DPSPU 76-30-1

ENVIRONMENTAL MONITORING IN THE VICINITY OF THE SAVANNAH RIVER PLANT

Annual Report

For 1975

Prepared for the U. S. Energy Research and Development Administration by the
Health Physics Department of
E. I. du Pont de Nemours & Co., the Administration's Prime Contractor
at the Savannah River Plant, Aiken, South Carolina

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FOREWORD

This report summarizes results of the environmental monitoring program at the Savannah River Plant (SRP) during 1975. Environmental monitoring has been an integral part of plant operations since the start of activities at SRP. Extensive monitoring was performed to provide baseline data on radiation levels before plant operations began. Monitoring programs have continued throughout the history of the plant, providing reliable measurement of radioactive materials both released at the source and concentrated in the environment. This annual report describes in detail the plantsite and facilities and the techniques of sample collection and analysis. This report has been expanded to include additional environmental conditions and an inventory of radioactive materials released to the environment.

INTRODUCTION

The Savannah River Plant occupies an area of about 300 square miles along the Savannah River, principally in Aiken and Barnwell Counties of South Carolina. Most of the plant's environs are rural. Population density of nearby counties ranges from 10 to over 400 people per square mile with the greatest concentration in Augusta, Georgia, and its suburbs, which have a population approaching 200,000. The countryside is predominantly forested. Farming is diversified, the main crops being cotton, soybeans, corn, and small grains. Production of beef cattle has rapidly expanded during the past few years. The climate is mild, with an average frost-free season of approximately 246 days. Annual rainfall averages about 45 inches and is fairly evenly distributed throughout the year.

Exclusion of the public from the plantsite creates a refuge for many animal species, both terrestrial and aquatic. Growth of the deer population is limited (to prevent range deterioration and to minimize deer/vehicle accidents) by public hunting which was initiated in 1965. Several hundred to over a thousand deer (1391 in 1975) have been taken annually during controlled hunts.

In 1972, the SRP site was designated as the nation's first National Environmental Research Park (NERP). This designation opened the site to investigators from universities and other research organizations who wish to design and conduct research studies on man's impact on the environment. Over twenty research projects were conducted at the SRP site under the NERP program in 1975. These projects were in addition to the ERDA-funded environmental research programs normally conducted at the site.

Since 1952, the U.S. Forest Service has planted over 100 million pine seedlings on over 80,000 acres of the plantsite. Great quantities of pine and pulpwood, along with some hardwood sawtimber, have been harvested during this same period.

SRP's primary function is the production of plutonium, tritium, and other special nuclear materials for the national defense, for other governmental uses, and for some civilian purposes. Facilities now operating include three nuclear reactors, a fuel and target fabrication plant, two chemical separations plants, a heavy water production plant, and the Savannah River Laboratory (a process development laboratory to support production operations). The reactors and separations plants are located near the center of the site; the other facilities, near its periphery.

The reactors are fueled with uranium and moderated and cooled by heavy water which is circulated in a closed system through heat exchangers. Savannah River water and water from Par Pond, a manmade cooling water impoundment covering 2640 acres, are used only as a secondary coolant in the heat exchangers. Water from the river or Par Pond does not pass directly through the reactors and so is not subject to neutron activation.

Nuclear fuels and targets, together with other components necessary for the reactors, are manufactured in the fuel and target fabrication facility.

Reactor products are recovered in the fuel separations areas. Plutonium-239 and uranium are separated from each other and from fission products by complex chemical processes. Plutonium-238 and californium-252 are also important SRP products that are processed in the separations areas. These areas also have facilities for the purification and packaging of tritium and for storage of fission product wastes.

The heavy water production plant separates and concentrates heavy water from the raw water of the Savannah River. The basic process for extraction of heavy water from river water is chemical exchange with hydrogen sulfide gas at about 300 psig. Heavy water is not radioactive, but a portion of the heavy water production facility is used for the reconcentration of moderator from the reactors and this heavy water contains some tritium.

SRP production areas and effluent streams are shown in figure 1.

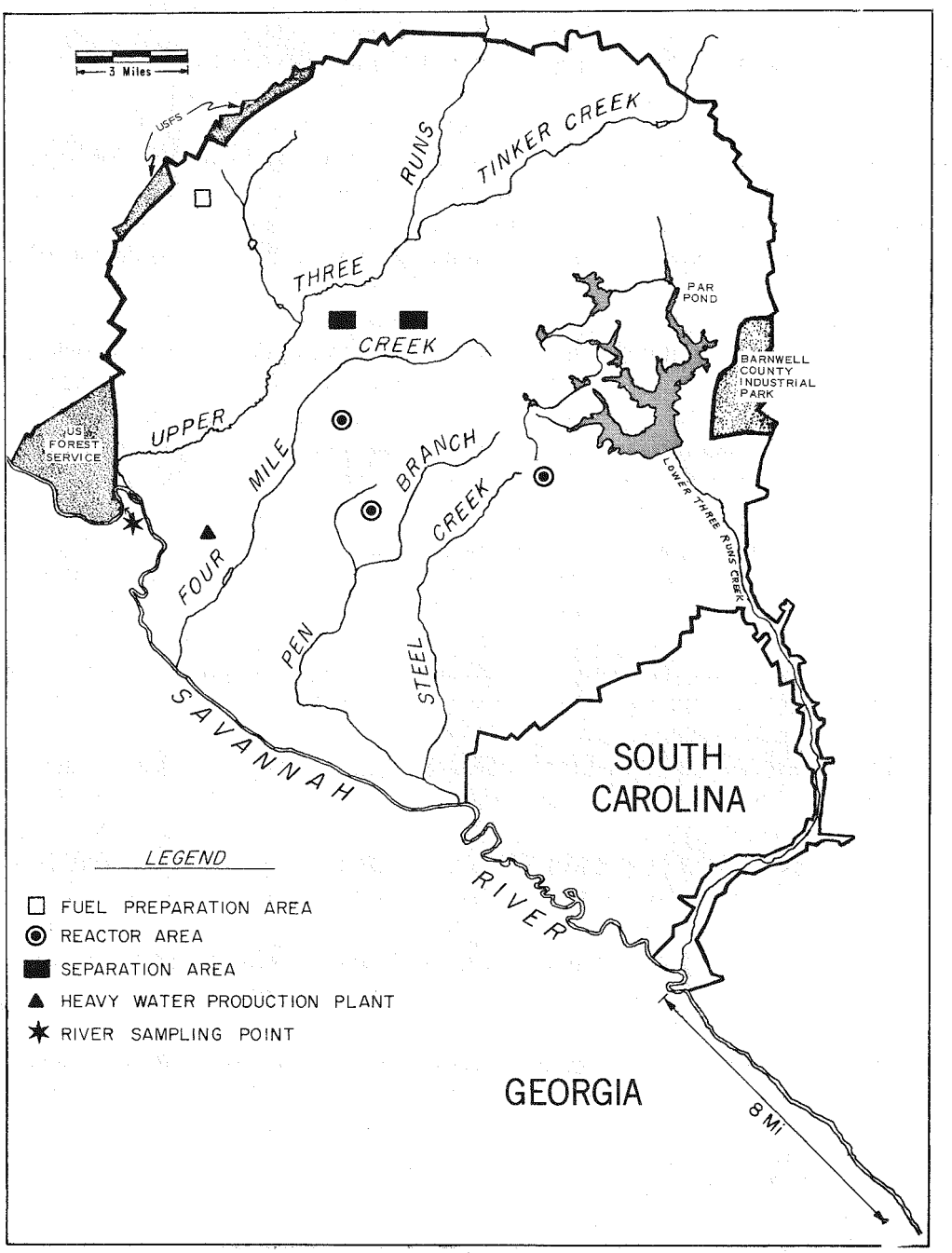

FIGURE 1. SRP PRODUCTION AREAS AND EFFLUENT STREAMS

SUMMARY

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine concentrations of radioactive materials in a 1200-square-mile area outside SRP. Included are parts of Aiken, Barnwell, and Allendale Counties in South Carolina; Richmond, Burke, and Screven Counties in Georgia. Although some gaseous and liquid radioactive materials are discharged from SRP operations, concentrations and doses to the surrounding population continued to be far below levels considered significant from a public health viewpoint.

The concentration of radioactivity added by SRP to its environs during 1975 was, for the most part, too small to be distinguished from natural background radiation and fallout from worldwide nuclear weapons tests. Beta activity in particulate air filters was about one-half of the 1974 level and was due entirely to global fallout. This concentration both at the plant perimeter and 25 miles away (0.05×10^{-12} μCi/ml) represents 0.05% of the Concentration Guide (defined in the Applicable Standards section which follows). Tritium oxide in air at the plant perimeter was greater than in air at more distant locations; the average concentration at the plant perimeter (88×10^{-12} μCi/ml) was less than 0.1% of the Concentration Guide.

An accidental release of tritium to the atmosphere occurred in a production facility on December 31. Monitoring teams were deployed along the estimated puff trajectory immediately following the release. Monitoring extended from the production facility to the Atlantic Ocean north of Charleston, SC. Environmental sample concentrations of tritium oxide were all within normal ranges. The low concentrations of tritium measured in environmental samples around the plantsite were of no health significance.

Tritium, cesium-137, and strontium-90 were the only radionuclides of plant origin detectable in river water by routine analyses. None of these had an average concentration exceeding 0.2% of the Concentration Guide in river water sampled 8 miles downstream from the plant. Special research programs using ultra low level techniques have detected trace quantities of other radionuclides of plant origin. Radioactive materials in river fish also continued to be very low.

Monitoring in an offsite swamp immediately below the SRP boundary has shown radioactivity (primarily cesium-137) above the natural background level in soil and vegetation. Only one-third of a five-square-mile swamp, which is largely uninhabited and inaccessible, bordering the Savannah River and downstream from SRP is affected. No restrictions on use of the swamp are considered warranted nor are remedial actions needed. Concentrations of radioactivity in vegetation and soil were, in most instances, lower than those reported in 1974.

During 1975 the average dose from atmospheric releases of radioactive materials from SRP was calculated to be 0.66 millirem (mrem) at the plant perimeter. The maximum dose at the plant perimeter was calculated to be 0.92 mrem, which is 0.2% of the ERDA Manual chapter 0524 standard. The population dose to people living within 80 km (50 miles) of the center of SRP (population: 465,000) is 93 man-rems. An individual consuming river water downstream from SRP would receive a maximum calculated dose of 0.29 mrem.

Various water-quality analyses of river water samples by SRP during 1975 indicated that Savannah River water was not adversely affected by SRP operations. This was substantiated by surveys of the health of the Savannah River biota by Academy of Natural Sciences of Philadelphia and pesticide analyses of river water and sediment by the U.S. Geological Survey Water Quality Laboratory, Atlanta, GA.

APPLICABLE STANDARDS

The standards applicable to concentration of radionuclides in air and water at SRP are the Concentration Guides (CG's) given in chapter 0524 of the ERDA Manual, and are derived for the most part from the whole body annual dose standard of 500 mrems to individuals at points of maximum probable exposure [1]. These CG's are based on recommendations of the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), and the Federal Radiation Council (the latter is now a part of the Environmental Protection Agency). Concentration guides are summarized in table 1. For whole-body dose calculations from ingestion of tritium, ICRP values for translating intake to dose are used [2]. Specific guidance of the Federal Radiation Council (Report 7) is used in translation of a given intake of cesium-137 to radiation dose [3].

Chemical and biological quality standards for the Savannah River are the requirements of the State of South Carolina for Class B streams [4] which are: "Waters suitable for domestic supply after complete treatment in accordance with requirements of the South Carolina Board of Health. Suitable also for propagation of fish, industrial and agricultural uses, and other uses requiring water of lesser quality." Specifications are summarized in table 2.

Principal nonradioactive releases to the atmosphere are sulfur dioxide (SO_2), oxides of nitrogen (NO_x), and fly ash. South Carolina emission standards [5] and South Carolina [5] and Georgia [6] ambient air quality standards are summarized in table 3.

TABLE 1
CONCENTRATION GUIDES (CG's)

	In Water, µCi/mℓ (Multiply by 10^{-9})	In Air, µCi/mℓ (Multiply by 10^{-12})
Alpha	30	0.02
Nonvolatile beta	3,000	100
Tritium	3,000,000	200,000
^{239}Np	100,000	20,000
^{131}I	300	100
^{140}Ba-^{140}La	20,000	1,000
^{137}Cs	20,000	500
^{144}Ce	10,000	200
$^{103,106}Ru$	10,000	200
^{95}Zr-^{95}Nb	60,000	1,000
^{65}Zn	100,000	2,000
^{60}Co	30,000	300
^{89}Sr	3,000	300
^{90}Sr	300	30
^{54}Mn	100,000	1,000
^{51}Cr	2,000,000	80,000
^{35}S	60,000	9,000

TABLE 2
SOUTH CAROLINA WATER QUALITY STANDARDS

1. Fecal coliform. Not to exceed a log mean of 1000/100 ml based on five consecutive samples during any 30-day period; not to exceed 2000/100 ml in more than 20% of the samples examined during such period (not applicable during or following periods of rainfall).
2. pH. Range between 6.0 and 8.5, except that swamp waters may range from pH 5.0 to pH 8.5.
3. Dissolved oxygen. Daily average not less than 5.0 mg per liter with a low of 4.0 mg per liter, except that swamp waters may have an average of 4 mg per liter.
4. Temperature. Maximum temperature increase after mixing: 2.8°C (5°F). Maximum temperature after mixing: 32.2°C (90°F).
5. Phenolic compounds. Not greater than 1 microgram per liter unless caused by natural conditions.

TABLE 3
SOUTH CAROLINA EMISSION STANDARDS

Fly ash - 0.6 lb/10^6 Btu heat input

SO_2 - 3.5 lb/10^6 Btu heat input

SOUTH CAROLINA AND GEORGIA AMBIENT AIR STANDARDS FOR PARTICULATES, SO_2, NO_x

	South Carolina	Georgia
Suspended particulates, µg/m^3		
24 hours	250	150
Annual geometric mean	60	60
SO_2, µg/m^3		
1 hour	-	715
3 hours	1300	-
24 hours	365	229
Annual	80	43
NO_x, µg/m^3		
24 hours	-	300
Annual	100	100

- No standard.

