, 26 curies of $Cs^{134,137}$ and $Sr\text{-}Y^{90}$ were pumped to the basins during June.

Nonvolatile beta concentration in basin water is shown in the following table.

	Nonvolatile Beta in Water, 1×10^{-9} c/ml				
	Basin 2	Basin 3	Basin 4	Basin 5	Basin 6
Average	2.7	1.3	1.4	1.0	0.4*
Previous Average	3.2	3.4	3.2	1.0	1.0

* No samples taken during May and June because water level was too low.

Radiostrontium concentration in seepage basins is shown in the following table.

	Radiostrontium in Water, 1×10^{-9} c/ml			
	Basin 2	Basin 3	Basin 4	Basin 5
Average	1.3	0.8	0.6	0.4
Previous Average	1.8	2.5	2.1	0.6

Greater than 90% of the total radioactivity in the basins was $Sr\text{-}Y^{90}$.

The maximum nonvolatile beta concentration observed in the analysis of 275 water samples collected from wells near the seepage basins was 81×10^{-12} c/ml in well A-5, located 50 feet from Basin 3. Seepage was detected as far as 90 feet from the basins. The highest concentration at this distance was 3.1×10^{-12} c/ml in a sample collected from well A-11 which is adjacent to Basin 5.

P AREA. Releases of radioactivity to the P-Area seepage basins resulted from the handling and transfer of Chalk River fuel elements. Specific analyses of liquid from this cask indicated that approximately 80% of the activity released to the basin was Cs-137; the remainder was $Sr\text{-}Y^{90}$.

K AND C AREAS. Releases of radioactivity to the seepage basins in K and C Areas were associated with fuel element failures. Analyses of waste discharged to the basins indicated that 80 to 90% of the activity was Np-239.

700 AREA

Waste discharged to the 700-Area seepage basins during the report period was approximately 9 mc alpha and 20 mc nonvolatile beta in 800,000 gallons of water.

Analyses of 6 water samples collected from Basin 1 are summarized in the following table.

Alpha, d/m/ml			Nonvolatile Beta, 1×10^{-12} c/ml		
Max	Avg	Prev Avg	Max	Avg	Prev Avg
12.9	1.6	4.7	6.5	3.7	5.0

TNX

TNX and CMX discharge waste to a seepage basin which overflows to the Savannah River swamp. Results of analyses of 25 water samples collected from the basin are summarized in the following table.

Alpha, d/m/ml			Nonvolatile Beta, 1×10^{-12} c/ml		
Max	Avg	Prev Avg	Max	Avg	Prev Avg
20	10	21	20	9	50

200 AREAS

The F and H seepage basins and monitoring well systems are shown in figure 10.

F AREA. During the report period, the average liquid input to the basin system was 4.9×10^4 gal/day of waste and 2.1×10^4 gal/day of rain. The average seepage and evaporation rate was 3.9×10^4 gal/day.

Waste released to the system is shown in the following table.

Radioactivity Released* in 8.9×10^6 Gallons of Water

	Alpha Emitters, mc			Beta Emitters, c	
	Total	Prev Release		Total	Prev Release
Uranium	344	124	$Ru^{103,106}$	20	6.2
Pu-239	101	156	$Sr^{89,90}$	0.6	2.4
	-	-	$Zr\text{-}Nb^{95}$	7.4	2.6
	-	-	Rare Earths	4.8	7.9
	-	-	Cs-137	0.4	0.5
	-	-	I-131	5.0	0.7
Total →	445	280		38.2	20.3

* In addition 1700 curies of tritium were discharged to the basins.

Results of analyses of 41 samples collected from the basins during the report period are summarized in the following table. The effects of increased releases to the seepage basins were not observed in all basins due to changes in sample locations.

