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HEALTH PHYSICS REGIONAL MONITORING

Semiannual Report, July through December 1957

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Explosives Department - Atomic Energy Division

Savannah River Plant

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Semiannual Report, July through December 1957

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H. G. Mealing, Jr., R. S. Harvey
and J. H. Horton

July 15, 1958

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

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Abstract

Radioactivity from both Plant operations and bomb fallout was detectable during the period from July 1957 through December 1957; bomb fallout was estimated to be approximately three times greater than during the previous 6-month period. Nonvolatile beta released to reactor effluent streams was readily detectable in the Savannah River, and more extensive biological sampling of the reactor effluent streams was begun. Nonvolatile beta discharged to R-Area seepage basins exceeded the previous total nonvolatile beta release to all Savannah River Plant seepage basins.

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 July through December 1957, is one of a series of reports concerning the regional monitoring program at the Savannah River Plant.

Data Reporting

Survey data were averaged for the 6-month period and compared with the previous 6-month averages (H. G. Mealing, Jr., and J. H. Horton, "Health Physics Regional Monitoring Semiannual Report," DPSP 57-25-43, November 20, 1957).

In reporting data, "average" or "total" refers to that of the 6-month report period, and "previous average" or "previous total" to the average or total for the preceding 6-month period. "Maximum" refers to the highest individual sample collected during the 6-month period.

Sensitivity and Standard Deviation of Laboratory Analyses

The 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 and is influenced by the 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 6-month averages of data in the report.

Analysis	Sample	Sensitivity	Standard Deviation, %	Spike Value
Alpha	Water	$0.33 \pm 0.11 \times 10^{-3}$ d/m/ml	13	100×10^{-3} d/m/ml
	Mud	0.33 ± 0.11 d/m/g	-	-
	Vegetation	0.17 ± 0.06 d/m/g	-	-
	Air	$0.026 \pm 0.009 \times 10^{-14}$ μc/cc	-	-
Beta	Water	$6.9 \pm 0.4 \times 10^{-15}$ c/ml	-	-
	Mud	$6.9 \pm 0.4 \times 10^{-12}$ c/g	-	-
	Vegetation	$3.5 \pm 0.2 \times 10^{-12}$ c/g	-	-
	Air	$1.2 \pm 0.07 \times 10^{-14}$ μc/cc	-	-
Uranium or Plutonium	Water	$0.40 \pm 0.13 \times 10^{-3}$ d/m/ml	12	100×10^{-3} d/m/ml
	Mud	0.42 ± 0.14 d/m/g	20	100 d/m/g
	Vegetation	0.044 ± 0.014 d/m/g	14	10 d/m/g
Radioiodine	Water	$9.3 \pm 0.4 \times 10^{-15}$ c/ml	19	300×10^{-15} c/ml
	OP & 25-MR* Vegetation	$0.67 \pm 0.03 \times 10^{-12}$ c/g	21	20×10^{-12} c/g
	H-Area Vegetation	$1.95 \pm 0.07 \times 10^{-12}$ c/g	17	60×10^{-12} c/g
	Air	$2.3 \pm 0.09 \times 10^{-14}$ μc/cc	-	-
Tritium	Water	1 μc/ℓ	4	7 to 60 μc/ℓ

* 25-mile radius outer perimeter.

Summary

- Waste Released by Plant Operations. Radioactivity released to the environment by stacks and effluent streams was approximately 0.30 curie alpha, 430 curies nonvolatile beta, 90 curies radioiodine and 860,000 curies tritium. Approximately 0.8 curie alpha, 2200 curies nonvolatile beta, 90 curies radioiodine, and 2600 curies tritium were released to seepage basins.

- Bomb Fallout. During the report period, an estimated 340 curies of nonvolatile beta was deposited on the Plant site in rain, while radioiodine deposition was estimated as 125 curies. At least 99 percent of the nonvolatile beta and 80 percent of the radioiodine consisted of debris from weapons tests.

- Vegetation. Plutonium was detectable in four samples collected near the Separations Areas; the maximum plutonium concentration observed was 0.4 d/m/g. Bomb fallout increased average nonvolatile beta concentrations by factors of 2 to 3, as compared to the previous 6-month averages. Radioiodine from bomb fallout was detectable throughout the report period, while stack released radioiodine caused slightly higher average concentrations near H Area than at other locations.

- Atmosphere. Concentrations of alpha in the atmosphere remained low; the highest weekly concentration observed was 0.5×10^{-14} μc/cc in a sample collected from F Area. Nonvolatile beta concentrations increased at all locations because of fallout from weapons tests. Decreased stack releases of radioiodine produced decreased concentrations of atmospheric radioiodine near the Separations Areas, but increased bomb fallout caused increased concentrations at other locations.

  Bomb fallout caused deposition of radioactive particles on adhesive papers at various locations to increase by factors of 3.5 to 5, as compared to deposition during the previous 6-month period. The greatest number of particles was observed during the week ending September 11.

  Radioactive particles suspended in the air were numerous from July through October (during the Nevada Weapons Tests), the maximum concentration at a single air monitoring location (1300 particles/1000 cubic meters of air) occurred at D-Area during the week ending August 6.

  Only three routine water vapor samples contained more than 1 μc/ℓ tritium, and the maximum concentration in routine samples was 1.6 μc/ℓ.

  The highest average radiation dose rate observed at the air monitor stations was 1.25 mrad/24 hours at Allendale. Along the area-perimeter fences the highest area average was 1.42 mrad/24 hours at H Area with a maximum of 1.76 mrad/24 hours at one location near Building 211-H.

- Rain Water. Alpha concentrations in rain water remained low and the maximum concentration observed in a single sample was 5.2×10^{-3} d/m/ml in a sample collected from Aiken Airport during the week ending July 31. Increased fallout from weapons tests increased nonvolatile beta concentrations at all locations, obscuring any effect of Plant released radioiodine. The maximum nonvolatile beta concentration observed was 5.5×10^{-12} c/ml in a sample collected from the 300/700 Area during the week ending July 17; the maximum radioiodine concentration was 1.8×10^{-12} c/ml in a sample collected from the Talatha Gatehouse during the same week.

- Streams. Concentrations of radioactivity in the effluents from M, C, and H Areas decreased, while increased concentrations were observed in the effluents from K, L, P, and R Areas. Concentrations in F Area effluent showed no significant change. The increased nonvolatile beta concentrations in the 100-Area effluent streams were due to increased amounts of nonvolatile beta discharged in disassembly basin water, aggravated in some cases by decreased cooling water flow during shutdowns. Increased nonvolatile beta concentrations were readily detectable in water samples collected from the Savannah River at locations downstream from Steel Creek, Pen Branch, and Lower Three Runs Creek.

- Ground Water. Bomb fallout caused slightly increased concentrations of nonvolatile beta in ZW (drilled, cased) wells, while maximum concentrations from open wells increased to 30×10^{-14} c/ml.

- Plant Drinking Water. Concentrations of radioactivity in Plant drinking water remained approximately the same, and showed no evidence of contamination from Plant operations or bomb fallout.

- Public Water Supplies. Slight increases in nonvolatile beta concentrations due to bomb fallout were observed at several locations; the highest average concentration was 1.9×10^{-14} c/ml in samples collected from North Augusta. The maximum concentration in a single sample was 2.6×10^{-14} c/ml.

- Seepage Basins. Concentrations of radioactivity in the first 700-Area basin increased due to an accidental release of a small but unknown quantity of high level waste to the basins during November. Increase had been observed in concentrations estimated as less than 0.1 curie in the second basin at the end of the report period.

  Concentrations of alpha and nonvolatile beta in the TNX basin decreased.

  The average concentration of alpha in F-Area basin No. 1 remained the same, while the average nonvolatile beta concentration decreased slightly.

  Alpha and nonvolatile beta concentrations in H-Area basin No. 1 increased, while the radioiodine concentration decreased.

  Seepage basins were recently constructed in all reactor areas; R, L, P, and C-Area basins were in use during the report period. Maximum nonvolatile beta concentrations observed in the basins were 8.5×10^{-7} c/ml in the R-Area basins, 2.5×10^{-10} c/ml in the L-Area basin, 6×10^{-9} c/ml in the P-Area basin, and 8.8×10^{-12} c/ml in the C-Area basin.

Survey Results

Radioactivity Released by Plant Operations

100 AREAS

The major sources of liquid waste from the 100 Areas were the thermal shield water, purged at rates of 1 to 9 gallons per minute; and the disassembly basin water, purged at rates of 700 to 1800 gallons per minute.

During the process-improvement shutdown in L Area (September through November) cooling water flow was discontinued, and essentially undiluted-disassembly basin water was discharged to Steel Creek.

Alpha activity discharged in the 100 Area effluent streams was negligible (estimated as 290 mc due to background activity in river water), while the nonvolatile beta release increased as compared to the previous 6-month period. A summary of the nonvolatile beta releases is given below.

	Nonvolatile Beta Released in Thermal Shield Water, curies					
Area →	R	P	L	K	C	Total for All Areas
Total	23	11	10	2	2	48
Previous Total	81	69	33	45	2	230

The decreased activity discharged in thermal-shield water resulted from decreased amounts of thermal-shield water purged to the effluent streams.

	Nonvolatile Beta Released in Disassembly Basin Water, curies					
Area →	R	P	L	K	C	Total for All Areas
Total	208	88*	74	6	10	386
Previous Total	171	20	2	12	8	213

* In addition to the nonvolatile beta, approximately 65 curies of radioiodine was discharged in P-Area disassembly basin water in July.

Fuel element failures in R, P, and L Areas caused the increases in nonvolatile beta discharged in disassembly basin water.

Tritium released from the 100-Area stacks totaled 42,000 curies during the report period. The maximum monthly release was 3700 curies from L Area in November.

200 AREAS

Stack releases of alpha, nonvolatile beta, and radioiodine from the 291 stacks decreased. Because of discontinuation of canyon operations in F Area, the 291-F stack was not monitored for radioiodine release.

300 AREA

An estimated 16 pounds (4.9 mc) of uranium was discharged from the 300 Area to Tims Branch as compared to 360 pounds (100 mc) during the previous 6-month period.

Bomb Fallout

Radioactivity deposited on the Plant site, estimated from results of rain water samples and rain gage readings, is listed in the following table.

	Nonvolatile Beta, c	Radioiodine, c
July	84	40
August	28	8
September	71	33
October	131	39
November	11	3
December	10	2
Total →	335	125
Previous Total →	102	48

At least 99 percent of the nonvolatile beta and 80 percent of the radioiodine was debris from weapons tests.

Radioactivity on Vegetation

There were 850 vegetation samples analyzed for both alpha and nonvolatile beta activity, while 1068 were analyzed for radioiodine. The sample locations are shown in figures 1 and 2.