ROUTINE COLLECTION AND ANALYTICAL PROCEDURES

Air Collection

Particulate airborne radioactivity is sampled continuously by drawing air through 2-inch-diameter high-efficiency asbestos paper filters that are collected weekly. The air is sampled at about 7×10^4 ml/min (2.5 cu ft/minute) with an auxiliary running-time meter and airflow meter at each station providing data on the volume sampled. A cartridge of activated coconut charcoal for collection of gaseous radioiodine is located downline from each paper filter. Moisture is concentrated from the atmosphere for determination of its tritium oxide content by pumping air through a silica gel column at a continuous rate of 100 ml/minute (operated off the manifold of each vacuum pump). The column contains nonindicating silica gel; a backup column of indicating silica gel is used for evidence of any saturation of the desiccant. The concentration of tritium oxide in the air is calculated from the concentration in atmospheric moisture and the absolute humidity.

Deposition rates of radioactive materials are also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). Fallout collection pans (2 ft × 2 ft) are located at 12 monitoring stations around the plant perimeter and 12 monitoring stations on a 25-mile radius from the center of the SRP site. Rain collected in the collection pan flows by gravity through an ion exchange column (cation and anion resin). The columns are analyzed directly by gamma spectrometry for gamma emitters. Alpha and beta emitters are removed from the column with acid (column eluate) and analyzed by chemical methods. The rainwater passing through the ion exchange column is collected in a plastic jug for weekly tritium analyses by liquid scintillation counting.

Alpha, Beta, and Gamma-Emitting Radionuclides are measured by a direct count of the asbestos paper filter; alpha on a ZnS scintillation counter, beta on a gas flow proportional counter, and gamma on a 9-in. × 9-in. NaI(Tl) well detector with a 400-channel gamma spectrometer.

Strontium-89,90 collected on filter papers is prepared for analyses by the following chemical procedures and counted on a gas flow proportional counter.

1. Filters are leached with hydrochloric acid, precipitated with fuming nitric acid, scavenged with barium chromate, precipitated as an oxalate and transferred to a stainless steel planchet (holder) for beta count.
2. In the presence of significant ruthenium, filters are leached with hydrochloric and hydrofluoric acids and ruthenium removed by thioacetamide precipitation, precipitated with fuming nitric acid, reprecipitated as an oxalate and transferred to a stainless steel planchet for beta counting.
3. In the presence of significant barium-lanthanum, filters are leached with hydrochloric and hydrofluoric acids. Barium-lanthanum is removed by ion-exchange, precipitated with fuming nitric acid, reprecipitated as an oxalate and transferred to a stainless steel planchet for beta count.

Uranium and Plutonium are leached from the filter paper in nitric acid, dried, dissolved in hydrochloric acid and transferred into triisooctylamine (TIOA) by liquid ion exchange. The alpha emitters are stripped from the TIOA organic layer with hydrochloric acid and evaporated to dryness. The residue is dissolved in nitric acid and transferred to a stainless steel planchet for count on a ZnS alpha scintillation counter.

Iodine-131 is measured by a direct count of the charcoal canister using a 9-in. × 9-in. NaI(Tl) well detector with a 400-channel gamma spectrometer.

Tritium analysis of atmospheric moisture is described in the sample collection section.

Plutonium is leached from the filter paper with 8N nitric acid and fuming nitric acid and passed through anion-exchange resin. The resin column is eluted with 0.35N HCl-0.01N HF and the plutonium in the eluate is electrodeposited on a platinum disk for alpha spectrometric analysis.

Water Collection

Continuous sampling of the Savannah River is accomplished with a sampler consisting of a "Plexiglas" water wheel suspended on two pontoons. As the water wheel is turned by flowing water, a small cup (or cups) on one paddle picks up a sample of water and deposits it into a trough. The sampled water flows by gravity from the trough through connecting tubing into a large polyethylene jug connected to the sampler. The sampled water (up to six gallons) is collected weekly at river locations above and below SRP. Increased analytical sensitivity for water samples (containing insufficient radioactivity for direct processing) is achieved through concentration of radionuclides by ion exchange. The ion exchange column is counted directly for gamma-emitting radionuclides.

Alpha and Beta-Emitting Radionuclides are measured by direct count of dried residue (in planchet) the same as for air.

Gamma-Emitting Radionuclides are measured by passing 25 liters of water through a cation-anion resin column and a direct count of the column using a 9-in. × 9-in. NaI(Tl) well detector with a 400-channel gamma spectrometer. The resin column is then eluted with nitric acid for subsequent strontium analysis.

Strontium-90 is recovered from an aliquot of the above eluate by liquid ion-exchange using di-2-ethylhexyl phosphoric acid. Equilibrium of yttrium-90 (^{90}Y) is allowed over a 15-day period and then the short-lived ^{90}Y daughter is stripped and counted in a low-level gas flow beta proportional counter.

Strontium-89,90 analysis of an aliquot of the above eluate is the same as for air 1, 2, and 3 with the following exceptions.

1. The sample is acidified with nitric acid before precipitation with fuming nitric acid.
2. No acid is added before removal of barium-lanthanum by ion exchange.

Tritium is measured in distilled water samples with a liquid scintillation spectrometer.

Milk

Strontium-90 is removed by a slurry of the whole milk with a cation resin. The resin is leached with nitric acid and then analyzed the same as for water.

Cesium-137 is removed by passing approximately 2 liters of whole milk through a potassium-cobalt-ferro-cyanide resin column and a direct count of the column using a 9-in. × 9-in. NaI(Tl) well detector with a 400-channel gamma spectrometer.

Iodine-131 is the same as for cesium-137 except an anion resin column is used.

Farm Produce

Uranium and Plutonium analysis is the same as for air after drying, ashing in furnace and wet ashing with hydrochloric acid.

Strontium-90 analysis is the same as for air after the pretreatment described for uranium and plutonium.

Gamma-Emitting Radionuclides are determined by counting a bottled sample of the hydrochloric acid solution.

Tritium is measured in water obtained by freeze drying samples and counting in a liquid scintillation counter.

Vegetation

Uranium/Plutonium and Strontium-90 analyses are the same as for farm produce.

Gamma-emitting Radionuclides are determined by counting dried, briquetted vegetation in cans using a 9-in. X 9-in. NaI(Tl) well detector and 400-channel gamma spectrometer.

Soil

The technique used for collection and preparation of soil samples generally follows that used by the ERDA Health and Safety Laboratory (HASL) [7].

Plutonium. Dried soil is blended in a Z-blender, pulverized in a hammer mill to size approximately 20 mesh. 50 grams of the soil is then leached with 8N HCl, passed through an anion-exchange resin. The resin column is eluted with 0.35N HCl - 0.01N HF and the plutonium in the eluate is electrodeposited on a platinum disk for alpha spectrometric analysis.

Gamma-emitting Radionuclides. Approximately 800 grams of the pulverized soil is bottled in a 500-ml plastic bottle and counted as described for vegetation.

Strontium-90. 300 grams of the pulverized soil is leached with 6N HCl. The strontium is precipitated from the leach solution as an oxalate. The precipitate is muffled and dissolved in 0.08N HCl and analyzed the same as water.

ATMOSPHERE MONITORING

Concentrations of radioactive materials in the atmosphere are measured by weekly analyses of air filter contents collected at twelve monitoring stations near the plant perimeter and twelve stations around a circle of about 25-mile radius from the center of the plant (figure 2). Stations are spaced to permit continuous monitoring within every 30° sector on the plant perimeter and at 25-mile-radius points thereby increasing the probability of detecting a significant release of airborne activity by SRP, regardless of wind direction. Deposition rates of radioactive materials at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). Four additional air monitoring stations at Savannah and Macon, GA, and at Columbia and Greenville, SC, are so distant from SRP that the effect of SRP operations is negligible; they serve as reference points for determining background activity levels (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between global fallout and SRP releases.

The small amount of particulate beta activity released to the atmosphere, primarily from the fuel separations areas, is obscured in the area surrounding the plant by worldwide fallout. The influence of nuclear tests, which were resumed in September 1961, is shown in figure 4. The slightly increasing trend (1967 through mid-1972 and again in 1974) is attributed to fallout from atmospheric testing by nonparticipants in the testing moratorium. Some increase occurs each spring as a result of the mixing of the stratosphere with the trophosphere. The beta activity for 1973, however, was relatively low and the characteristic spring maximum – noted in previous years and again in 1974 and 1975 – was absent. Radioactivity in air, determined from filter analysis, is shown in table B-1.

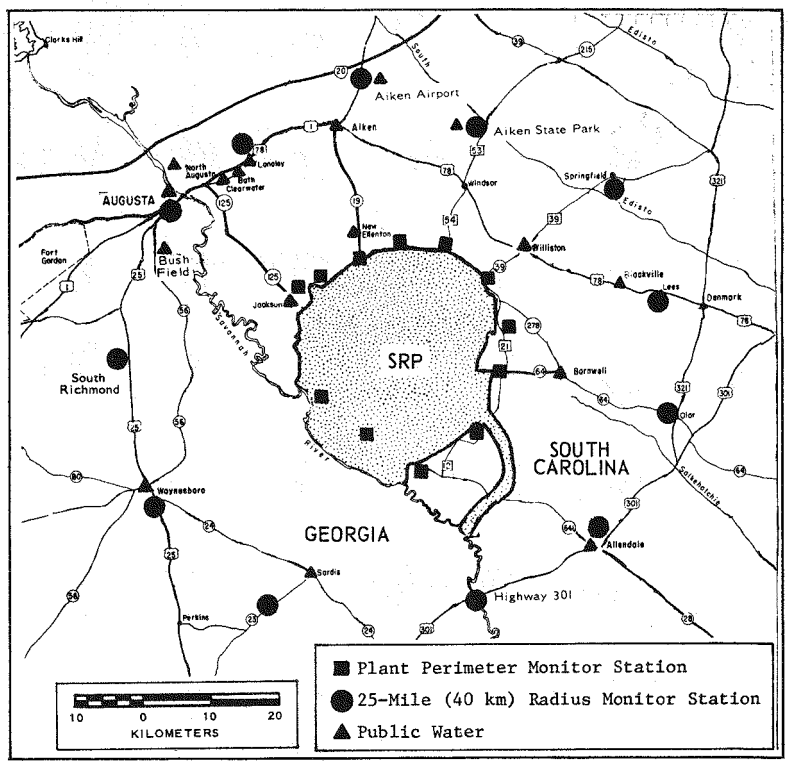

FIGURE 2. CONTINUOUS AIR MONITORING STATIONS AND PUBLIC WATER SAMPLE LOCATIONS

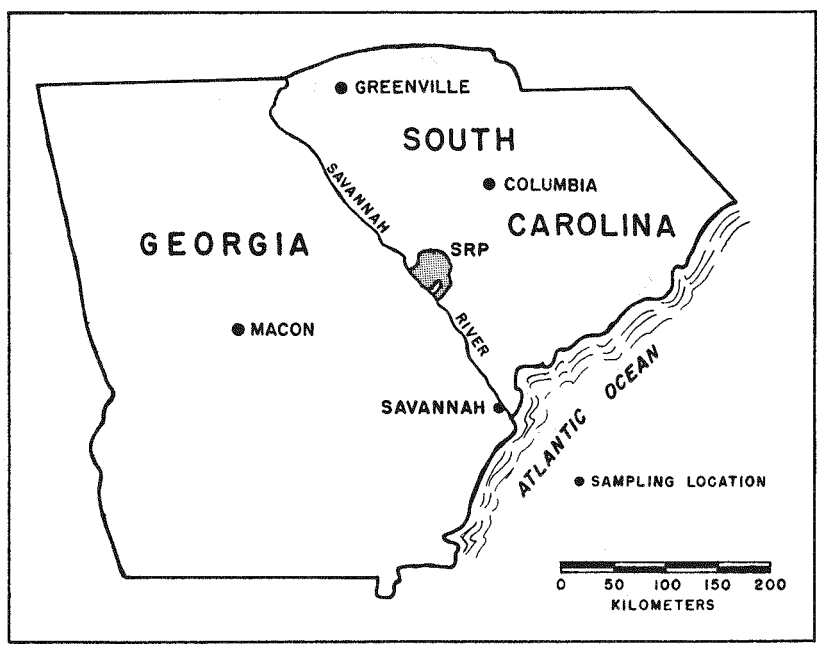

FIGURE 3. DISTANT AIR MONITORING STATIONS

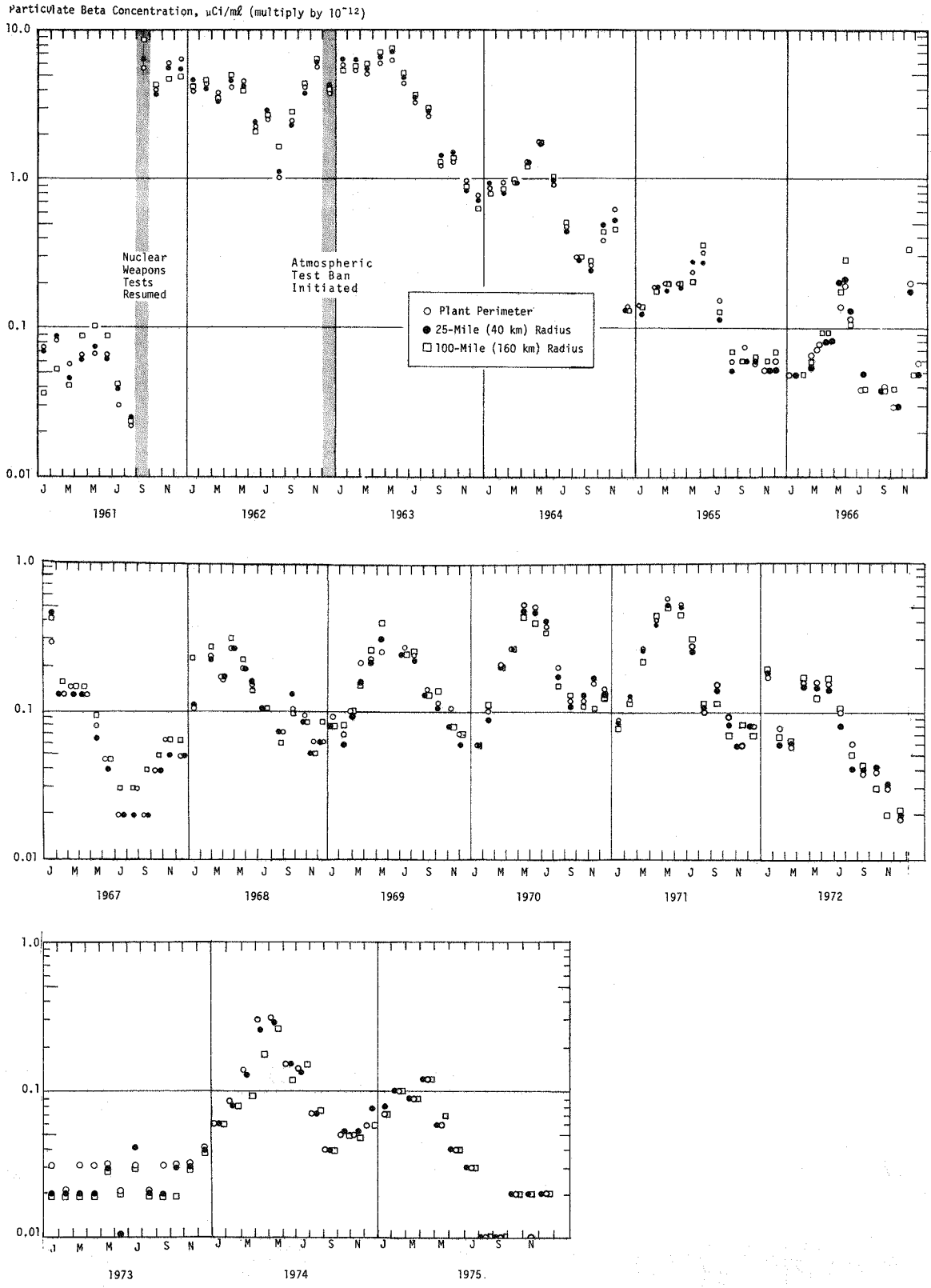

FIGURE 4. ATMOSPHERIC RADIOACTIVITY

The average particulate beta concentration in air decreased from 0.12×10^{-12} μCi/ml during 1974 to 0.05×10^{-12} μCi/ml during 1975. Alpha activity in air averaged 0.0007×10^{-12} μCi/ml. The 1975 concentrations of beta and alpha activity in air are 0.05% and 3.5% of the respective CG's. Radionuclides of global fallout origin observed in air filters throughout the first half of 1975 were zirconium-niobium-95; ruthenium-106; cerium-144; cesium-137; and strontium-89,90. No gamma-emitting fallout radionuclides were identified in air samples or fallout collectors during the last half of 1975. The major component, beryllium-7, in air filters is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. Plant releases of airborne beta or gamma activity, with the exception of tritium, are not detectable at the plant perimeter. Therefore, concentrations are calculated using standard meteorological dispersion equations, normalized to agree with measured dispersion of tritium. These calculated concentrations are listed in table 6 (page 23) along with the yearly releases at the emission source and dose estimates.