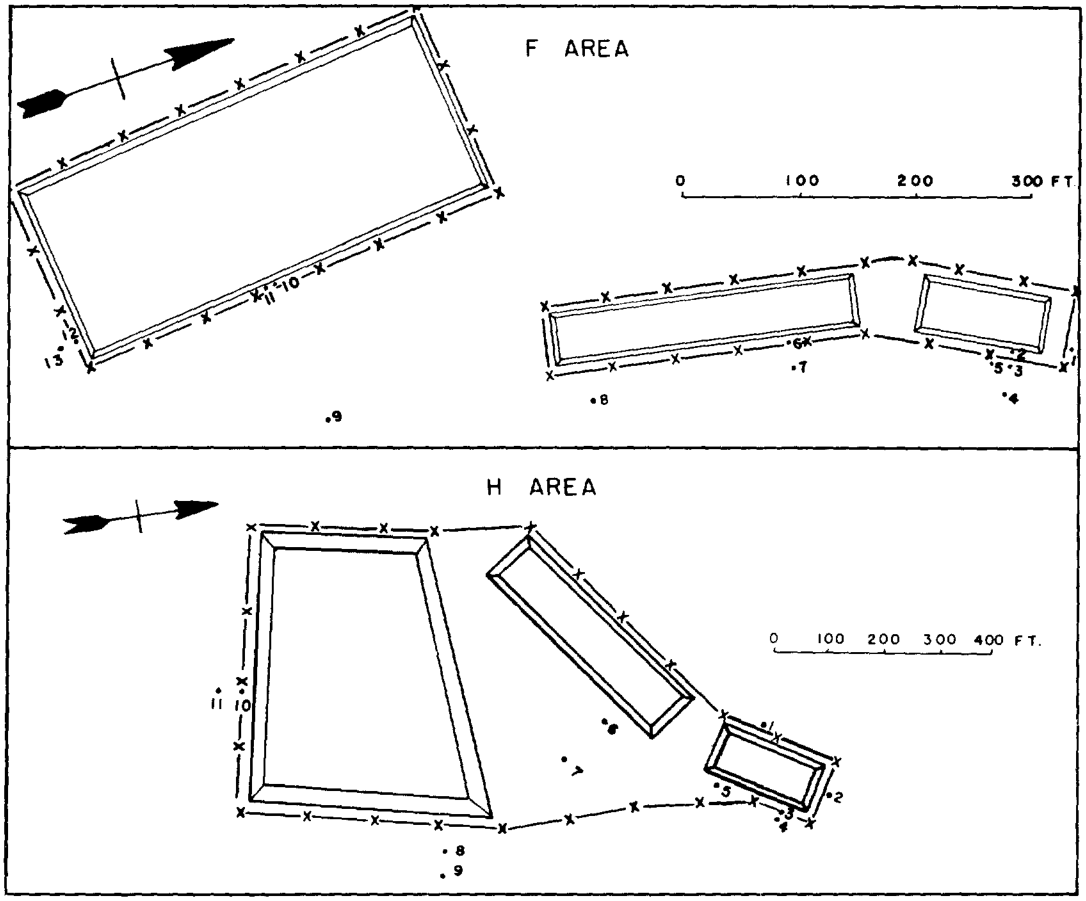

Figure 10. Seepage-Basin Monitoring Wells in F and H Areas

Radioactivity in Water

Basin No.	Alpha, d/m/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radioiodine, 1×10^{-12} c/ml Max	Avg	Prev Avg
1	127	33	32	1320	572	1300	240	82	-
2	33	25	20	740	510	550	13	8	-
3	12	8.5	15	510	380	200	6	4	-

H AREA. During the report period, the average liquid input to the basin system was 4.0×10^4 gal/day of waste and 1.4×10^4 gal/day of rain. The average seepage and evaporation rate was 3.9×10^4 gal/day.

Waste released to the system is shown in the table below.

Radioactivity Released* in 7.3×10^6 Gallons of Water

	Alpha Emitters, mc Total	Prev Release		Beta Emitters, c Total	Prev Release
Uranium	85	27	$Ru^{103,106}$	60	11.1
Pu-239	104	45	$Sr^{89,90}$	0.1	0.1
	-	-	$Zr\text{-}Nb^{95}$	2.8	19.3
	-	-	Rare Earths	1.6	0.7
	-	-	Cs-137	0.3	0.2
	-	-	I-131	37	13
Total →	189	72		101.8	44.4

* In addition, 1500 curies of tritium were discharged to the basins.

Analyses of 57 water samples collected from the basins during the report period are summarized below. The effects of increased releases to the seepage basins were not observed in all basins due to changes in sample locations.

Radioactivity in Water

Basin No.	Alpha, d/m/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radioiodine, 1×10^{-12} c/ml Max	Avg	Prev Avg
1	27	11	11	3500	880	1000	580	175	210
2	6.3	4.2	3.0	610	440	140	140	54	13
3	2.5	2.0	1.9	160	120	42	40	13	3

MONITORING WELLS, F AREA. Analyses of 75 samples are summarized in the following table.

Well No.	Depth to Water, ft	Distance from Basin, ft	Radioactivity in Water: Alpha, 1 × 10^{-3} d/m/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1 × 10^{-15} c/ml Max	Avg	Prev Avg
1	22.0 - 23.3	34	620	200	150	140,000	62,000	44,000
2	65.4 - 66.4	5	12	6	9	500	360	480
3	64.0 - 65.3	29	3	2	2	20	17	25
4	64.3 - 66.0	73	4	3	10	81	29	65
5	13.7 - 16.8	24	2	1	Dry	5,800	1,300	Dry
6	7.2 - 11.1	6	2300	400	34	130,000	29,000	12,000
7	9.1 - 12.5	46	200	52	Dry	44,000	13,000	Dry
8	64.1 - 66.1	63	3	2	2	18	13	14
9	56.9 - 59.0	150	2	1	2	19	13	13
10	5.6 - 7.5	9	170	59	580	180,000	89,000	31,000
11	65.9 - 67.2	9	2	1	5	400	110	39
12	9.3 - 11.2	29	71	30	38	170,000	74,000	21,000
13	11.2 - 13.4	58	26	14	11	320,000	71,000	15,000

A sharp drop in the pH of the basin water occurred during April. A correspondingly sharp rise in nonvolatile beta activity in ground water followed.