The 6-month average concentrations of alpha on vegetation are listed below.

	Alpha, d/m/g		
Location	Max	Avg	Previous Avg
F Area (at 1-mile radius)	1.9	0.4	0.4
H Area (at 1-mile radius)	1.5	0.4	0.5
Inner Perimeter (IP)	1.5	0.3	0.5
Outer Perimeter (OP)	1.7	0.3	0.4
25-Mile Radius (25 MR)	1.3	0.3	0.4
Burial Ground (at fence)	0.7	0.3	0.5

Twenty of the samples containing the highest concentrations of alpha were analyzed for uranium and plutonium by TBP extraction and alpha pulse-height analysis. Plutonium was detectable in four of the nine 200-Area samples analyzed by this method, and the maximum plutonium concentration was 0.4 d/m/g in a sample collected near F Area on October 25. No uranium or plutonium was detectable in samples collected from inner perimeter, outer perimeter, or 25-mile radius locations.

A summary of nonvolatile beta concentrations on vegetation is shown in the following table.

Location	Nonvolatile Beta, 1×10^{-12} c/g Max	Avg	Previous Avg
F Area (at 1-mile radius)	1100	260	110
H Area (at 1-mile radius)	1600	300	110
Inner Perimeter (IP)	1600	390	120
Outer Perimeter (OP)	1000	260	110
25-Mile Radius (25 MR)	2600	250	90
Burial Ground (at fence)	970	270	140

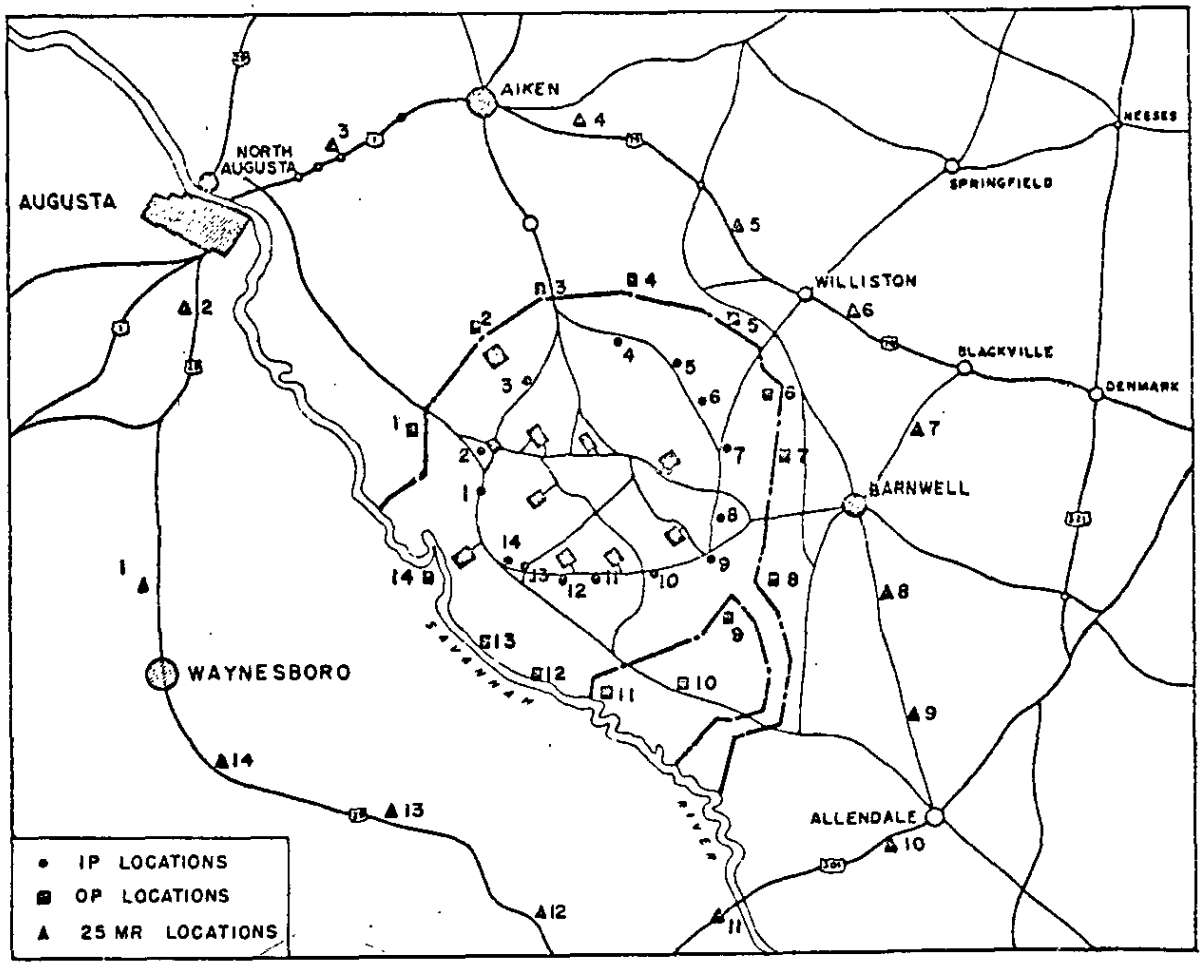


Figure 1. Vegetation Sample Locations

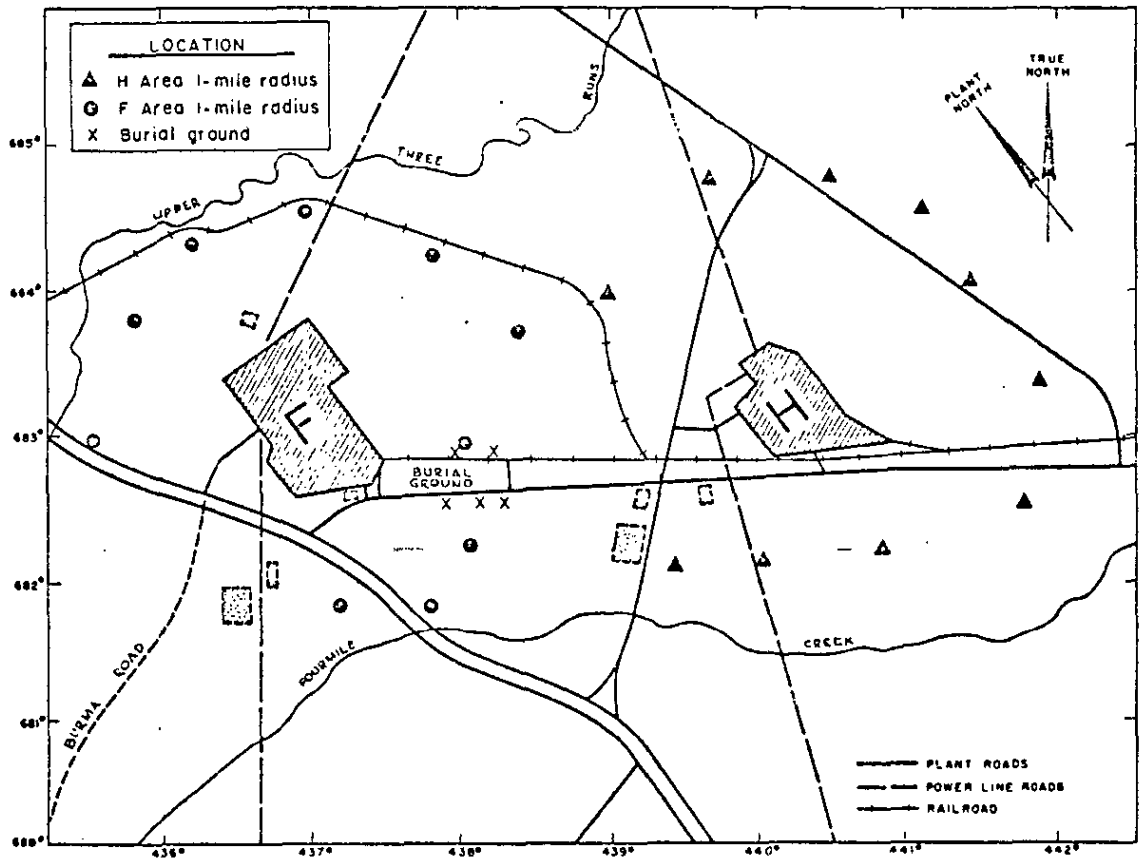


Figure 2. Vegetation Sample Locations in F and H Areas

The increased nonvolatile beta concentrations were due to increased fallout from weapons tests. The maximum concentration was collected from a 25 MR location and occurred in a sample collected on October 2; the maximum concentrations at all locations occurred in samples collected between September 30 and October 25. Monthly average concentrations of nonvolatile beta on vegetation are shown in figure 3.

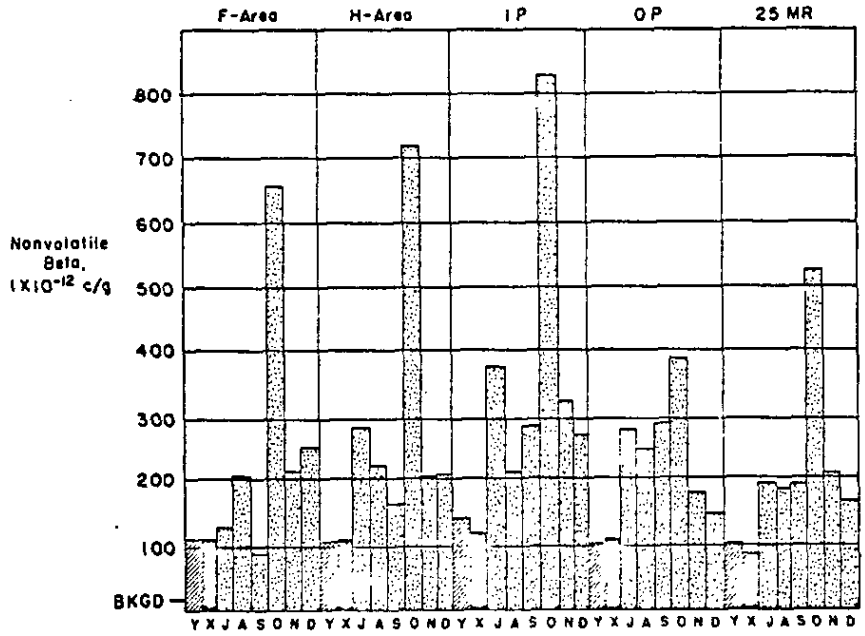
Analyses of special samples collected during October on routes from Wagener, S. C. to Lake View, S. C. and from Gaffney, S. C. to Linville, N. C. showed that the radioactivity was not confined to the vicinity of the Savannah River Plant. Results of analyses of the special samples are compared to concentrations of nonvolatile beta in routine samples collected during the same period in the following table.