After being measured for particulate alpha, beta, and gamma activities, weekly filters from each of the location groups (plant perimeter, 25-mile radius, and 100-mile radius) are combined and dissolved to produce three composite monthly samples for isotopic plutonium analyses. Plutonium is separated by ion exchange, electrodeposited, and counted for alpha emission with a solid-state alpha detection system. Many of the individual plutonium measurements, particularly those for plutonium-238, showed net values that are lower than the minimum detection level of the analyses. Plutonium-238 and -239 concentrations in air are listed in table B-1. The average concentrations of plutonium-239 in air were 17.2×10^{-18} μCi/ml at the plant perimeter, 16.8×10^{-18} μCi/ml at a 25-mile radius, and 18.6×10^{-18} μCi/ml at a 100-mile radius. The respective plutonium-238 concentrations were 1.3×10^{-18} μCi/ml, 1.0×10^{-18} μCi/ml, and 1.1×10^{-18} μCi/ml.

Deposition rates of plutonium were also determined from rainwater ion exchange columns (fallout collectors). Monthly samples were composited according to two groups: plant perimeter and 25-mile radius (table B-2). Plutonium-239 deposition at the plant perimeter for 1975 was 2.2×10^{-6} μCi/m^2 and 1.9×10^{-6} μCi/m^2 at 25-mile radius. The respective plutonium-238 depositions were 0.11×10^{-6} μCi/m^2 and 0.15×10^{-6} μCi/m^2. Most plutonium-238 values were below the sensitivity of analysis.

Deposition of other radionuclides from weapons test fallout during 1975 averaged 6.2×10^{-3} μCi/m^2 at the plant perimeter and 6.5×10^{-3} μCi/m^2 at 25-mile radius locations (table B-2); comparable values for 1974 were 6.4×10^{-3} μCi/m^2 at the plant perimeter and 11.4×10^{-3} μCi/m^2 at 25-mile-radius locations. Naturally occuring beryllium-7 (deposition of 10 to 15×10^{-3} μCi/m^2), as in air filter samples, is the major component. Rainwater is analyzed weekly for tritium. The average concentration during 1975 at the plant perimeter was 3.4×10^{-6} μCi/ml as compared with 1.0×10^{-6} μCi/ml at 25-mile-radius locations (table B-2).

Annual tritium oxide concentration in air at plant perimeter stations did not exceed 0.1% of the CG. The average of all plant perimeter stations was 88×10^{-12} μCi/ml (0.04% CG) compared with 45×10^{-12} μCi/ml at 25-mile radius. Release of more than the usual amount of tritium gas from a plant facility occurred in December; no increased levels of tritium beyond the plant boundary could be attributed to the release. Extensive environmental sampling showed tritium concentrations within the range observed during normal operations (page 24).

Gamma radiation is measured quarterly with thermoluminescent dosimeters at the plant perimeter, 25- and 100-mile-radius air monitoring locations (figures 2 and 3). 1975 environmental gamma radiation data (table B-3) were characteristic of measurements observed at individual stations for the past several years (approximately 64 mR/year). A special environmental radiation thermoluminescent dosimeter (TLD) monitoring program was initiated during 1973 to measure background radiation at 79 stations selected at one-mile intervals along the plant perimeter. Exposure rates at the 79 perimeter stations averaged 62 ± 10.9 mR/year for the four 1974 quarterly cycles monitored, the same as the average for 1973. This average for 1975 was 61 ± 8.7 mR/year. All measurements are taken at one meter above the ground.

Exposure rates were measured over the Clark Hill reservoir, approximately 40 miles upstream from SRP, to determine cosmic radiation components for this latitude and elevation. The annual exposure averaged 29 ± 1.5 mR for quarterly cycles during 1973 and 1974. This measured cosmic radiation agrees well with the cosmic-ray air dose rates of approximately 30 mR/year reported for a one-meter altitude [8]. Thus, the average exposure rate from terrestrial radiation and atmospheric radioactivity along the plant perimeter is 32 ± 8.8 mR/year (61 ± 8.7 minus 29 ± 1.5) with a range from 15 ± 3.9 to 55 ± 3.2 mR/year at individual stations. In situ spectrometric measurements of radionuclides in soil indicated that these differences could be attributed to variation and distribution of naturally occurring uranium-238, thorium-232, and potassium-40. No significant differences in cesium-137 activity were detected at individual stations monitored.

Atmospheric emissions of SO_2, NO_x, and fly ash are presently within applicable standards with the exception of fly ash from several steam power plants. The fly ash emissions from the largest source (near the heavy water production area) were 2.75 lb/10^6 Btu heat input. Operation of newly installed fly ash emission control equipment at the heavy water production area will begin in 1976. A program of ambient air measurements of SO_2 was initiated in 1973. Statistical analyses of data collected at a location on the site boundary near the powerplant in the heavy water production area indicate the possibility of exceeding the Georgia one-hour standard (715 $\mu g/m^3$) at a frequency of less than twice per year. The South Carolina standard for a three-hour maximum value is 1300 $\mu g/m^3$, not to occur more than once per year. This value would be exceeded at a frequency much less than once per 10 years, well within the South Carolina standard, which is also the national secondary standard.

VEGETATION AND FOOD MONITORING

Vegetation

Radioactive contamination of growing plants may result from sorption of radioactive materials from the soil or from foliar deposition. Bermuda grass is selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Grass samples are routinely collected at seven locations along the plant perimeter and at seven other locations along a 25-mile-radius route. (Collection locations are shown in figure 5.) Samples from each quadrant of the plant and of the surrounding area are composited for monthly analysis. Concentrations of gamma-emitting radionuclides from general fallout, as in the atmosphere, were detectable only during the first half of 1975. Iodine-131 was less than the sensitivity of analysis throughout the year. Radioisotopic concentrations found in vegetation are shown in table B-4. Naturally occurring beryllium-7 is the major component. In these samples, tritium is the only radionuclide of plant origin detected in vegetation. The average concentration in the free water of vegetation collected at the plant perimeter is 14×10^{-6} μCi/ml as compared with 6×10^{-6} μCi/ml at a 25-mile radius and 4×10^{-6} μCi/ml at a 100-mile radius.

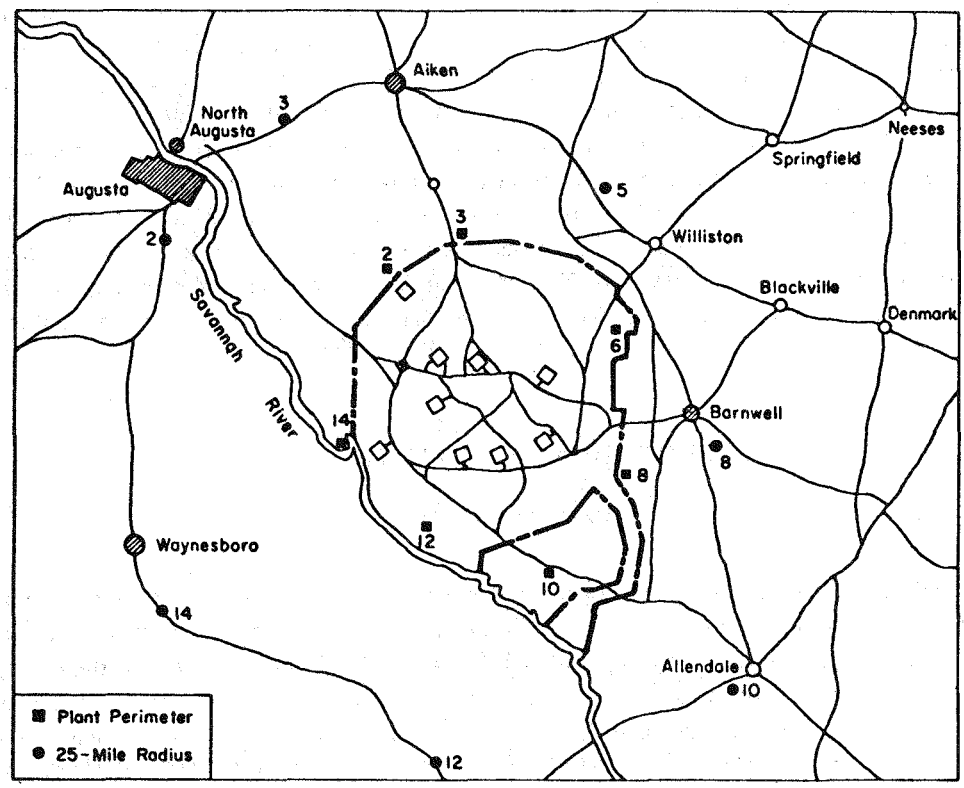

FIGURE 5. VEGETATION SAMPLE LOCATIONS AT PLANT PERIMETER AND 25-MILE RADIUS

Milk

Milk is sampled at two dairies (North Augusta, SC, and Waynesboro, GA) within a 25-mile radius of SRP. Samples are collected twice monthly and analyzed for tritium and radioiodine. Analyses are made quarterly for strontium-90 and monthly for cesium-137. Milk produced in the area and sold by a major distributor is also analyzed for these radionuclides. Results are summarized in table B-5.

Strontium-90 and cesium-137 in milk are attributed to fallout. Average concentrations of the radionuclides in milk were 10×10^{-9} μCi/ml of strontium-90 and 11×10^{-9} μCi/ml of cesium-137. Iodine-131 in milk samples was less than the sensitivity of analysis (1×10^{-9} μCi/ml) throughout the report period. Strontium, cesium, and iodine values represent 3.3, 0.05, and approximately 0.3% of the respective CG's for water. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (970×10^{-9} μCi/ml) is 0.03% of the CG for water.

Farm Produce

Over 60 samples of farm produce representing 5 food categories (grain, fruit, leafy vegetables, poultry, and beef) are collected at 14 localities in the 6 counties surrounding SRP. Six locations are near the plant perimeter and 8 locations at a distance of approximately 25 miles (figure 6). The samples of local beef were collected near Waynesboro and Sylvania, GA, and Aiken and Ehrhardt, SC. All samples were analyzed by gamma spectrometry for gamma-emitting radionuclides. Radiochemical analyses are used for strontium-90 and alpha emitters (uranium and plutonium). Liquid scintillation counting is used for tritium. With exception of grains, all foods are prepared as though for human consumption. Peelings, seeds, and other nonedible parts are removed. Wheat containing the whole grains only, and oats containing both grains and husks, are processed unwashed. Results for 1975 are summarized in table B-6.

SRP contributions to the levels of radioactivity (excluding tritium) in farm produce were so low in 1975 that they were indistinguishable from fallout. All radionuclides in food were near or below the levels of detection. Results for strontium-90 are about the same as in the 1974 samples with the highest concentration again in collards (2.9×10^{-6} μCi/g). Tritium concentrations in foods were similar to those found in rainwater, with a maximum value of 6×10^{-6} μCi/ml.

Fish

Fish are trapped in the Savannah River, upstream, adjacent to, and downstream from the SRP effluents. Individual whole fish are analyzed by gamma spectrometry for cesium-137 and other gamma-emitting radionuclides; bone from each specimen is composited monthly for strontium-89,90 analysis. Fish are also analyzed for mercury content. Fish analysis data for 1975 are presented in table B-7.

During 1975 the radioactivity in bone and flesh showed only minor contribution by SRP and concentrations are of minor significance from a radiation dose viewpoint. An adult regularly consuming fish from the river adjacent to SRP (at a rate of 25 pounds/year) would receive a whole-body dose of only 0.2 mrem compared to approximately 115 mrems from natural radiation [9]. Studies also show that SRP operations do not significantly contribute to the mercury concentration in river fish; there is little difference between the mercury values in fish from the Savannah River above and below the plant boundaries. Direct releases of mercury to SRP effluents are small – one to two pounds per year.