MONITORING WELLS, H AREA. Analyses of 166 samples are summarized in the following table.

Well No.	Depth to Water, ft	Distance from Basin, ft	Radioactivity in Water: Alpha, 1 × 10^{-3} d/m/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1 × 10^{-15} c/ml Max	Avg	Prev Avg	Radioiodine, 1 × 10^{-15} c/ml Max	Avg	Prev Avg
1	22.6 - 26.1	24	48	24	58	1700	1200	2500	550	200	57
2	21.4 - 25.1	25	2	1	2	51	26	14			
3	18.6 - 22.0	15	1	1	1	480	280	49			
4	18.3 - 21.6	45	3	2	1	41	28	20			
5	20.5 - 23.7	13	1	1	1	1200	650	700	2700	1100	380
6	22.8 - 26.3	6	1	1	1	43	24	49			
7	21.8 - 24.4	66	2	1	1	27	15	18			
8	18.8 - 20.5	18	2	1	1	69	47	21			
9	13.9 - 17.0	78	2	1	1	27	15	16			
10	20.7 - 22.4	19	2	1	1	120	36	36			
11	13.0 - 15.1	79	1	1	1	320	200	130			
A-37	-	-	-	-	-	1200	950	-	-	-	-
A-38	-	-	-	-	-	2200	1500	-	-	-	-
A-39	-	-	-	-	-	1600	1300	-	-	-	-
A-40	-	-	-	-	-	1200	930	-	-	-	-
A-41	-	-	-	-	-	500	240	-	-	-	-

Wells A-37 through A-41 are located about $12\frac{1}{2}$ feet apart, a few feet uphill from a swamp bordering the H-Area effluent, and approximately 500 feet east of the seepage basins. These five test wells were installed in the zone of the most rapid movement of seepage basin water into the swamp, determined by using tritium present in the basin as a tracer. Tritium was detected in water from all of these wells. The average concentration from analyses of 90 samples was 2.2×10^{-8} c/ml with a maximum of 4.5×10^{-8} c/ml. Gamma pulse height analyses and specific chemical analyses of 16 water samples collected from February 19 to March 11 indicated that practically all of the nonvolatile beta activity could be accounted for by isotopes of strontium and yttrium. Alpha activity was negligible.

Radioactivity in Biological Specimens

TERRESTRIAL AND AVIAN SPECIMENS

Five terrestrial and three avian specimens including 3 turtles, 1 rabbit, 1 squirrel, 2 quail and 1 duck were collected at random from the Plant site. (Fifty ducks collected from Par Pond are reported in the aquatic section.) Radioiodine concentrations in the thyroids and nonvolatile beta concentrations in the bones and flesh were less than 10×10^{-12} c/g.

AQUATIC SPECIMENS

A total of 663 aquatic specimens including 607 fish, 50 ducks, 3 turtles, 2 clams, and 1 frog were collected and radioanalyzed. The turtles, clams and frog were collected from Lower Three Runs and all contained radiostrontium in the bones and radiocesium in the flesh. Par Pond, fed by R-Area effluent which discharges to Steel Creek and Lower Three Runs, was the main contributor of long-lived radioisotopes to Plant streams; therefore, primary emphasis was placed on the collection of samples from this system. Because of high water temperatures fish were collected at only one location in both Steel Creek and Four Mile Creek; none were collected from Pen Branch.

PAR POND. Compared to the previous report period, nonvolatile beta in the bones of Par Pond fish decreased 20% while the concentrations in flesh increased 25%. The main isotopes in the bones were Sr-89 and Sr-Y^{90}, while the main isotopes in the flesh were Cs-134, Cs-137 and Zn-65.

Specific radiochemical analyses showed that the bones and flesh of Par Pond fish concentrated the radiostrontium and radiocesium from the water by factors of 10^4 and 10^3, respectively. Nonvolatile beta found in fish from this location for the past two report periods are shown in the following table.