Location	Date	Samples	Nonvolatile Beta, 1×10^{-12} c/g Max*	Avg*
F Area	10/25	12	1100	660
H Area	10/25	12	1100	510
Inner Perimeter (IP)	10/23	14	1000	630
Outer Perimeter (OP)	10/21	14	680	340
25-Mile Radius (25 MR)	10/22	14	840	460
Wagener to Lake View	10/19	12	1100	550
Gaffney to Linville	10/19	8	960	440

* Maximum and average concentrations in samples collected on indicated dates.

The maximum concentrations in the special samples occurred in samples collected at Marion, S. C. and at Linville, N. C.

The half-life of the nonvolatile beta on vegetation was approximately 20 days from July through September, but after the completion of the Nevada weapons tests in October, the half-life increased, as shown in figure 4.



Y - July through December 1956
X - January through June 1957

Figure 3. Radioactivity on Vegetation, July through December 1957

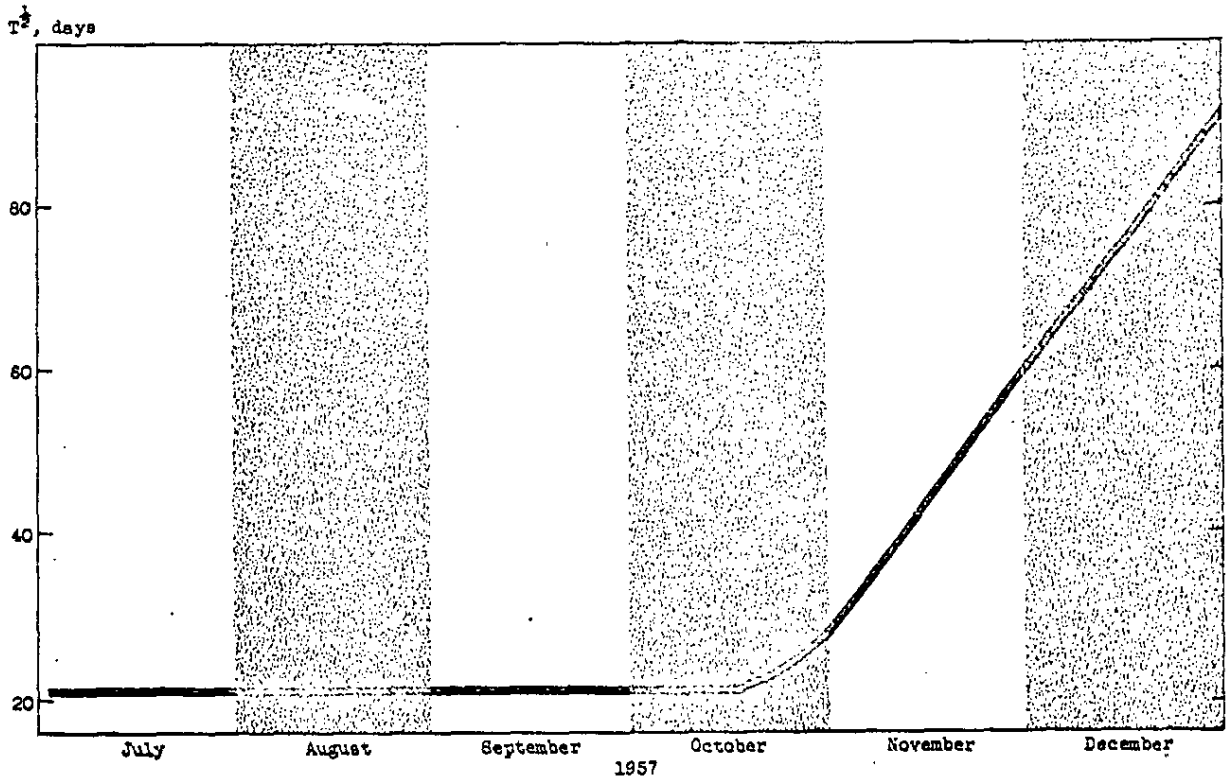


Figure 4. Half-Life of Nonvolatile Beta on Vegetation

Because of continued decreases in stack released radioiodine, radioiodine analysis of vegetation from F Area and IP locations was discontinued. Results of analyses of samples from other locations are summarized in the following table.

Location	Radioiodine, 1×10^{-12} c/g Max	Avg	Previous Avg
H Area (at 1-mile radius)	140	19	36
Outer Perimeter (OP)	130	11	3
25-Mile Radius (25 MR)	200	12	2

The 200-H Area locations indicated decreased stack releases of radioiodine, while bomb fallout resulted in the highest 6-month average concentrations ever observed at OP and 25 MR locations. The maximum concentration at H Area occurred in a sample collected on August 1, and was due to bomb fallout and stack released radioiodine. The maximum concentrations at the OP and 25 MR locations occurred during October and were due almost entirely to bomb fallout. The highest concentration in samples collected from H-Area locations in October was 130×10^{-12} c/g.

Comparison of results of analyses of routine samples and results of analyses of samples collected on special sampling routes during October showed that very little of the radioiodine on vegetation at the OP and 25 MR locations was due to stack releases. Results of the analyses are shown in the following table.

Location	Date	No. of Samples	Radioiodine, 1×10^{-12} c/g Max*	Avg*
H Area	10/18	10	68	35
Outer Perimeter (OP)	10/21	14	34	17
25-Mile Radius (25 MR)	10/22	14	46	17
Wagener to Lake View	10/19	18	39	15
Gaffney to Linville	10/19	12	34	13

* Maximum and average concentrations in samples collected on indicated dates.

The maximum concentrations in the special samples occurred in samples collected from Linville, N. C. and Columbia, S. C.

RADIOIODINE IN MILK

Weekly milk samples collected from Plant perimeter locations contained an average of 5×10^{-13} c/ml radioiodine, as compared to an average concentration of 2×10^{-13} c/ml in samples collected during the previous report period.

Radioactivity in the Atmosphere

Radioactivity in the atmosphere was determined by counting 275 two-inch diameter air filters for alpha and beta activity and 356 two-inch diameter silver nitrate impregnated air filters for radioiodine, by determining by radioautograph the number of radioactive particles collected on 270 eight-inch by ten-inch filters and 945 eight-inch by ten-inch adhesive papers, and by the collection and analysis of 344 water vapor samples for tritium. Radiation dosage was determined by 1242 ionization chamber readings and 140 film badge readings. The air filters, film badges, and tritium monitors were located at the air monitoring stations while ionization chambers were located at the perimeters of each of the Plant areas and at the air monitoring stations. Adhesive papers were located at IP vegetation monitoring locations, near H and F Areas, and at the 643-G burial ground fence. The locations of Plant areas and air monitoring stations are shown in figure 5.

ATMOSPHERIC RADIOACTIVITY AS DETERMINED BY COUNTING AIR FILTERS

Three days were allowed for the decay of radon and thoron daughters before counting the filters for alpha and beta activity.

	Atmospheric Radioactivity, 1×10^{-14} μc/cc								
	Alpha			Beta			Radioiodine		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
F Area	0.5	0.1	0.2	2800	510	380	500	94	150
H Area	0.3	0.1	0.1	1800	380*	270	640	110	390
400 Area	0.3	0.1	0.2	2200	460	360	280	49	54
Talatha Gate House	0.3	0.1	0.1	2300	440	360	280	54	40
Williston Gate House	0.3	0.1	0.1	2900	520	350	230	42	41
300/700 Area	0.4	0.1	0.2	2800	520	320	310	53	45
Dunbarton Fire Tower	0.2	0.1	0.1	2300	450	300	230	42	27
Waynesboro	0.4	0.1	0.1	2600	460	370	230	43	30
Aiken Airport	0.3	0.1	0.1	1400	410	310	110*	20*	27
Allendale	0.2	0.1	0.1	900	360*	210	130*	28*	21
Bush Field	-	-	-	-	-	-	140*	24*	31
Langley	-	-	-	-	-	-	180*	27*	24
Barnwell	-	-	-	-	-	-	220	56	22
Williston	-	-	-	-	-	-	320	45	29
Sardis	-	-	-	-	-	-	180	35	-

* Accuracy of results doubtful because of difficulties with sampling equipment.

The greatest concentrations of beta and radioiodine in the air occurred during the week ending August 6.

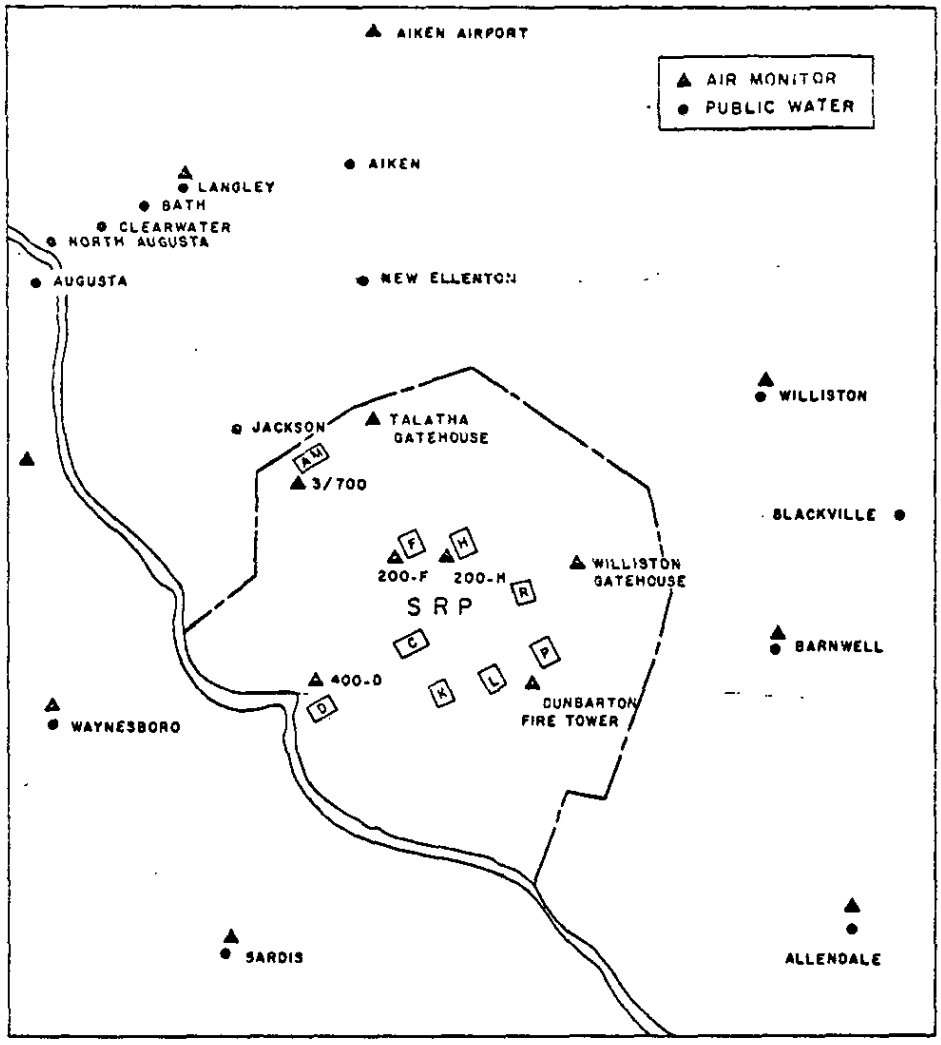


Figure 5. Constant Air Monitoring Stations and Public Water Sampling Locations

Decay studies showed that the average half-life of the beta activity ranged from 7 days for the activity on the filters collected during the week ending July 30 to 75 days for the activity on the filters collected during the week ending December 10. Generally, increases in atmospheric concentrations of beta activity were accompanied by decreases in the half-life of the activity, indicating that the increased concentrations were due to freshly formed fission products (fallout from weapons tests).