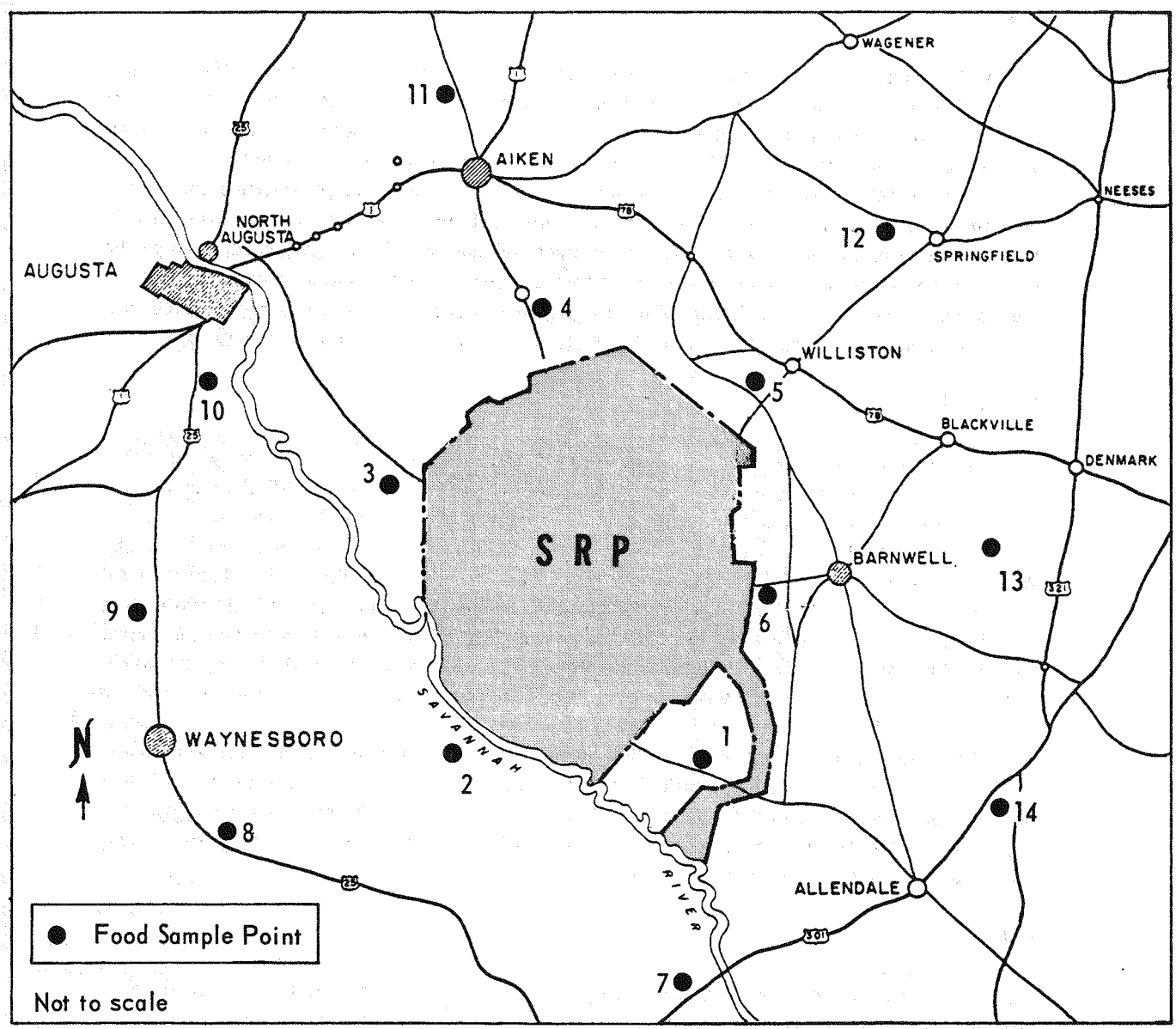

FIGURE 6. AGRICULTURAL PRODUCTS SAMPLE LOCATIONS

Deer and Hogs

Concentrations of cesium-137 in 1391 deer and 45 hogs killed during the autumn 1975 hunts were estimated with a portable, single-channel scintillation instrument before release of the animals to the hunters. The estimated cesium-137 content was verified by gamma spectrometric analysis of muscle tissue from 66 deer.

Cesium-137 concentrations in deer originated almost entirely from fallout deposits from nuclear weapons tests. The average cesium-137 concentration in deer was 9×10^{-6} μCi/g with a maximum of 36×10^{-6} μCi/g. Edible meat from the deer containing 36×10^{-6} μCi/g weighed about 66 pounds and would therefore contain about 1.08 μCi of cesium-137. An adult eating all of this deer meat would receive a radiation dose of 65 mrems to the whole body, less than the annual dose South Carolina residents receive from natural radiation [9]. Deer and hog data are shown in table B-8. A summary of the cesium-137 concentration detected in deer during all of the public hunts beginning in 1965 are summarized in table 4. Cesium-137 in SRP deer since 1968 is also compared with data on South Carolina Coastal Plains (SCCP) deer provided by the School of Forest Resources, University of Georgia, Athens, GA.

TABLE 4
^{137}Cs IN DEER, $\times 10^{-6}$ μCi/g

Year	No. of Deer Killed		Average		Maximum	
	SRP	SCCP[a]	SRP	SCCP[a]	SRP	SCCP[a]
1965	198		<10		10	
1966	541		6		24	
1967	1032		9		104[c]	
1968	699	34	11	23	74[d]	80
1969	889[b]	31	15	15	204[d]	72
1970	864	33	18	20	77[d]	57
1971	865	42	11	21	48	42
1972	808	72	8	11	38	32
1973	1158	78	6	16	31	49
1974	1551	89	5	9	52	23
1975	1391		9	-	36	-

[a] South Carolina Coastal Plains.
[b] Approximately 20% of deer monitored before 1969; each deer monitored since 1969.
[c] Killed along Four Mile Creek, a plant effluent.
[d] Killed near Steel Creek, a plant effluent.
- Data not available.

Game Birds

Concentrations of cesium-137 were determined in 40 doves obtained on the plantsite and 17 doves obtained near the plant perimeter. Most concentrations of cesium-137 were near the limit of detection, averaging less than 1×10^{-6} μCi/g. Maximum concentration in an onplant dove was 22×10^{-6} μCi/g and in a plant perimeter dove, 11×10^{-6} μCi/g.

Waterfowl collected onplant for radioanalysis included 11 wood ducks and 4 coots from Par Pond, and 7 wood ducks from Steel Creek. Average concentrations of cesium-137 in waterfowl were 15×10^{-6} μCi/g in both ducks and coots from Par Pond, and 20×10^{-6} μCi/g in the Steel Creek duck. Maximum concentration of cesium-137 was 81×10^{-6} μCi/g measured in a Par Pond wood duck.

WATER MONITORING

Savannah River

The plantsite is drained by 5 streams that flow several miles through the reservation before reaching the river (figure 1). The primary sources of the very small amount of radioactivity that reaches the river are the reactor facilities. Tritium accounts for the largest quantity of radioactivity released by the reactors to the effluent streams. However, the contribution of tritium to the Savannah River results in concentration of only 0.13% of the concentration guide.

River water is sampled above and below the plant (sampling method described earlier) and is analyzed weekly. Concentrations of gross alpha and nonvolatile beta emitters in river water for 1975 are summarized in table B-9. The values represent the radioactivity associated with dissolved and suspended solids and are all near or less than the sensitivity of analysis. Upstream measurements are attributed to natural radioactivity and worldwide fallout from nuclear weapons tests. Downstream measurements reflect these sources plus releases from SRP.

Tritium, trace amounts of cesium-137, and strontium-90 were the only radionuclides of SRP origin detected in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river water upstream from SRP effluents. Average concentrations of all radionuclides found in river water during 1975 (table B-10) are only small fractions of the concentration guides.

The water quality of the Savannah River (table B-11) is not adversely affected by the operation of the Savannah River Plant. More fecal coliform bacteria are in the river water entering the plant than in the effluent water re-entering the river. With respect to thermal effect, several miles of onsite streams and a large swamp permit dissipation of almost all heat generated at SRP. The maximum temperature increase of river water is less than 1°F, well under South Carolina and Georgia standards. Results of surveys of the Savannah River biota by the Academy of Natural Sciences of Philadelphia and pesticide analyses of the river by the U.S. Geological Survey (USGS) Water Quality Laboratory, Atlanta, GA, are summarized in appendix D. Pesticides and herbicides are used moderately in areas where insect and vegetation control is necessary for security and safety. Some herbicide and chemical treatment is also carried on by the U.S. Forest Service in timber management. Results from river water samples analyzed during the period 1967-1975 have shown no indication of any significant concentration of pesticides. Only trace quantities of pesticides (approximately 0.05 parts per billion, primarily dieldrin) have been detected in river water both upstream and downstream from SRP. Dieldrin is an agricultural pesticide and is not used at SRP. River sediment showed trace quantities of dieldrin, aldrin, DDD, DDT, and chlordane, but these pesticides, with the exception of small amounts of chlordane, are not used at SRP.

Drinking Water

Communities near SRP get drinking water from deep wells or surface streams. Public water supplies from fourteen surrounding towns are collected in April and October. Data from analyses of all public water samples from the immediate vicinity of the plant are shown in table B-12. Deep wells onplant show concentrations of radioactivity similar to those offplant.

Alpha activity (0.9×10^{-9} μCi/ml) and beta activity (1×10^{-9} μCi/ml) are essentially the same as those observed before plant startup. Very low levels of tritium are found in drinking water of several of the towns that use surface water (annual maximum of 0.65×10^{-6} μCi/ml). Concentrations of tritium in water from deep wells are near or less than the sensitivity of the analyses (0.3×10^{-6} μCi/ml).

The Beaufort-Jasper Water Authority operates a treatment facility to furnish drinking water, partially obtained from the Savannah River, to most of Beaufort County, SC. Water is supplied through a canal from the river at a point about 90 miles below SRP. A water treatment plant at Port Wentworth, GA, supplies water to a business-industrial complex near Savannah. These two water supplies are analyzed monthly for tritium content.

Tritium concentrations in water collected from the Beaufort-Jasper plant averaged 2100×10^{-9} μCi/ml (0.07% CG, as defined in the foregoing section on Applicable Standards) and 3300×19^{-9} μCi/ml in water from the Port Wentworth plant (0.11% CG) during 1975.

SOIL MONITORING

Concentrations of radiocesium and plutonium in soils collected at four locations near the plant perimeter and two locations approximately 100 miles distant during 1975 are similar to the deposition values reported for 1973 and 1974. The average concentration of cesium-137 in the top 15 cm at the plant perimeter is 0.45×10^{-6} μCi/g and at the 100-mile distance, 0.32×10^{-6} μCi/g. The total plutonium average in the top 5 cm at the plant perimeter is 0.016×10^{-6} μCi/g and at 100 miles, 0.009×10^{-6} μCi/g. Deposition of cesium and plutonium measured in soils for the past three years are summarized in table 5. Total plutonium deposition and cesium-137 deposition in all samples are within the range normally found in global fallout. Individual plutonium and cesium in soils are shown in table B-13.

Soil samples from noncultivated areas were first collected in 1973 at four locations along the plant perimeter (representing each quadrant) and at three locations up to 100 miles from the plant for radioanalysis. The 1975 samples were collected at the sample plant perimeter locations and at two of the 100-mile-radius locations. At each site 10 soil cores 5 cm deep were taken in a straight line 30 cm apart for plutonium analysis. Ten 15-cm soil cores were taken at each site for cesium-137 analysis. The soil cores were composited by location for radioanalysis.

Additional soil cores were collected at Springfield, SC, and at the Aiken airport to confirm the comparatively high plutonium-238 alpha percentages (expressed as the percentage of plutonium-238 of total plutonium) observed in the 1974 soil samples collected at these two locations (59% at Springfield, and 29% at Aiken airport). This anomaly was not observed in the resampled soil – the total plutonium concentrations in soil at both stations, as in 1974, were similar to that in other soils in this region and the respective plutonium-238 alpha percentages (7% and 11%) were within the normal range for this area. Individual results for the Springfield and Aiken airport soil samples are also shown in table B-13.

TABLE 5
DEPOSITION OF RADIOACTIVITY IN SOIL
$\times 10^{-3}$ $\mu Ci/m^2$

	Plant Perimeter			100-Mile Radius		
Year	^{239}Pu	^{238}Pu	^{137}Cs	^{239}Pu	^{238}Pu	^{137}Cs
1973	1.78	0.080	78	1.69	0.120	105
1974	1.19	.110	73	1.26	.129	59
1975	1.13	0.066	88	0.68	0.022	72

SAVANNAH RIVER SWAMP MONITORING

During the 1960's, radioactive materials from SRP releases were deposited in about 1.7 square miles of offsite swamp downstream from SRP. Waterborne sediments settle in the swamp during periods of high flow in the river when the river overflows its natural banks into the swamp. When the swamp is flooded, the flow from SRP surface streams generally follows a path in the swamp paralleling the main river channel and bordering the north swamp margin. This swamp flow does not enter the main river channel until high ground is encountered at Little Hell Landing, approximately four miles from the SRP boundary (figure 7).

Associated with the deposit in the offsite swamp were approximately 25 Ci of cesium-137 and less than 1 Ci of cobalt-60. Most of the cesium-137 and cobalt-60 in the swamp were from releases from L and P reactor fuel basins to Steel Creek. The discharges to Steel Creek were substantially reduced in 1970 following modifications to one reactor and shut down of the other reactor. Aerial radiological surveys and ground surveys conducted in 1974 [10,11] showed that approximately 4.8 Ci of cesium-137 and most of the cobalt-60 was deposited in a quarter-mile-long section of swamp (43 acres) immediately adjacent to the SRP boundary (figure 7). The remainder of detectable radioactivity was deposited in a four-mile-long band bordering the north swamp margin, terminating at the Little Hell Landing area. The 1975 radiation survey of the swamp showed no significant change in levels of radioactivity from those measured and reported in 1974.

Fifty-three locations along ten trails transecting the swamp were selected for sampling vegetation and soil and radiation (TLD) measurements. The trails were established in 1974 and the locations selected were as near as possible to locations used in the 1974 survey. Additionally, tree cores, animals along the trail nearest the plant (trail 1), and fish from three lakes in the river swamp were collected for radioanalysis. Maximum cesium-137 concentrations were 190×10^{-6} $\mu Ci/g$ in vegetation, 260×10^{-6} $\mu Ci/g$ in soil, 4.5×10^{-6} $\mu Ci/g$ in fish. The maximum radiation exposure rate measured was 65 $\mu R/hr$ (includes approximately 10 $\mu R/hr$ background). All maximum concentrations of cesium and radiation measurements were found along trail 1 and are well within the ranges observed during 1974. The maximums in tree cores (3×10^{-6} $\mu Ci/g$) and in animals (3.3×10^{-6} $\mu Ci/g$ in a raccoon) are comparable to global fallout levels.

Sediment cores were collected along each of the trails at the location showing the highest observed radiation level. At each site 10 sediment cores, approximately 25 cm deep, were taken in a straight line 30 cm apart. Each soil core was divided into increments of 0 to 7.6 cm and 7.6 to 25 cm and composited by increment from each location for plutonium analysis. Most of the plutonium (approximately 75%) was confined in the top 7.6-cm depth. Deposition of plutonium at this depth ranged from 2.5 to 11×10^{-3} $\mu Ci/m^2$ of plutonium-239 and 0.3 to 6×10^{-3} $\mu Ci/m^2$ of plutonium-238. Deposition of plutonium attributed to global fallout found in other terrestrial soil cores (top 5-cm depth) is approximately 1×10^{-3} $\mu Ci/m^2$ for plutonium-239 and 0.1×10^{-3} $\mu Ci/m^2$ for plutonium-238. The plutonium-238 alpha percentage (ratio of plutonium-238 to total plutonium) ranged from 12 to 35% and is indicative of some plant contribution.