Samples	Nonvolatile Beta in Fish, 1×10^{-12} c/g					
	Bone			Flesh		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
145	865	225	280	165	50	40

Sampling of migratory waterfowl at Par Pond began on January 6 and continued until the ducks left the pond in April. During this period 50 specimens were collected including 43 ring-necks, 2 mallards, 2 gadwalls, 2 grebes and 1 coot. The main radioisotopes present in the bones and flesh were $Sr^{89,90}$ and $Cs^{134,137}$; Zn-65 was the secondary isotope in the fleshy tissues. Nonvolatile beta found in the bones and flesh of each species during this period is shown in the following table.

Species	Nonvolatile Beta in Ducks, 1×10^{-12} c/g			
	Bone		Flesh	
	Max	Avg	Max	Avg
Grebe	35	25	80	50
Ring-Neck	35	20	80	30
Coot	-	25	-	45
Mallard	15	10	20	15
Gadwall	20	15	30	20

LOWER THREE RUNS. There were no changes in the concentrations of radioactivity in Lower Three Runs fish which were evident throughout the stream; changes were noted but were confined to segments of the stream. At upstream locations nonvolatile beta in the bones generally decreased while flesh concentrations remained essentially the same. At downstream locations the nonvolatile beta concentration increased in both bones and flesh. The bones of Lower Three Runs fish concentrated the radiostrontium from the water by factors that ranged from 9×10^3 to 3×10^4; the flesh concentration factor was 3×10^4. A fish collected in April at Highway 28, 14 miles below Par Pond dam, contained 600×10^{-12} c/g of nonvolatile beta in the flesh, the highest flesh concentration found this far downstream to date. Concentrations of nonvolatile beta found in these fish are summarized in the following table.

Location, Miles Downstream from Par Pond Dam	Nonvolatile Beta in Fish, 1×10^{-12} c/g					
	Bone			Flesh		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
0.2	940	440	805	495	115	100
1	3080	555	940	985	140	120
6	835	450	550	440	135	160
11	895	255	205	515	80	40
14	370	160	145	615	65	25

STEEL CREEK. Radioactivity in Steel Creek fish was higher than that reported during the previous six-month period. Slight increases in the nonvolatile beta concentration in fish bones occurred as a result of the discharge of Par Pond water to Steel Creek and further increases occurred due to fuel element failures in L and P Areas. Barely detectable concentrations of nonvolatile beta were also found in fish flesh. The main isotope present in the bones was $Sr^{89,90}$; $Cs^{134,137}$ and Zn-65 were the main isotopes found in the flesh. The bones and flesh of Steel Creek fish concentrated the radiostrontium and radiocesium from the water by factors of 5×10^3 and 7×10^2, respectively. A summary of the nonvolatile beta concentrations in Steel Creek fish is shown in the following table.

Nonvolatile Beta in Fish, 1×10^{-12} c/g

Bone			Flesh		
Max	Avg	Prev Avg	Max	Avg	Prev Avg
165	50	30	20	10	<10

FOUR MILE CREEK. Fish collected 6 miles downstream from C Area during the beginning of the report period contained low level concentrations of nonvolatile beta in the bones and barely detectable concentrations in the flesh. As a result of fuel element failures in C Area in March, the nonvolatile beta in the bones of fish collected in April and May increased by a factor of 2 with no significant changes in the flesh concentrations. The main radioisotopes present in the bones and flesh were $Sr^{89,90}$ and Zn-65, respectively. Gamma pulse height analyses of several fish collected after the failures occurred revealed the presence of the short-lived isotope Np-239 in the intestinal tracts. No fish were collected from this stream last period; nonvolatile beta found in fish collected this period are shown in the following table.

Nonvolatile Beta in Fish, 1×10^{-12} c/g

Bone		Flesh	
Max	Avg	Max	Avg
370	65	15	10

SAVANNAH RIVER. A total of 140 fish were collected from the Savannah River this period; only two contained significant concentrations of radioactivity in the flesh. The flesh of single fish collected near the mouth of Lower Three Runs and at Stokes Bluff had nonvolatile beta concentrations of 35×10^{-12} c/g and 25×10^{-12} c/g, respectively. Nonvolatile beta in the bones of fish collected near the mouth of Four Mile Creek increased but decreased near the mouth of Lower Three Runs. The main radioisotopes present in the bone and flesh were $Sr^{89,90}$ and $Cs^{134,137}$, respectively. Nonvolatile beta found in these fish for the past two periods are shown in the following table.

Location	No. of Samples	Nonvolatile Beta in Fish, 1×10^{-12} c/g					
		Bone			Flesh		
		Max	Avg	Prev Avg	Max	Avg	Prev Avg
Upper Three Runs	33	15	10	10	10	5	4
Four Mile Creek	16	115	25	10	5	4	4
Steel Creek	22	50	15	15	10	5	4
Lower Three Runs	11	110	25	45	35	7	3
Highway 301	8	30	15	-	10	4	-
Stokes Bluff	52	35	15	10	25	6	4