From July through October, during the Nevada weapons tests, the average concentration of beta in the air was 6×10^{-12} μc/cc and the average half-life of the material was 23 days. During November and December, the average concentration decreased to 2×10^{-12} μc/cc and the average half-life increased to 44 days.

PARTICULATE FALLOUT

Bomb fallout increased the deposition of radioactive particles at all sampling locations, as shown in the following table.

Location	Particles/Ft²/Wk Max	Avg	Previous Avg
IP	450	25	5.0
F Area	350	23	5.9
F Area (at 1-mile radius)	330	19	5.5
H Area	320	18	4.7
H Area (at 1-mile radius)	300	19	4.1
Burial Ground Fence*	160	5	1.4

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

Eighty-nine percent of the particulate fallout at the IP locations occurred during three weeks of the report period. Forty-eight percent occurred during the week ending September 11, 26% occurred during the week ending October 2, and 15% occurred during the week ending October 9. Of the particles collected during the report period, 162 of the most radioactive individual particles were counted with end-window GM counters, and decay studies were made on 60 particles. Monthly deposition of the particles, results of the beta counts, and results of the decay studies are summarized in the following table.

	Particles/Ft^2/Wk	Beta Activity/ Particle, d/m Max	Avg	Average Half-Life, days
July	8	2300	220	10
August	6	160	67	11
September	82	430	260	21
October	55	930	240	33
November	1	180	66	56
December	1	250	61	38

SUSPENDED RADIOACTIVE PARTICLES

Location	Particles/1000 Cu Meters of Air Max	Avg	Previous Avg
F Area	1200	170	120
H Area	1100	130	90
Talatha Gate House	980	140	140
Williston Gate House	510	120	110
Dunbarton Fire Tower	1200	150	130
400 Area	1300	220	110
300/700 Area	740	140	-
Aiken Airport	390	120	110
Allendale	530	100	120
Waynesboro	600	110	90

Suspended radioactive particles from bomb fallout were numerous from July through October and the maximum concentration was observed during the week ending August 6. Of the particles collected during the report period, 266 individual particles were counted with end-window GM counters and decay studies were carried out with 62 of the particles counted. Monthly average concentrations of particles in the air, results of the beta counts of the particles and results of the decay studies are shown in the following table.

	Particles/1000 Cu Meters of Air	Beta Activity, d/m Max	Avg	Average Half-Life, days
July	210	1200	130	5
August	280	300	89	27
September	160	340	100	37
October	130	310	73	70
November	49	98	28	100
December	73	310	86	100

RADIATION DOSAGE

Location	Mrad/24 Hrs Avg	Mrad/24 Hrs Previous Avg
H Area	1.42	1.15
P Area	1.38	0.83
L Area	1.37	0.90
300/700 Area	1.32	0.99
R Area	1.32	0.92
K Area	1.28	0.84
Allendale	1.25	1.13
Dunbarton Fire Tower	1.25	1.08
TC Area	1.21	0.82
F Area	1.18	0.98
Aiken Airport	1.17	1.18
C Area	1.17	0.90
400 Area	1.15	0.78
Talatha Gate House	1.14	0.84
Waynesboro	1.08	1.02
Williston Gate House	1.06	0.81

The highest radiation dose recorded at a single location in H Area was 1.76 mrad/24 hours at a location near the Building 211-F facility. The highest radiation level indicated by film badges at any air monitoring station during any two week sampling period was 20 mr.

TRITIUM IN ATMOSPHERIC WATER VAPOR

Tritium in atmospheric water vapor was monitored by the analysis of weekly samples collected by pumping air through silica gel columns. Of 344 routine water vapor samples collected by this method, only 3 samples contained more than 1 $\mu c/\ell$. Samples collected from Langley during the weeks ending September 10 and October 15 contained 1.1 $\mu c/\ell$ and 1.3 $\mu c/\ell$, respectively, and a sample collected from the Dunbarton Fire Tower air monitoring station during the week ending October 7 contained 1.6 $\mu c/\ell$. A special sample collected at a location $1\frac{1}{2}$ miles from H Area during the week ending July 24 contained 3.3 $\mu c/\ell$, the highest concentration observed during the report period.

Radioactivity in Rainwater

The results of analyses of 196 weekly rainwater samples collected at the air monitoring stations shown in figure 5 are summarized in the following table.

Location	No. of Samples	Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml			Radioiodine, 1×10^{-15} c/ml		
		Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
F Area	19	2.6	1.7	2.2	1500	530	280	620	140	230
H Area	19	3.1	1.4	2.5	2000	550	310	750	180	350
300/700 Area	20	4.1	2.1	2.6	5500	950	320	1700	230	71
Talatha Gate House	20	2.5	1.0	1.7	2800	650	240	1800	280	73
Williston Gate House	20	3.3	1.7	1.8	3700	450	280	1500	230	170
Dunbarton Fire Tower	19	1.8	1.1	1.2	1800	550	320	1300	270	49
400 Area	20	2.6	1.3	1.2	1800	460	450	1700	280	305
Aiken Airport	19	5.2	1.3	1.3	2600	540	180	680	180	24
Allendale	19	1.9	1.0	1.6	1800	360	93	1100	220	18
Waynesboro	21	1.6	0.8	1.3	1800	490	340	1200	170	151

The maximum alpha concentration at the Aiken Airport occurred in a sample collected during the week ending July 31. Less than one-tenth of the alpha in the sample was extractable with TBP.

The maximum nonvolatile beta concentration at 300/700 Area and the maximum radioiodine concentration at the Talatha Gate House occurred in samples collected during the week ending July 17 and were due to bomb fallout.

Radioactivity in Streams

Water samples were collected weekly from the locations shown in figure 6. Mud samples were collected monthly at the same locations except at the Savannah River location No. 10, where weekly samples were collected; and at the TNX effluent, where mud was not sampled. A total of 972 water samples and 265 mud samples were analyzed for alpha and nonvolatile beta activity. Of these, 108 water samples and 195 mud samples were analyzed for uranium and/or plutonium by TBP extraction. Monthly water samples collected from A, R, C, P, L, and K- Area effluents and weekly samples collected from the Savannah River at location No. 10 were analyzed for tritium. (All of the 75 samples analyzed for tritium contained less than 1 μc H-3/ℓ.) Results of other analyses are summarized in the tables on pages 21 to 27.

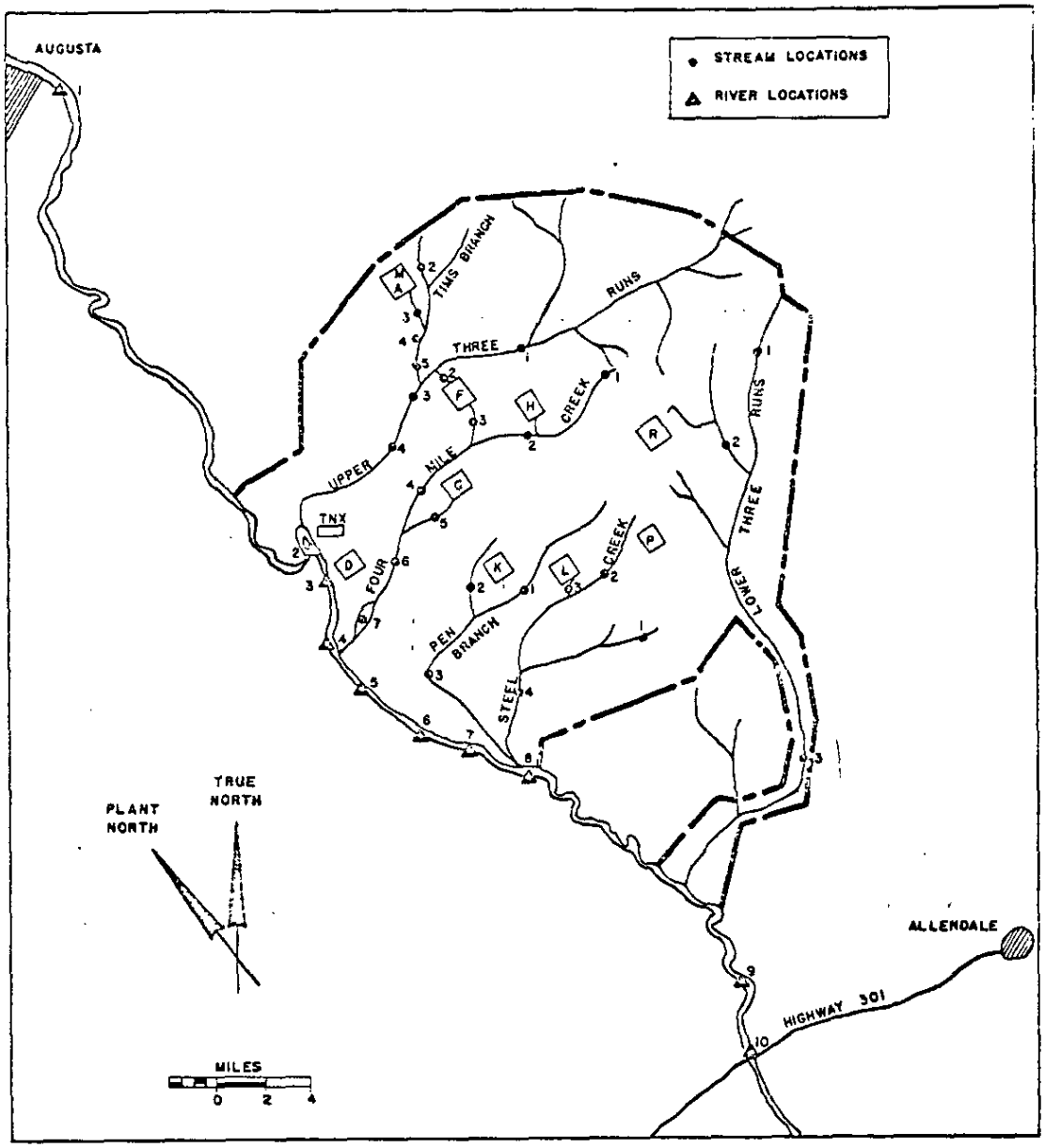


Figure 6. Stream and River Sample Locations

UPPER THREE RUNS

	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	6	4	3	35	16	10
2	45	8	24	430	74	670
3	6	3	5	45	15	15
4	5	3	3	54	18	12

	Radioactivity in Mud					
	U and/or Pu, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	54	29	34	12	8	16
2	130	76	320	290	150	820
3	58	37	41	36	11	13
4	69	50	84	22	12	14

The maximum alpha and nonvolatile beta concentrations at location 2 (F-Area storm sewer) occurred during October 17 through October 24 and were probably due to radioactivity from previous F-Area spills, washed into the sewer by rain.