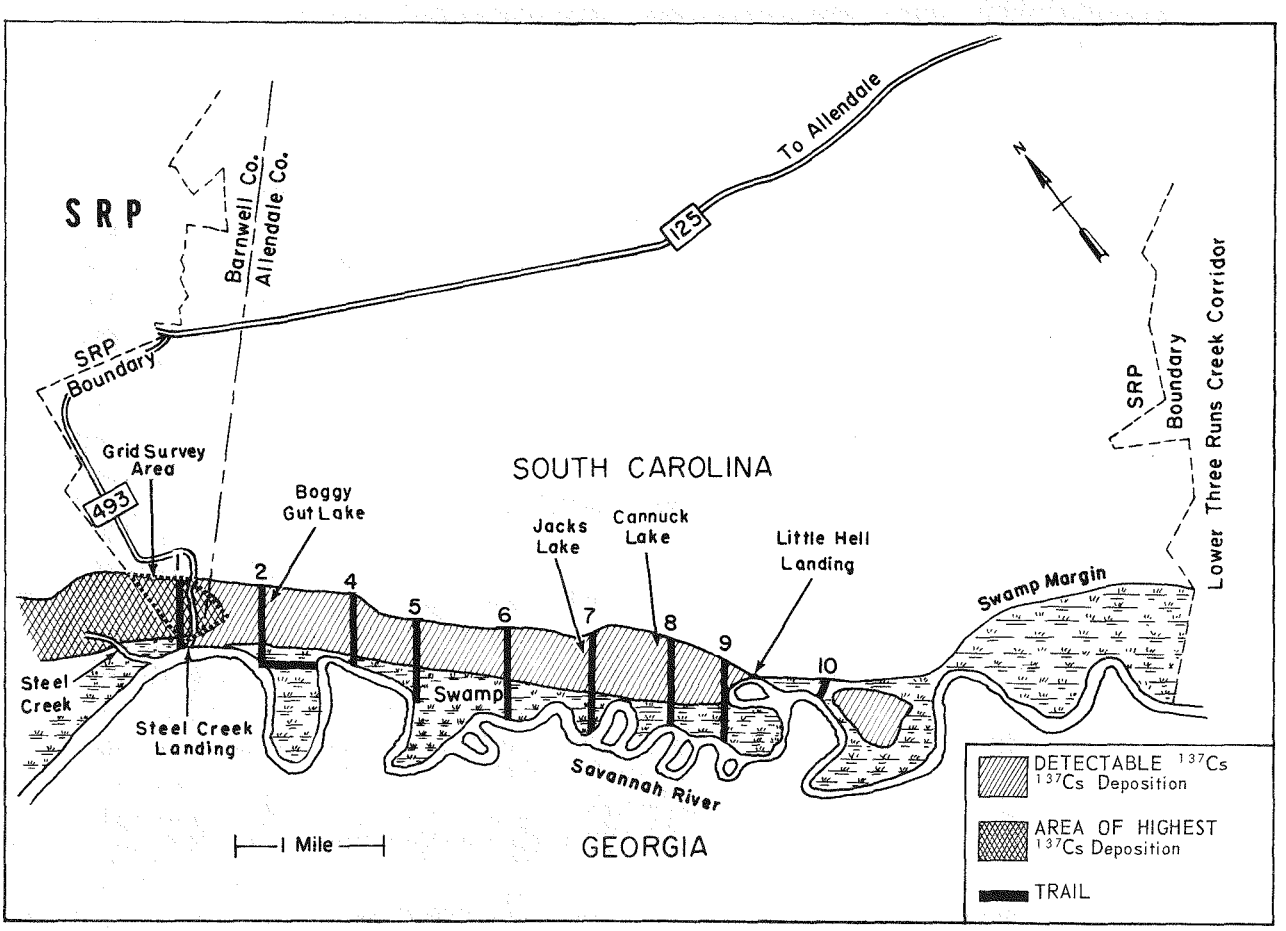

FIGURE 7. RADIOACTIVITY DEPOSITION IN THE SAVANNAH RIVER SWAMP

RADIATION DOSE COMMITMENT – INDIVIDUAL AND POPULATION

As used in this report, "radiation dose" means "radiation dose equivalent" as defined by the International Commission on Radiological Protection [12]. Radiation dose commitment is the amount of radiation dose received from major pathways of exposure, internal and external, throughout the lifetime of an individual from direct first-pass exposure. (A brief description of dose calculational techniques is given in appendix C.) Population dose commitment is the sum of radiation dose commitment of individuals and is expressed in units of man-rem. (For example, if 1000 people each received a dose of 1 rem, their population dose would be 1000 man-rems.) The segments of the population that receive the highest radiation dose commitments from SRP releases of radioactive materials to the environment are described in the following sections.

Persons Living in the Area Surrounding the Savannah River Plant and Exposed to Radioactive Materials via Atmospheric Pathways

Radioactive materials released from exhaust stacks are diluted by the atmosphere and the concentration in air decreases with distance from point of release because of mixing by turbulent movements of the atmosphere. As a result of this dispersion, the average radiation dose commitment from SRP releases to individuals 50 miles from the center of the plant is only about 23% of that received by people living near the plant perimeter. The radiation dose received by people from atmospheric releases of radioactive materials from SRP is too low to permit direct measurement of all pathways of exposure; therefore, radiation dose commitments are calculated with mathematical models using known dispersive characteristics of the atmosphere and the known major pathways of exposure to man.

During 1975, the average dose commitment to an individual from atmospheric releases of radioactive materials from SRP was calculated to be 0.67 mrem at the plant perimeter (table 6). The major contributors to this dose were tritium (hydrogen-3), 74%; argon-41, 18%; and carbon-14, 7%. The remaining 1% was from krypton and xenon isotopes (chemically inert noble gases), iodine-129,131, and miscellaneous radioactive particles. The calculated population dose commitment from release of radioactive materials from SRP to the atmosphere in 1975 to people living within 80 km (50 miles) of the center of SRP (population: 465,000) is 94 man-rems. This population dose does not include a calculated population dose of 0.2 man-rem distributed over eastern parts of South Carolina from a tritium release incident on December 31, 1975, described on page 24 of this report. Table 6 shows the amount of each radionuclide released to the atmosphere from normal SRP operations and calculated whole-body radiation dose commitment.

Tritium (T), the major contributor to population dose from normal SRP releases in 1975, is a radioactive isotope of hydrogen with a radiological half-life of 12.33 years. The maximum energy of the beta particle emitted during decay is 0.0186 MeV; the average energy is about 0.006 MeV. At SRP, some tritium is unavoidably released during normal operations both as an elemental gas (T_2, HT, DT) and in combination with oxygen (T_2O, HTO, DTO). Both forms are readily dispersed in air and will enter into the same chemical and biological reactions as hydrogen or water vapor.

TABLE 6
ATMOSPHERIC TRANSPORT AND DOSE — 1975

Nuclide	Curies Released at Emission Source	Calculated Avg Conc at Plant Perimeter, μCi/ml	Calculated Whole Body Dose to Individual at Plant Perimeter, mrem		Calculated Population Dose Commitment, man-rem	
			Average	Maximum	80 km	100 km
Gases and Vapors						
^{3}H[a]	3.06×10^{5}	8.3×10^{-11}	0.49	0.67	76.7	96.0
^{14}C	6.6×10^{1}	1.8×10^{-14}	0.046	0.063	7.18	8.99
^{41}Ar	6.5×10^{4}	8.6×10^{-12}	0.12	0.18	8.58	9.23
^{85m}Kr	3.7×10^{2}	7.1×10^{-14}	0.00014	0.00021	0.014	0.016
^{85}Kr	5.2×10^{5}	1.4×10^{-10}	0.0018	0.0026	0.32	0.42
^{87}Kr	1.2×10^{3}	1.3×10^{-13}	<0.00001	<0.00001	0.00011	0.00012
^{88}Kr	8.6×10^{2}	1.4×10^{-13}	0.0036	0.0055	0.31	0.34
^{131m}Xe	5.8	1.6×10^{-15}	<0.00001	<0.00001	0.0004	0.00049
^{133}Xe	1.1×10^{3}	3.0×10^{-13}	0.00027	0.00038	0.036	0.044
^{135}Xe	7.3×10^{2}	1.6×10^{-13}	0.00049	0.00071	0.055	0.064
^{129}I	1.4×10^{-1}	3.8×10^{-17}	0.00090	0.0013	0.10	0.12
^{131}I	1.2×10^{-1}	2.1×10^{-17}	0.00002	0.00003	0.0023	0.0027
Particulates						
^{60}Co	1.1×10^{-3}	6.4×10^{-20}	<0.00001	<0.00001	<0.00001	<0.00001
$^{89,90}Sr$	5.0×10^{-3}	2.9×10^{-19}	<0.00001	<0.00001	<0.00001	<0.00001
^{95}Zr	1.4×10^{-2}	8.1×10^{-19}	<0.00001	<0.00001	<0.00001	<0.00001
^{95}Nb	2.4×10^{-2}	1.4×10^{-18}	<0.00001	<0.00001	<0.00001	<0.00001
^{103}Ru	1.8×10^{-3}	1.0×10^{-19}	<0.00001	<0.00001	<0.00001	<0.00001
^{106}Ru	3.7×10^{-2}	2.1×10^{-18}	<0.00001	<0.00001	<0.00001	<0.00001
^{134}Cs	2.0×10^{-4}	1.2×10^{-20}	<0.00001	<0.00001	<0.00001	<0.00001
^{137}Cs	1.1×10^{-3}	6.4×10^{-20}	<0.00001	<0.00001	<0.00001	<0.00001
^{141}Ce	2.8×10^{-4}	1.6×10^{-20}	<0.00001	<0.00001	<0.00001	<0.00001
^{144}Ce	1.6×10^{-2}	9.2×10^{-19}	<0.00001	<0.00001	0.00004	0.00004
U	4.7×10^{-3}	2.7×10^{-19}	<0.00001	<0.00001	0.00020	0.00022
^{238}Pu	2.0×10^{-3}	1.2×10^{-19}	0.00015	0.00020	0.013	0.015
^{239}Pu	5.2×10^{-4}	3.0×10^{-20}	0.00005	0.00006	0.0043	0.0048
		Total →	0.663	0.924	93.3	115.3

[a] Does not include 182,000 Ci of tritium released on December 31, 1975 and associated dose commitment.

The low energy beta particle emitted by tritium during decay will penetrate human tissue only 0.013 cm. As an elemental gas, tritium constitutes little hazard because the weak beta is completely attenuated (absorbed) in the inert external skin layer (epidermis). Only 0.004% of the gas inspired is converted to the oxide and retained in the body. Almost all tritium oxide (water vapor) inhaled is absorbed in the lungs and enters the body water pool. In addition, almost as much tritium oxide is absorbed through the skin as is absorbed during inhalation. Because of the great difference between the biological assimilation of tritium gas and tritium oxide, the concentration guide [1] for tritium oxide is several hundred times more restrictive than for elemental gas. The environmental radiation dosimetry program used at SRP makes the conservative assumption that all normal SRP releases are in the oxide form and thus, there is an overestimation of individual and population dose commitment from tritium.

Environmental Effects of a Tritium Gas Release from SRP on December 31, 1975

On December 31, 1975, 182,000 Ci of tritium gas were released from a tritium processing facility at SRP. The accidental release was exhausted to the atmosphere through a 200-ft stack; about 90% of the tritium was released over a period of 1.5 minutes and was mixed with building ventilation air, which was being discharged at a rate of 130,000 cu ft/minute. A public announcement of the release was made on January 1, 1976, and a detailed report [13] of the environmental effects was published in April 1976.

Winds averaging 20 mph carried the tritium offplant toward the east. Calculations indicate that the puff passed out to sea about 35 miles north of Charleston, SC, about seven hours after the release occurred. Samples from the facility exhaust system indicated that 99.4% of the tritium was in elemental form and 0.6% was in the more biologically active oxide form (water). The maximum potential dose to a person (from inhalation and skin absorption) at the puff centerline on the plant boundary was calculated to be 0.014 mrem, about 0.01% of the annual dose received from natural radioactivity. The integrated dose to the population under the release path (approximately 40,000 people) was calculated to be 0.2 man-rem before the tritium passed out to sea.

Over 300 environmental samples were collected and analyzed following the release. These samples included air moisture, atmospheric hydrogen, vegetation, soil, surface water, milk, and human urine. Positive results were found in some onplant and plant perimeter samples and aided in confirming the close-in puff trajectory. Tritium concentrations in nearly all samples taken beyond the plant perimeter fell within normal ranges; urine samples indicated no tritium uptakes as a result of the release. Two milk samples indicated a measurable tritium uptake; the maximum potential dose to an individual drinking this milk was calculated to be about 0.1 mrem.

Persons Living Downstream from SRP and Consuming Savannah River Water Containing Low Concentrations of Radioactive Materials

Radioactive materials released to effluent streams on the SRP site flow to the Savannah River. There is no known use of river water for irrigation downstream from SRP. Fish from the river are not an important source of food for any large segment of the population. The most important pathway of exposure of a population segment to radioactive materials in the river is from consumption of river water. Two water treatment plants downstream from SRP supply treated river water to customers in Beaufort and Jasper Counties in South Carolina and Port Wentworth, GA. Of the radioactive materials released to effluent streams on SRP during 1975 (table 7), only tritium is measurable by routine water monitoring techniques of the water from the treatment plants. Data shown for other nuclides are calculated, based on dilution by known river flow rates. Of the radioactive materials in water, tritium is the source of 98% of the whole-body dose commitment to consumers. People who consume this water at a rate of 1.2 liters per day would receive a dose commitment from tritium of:

Beaufort-Jasper	0.19 mrem
Port Wentworth	0.29 mrem

The population dose commitment from tritium to these two groups from 1975 SRP tritium releases are 9.5 man-rems to consumers of Beaufort-Jasper water (population: 50,000) and 5.8 man-rems to consumers of Port Wentworth water (estimated consumer population: 20,000 – most of Port Wentworth water is used for industrial purposes), a total of 15.3 man-rems to river water consumers. Radionuclides other than tritium contribute an additional 0.2 man-rem population dose commitment as shown in table 7.

TABLE 7
RIVER TRANSPORT AND DOSE – 1975

Nuclide	Curies Released at Emission Source	Avg Conc in River, μCi/ml	Calculated Individual Dose Commitment, mrem						Calculated Population Dose Commitment, man-rem
			Whole Body	Bone	Lower Large Intestine	Testis	Prostate	Liver	
^{3}H	5.3×10^{4}	2.1×10^{-6}[a]	0.19						9.5
		3.3×10^{-6}[b]	0.29						5.8
^{32}P	2×10^{-3}	1.4×10^{-13}	<0.00001	0.00001	<0.00001				0.0007
^{35}S	2.9×10^{-1}	2.1×10^{-11}	0.00002			0.00009			0.0014
^{51}Cr	1.2×10^{-1}	8.6×10^{-12}	<0.00001		0.00002				0.0007
$^{58,60}Co$	1.6×10^{-2}	1.1×10^{-12}	<0.00001		0.00001				0.0007
^{65}Zn	2×10^{-3}	1.4×10^{-13}	<0.00001				<0.00001	<0.00001	0.0007
$^{89,90}Sr$	1.4	1.0×10^{-10}	0.00016	0.066					0.011
^{91}Y	1.4×10^{-2}	1.0×10^{-12}	<0.00001		0.00001				0.0007
$^{95}ZrNb$	4.3×10^{-2}	3.1×10^{-12}	<0.00001		0.00002				0.0007
$^{103,106}Ru$	5.6×10^{-2}	4.0×10^{-12}	<0.00001		0.00012				0.0007
$^{124,125}Sb$	1×10^{-3}	7.1×10^{-14}	<0.00001		<0.00001				0.0007
^{134}Cs	1.8×10^{-1}	1.3×10^{-11}	0.00059						0.041
$^{134,137}Cs$	7.6×10^{-1}	5.4×10^{-11}	0.0014						0.098
$^{141,144}Ce$	4×10^{-2}	2.9×10^{-12}	<0.00001		0.00008				0.0007
^{147}Pm	3.4×10^{-2}	2.4×10^{-12}	<0.00001		<0.00001				0.0007
U	4.4×10^{-1}	3.1×10^{-11}	<0.00001		0.00029				0.0007
^{239}Np	8×10^{-3}	5.7×10^{-13}	<0.00001		<0.00001				0.0007
^{239}Pu	18.6×10^{-3}	1.3×10^{-12}	0.00002	0.00063					0.0015
		Total	0.19[c] 0.29[d]	0.066	0.00059	0.00009	0.00001	0.00001	15.5

[a] Beaufort-Jasper. Concentrations are measured values.
[b] Port Wentworth. Concentrations are measured values.
[c] Summation for Beaufort-Jasper.
[d] Summation for Port Wentworth.

Comparison of Calculated Dose Commitment from Plant Releases with that from Other Sources

Population dose commitment (man-rem) can be used for comparison with radiation exposure from other sources, such as natural radioactivity and medical radiation exposure. The 1975 population dose commitment from SRP releases (94 man-rems from atmospheric releases to people within 80 km of the center of the plant and 15.5 man-rems from liquid releases to people consuming Beaufort-Jasper and Port Wentworth water) is compared with radiation dose from natural and medical sources in the following table.

Source of Exposure	Population Dose, man-rem
Natural	63,000
Artificial	
Medical diagnosis [14]	54,000
Weapons fallout [15]	2,700
SRP releases	110

Even though SRP contribution to population dose is very small (0.17% of that from natural sources), SRP has a continuing program to improve operating techniques and to develop new technology directed toward reducing releases of radioactive materials to the environment.

Tritium Quality Factor

Tritium doses were calculated using a quality factor of 1.7 for the low energy beta particle emission. The Concentration Guide (CG) for tritium published in the Code of Federal Regulations, Title 10, Part 20 (10CFR20) was derived with this same quality factor. In 1969 [16], the International Commission on Radiological Protection (ICRP), and in 1971, the National Council on Radiation Protection and Measurement (NCRP) recommended a quality factor of 1.0 as being appropriate within the degree of precision required for purposes of radiological protection. However, this recommendation has not yet been reflected in the federal regulations. A quality factor of 1.0 would have the effect of lowering the calculated population dose from tritium.

APPENDIX A.
DATA ANALYSIS AND QUALITY CONTROL

The sensitivity of laboratory analyses (shown in table on page 28) refers to the minimum amount of radioactivity that can be detected by the radiochemical analytical technique in use. It is based on statistical counting error (95% confidence level) and is influenced by sample size, counter and procedure efficiencies, length of count, counter background, and decay. Where samples are analyzed by gamma spectrometry, the lower level of detection of a given radionuclide varies with the background of each individual channel grouping, with the geometry and volume of sample analyzed, and with number of radionuclides present in the sample. For this reason average sensitivities are given for only milk and vegetation.

Survey data (appendix B) show the arithmetic annual averages of individual measurements. Many of the individual measurements, after subtracting instrument background, showed net values lower than minimum detection level of analyses. For averaging purposes, however, these very small or zero values are included with larger, positive values.

Average values are usually accompanied by a plus or minus (±) limit value. This value, designated 2 Std Dev, is the standard deviation (95% confidence level) of the average and is a measure of the range in the concentration encountered at that location. When the average is given for groups of locations, the Std Dev is the measure of the range in concentration found at all locations. In some tables the standard deviation is not calculated because of the small number of sample results. When a ± figure accompanies an individual result, such as the maximum (max) of minimum (min), it represents the statistical counting error at the 95% confidence level, which in many cases exceeds the net value of the sample. Max and min refer to the greatest and smallest concentration found in a single sample collected during the year.

No self-absorption corrections have been applied to gross alpha and gross nonvolatile beta results.

Because of the voluminous amount of data and computer handling, the numbers presented in the tables are not rounded off to the significant digit.

An internal quality control program is maintained by (1) monthly calibration of counting instruments; (2) daily source and background counts; (3) routine yield determinations of radiochemical procedures; (4) duplicate analyses to check precision; (5) reagent blank analyses to check purity of all chemicals. Accuracy of radioactivity measurements is established by use of standards obtained from the National Bureau of Standards or their equivalent. The Environmental Monitoring Laboratories at SRP are also participating in the Interlaboratory Comparison program established with the Las Vegas Quality Assurance Branch of EPA. A number of different environmental samples (water, air filters, milk, and diet) containing a variety of radionuclides of interest are forwarded to all laboratories participating in the program. Three separate determinations are performed on each sample and the results returned to EPA for comparison with the known value and the results from the other laboratories. Comparisons of reported values with EPA values and those of other laboratories permit evaluation of precision and accuracy.

TABLE A-1
SENSITIVITY AND STANDARD DEVIATIONS OF LABORATORY ANALYSES

Analysis	Sample Type	Length of Count, Minutes	Standard Aliquot	Sensitivity and Precision (95% Confidence Level)	Units
	Zinc Sulfide Alpha Counters				
Gross alpha	Water	20	1 ℓ	0.25 ± 0.13	$\times 10^{-9}$ µCi/ml
	Vegetation	20	2 g	.12 ± .06	$\times 10^{-6}$ µCi/g
	Rain (collection pan)	20	0.37 m^2	.0007 ± .0004	$\times 10^{-3}$ µCi/m^2
	Air	20	∿800 m^3	.0003 ± .0002	$\times 10^{-12}$ µCi/ml
U or Pu (alpha)	Food	20	100 g	0.002 ± 0.001	$\times 10^{-6}$ µCi/g
	Gas Flow Proportional Beta Counters				
Gross beta	Water	10	1 ℓ	7.05 ± 0.39	$\times 10^{-9}$ µCi/ml
	Air	10	∿800 m^3	0.0088 ± .0005	$\times 10^{-12}$ µCi/ml
Strontium-89,90	Bone	10	2 g	4.5 ± .25	$\times 10^{-6}$ µCi/g
	Rain	10	0.37 m^2	0.02 ± .001	$\times 10^{-3}$ µCi/m^2
	Air composites				
	Plant perimeter and				
	25-mile radius	10	∿19,200 m^3	.0005 ± .00003	$\times 10^{-12}$ µCi/ml
	100-mile radius	10	∿ 6,400 m^3	0.0016 ± 0.0001	$\times 10^{-12}$ µCi/ml
	Low Background Beta Counter				
Strontium-90	River water	50	20 ℓ	0.02 ± 0.002	$\times 10^{-9}$ µCi/ml
	Milk	50	0.5 ℓ	1.10 ± .12	$\times 10^{-9}$ µCi/ml
	Food	50	20 g	0.02 ± .002	$\times 10^{-6}$ µCi/g
	Rain	50	0.37 m^2	0.004 ± 0.0004	$\times 10^{-3}$ µCi/m^2
	Liquid Scintillation Counters				
Tritium	Drinking water	300	4 ml	300 ± 10	$\times 10^{-9}$ µCi/ml (0.3 ± 0.01 $\times 10^{-6}$ µCi/ml)
	River water	300	4 ml	300 ± 10	$\times 10^{-9}$ µCi/ml
	Rainwater	300	4 ml	300 ± 10	$\times 10^{-9}$ µCi/ml
	Milk	300	4 ml	300 ± 10	$\times 10^{-9}$ µCi/ml
	Air (atmospheric moisture)	300	4 ml (water)	300 ± 10	$\times 10^{-9}$ µCi/ml (× avg abs humidity = ∿3.6 10^{-12} µCi/ml of air)
	Food	20	3 ml	1 ± 0.05	$\times 10^{-6}$ µci/ml
	Vegetation	20	3 ml	1 ± 0.05	$\times 10^{-6}$ µCi/ml
	Solid-State Alpha Spectrometer				
Plutonium-238	Air composites				
	Plant perimeter and				
	25-mile radius	72[a]	∿19,200 m^3	0.20	$\times 10^{-18}$ µCi/ml
	100-mile radius	72[a]	∿ 6,400 m^3	.59	$\times 10^{-18}$ µCi/ml
	Rain composites				
	Plant perimeter and				
	25-mile radius	75[a]	4.44 m^2	.0022	$\times 10^{-6}$ µCi/m^2
	100-mile radius	72[a]	1.48 m^2	.0053	$\times 10^{-6}$ µCi/m^2
	Soil	24[a]	50 g	.0002	$\times 10^{-6}$ µCi/g
Plutonium-239	Air composites				
	Plant perimeter and				
	25-mile radius	72[a]	∿19,200 m^3	.18	$\times 10^{-18}$ µCi/ml
	100-mile radius	72[a]	∿ 6,400 m^3	.56	$\times 10^{-18}$ µCi/ml
	Rain composites				
	Plant perimeter and				
	25-mile radius	72[a]	4.44 m^2	.0021	$\times 10^{-6}$ µCi/m^2
	100-mile radius	72[a]	1.48 m^2	.0051	$\times 10^{-6}$ µCi/m^2
	Soil	24[a]	50 g	0.0002	$\times 10^{-6}$ µCi/g
	Na(I) Detector (9 in. × 9 in.)				
Iodine-131	Milk	200	3.8 ℓ	1.0 ± 0.5	$\times 10^{-9}$ µCi/ml
	Vegetation	10	50 g	0.2 ± 0.01	$\times 10^{-6}$ µCi/g
Cesium-137	Milk	200	1.8 ℓ	3 ± 2	$\times 10^{-9}$ µCi/ml

[a] Hours

APPENDIX B. SURVEY DATA

TABLE B-1
RADIOACTIVITY IN AIR

Location	No. of Samples	Max	CT Err 95% CL	Min	CT Err 95% CL	Arithmetic Mean	2 Std Dev
			Alpha, $\times 10^{-12}$ µCi/ml				
Plant Perimeter							
Allendale Gate	53	0.0028	±0.0010	0.0000	±0.0004	0.0006	±0.0008
A-14	50	.0031	± .0030	.0000	± .0005	.0007	± .0012
Barnwell Gate	52	.0014	± .0009	.0000	± .0004	.0005	± .0006
D Area	50	.0022	± .0010	.0000	± .0002	.0009	± .0008
Dark Horse	53	.0016	± .0009	.0000	± .0003	.0006	± .0006
East Talatha	52	.0036	± .0013	.0000	± .0006	.0007	± .0010
Green Pond	53	.0026	± .0013	.0002	± .0004	.0010	± .0008
Highway 21/167	52	.0020	± .0011	.0000	± .0005	.0006	± .0006
Jackson	52	.0067	± .0016	.0002	± .0005	.0009	± .0018
Pattersons Mill	52	.0020	± .0009	.0000	± .0005	.0007	± .0008
Talatha Gate	53	.0018	± .0009	.0000	± .0005	.0007	± .0008
Windsor Road	53	0.0020	±0.0009	0.0000	±0.0003	.0008	± .0008
Avg →						0.0007	±0.0010
25-mile Radius							
Aiken Airport	53	0.0013	±0.0009	0.0000	±0.0004	0.0004	±0.0006
Aiken State Park	53	.0013	± .0009	.0000	± .0002	.0006	± .0006
Allendale	53	.0022	± .0010	.0000	± .0005	.0007	± .0008
Augusta	53	.0038	± .0031	.0003	± .0004	.0012	± .0010
Highway 301	52	.0020	± .0010	.0000	± .0004	.0006	± .0008
Langley	53	.0019	± .0009	.0001	± .0005	.0008	± .0008
Lees	52	.0017	± .0008	.0000	± .0004	.0008	± .0008
Olar	53	.0012	± .0008	.0000	± .0004	.0005	± .0004
Perkins	50	.0015	± .0010	.0000	± .0005	.0006	± .0006
South Richmond	52	.0018	± .0008	.0002	± .0005	.0008	± .0008
Springfield	53	.0018	± .0022	.0000	± .0004	.0008	± .0008
Waynesboro	53	0.0015	±0.0007	0.0000	±0.0005	.0007	± .0008
Avg →						0.0007	±0.0008
100-mile Radius							
Columbia	53	0.0026	±0.0011	0.0000	±0.0003	0.0008	±0.0010
Greenville	53	.0017	± .0010	.0000	± .0002	.0008	± .0008
Macon	48	.0015	± .0009	.0000	± .0002	.0008	± .0006
Savannah	51	0.0023	±0.0020	0.0002	±0.0004	.0008	± .0008
Avg →						0.0008	±0.0008
			Nonvolatile Beta, $\times 10^{-12}$ µCi/ml				
Plant Perimeter							
Allendale Gate	54	0.20	±0.02	0.00	±0.01	0.05	±0.09
A-14	50	.31	± .05	.00	± .01	.06	± .11
Barnwell Gate	53	.16	± .02	.00	± .01	.05	± .09
D Area	52	.18	± .02	.00	± .01	.05	± .09
Dark Horse	53	.14	± .01	.00	± .01	.04	± .06
East Talatha	52	.18	± .02	.00	± .01	.05	± .08
Green Pond	53	.14	± .01	.00	± .01	.05	± .07
Highway 21/167	52	.18	± .02	.00	± .06	.05	± .09
Jackson	52	.17	± .01	.00	± .01	.05	± .09
Pattersons Mill	52	.20	± .02	.00	± .01	.05	± .09
Talatha Gate	52	.19	± .01	.01	± .01	.05	± .08
Windsor Road	53	0.15	±0.01	0.00	±0.01	.05	± .08
Avg →						0.05	±0.09
25-mile Radius							
Aiken Airport	53	0.10	±0.01	0.00	±0.01	0.03	±0.05
Aiken State Park	53	.17	± .01	.00	± .01	.05	± .08
Allendale	53	.18	± .02	.01	± .01	.06	± .08
Augusta	53	.19	± .04	.01	± .01	.05	± .09
Highway 301	52	.18	± .02	.00	± .01	.05	± .10
Langley	53	.19	± .02	.00	± .01	.05	± .09
Lees	52	.18	± .01	.00	± .01	.05	± .09
Olar	53	.20	± .02	.00	± .01	.05	± .09
Perkins	51	.16	± .01	.01	± .01	.05	± .09
South Richmond	52	.20	± .01	.01	± .01	.06	± .10
Springfield	53	.21	± .01	.01	± .01	.05	± .09
Waynesboro	54	0.20	±0.02	0.00	±0.01	.05	± .09
Avg →						0.05	±0.09
100-mile Radius							
Columbia	53	0.17	±0.02	0.00	±0.01	0.04	±0.08
Greenville	53	.19	± .02	.00	± .01	.05	± .08
Macon	48	.15	± .02	.00	± .01	.05	± .08
Savannah	51	0.19	±0.03	0.01	±0.01	.05	± .09
Avg →						0.05	±0.08