FOUR MILE CREEK

	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	3	1	1	34	14	9
2	6	2	2	300	72	190
3	7	4	6	240	60	46
4	3	1	2	140	40	46
5	3	1	1	1100	89	140
6	4	2	1	130	45	58
7	2	1	1	93	40	54

The increased average nonvolatile beta concentrations at all No. 1 (control) locations were due to bomb fallout. Higher than normal concentrations at these locations occurred in July, September, and October, coincident with the deposition of large quantities of bomb fallout nonvolatile beta in rainwater.

TIMS BRANCH

	Radioactivity in Water					
	U and/or Pu, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	4200	350	290	2300	280	180
3	320	74	1800	910	130	310
4	300	41	--	220	50	100
5	53	20	81	84	27	35

	Radioactivity in Mud					
	U and/or Pu, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	3400	2300	1800	550	290	240
3	5500	930	3800	110	78	310
4	400	202	320	28	19	23
5	280	140	100	20	10	12

The increased concentrations at location 2 (700-Area effluent) had no noticeable effect on concentrations downstream, as location 2 is separated from Tims Branch proper by a large swampy area. The maximum alpha and nonvolatile beta concentrations at location 2 occurred in a sample collected during the week ending November 14 and were due to natural uranium released during the cleaning of an autoclave in Building 773-A.

The decreased concentrations at locations 3 and 4 were because of decreased amounts of uranium discharged from the 300 Area, while the slight increase in U and/or Pu in mud at location 5 probably resulted from previously discharged uranium washing downstream.

	Radioactivity in Mud					
	U or Pu, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	34	14	16	13	8	8
2	180	36	32	17	11	18
3	56	29	56	10	8	7
4	35	12	8	8	7	8
5	24	18	18	47	14	34
6	86	27	25	29	15	7
7	87	26	12	23	11	10

The maximum nonvolatile beta concentration in water at location 5 (C-Area effluent) occurred in a sample collected on October 24, during a charge and discharge shutdown of the C-Area reactor. The half-life of the nonvolatile beta in water at location 5 ranged from 5 days to 80 days, with a weighted average half-life of 22 days.

PEN BRANCH

	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	3	1	1	79	21	11
2	4	1	1	15,000	750	150
3	3	1	1	2,600	230	110

	Radioactivity in Mud					
	Alpha, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	0.9	0.6	1.2	11	8	15
2	2.4	1.6	2.3	91	33	51
3	1.6	0.8	1.8	57	27	36

The maximum nonvolatile beta concentrations at locations 2 and 3 occurred in samples collected on December 12 during a charge and discharge shutdown in K Area; the increased average concentrations were due entirely to temporarily increased concentrations during December 12 through December 19. Samples collected from both locations on December 19 contained approximately 1×10^{-12} c/ml. The average nonvolatile beta concentration at location 2 during the remaining 24 weeks of the report period was $.09 \times 10^{-12}$ c/ml.

Health Physics survey records show that of 6 curies nonvolatile beta released to the stream in disassembly basin water during the report period, 4 curies were released in December. The half-life of the nonvolatile beta in the water samples collected from location 2 ranged from 5 days to 120 days, with a weighted average of 21 days.

STEEL CREEK

	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	3	1	1	48	17	11
2	5	2	1	12,000	1,400	120
3	4	1	1	110,000	13,000	65
4	3	1	1	3,100	890	51

	Radioactivity in Mud					
	Alpha, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	2.9	0.9	0.5	12	8	7
2	2.3	1.7	2.0	220	91	35
3	3.1	1.4	1.6	130	43	22
4	2.6	1.0	1.6	85	26	24

Increased discharge of nonvolatile beta in disassembly basin water from L and P Areas caused the increased concentrations at locations 2, 3, and 4. The maximum concentration at location 2 occurred during the week ending August 29 and the maximum concentration at location 3 occurred during the week ending September 5. Both maximum concentrations occurred immediately following the discharge of failed fuel elements. The concentrations at location 3 were aggravated by discontinuation of cooling water flow from L Area in preparation for a process improvement shutdown, and concentrations at this location remained high until mid-November, when cooling water flow was resumed.

Radioiodine was detectable in water samples collected from locations influenced by P Area after the July fuel element failures, and the maximum radioiodine concentration observed was 2.2×10^{-11} c/ml in a sample collected at location 2 from July 4 through July 11.

LOWER THREE RUNS

	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	3	1	1	38	13	10
2	3	1	1	10,000	2100	1500
3	6	1	1	780	210	70

	Radioactivity in Mud					
	Alpha, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	1.4	0.7	0.5	13	8	8
2	2.7	1.1	1.7	870	240	130
3	1.4	0.7	0.8	32	12	12

The increased concentrations of nonvolatile beta in water at locations 2 and 3 were because of increased amounts of nonvolatile beta discharged in water purged from R-Area disassembly basin. The maximum concentration at location 2 occurred during the week ending November 14 and was due to the release of relatively long half-lived radioactivity (approximately 120 days) from the emergency section of the R-Area disassembly basin.

Radiostrontium content in the November 14 sample was 54% of the nonvolatile beta, as compared to an average radiostrontium content of 15% from August 8 through December 26.

The half-life of the nonvolatile beta at location 2 ranged from 5 days to 120 days, with a weighted average of 64 days.

TNX EFFLUENT

Radioactivity in Water					
Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
Max	Avg	Prev Avg	Max	Avg	Prev Avg
6	2	7	39	17	11

SAVANNAH RIVER

	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	140	23	11
2	3	1	1	130	23	10
3	2	1	1	130	25	9
4	2	1	1	150	27	10
5	2	1	1	110	24	16
6	3	1	1	120	26	11
7	4	1	1	130	27	11
8	2	1	1	610	85	27
9	2	1	1	210	54	15
10	2	1	1	180	53	14

	Radioactivity in Mud					
	U or Pu, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	15	10	8	41	27	29
2	17	9	9	48	25	24
3	12	8	11	32	25	20
4	13	8	7	32	24	22
5	10	6	9	41	31	31
6	17	10	10	40	28	23
7	8	6	7	30	21	16
8	10	7	10	49	38	29
9	18	9	13	12	8	10
10	45	11	10	44	17	14

The increased nonvolatile beta concentrations in water at locations 1 through 7 were due to bomb fallout, while the concentrations at locations 8, 9, and 10 were influenced by increased nonvolatile beta concentrations in Steel Creek and Lower Three Runs. The maximum concentrations due to bomb fallout occurred in samples collected on September 9 (locations 5, 6, and 7), September 30 (locations 2, 3, and 4), and October 8 (location 1). Maximum concentrations at locations 8, 9, and 10 occurred in samples collected on September 9 and 10, and showed the combined effect of increased nonvolatile beta concentrations in Steel Creek and bomb fallout.

Study, radioiodine released from P Area was detectable water samples collected from the Savannah River; the maximum tration observed was 3.8×10^{-12} c/ml in a sample collected f location 8 on July 8. A sample collected from location 10 on 9 contained 0.8×10^{-12} c/ml.

A series of sample traverses of the river on July 15, tabulated the following table, showed relatively rapid mixing of the radi iodine in the creek water with the main river current.

From South Carolina Side →

		Radioiodine, 1×10^{-15} c/ml at Various Positio				
		S.C. Side		Midstream		Ga. Sid
		at 0.0	at 0.25	0.50	at 0.75	at 1.00
Downstream from Steel Creek	40 Yards	304	167	<8	<9	<9
	¼ Mile	193	133	45	<8	<9
	½ Mile	144	179	122	35	<8
	15 Miles	74	-	-	-	-
	25 Miles	-	-	-	-	49

[redacted]

Radioactivity in Ground Water

Ground water was monitored by analyses of water samples from ZW wells (drilled, cased wells near F and H Areas), from open wells selected near operating areas, and from wells at the burial ground. Only slightly increased nonvolatile beta concentrations were observed in ZW-well water, while the open well samples contained fairly large concentrations of bomb fallout.

ZW WELLS

		Radioactivity in Water					
		Alpha 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
Location	No. of Samples	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	Dry	-	-	-	-	-	-
2	3	2	2	1	12	9	7
3	3	2	2	1	11	9	7
4	3	5	4	3	14	11	8
5	2	4	3	2	8	8	9
6	3	2	2	2	19	14	10
7	2	1	1	1	7	6	7
8	2	3	3	1	16	13	6
9	3	2	2	1	8	8	7
10	2	3	3	3	13	11	9

OPEN WELLS

		Radioactivity in Water					
		Alpha 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
Location*	No. of Samples	Max	Avg	Prev Avg	Max	Avg	Prev Avg
C-1	2	3	2	2	79	64	13
H-4	4	4	3	3	79	57	25
K-1	2	1	1	2	320	180	21
K-2	2	2	2	3	76	60	33
K-9	2	3	3	3	51	47	27
L-1	2	3	3	2	33	31	20
L-4	2	2	2	1	41	27	16
L-11	2	3	3	1	73	55	27
L-15	2	1	1	1	170	120	15
P-14	3	6	4	2	140	120	23
P-16	4	3	2	1	57	35	40
P-19	2	2	2	2	31	24	16
R-1	2	2	2	2	33	28	14
R-3	4	2	2	2	110	80	15
R-7	2	3	2	2	340	210	23

* Letter in location number designates nearest Plant Area, ie, C-1 is near C Area.

Burial Ground Wells. Sixty-two water samples collected from the burial ground wells shown in figure 7 contained no significant alpha or nonvolatile beta activity.