TABLE B-1, contd
RADIOACTIVITY IN AIR

Location	No. of Samples	Atmospheric Moisture Analysis Tritium in Air, $\times 10^{-12}$ µCi/ml Max	Min	Avg	2 Std Dev
Plant Perimeter					
Allendale Gate	25	120	30	50	±50
A-14	25	440	20	110	±160
Barnwell Gate	25	200	10	80	±90
D Area	25	500	60	170	±200
Dark Horse	25	390	30	100	±150
East Talatha	22	200	10	70	±90
Green Pond	25	320	20	90	±120
Highway 21/167	22	180	10	70	±90
Jackson	25	230	10	80	±100
Pattersons Mill	26	160	30	70	±60
Talatha Gate	24	210	10	90	±100
Windsor Road	25	180	20	80	±70
Avg →				88	
25-mile Radius					
Aiken Airport	25	120	10	50	±70
Aiken State Park	26	130	10	50	±60
Allendale	25	140	10	40	±60
Augusta	26	80	10	30	±50
Highway 301	25	160	10	50	±70
Langley	25	180	10	40	±70
Lees	22	100	10	40	±50
Olar	21	140	10	50	±70
Perkins	26	70	10	40	±30
South Richmond	24	100	20	40	±50
Springfield	25	110	10	50	±70
Waynesboro	23	110	20	60	±60
Avg →				45	

SPECIFIC RADIONUCLIDES IN AIR

Radionuclide	Plant Perimeter No. of Samples[a]	Max	CT Err	Min	CT Err	Avg	2 Std Dev	25-mile Radius No. of Samples[a]	Max	CT Err	Min	CT Err	Avg	2 Std Dev
Gamma Emitters, $\times 10^{-12}$ µCi/ml														
^{7}Be	12	0.183	±0.016	0.033	±0.007	0.107	±0.082	12	0.216	±0.02	0.058	±0.006	0.115	±0.086
$^{89,90}Sr$	12	.002	±.001	.0	±.001	.0	±.002	12	.001	±.001	.0	±.001	.0	±.002
^{95}Zr-^{95}Nb	12	.044	±.001	.0	±.004	.014	±.036	12	.057	±.002	.0	±.001	.017	±.042
$^{103,106}Ru$	12	.024	±.004	.0	±.003	.010	±.018	12	.052	±.004	.0	±.001	.012	±.030
^{137}Cs	12	.004	±.001	.0	±.001	.002	±.004	12	.009	±.002	.0	±.001	.002	±.006
$^{141,144}Ce$	12	0.025	±0.003	0.001	±0.001	0.009	±0.018	12	0.003	±0.003	0.002	±0.001	0.012	±0.022
Alpha Emitters, $\times 10^{-18}$ µCi/ml														
^{238}Pu	12	2.5	±0.9	0.2	±0.9	1.3	±1.6	12	3.5	±1.0	0.1	±0.1	1.0	±2.0
^{239}Pu	12	41.6	±2.8	1.5	±0.6	17.2	±26.4	12	43.0	±2.7	3.7	±0.9	16.8	±23.6

Radionuclide	100-mile Radius No. of Samples[a]	Max	CT Err	Min	CT Err	Avg	2 Std Dev
Gamma Emitters, $\times 10^{-12}$ µCi/ml							
^{7}Be	12	0.210	±0.030	0.064	±0.017	0.117	±0.086
$^{89,90}Sr$	12	.003	±.002	.0	±.001	.001	±.004
^{95}Zr-^{95}Nb	12	.054	±.003	.0	±.018	.019	±.044
$^{103,106}Ru$	12	.065	±.011	.0	±.011	.016	±.036
^{137}Cs	12	.008	±.002	.0	±.002	.003	±.004
$^{141,144}Ce$	12	0.032	±0.006	0.002	±0.005	0.012	±0.022
Alpha Emitters, $\times 10^{-18}$ µCi/ml							
^{238}Pu	12	2.8	±1.9	0.2	±0.2	1.1	±1.8
^{239}Pu	12	59.3	±6.3	3.6	±1.3	18.6	±33.4

[a] Monthly composite of weekly samples.

TABLE B-2
FALLOUT AND RAINWATER ANALYSES

Location	No. of Samples	Gross Alpha	^{7}Be	^{89}Sr	^{90}Sr	^{95}Zr, ^{95}Nb	$^{103,106}Ru$	^{131}I	^{137}Cs	$^{141,144}Ce$
		Total Fallout Deposited, $\times 10^{-3}$ $\mu Ci/m^2$								
Plant Perimeter										
Allendale Gate	13	0.03	7.10	0.04	0.33	1.95	<2.80	<0.42	0.66	3.00
Road A-14	13	.06	12.61	<.01	.52	1.54	<2.20	<.39	.75	3.41
Barnwell Gate	13	.01	8.41	.06	.47	0.85	<1.66	<.30	.67	2.74
D Area	13	.06	30.06	<.01	.87	3.29	<3.29	<.49	.82	4.39
Dark Horse	13	.02	11.44	<.01	.51	1.29	<2.19	<.57	<.70	2.74
East Talatha	13	.03	13.97	.09	.55	1.71	<2.02	<.37	.70	2.66
Green Pond	13	.05	15.93	<.01	.54	1.97	<2.09	<.37	.65	3.04
Highway 21/167	13	.03	10.81	<.01	.57	1.21	<2.15	<.43	<.74	<2.37
Jackson	13	.06	21.09	<.01	.80	1.91	<2.51	<.43	.66	3.45
Pattersons Mill	13	.03	<5.95	.22	.39	0.56	<2.61	<.49	<.71	3.14
Talatha Gate	13	.05	27.18	.09	.83	2.24	<2.94	<.48	<.87	3.84
Windsor Road	13	.03	13.72	.29	.44	1.87	<2.62	<.66	<1.07	<3.10
Avg →		.04	14.86	.07	.57	1.70	<2.42	<.45	0.75	3.16
2 Std Dev →		±0.04	±15.24	±0.18	±0.34	±1.42	±0.90	±0.20	±0.24	±1.12
25-mile Radius										
Aiken Airport	13	0.06	17.20	0.40	0.60	1.41	<2.13	<0.40	0.73	<2.66
Aiken State Park	13	.03	5.87	<.01	.67	1.79	<2.42	<.37	.91	2.64
Allendale	13	.04	22.81	.23	.54	3.84	<3.01	<.47	.80	3.90
Augusta	13	.13	24.18	<.01	.72	2.66	<2.98	<.44	.74	3.09
Highway 301	13	.03	11.43	<.01	.65	1.27	<1.82	<.46	.79	2.63
Langley	13	.08	14.72	<.01	.82	1.79	<2.42	<.34	.79	2.52
Lees	13	.11	21.96	.29	.46	1.85	<1.55	<.37	<.88	3.18
Olar	13	.08	19.82	.37	.43	2.68	<3.09	<.37	.93	3.64
Perkins	13	.08	13.53	.68	.59	1.63	<2.82	<.37	<.72	2.48
South Richmond	13	.03	17.78	<.01	.50	1.35	<2.78	<.45	.84	3.00
Springfield	13	.02	13.34	<.01	.73	1.46	<2.53	<.36	.85	3.42
Waynesboro	13	.03	13.12	<.01	.78	2.27	<2.44	<.43	.78	2.53
Avg →		.06	16.31	.16	.62	1.92	<2.49	<.40	.81	2.97
2 Std Dev →		0.08	±10.68	±0.44	±0.26	±1.58	±0.96	±0.08	±0.14	±0.96

Location	No. of Samples	Max	CT Err 95% CL	Min	CT Err 95% CL	Arithmetic Mean	Arithmetic 2 Std Dev
		Tritium in Rainwater, $\times 10^{-6}$ $\mu Ci/ml$					
Plant Perimeter							
Allendale Gate	23	5.44	±0.38	0.29	±0.30	1.56	±2.40
A-14	25	25.40	±1.50	.36	±.30	6.47	±11.28
Barnwell Gate	24	15.10	±1.00	.00	±.30	4.28	±8.66
D Area	25	66.90	±4.00	.11	±.30	9.88	±26.42
Dark Horse	25	10.00	±0.60	.26	±.30	2.69	±4.72
East Talatha	23	5.00	±.35	.00	±.30	1.78	±2.58
Green Pond	24	10.00	±.60	.23	±.30	3.02	±5.46
Highway 21/167	24	11.74	±.82	.11	±.30	2.64	±5.82
Jackson	25	7.90	±.55	.02	±.01	2.21	±3.82
Pattersons Mill	22	3.90	±.20	.02	±.01	1.63	±2.04
Talatha Gate	25	7.33	±.30	.00	±.30	2.34	±3.94
Windsor Road	24	9.57	±0.67	±0.00	±0.30	2.39	±4.72
Avg →						3.40	±10.48
25-mile Radius							
Aiken Airport	19	7.80	±0.55	±0.00	±0.30	1.43	±3.76
Aiken State Park	25	3.00	±.20	.00	±.30	1.21	±1.32
Allendale	22	3.33	±.07	.00	±.30	0.82	±1.80
Augusta	25	4.90	±.30	.00	±.07	1.03	±2.20
Highway 301	21	2.50	±.15	.00	±.07	0.59	±1.28
Langley	24	2.58	±.30	.00	±.07	0.85	±1.26
Lees	24	4.10	±.30	.00	±.04	1.30	±2.52
Olar	25	3.00	±.18	.00	±.00	0.72	±1.72
Perkins	23	1.89	±.30	.00	±.07	0.60	±1.14
South Richmond	25	8.60	±.50	.00	±.07	1.06	±3.42
Springfield	25	3.80	±.30	.00	±.30	0.94	±1.58
Waynesboro	25	7.20	±0.40	0.14	±0.30	1.10	±2.86
Avg →						0.97	±2.23

Plutonium in Deposition, $\times 10^{-6}$ $\mu Ci/m^2$

Location	^{238}Pu		^{239}Pu		^{238}Pu Alpha %
Plant Perimeter	0.11	±0.01	2.24	±0.02	4.7
25-mile Radius	0.15	±0.01	1.92	±0.03	7.2

TABLE B-3
ENVIRONMENTAL GAMMA RADIATION

Location	No. of Samples	mR/day Max	Error[a]	Min	Error[a]	Arithmetic Mean	2 Std Dev	mR/year Mean
Plant Perimeter								
Allendale Gate	3	0.13	±0.02	0.12	±0.02	0.13	-	47.5
A-14	3	.17	±.02	.16	±.02	.17	-	62.1
Barnwell Gate	3	.18	±.02	.16	±.02	.17	-	62.1
D Area	3	.19	±.02	.18	±.02	.18	-	65.7
Dark Horse	3	.16	±.02	.14	±.02	.15	-	54.8
East Talatha	3	.17	±.02	.16	±.02	.17	-	62.1
Green Pond	3	.19	±.02	.16	±.02	.18	-	65.7
Highway 21/167	1	.15	±.02	.15	±.02	.15	-	54.8
Jackson	3	.19	±.02	.18	±.02	.18	-	65.7
Pattersons Mill	3	.16	±.02	.15	±.02	.15	-	54.8
Talatha Gate	3	.19	±.02	.17	±.02	.18	-	65.7
Windsor Road	3	0.18	±0.02	0.15	±0.02	.17	-	62.1
Avg →						0.16	±0.03	60.3
25-mile Radius								
Aiken Airport	3	0.19	±0.02	0.18	±0.02	0.19	-	69.4
Aiken State Park	3	.16	±.02	.14	±.02	.15	-	54.8
Allendale	3	.19	±.02	.17	±.02	.18	-	65.7
Augusta	3	.18	±.02	.17	±.02	.18	-	65.7
Highway 301	1	.19	±.02	.19	±.02	.19	-	69.4
Langley	3	.19	±.02	.17	±.02	.18	-	65.7
Lees	3	.20	±.02	.19	±.02	.20	-	73.0
Olar	3	.16	±.02	.15	±.02	.16	-	58.4
Perkins	3	.19	±.02	.17	±.02	.18	-	65.7
South Richmond	2	.19	±.02	.17	±.02	.18	-	65.7
Springfield	3	.27	±.03	.19	±.02	.22	-	80.3
Waynesboro	2	0.15	±0.02	0.15	±0.02	.15	-	54.8
Avg →						0.18	±0.04	65.7
100-mile Radius								
Columbia	3	0.21	±0.02	0.19	±0.02	0.20	-	73.0
Greenville	3	.33	±.03	.32	±.03	.33	-	120.4
Macon	3	.23	±.02	.23	±.02	.23	-	84.0
Savannah	2	0.18	±0.02	0.16	±0.02	.17	-	62.1
Avg →						0.23	±0.12	84.9

- Insufficient Data.
[a] The error shown is the precision observed from known exposures of the same magnitude under similar conditions.