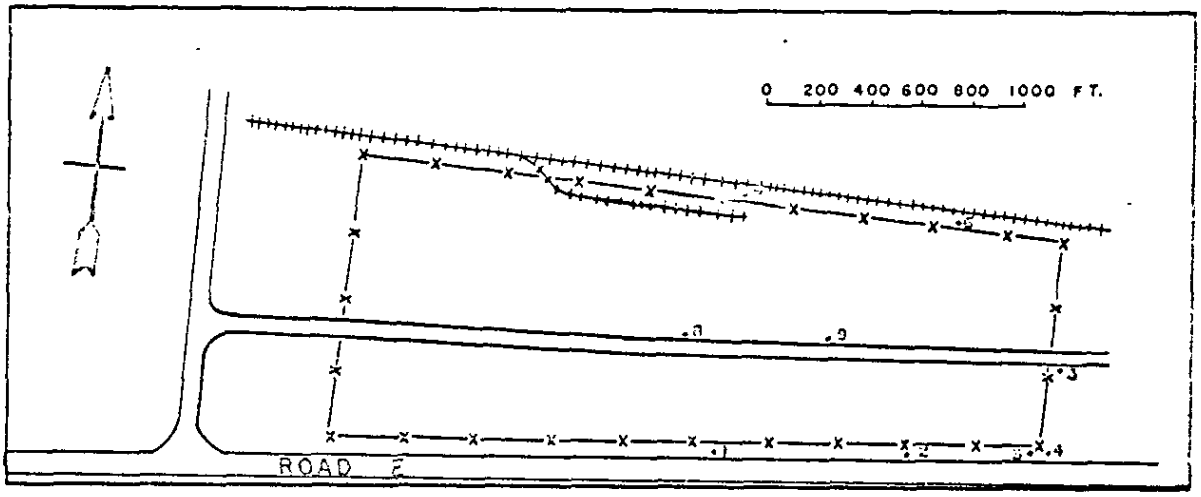


Figure 7. Burial Ground Wells

Radioactivity in Plant Drinking Water

Samples of drinking water were collected monthly from operating areas and quarterly from other domestic water systems. Results of analyses of 95 samples are summarized in the following table.

Location	Alpha 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
Barricade No. 2*	9	7	7	14	11	13
H Area	9	6	7	14	9	10
TC-1*	7	6	10	7	7	14
Barricade No. 4*	7	5	8	12	10	8
Barricade No. 1*	3	3	3	8	7	7
300/700 Area	6	3	1	7	7	7
F Area	9	2	4	13	9	10
400 Area	3	2	2	8	7	8
TNX	3	2	1	9	7	7
Classification Yards	2	1	1	9	8	8
Central Shops*	1	1	1	7	7	7
Pump House No. 2*	1	1	2	7	7	8
Pump House No. 1*	1	1	2	7	7	8
R Area	2	1	1	14	8	7
K Area	2	1	1	18	9	8
L Area	2	1	1	9	7	7
P Area	2	1	1	9	8	7
C Area	1	1	1	15	10	8
Barricade No. 3*	1	1	1	7	7	7
Barricade No. 5*	1	1	1	9	9	8

* Quarterly samples.

Radioactivity in Public Water Supplies

Samples of public drinking water were collected monthly from the 14 surrounding towns shown in figure 5. The results of analyses of 98 samples collected during the report period are summarized in the following table.

	Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
Jackson	11	7	5	22	11	8
Langley	7	5	4	15	11	8
Aiken	9	5	7	9	8	8
Bath	7	4	4	26	14	7
New Ellenton	5	3	2	10	8	8
North Augusta	4	3	3	26	19	9
Williston	3	2	2	8	7	7
Barnwell	2	1	1	14	8	7
Clearwater	2	1	1	21	13	8
Blackville	2	1	1	11	8	8
Waynesboro	2	1	1	15	11	7
Augusta	1	1	1	20	11	7
Allendale	1	1	1	7	7	7
Sardis	1	1	1	9	7	7

The slight increases in nonvolatile beta concentrations were due to bomb fallout. Maximum concentrations at different locations occurred on widely separated sampling dates, but no evidence of contamination was observed after October. The maximum concentration in the Bath water sample occurred in a sample collected on August 27, while the maximum concentration in the North Augusta water sample occurred in a sample collected on October 22. Recounts of both samples showed that the nonvolatile beta was short half-lived (3 to 7 day half-life).

Radioactivity in Seepage Basins

700 AREA

From July through September, weekly water samples were collected from basins No. 1 and 2. In October, sampling of basin No. 2 was discontinued, and from October through December basin No. 1 was sampled monthly.

Results of analyses of 29 water samples collected during the report period are summarized in the following table.

	Radioactivity in Water					
	Alpha, d/m/ml			Nonvolatile Beta, 1×10^{-12} c/ml		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
Basin No. 1	2.9	0.8	2	600	53	4
Basin No. 2	0.5	0.2*	1	2	1*	3

* Three month average.

The accidental release of an unknown quantity of high level waste (estimated as less than 0.1 curie) to the seepage basins in mid-November increased the nonvolatile beta concentration in basin No. 1 from 7×10^{-13} c/ml on October 24 to 6000×10^{-13} c/ml on December 19. The alpha concentration increased from 0.7 d/m/ml to 3 d/m/ml during the same period.

TNX SEEPAGE BASIN

TNX and CMX discharge waste, consisting of uranium and its daughters, to a seepage basin which overflows to the Savannah River swamp.

Results of analyses of 27 weekly water samples from the basin are summarized below:

Radioactivity in Water					
Alpha, d/m/ml			Nonvolatile Beta, 1×10^{-12} c/ml		
Max	Avg	Prev Avg	Max	Avg	Prev Avg
24	3.4	9.4	20	3.2	7.5

200-AREA SEEPAGE BASINS

Each 200 Area has a system of seepage basins, as shown in figure 8.

F Area. During the report period, the average liquid waste input to the system was 32,000 gal/day and the average seepage and evaporation rate was 10,000 gal/day.

Waste released to the system was collected by a proportional sampler in the line to the basins and samples were analyzed for radioactivity. Results are shown in the following table.

Waste Released in 5.9×10^6 Gallons Water	
Alpha, mc	240
Nonvolatile Beta, c	25
Radioiodine, c	3

* Estimated.

Of the radioactivity discharged to the basins, 7% of the alpha was plutonium and 7% of the nonvolatile beta was radiostrontium. Other isotopes in the waste included natural uranium and radioactive zirconium, ruthenium, and rare earths.

Results of analyses of 74 water samples collected from the basins during the report period are summarized below.

	Radioactivity in Water					
	Alpha, d/m/ml			Nonvolatile Beta, 1×10^{-12} c/ml		
Basin No.	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	61	25	25	2900	1200	1400
2	31	15	22	1500	640	1000
3	77	30	11	5000	730	360

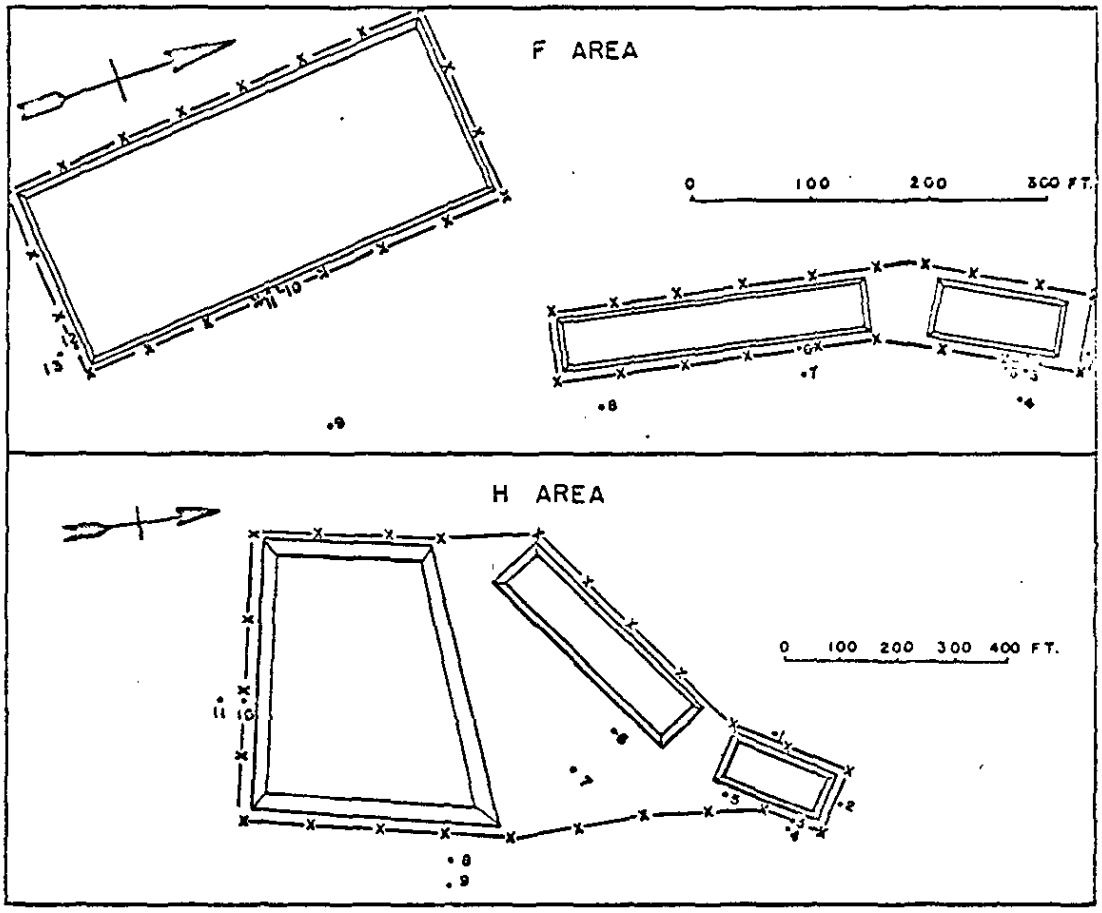


Figure 8. Seepage-Basin Monitoring Wells in F and H Areas

H Area. From July through November, the liquid waste input to the basin system was approximately 71,000 gal/day from Building 211-H and 65,000 gal/day from Building 232-H, but on December 3, the Building 232-H waste line was diverted to Four Mile Creek to halt a 4-inch per week increase in seepage basin No. 3 water level. The average seepage and evaporation rate for the basin system during the 6-month period was 85,000 gal/day.

Radioactive waste discharged to the basins was sampled by a proportional sampler. Results of analyses of these samples are shown in the following table.

Waste Released in 2.3×10^7 Gallons Water	
Alpha, mc	210
Nonvolatile Beta, c	24
Radioiodine, c	88

Of the radioactivity discharged to the basins, 12% of the alpha was plutonium and 9% of the nonvolatile beta was radiostrontium. Other isotopes in the waste included natural uranium and radioactive zirconium, ruthenium, and rare earths.

Results of analyses of 77 water samples collected from the basins are summarized in the following table.

	Radioactivity in Water								
	Alpha, d/m/ml			Nonvolatile Beta, 1×10^{-12} c/ml			Radioiodine, 1×10^{-12} c/ml		
Basin No.	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	48	12	6	3400	560	370	4600	1050	8000
2	6	3	5	320	100	250	2500	480	5000
3	5	2	5*	110	60	100*	1900	230	3000*

* One sample.

200-AREA SEEPAGE BASIN MONITORING WELLS

F Area. Results of analyses of 74 samples are summarized below.

Well	Depth to Water, ft	Distance from Basin, ft	Radioactivity in Water: Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
			Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	23 to 24	34	550	290	18	82,000	40,000	4,500
2	69 to 70	5	4	4	3	5,600	1,200	82
3	66 to 68	29	6	4	2	27	18	27
4	68*	73	-	-	-	-	-	-
5	17*	24	-	-	6	-	-	418
6	11 to 13	6	330	88	450	37,000	21,000	10,400
7	12 to 13*	46	87	54	70	27,000	13,000	16,250
8	66 to 68*	63	5	3	2	72	26	14
9	60 to 61*	258	4	2	1	93	24	15
10	9 to 12*	9	780	420	128	170,000	122,000	122,000
11	68 to 70	9	3	2	5	78	42	62
12	13 to 18	29	380	190	162	110,000	52,000	44,000
13	14 to 18*	58	8	6	14	11,000	9,200	13,000

* Dry

H Area. Results of analyses of 73 samples are summarized below.

Well	Depth to Water, ft	Distance from Basin, ft	Radioactivity in Water: Alpha, 1×10^{-3} d/m/ml			Nonvolatile Beta, 1×10^{-15} c/ml			Radioiodine, 1×10^{-14} c/ml		
			Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	25 to 26*	24	230	200	200	15,000	11,000	17,000	78	43	840
2	25 to 28	25	5	2	3	130	56	210			
3	22 to 25	15	2	1	1	150	40	40			
4	21 to 24	45	2	2	2	54	31	30			
5	23 to 26	13	380	180	560	270,000	76,000	36,000	40,000	7900	53,000
6	25 to 28	6	2	1	1	100	46	34			
7	24 to 27	66	3	2	1	77	41	14			
8	18 to 20	18	2	1	1	79	38	12			
9	15 to 17	78	1	1	1	60	42	13			
10	19 to 22	19	1	1	1	73	42	12			
11	15 to 19	79	1	1	1	76	42	11			

* Dry

100-AREA SEEPAGE BASINS

Seepage basins were constructed at all reactor areas, primarily for the purpose of disposing of waste discharged by underwater vacuum cleaning of the disassembly basins. During the report period, most of the radioactivity discharged to the basins was from sources other than vacuum cleaner discharge.

R-Area. The first R-Area seepage basin was placed in service on June 26, 1957, and from July through October, approximately 9 curies of nonvolatile beta was discharged from the R-Area disassembly basin to the seepage basin. The average nonvolatile beta concentration in the seepage basin water from July through October was 5.2×10^{-10} c/ml.

On November 8, during an experiment [redacted] released large quantities of nonvolatile beta to the water in the emergency section of the basin as sludge deposited on the basin floor. Analyses of water samples collected from the emergency section of the basin on November 8 and sludge samples collected on November 26 showed that the composition of the nonvolatile beta in the water was 37% Sr, 37% Cs, 23% rare earths and Y, 0.8% Ru and 3.6% Zr-Nb, while the sludge contained 75% Zr-Nb, 10% rare earths and Y, 10% Ru-Rh, and 3% Sr.

To minimize contamination of the main portion of the disassembly basin, water and radioactivity were discharged from the emergency section of the basin to the seepage basin. A second basin was placed in service on November 16, followed by a third basin on November 21 and a fourth basin on November 28. Discharge to the system was estimated as 1900 curies of nonvolatile beta and 0.3 curies alpha in 10^6 gallons of water during November, and 230 curies of nonvolatile beta in 8×10^5 gallons of water during December. These releases contributed the greatest amount of nonvolatile beta discharged to SRP seepage basins to date. Analysis of water collected from the seepage basin on November 13 showed that the composition of the nonvolatile beta was 54% Sr, 14% Cs, 26% rare earths and Y, 4% Zr-Nb, and 0.6% Ru.

Loss of water from the first basin, due to surface outcrop and leakage through an abandoned sewer system, caused use of this basin to be discontinued on December 3, resulting in the backfilling of the basin.

The maximum nonvolatile beta concentration observed in samples collected from the basins was 85×10^{-8} c/ml in a sample collected from the first basin on November 13. The average concentration in weekly samples collected from the second, third, and fourth basins during December was 5.4×10^{-8} c/ml with a maximum of 6.3×10^{-8} c/ml in a sample collected from the fourth basin on December 13.

Film badges exposed to radiation at the fence around the first basin showed that radiation levels were negligible from July through October, but that the average radiation level at five locations from November 6 through December 31 was 400 mr/week. The highest weekly radiation level at one location was 1300 mr/week at the south end of the basin during the week ending December 4.

Film badges were located at the second, third, and fourth basins only during the last two weeks of the report period, but results indicated that the highest radiation level at these basins was at the north end of the third basin. The maximum level observed at this location was 440 mr/week.

L Area. The amount of radioactivity discharged to the L-Area seepage basin was estimated to be 0.2 curies nonvolatile beta; most of the activity resulted from the washing of purification filters at the basin. Sampling of the basin was begun on October 10, and during the remainder of the report period, the average nonvolatile beta concentration in water samples collected from the basin was 1.3×10^{-10} c/ml. The maximum concentration was 2.5×10^{-10} c/ml in a sample collected on November 14.

Film badges exposed to radiation at the seepage basin fence showed that during October radiation levels were insignificant, but from November through December the average radiation level at one location was 550 mr/week. The highest weekly radiation level observed was 1400 mr/week during the week ending December 18.

P-Area. The first P-Area seepage basin was placed in service on July 23. On July 24, pumping of water from the emergency section of P-Area disassembly basin to the seepage basin was begun, and during July the basin received 22 curies of nolvolatile beta due to failed fuel elements. A second basin was constructed and placed in service in November. The total nonvolatile beta discharged to the two-basin system during the report period was 32 curies. The average nonvolatile beta concentration in water samples collected from the first basin during the report period was 20×10^{-10} c/ml, with a maximum of 60×10^{-10} c/ml in a sample collected on September 5.

Film badges exposed to radiation at the basin fence from August through December showed that the highest radiation levels occurred near the inlet pipe. The average radiation level at that location was 230 mr/week with a maximum of 1500 mr during the two-week period from November 6 through 20.

C-Area. The C-Area seepage basin was placed in service on December 4 and received underwater vacuum cleaner discharge during the remainder of the report period. Nonvolatile beta discharged to the basin was estimated as 0.01 curie. The average concentration of nonvolatile beta in three water samples collected during December was 0.076×10^{-10} c/ml, with a maximum of 0.088×10^{-10} c/ml in a sample collected on December 19. Film badges exposed at the fence around the basin showed that radiation levels during the report period were negligible.

Lower Three Runs Aquatic Specimens. The aquatic specimens collected from Lower Three Runs from July 1 to November 8 generally contained low level concentrations of nonvolatile beta. Algae collected during this period from locations two and eighteen miles below R-Area contained maximum nonvolatile beta concentrations of 11,000 × 10^{-12} c/g and 100 × 10^{-12} c/g, respectively. Fish collected from Lower Three Runs during this period generally contained low level concentrations of nonvolatile beta in the bones, gills, the skin and scales as well as the intestinal tracts. No significant concentrations of radioactivity were found in the flesh, livers, or gonads. The maximum and average nonvolatile beta concentrations found in the organs of these fish collected from five locations are shown in the following table.

Nonvolatile Beta at Various Distances Below R Area, 1 × 10^{-12} c/g
(July through November)

	5 Miles		7 Miles		10 Miles		15 Miles		18 Miles	
	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg
Bone	120	85	130	90	90	50	40*		20*	
Bone, Sr	60	60	90	40	50	35	15*		NS**	
Gills	80	65	60	40	55	30	NS**		NS**	
Skin & Scales	90	75	75	55	65	30	NS**		NS**	
Intestinal Tract	40	35	40	30	30	20	NS**		NS**	

* Only one sample.
** No significant radioactivity.

Aquatic specimens collected from Lower Three Runs from November 8 to December 25 were exposed to additional radioactive material which included significant Ce-137 for the first time. Algae samples collected from locations two and eighteen miles below R Area during this period contained maximum nonvolatile beta concentrations of 130,000 × 10^{-12} c/g and 800 × 10^{-12} c/g, respectively. These concentrations were higher by factors of 12 and 8 than the maximum concentrations found during the period from July 1 through November 8. Of the aquatic biological specimens, crayfish contained the highest nonvolatile beta concentrations, with a maximum of 4400 × 10^{-12} c/g. Fish collected from Lower Three Runs during this period contained significant concentrations of nonvolatile beta in the flesh, livers, and gonads with substantially increased concentrations in other organs, as shown in the following table. In the fish radiostrontium contributed approximately 60% of the total bone radioactivity while radiocesium was the prime contributor of radioactivity in muscular tissue.

Radioactivity in Biological Specimens

In July of 1957 due to the increased releases of radioactivity into Steel Creek, Lower Three Runs, and the Savannah River as a result of fuel element failures in R, P, and L Areas, the biological sampling program was expanded and primary emphasis was placed on the collection and radioanalysis of aquatic specimens from these streams. A total of 540 aquatic specimens, which included 133 algae, 282 fish, 14 turtles, 22 crayfish, 30 shrimp, 42 minnows, 20 clams, and 17 frogs were collected for radioanalysis. Aquatic specimens collected from Pen Branch, Four Mile Creek, and Upper Three Runs generally did not contain significant concentrations of radioactivity. Uptake of radioactivity by terrestrial animals, collected at random on the Plant site, was confined to thyroid concentration of radioiodine (maximum $280{,}000 \times 10^{-12}$ c/g) and very low level nonvolatile beta in the bones (maximum 45×10^{-12} c/g). Both of the maximum concentrations were contained in rabbits collected near the Separations Areas.

ALGAE AND AQUATIC SPECIMENS

Algae samples collected from Steel Creek, Lower Three Runs, and the Savannah River contained higher concentrations of radioactivity than aquatic specimens collected from these streams. The algae samples generally contained concentrations of nonvolatile beta that ranged from 1000 to 10,000 times the concentrations contained in the stream water. The radioisotopes found in algae included Sr-89, Sr-90, Ru-103, Ru-106, Zr-Nb^{95}, Cr-51, rare earths, and trace amounts of Fe-59 and/or Co-60. Cs-137 was also found in detectable concentrations in Lower Three Runs algae.

Crayfish and shrimp are representative aquatic specimens that feed on algae and organic matter in the stream bed and then serve as food for fish and higher animals. Crayfish and shrimp collected from Lower Three Runs contained concentrations of nonvolatile beta that ranged from 700 to 2000 times the concentrations found in stream water. In specimens collected from Lower Three Runs the main isotopes present were Sr-89, Sr-90, Cs-134, and Cs-137. Aquatic specimens of this type which were collected from Steel Creek and the Savannah River did not contain significant concentrations of Cs-137.

The fish collected from Steel Creek and Lower Three Runs generally contained significant concentrations of nonvolatile beta in the bones, gills, the skin and scales, and the intestinal tracts. Fish collected from Lower Three Runs during November and December contained significant concentrations of nonvolatile beta, due to the presence of Cs-137, in the flesh, livers, and gonads. The bone was the organ that contained the highest concentration of radioactivity in each specimen and radiostrontium contributed from 50 to 80% of the total bone radioactivity. The bones of these fish contained concentrations of nonvolatile beta that ranged from 200 to 400 times the concentrations found in stream water.

Nonvolatile Beta Activity Below
R Area, 1×10^{-12} c/g
(November through December)

	2 Miles		5 Miles		10 Miles		15 Miles	
	Max	Avg	Max	Avg	Max	Avg	Max	Avg
Bone	900*		1100*		220	160	200	50
Bone, Sr	820*		600*		90	65	85	20
Gills	880*		580*		110	95	120	25
Skin & Scales	70*		700*		135	120	400	40
Intestinal Tract	50*		640*		510	230	90	40
Flesh	30*		70*		NS**		50	15
Liver	NS**		40*		40	25	130	20
Gonads	NS**		140*		50	20	35	10

* Only one sample.
** No significant radioactivity.

By the end of November, small aquatic specimens in Lower Three Runs had accumulated enough radioactivity to be radioautographed by using long exposure times and forced development of the film. A photograph and a radioautograph of specimens collected from the stream on November 29 are shown on page 44. Results of analyses of similar specimens collected at the same time are shown in the following table. The radioautograph was obtained by exposing Du Pont "Xtra-Fast" X-ray Film (medical type 508), separated from the specimens by 0.2 mil "Mylar," for seven weeks. The film was developed twice the normal development time.

Nonvolatile Beta in Small Aquatic Specimens
Collected at Various Distances Downstream
from R Area, 1×10^{-12} c/g

	2 Miles	5 Miles	7 Miles	10 Miles	13 Miles	15 Miles
Shrimp	-	-	-	1000	620	470
Crayfish	-	-	-	-	1200	820
Minnows	510	440	75	86	-	-

Steel Creek Aquatic Specimens. Algae samples collected from Steel Creek during October and November contained the highest concentrations of nonvolatile beta found in any aquatic specimens during this report period. Algae samples collected near L-Area effluent contained maximum and average nonvolatile beta concentrations of $140,000 \times 10^{-12}$ c/g and $80,000 \times 10^{-12}$ c/g, respectively. Algae samples collected ten miles below the Reactor Area in October and November contained a maximum nonvolatile beta concentration of 3000×10^{-12} c/g with an average concentration of 700×10^{-12} c/g. One algae sample collected from the mouth of Steel Creek on September 24, analyzed $31,000 \times 10^{-12}$ c/g. This unusually high sample probably resulted from algae washing downstream from the reactor effluents.

Sixty-seven fish representing four species, were collected from Steel Creek approximately eleven miles below the Reactor Area (approximately one mile from the Savannah River). Radioanalysis of these specimens, which were routinely collected throughout the report period, revealed significant concentrations of nonvolatile beta in the bones, the skin and scales, gills, and the intestinal tracts; concentrations decreasing in magnitude in the order listed. No significant concentrations were found in the flesh, livers, or gonads. The concentration of radioactivity found in the fish bones ranged from 100 to 400 times the concentrations found in stream water; equilibrium was apparently reached within two weeks after the fish was first exposed to the radioactively contaminated water. Radiostrontium contributed approximately 55% of the total bone radioactivity. The maximum and average nonvolatile beta concentrations found in the bones, gills, and the skin and scales of the four main species of fish collected are shown in the following table.

	Number & Species	Date	Nonvolatile Beta, 1×10^{-12} c/g			
			Bone	Bone, Sr	Gills	Skin & Scales
Max	13 Bream	10/25/57	630	400	240	500
Avg		8/1 - 12/25	260	200	170	260
Max	8 Garfish	9/16/57	350	75	75	190
Avg		8/1 - 12/25	180	65	50	110
Max	21 Bass	9/5/57	700	690	360	510
Avg		8/1 - 12/25	220	110	140	100
Max	25 Catfish	10/23/57	1300	1300	350	NS*
Avg		8/1 - 12/25	240	130	110	NS*

* Not significant.

Savannah River Aquatic Specimens. Radioanalysis of algae samples collected from the Savannah River during the period July 1 to December 25 revealed detectable nonvolatile beta due to Plant operation in samples collected at the mouth of both Steel Creek and Lower Three Runs and as far downstream as ten miles below Lower Three Runs. The maximum and average nonvolatile beta concentration contained in Savannah River algae during the report period are shown in the following table.

Savannah River Location	Nonvolatile Beta, 1×10^{-12} c/g	
	Max	Avg
15 Miles above Steel Creek	200	100
150 Yards below Steel Creek	2150	1270
15 Miles below Steel Creek (150 Yards below Lower Three Runs)	450	320
10 Miles below Lower Three Runs	350	170

Approximately 50% of the fish collected from the Savannah River from the mouth of Steel Creek and Lower Three Runs, during the report period, contained low level concentrations of nonvolatile beta in the bones, the skin and scales, gills, and the intestinal tracts. Radiostrontium contributed approximately 50% of the total bone radioactivity. Radiocesium, while present in significant quantities in fish collected from Lower Three Runs itself, was not detectable in the organs of fish collected from the mouth of Lower Three Runs. The maximum and average concentrations of nonvolatile beta contained in the organs of fish collected at the mouth of each stream is shown below.

		Nonvolatile Beta, 1×10^{-12} c/g		
Location		Bones	Skin & Scales	Gills
Mouth Steel Creek	Max	640	240	140
	Avg	115	20	45
Mouth Lower Three Runs	Max	55	30	30
	Avg	35	25	20

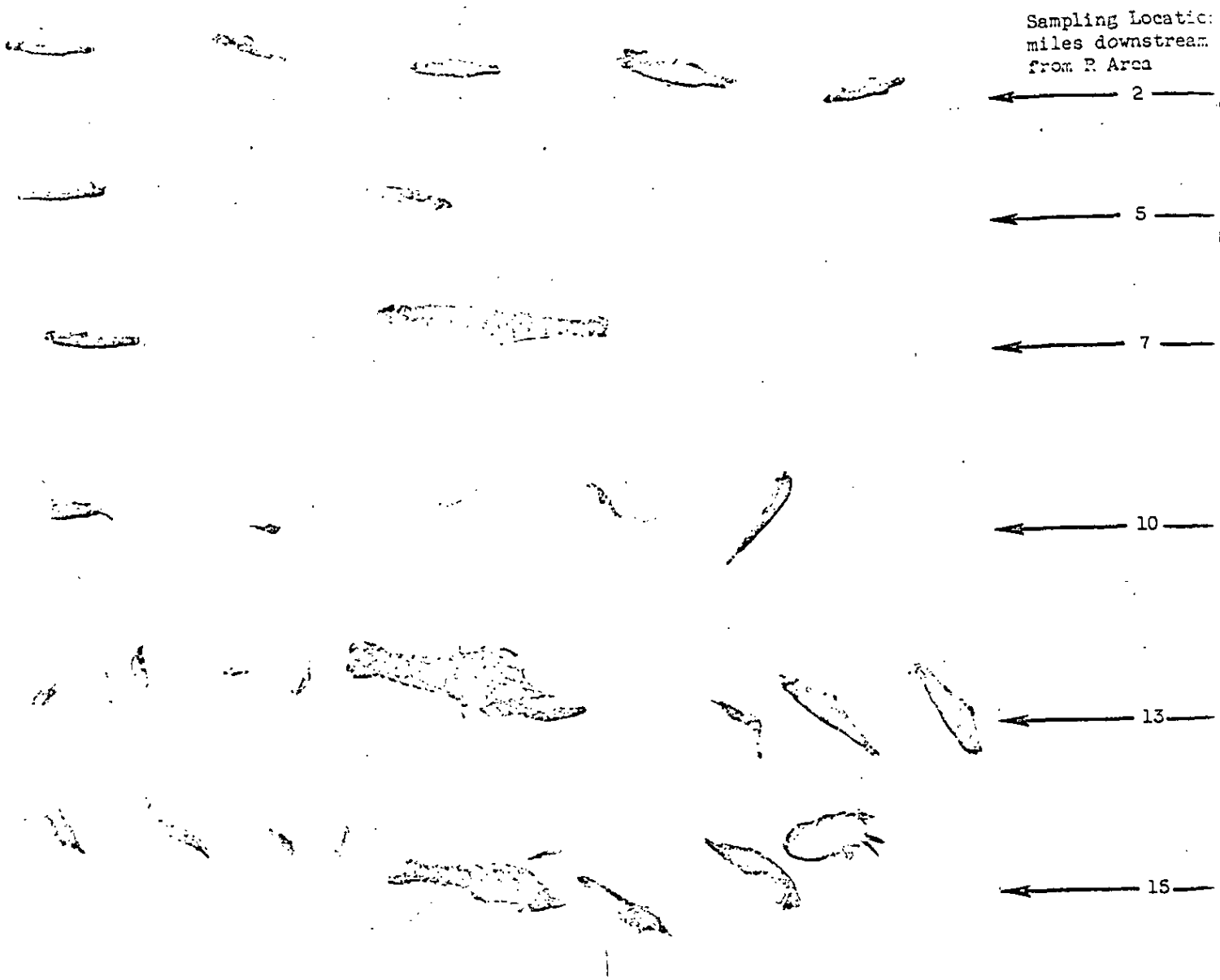


Figure 9. Photograph of Radioactive Specimens Collected from Lower Three Runs

Sampling Locations,
miles downstream
from R Area

2

5

7

10

13

15

Figure 10. Radioautograph of Specimens
Collected from Lower Three Runs