TABLE B-4
RADIOACTIVITY IN VEGETATION
$\times 10^{-6}$ µCi/g (dry weight)

Location	No. of Samples	Max	CT Err	Min	CT Err	Avg	2 Std Dev	Max	CT Err	Min	CT Err	Avg	2 Std Dev
				Gross Alpha						^{7}Be			
Plant Perimeter[a]	13	0.61	±0.32	0.0	±0.23	0.16	±0.29	28.14	±2.20	3.48	±3.35	10.22	±15.26
25-mile Radius[a]	13	.68	±.33	.0	±.14	.11	±.24	22.00	±1.46	0.64	±2.70	7.98	±14.74
100-mile Radius[b]	13	0.59	±0.32	0.0	±0.17	0.09	±0.27	31.64	±2.12	2.85	±3.60	8.98	±18.23
				^{95}Zr-^{95}Nb						$^{103,106}Ru$			
Plant Perimeter[a]	13	4.20	±0.23	0.00	±0.15	1.18	±2.62	1.90	±0.87	0.07	±0.85	1.22	±2.01
25-mile Radius[a]	13	3.40	±.18	.07	±.12	1.16	±3.00	2.70	±0.74	.06	±.72	1.30	±3.18
100-mile Radius[b]	13	4.47	±0.21	0.10	±0.16	1.12	±3.08	3.62	±1.50	0.13	±0.95	1.68	±2.06
				^{137}Cs						$^{141,144}Ce$			
Plant Perimeter[a]	13	10.60	±0.54	0.00	±0.29	1.40	±2.84	8.22	±0.85	0.87	±0.46	3.23	±4.72
25-mile Radius[a]	13	0.89	±.11	.04	±.24	0.53	±0.53	7.93	±0.60	.50	±1.20	2.56	±5.13
100-mile Radius[b]	13	3.76	±0.33	0.09	±0.26	0.67	±1.50	9.84	±1.05	0.21	±1.1	3.17	±5.25
				Tritium, $\times 10^{-6}$ µCi/ml Free Water									
Plant Perimeter[a]	13	195	±5	0	±1	14	±62						
25-mile Radius[a]	13	70	±3	0	±1	6	±22						
100-mile Radius[b]	13	21	±2	0	±1	4	±11						

[a] Composite of 7 locations.
[b] Composite of 4 locations.

TABLE B-5
RADIOACTIVITY IN MILK
$\times 10^{-9}$ µCi/ml

		Tritium CG: 3,000,000				Strontium-90 CG: 300				Cesium-137 CG: 20,000			
Local Dairies	No. of Samples	Max	Min	Avg	2 Std Dev	Max	Min	Avg	2 Std Dev	Max	Min	Avg	2 Std Dev
North Augusta	25	2920	900	1660	±900	24	2	11	±14	23	<3	18	±26
Waynesboro	12	1400	<300	760	±840	24	<1	10	±22	16	<3	6	±11
Major distributor[a]	25	1400	<300	490	±700	31	<1	10	±25	10	<3	10	±15
Sensitivity of analysis			300				1.0				1		

[a] Milk produced in local dairies but sold by major distributor.

TABLE B-6
RADIOACTIVITY IN FOOD

$\times 10^{-6}$ µCi/g (wet weight)

	No. of Samples	Alpha Emitters Max	Min	Avg	2 Std Dev	^{90}Sr Max	Min	Avg	2 Std Dev	^{95}Zr-^{95}Nb Max	Min	Avg	2 Std Dev
Collards	14	0.018	<0.002	0.003	±0.008	2.96	0.08	1.13	±1.86	<0.04	<0.01	0.02	±0.02
Plums	14	.003	<.002	.001	±.002	0.06	.01	0.03	±0.02	<.03	<.01	.02	±.02
Oats, rye & wheat	14	.029	<.002	.004	±.014	.38	.06	.20	±.22	.04	<.01	.03	±.06
Corn	14	.026	<.002	.004	±.012	.46	.01	.10	±.22	<.02	<.01	.01	±.02
Chicken	4	.017	<.002	.009	±.010	.32	.01	.14	±.24	.05	<.01	.02	±.04
Beef	4	0.012	<0.002	0.003	±0.008	0.78	0.02	0.21	±0.62	<0.02	<0.01	0.01	±0.01

		^{137}Cs Max	Min	Avg	2 Std Dev	$^{141,144}Ce$ Max	Min	Avg	2 Std Dev	Tritium, $\times 10^{-6}$ µCi/ml Free Water Max	Min	Avg	2 Std Dev
Collards	14	0.18	<0.01	0.05	±0.10	0.11	<0.01	0.04	±0.06	a	a	a	a
Plums	14	.08	<.01	.03	±.04	.30	<.02	.08	±.18	6	<1	2	±2
Oats, rye & wheat	14	.07	<.01	.03	±.02	.13	<.01	.06	±.06	6	2	4	±1
Corn	14	.10	<.01	.03	±.06	.08	<.01	.05	±.04	3	1	2	±1
Chicken	4	.02	<.01	.01	±.02	<.04	<.02	.03	±.02	a	a	a	a
Beef	4	0.04	<0.01	0.02	±0.02	0.10	<0.05	0.07	±0.04	a	a	a	a

[a] No analysis.

TABLE B-7
RADIOACTIVITY AND MERCURY IN SAVANNAH RIVER FISH

	No. of Fish Assayed			Radioactivity $\times 10^{-6}$ µCi/g (Wet Weight) ^{137}Cs (Whole Fish) Bass Max	Min	Avg	2 Std Dev	Bream[a] Max	Min	Avg	2 Std Dev	Catfish[b] Max	Min	Avg	2 Std Dev	$^{89,90}Sr$ Bone[c] Max	Min	Avg	2 Std Dev
Location	Bass	Bream	Catfish																		
Above SRP Boundary	2	39	46	0.2	<0.1	0.1	-	2.4	<0.1	<0.2	±0.8	0.3	<0.1	0.1	±0.3	10.9	0.0	4.5	±6.9
Adjacent to SRP	0	28	27	-	-	-	-	0.6	<.1	.2	±.3	3.4	<0.1	.3	±1.3	9.4	.0	3.5	±6.3
Below SRP at Highway 301	1	32	57	0.2	0.2	0.2	-	0.3	<0.3	0.1	±0.2	0.9	<0.1	0.2	±0.3	10.9	0.0	3.5	±6.4

	Mercury No. of Fish Assayed[d] Bass	Bream	Catfish	µg/g (Wet Weight) Bass	Bream	Catfish
Above SRP Boundary	2	39	46	0.16	0.11	0.19
Adjacent to SRP	0	28	27	-	.25	.24
Below SRP at Highway 301	1	32	57	0.41	0.10	0.27

- No analysis.
[a] Shell cracker, bluegill, and redbreast (Leopomis).
[b] Predominantly yellow cat (Ictalurus).
[c] Bass, bream, and catfish composited monthly.
[d] Analysis of January-June and July-December composites.

TABLE B-8
RADIOACTIVITY IN DEER AND HOGS

$\times 10^{-6}$ µCi/g (wet weight)

Number of Animals	Species	^{137}Cs in Flesh Average	Range	$^{89,90}Sr$ in Bone Average	Range
1391	Deer	9	<1-36	9	<1-25
45	Hogs	3	<1-11	-	-

- No analysis.

TABLE B-9
RADIOACTIVITY IN SAVANNAH RIVER WATER

Location	No. of Samples	Max	CT Err 95% CL	Min	CT Err 95% CL	Arithmetic Mean	2 Std Dev
			Alpha, $\times 10^{-9}$ µCi/ml				
Savannah River[a]							
R-2 Dissolved	49	0.97	±0.55	0.00	±0.27	0.12	±0.38
R-2 Suspended	48	1.43	± .65	.00	± .39	.26	± .62
R-10 Dissolved	52	1.52	± .66	.00	± .20	.15	± .46
R-10 Suspended	50	1.74	± .76	.00	± .27	.19	± .54
Control							
Edisto River	52	2.05	±0.80	0.07	±0.36	0.73	±0.82
			Nonvolatile Beta, $\times 10^{-9}$ µCi/ml				
Savannah River[a]							
R-2 Dissolved	49	5.81	±7.24	0.00	±5.49	1.80	±3.48
R-2 Suspended	48	6.81	±6.99	.00	±5.50	0.70	±2.96
R-10 Dissolved	52	6.53	±6.78	.00	±5.57	1.92	±4.08
R-10 Suspended	50	5.68	±7.21	.00	±5.55	0.63	±2.68
Control							
Edisto River	52	9.59	±6.24	0.00	±5.68	3.74	±5.78
			Tritium, $\times 10^{-6}$ µCi/ml				
Savannah River[a]							
R-2 Above Plant	12	0.91	±0.06	0.24	±0.02	0.49	±0.42
R-10 Highway 301	12	6.70	±0.07	2.30	±0.00	4.02	±2.64

[a] R-2 1 mile upstream from Upper Three Runs Creek.
R-10 8 miles downstream from Lower Three Runs Creek.

TABLE B-10
RADIONUCLIDES IN SAVANNAH RIVER WATER

Radionuclide	Sensitivity of Analysis	Concentration, $\times 10^{-9}$ µCi/ml: 1 Mile Upstream from Upper Three Runs Creek R-2 (control)	8 Miles Downstream from Lower Three Runs Creek at Highway 301 R-10	% of CG at Highway 301
^{3}H	300	490	4020	0.13
^{35}S	5.0	ND	ND	<.01
^{51}Cr	4.3	ND	ND	<.001
^{54}Mn	0.4	ND	ND	<.0004
^{60}Co	1.4	ND	ND	<.005
^{65}Zn	1.1	ND	ND	<.001
^{89}Sr	0.3	ND	ND	<.001
^{90}Sr	0.02	0.5	0.5	.17
^{95}Zr-^{95}Nb	0.5	ND	ND	<.001
$^{103,106}Ru$	3.2	ND	ND	<.03
^{131}I	0.2	ND	ND	<.07
^{137}Cs	<0.01	ND	0.015	<.001
^{140}Ba-^{140}La	1.6	ND	ND	<.01
$^{141,144}Ce$	2.5	ND	ND	<.02
^{239}Np	2.2	ND	ND	<0.002

ND = Less than sensitivity of analysis.

TABLE B-11
SAVANNAH RIVER WATER QUALITY

	River 2 Above Plant			River 10 Below Plant		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Temperature, °C	17.9	25.3	10.0	18.0	25.3	10.0
pH		7.2	5.9		6.9	5.8
Dissolved oxygen, mg/l	9.6	11.3	8.3	9.4	11.3	7.0
Alkalinity, mg/l	12	29	1	14	38	3
Hardness, mg/l	11	22	6	12	36	4
Conductivity, μmhos	64	79	43	63	73	46
Suspended solids, mg/l	14	44	<1.0	15	57	3
Volatile solids, mg/l	25	59	10	24	37	11
Total dissolved solids, mg/l	43	79	13	40	54	21
Fixed residue, mg/l	18	41	3	16	35	1
Biological oxygen demand, mg/l	1	2	<1.0	1	2	<1.0
Lignin, mg/l	0.3	2.9	<1.0	0.3	1.9	<1.0
Surfactant, mg/l	0.005	0.020	<0.02	0.005	0.030	<0.02
Fecal coliform, c/100 ml	2512	7000	51	504	880	100
Chloride (Cl), mg/l	5.2	8.8	2.9	4.9	7.5	2.9
Nitrite (N), mg/l	0.08	0.36	<0.02	0.02	0.09	<0.02
Nitrate (N), mg/l	0.67	1.42	0.07	0.72	1.40	0.32
Sulfate (SO_4), mg/l	4.1	6.0	2.5	4.5	11.0	2.0
Sulfide (S), mg/l	0.1	0.8	<1.0	0.1	0.5	<1.0
Total phosphate (PO_4), mg/l	0.6	4.7	<0.02	0.5	3.9	<0.02
Aluminum (Al), mg/l	0.1	1.7	<0.5	0.1	1.3	<0.5
Ammonia (NH_4), mg/l	0.029	0.2	<0.1	0.029	0.200	<0.1
Calcium (Ca), mg/l	1.86	2.6	1.4	2.0	2.5	1.6
Sodium (Na), mg/l	5.9	7.9	3.5	5.5	6.8	3.7
Total iron (Fe), mg/l	0.2	0.7	<0.1	0.2	0.7	<0.1

TABLE B-12
RADIOACTIVITY IN DRINKING WATER

Location (source)	No. of Samples	Max	CT Err 95% Cl	Min	CT Err 95% Cl	Arithmetic Mean	2 Std Dev
			Alpha, $\times 10^{-9}$ µCi/ml				
Aiken (stream & well)	2	1.27	±0.70	0.94	±0.57	1.11	-
Allendale (deep well)	2	1.14	± .67	.80	± .54	0.97	-
Augusta (river)	2	1.07	± .60	.74	± .58	.91	-
Barnwell (deep well)	2	0.33	± .48	.13	± .33	.23	-
Bath (deep well)	2	.40	± .42	.40	± .42	.40	-
Clearwater (lake)	2	0.47	± .52	0.07	± .30	.27	-
Jackson (deep well)	2	1.47	± .73	1.41	± .67	1.44	-
Langley (deep well)	2	0.60	± .48	0.54	± .54	0.57	-
New Ellenton (deep well)	2	1.14	± .61	.40	± .50	0.77	-
North Augusta (river)	2	1.07	± .66	.94	± .57	1.01	-
Sardis (deep well)	2	0.13	± .33	.00	± .38	0.07	-
Waynesboro (stream)	2	.60	± .55	.00	± .23	.30	-
Williston (deep well)	2	0.80	±0.66	0.74	±0.52	0.77	-
Avg →						0.93	±1.63
Treatment Plants							
Savannah treated	12	0.94	±0.57	0.00	±0.26	0.28	±0.52
Beaufort treated	12	0.60	±0.48	0.00	±0.23	0.25	±0.44
			Nonvolatile Beta, $\times 10^{-9}$ µCi/ml				
Aiken (stream & well)	2	4.15	±6.87	0.00	±5.50	2.08	-
Allendale (deep well)	2	5.23	±6.91	1.80	±5.69	3.52	-
Augusta (river)	2	3.35	±6.84	0.42	±6.60	1.89	-
Barnwell (deep well)	2	0.27	±6.72	.00	±5.44	0.14	-
Bath (deep well)	2	0.72	±5.65	.67	±6.73	0.70	-
Clearwater (lake)	2	2.92	±6.70	.00	±6.66	1.46	-
Jackson (deep well)	2	0.28	±6.71	.00	±6.70	0.14	-
Langley (deep well)	2	0.00	±6.70	.00	±5.47	0.00	-
New Ellenton (deep well)	2	4.31	±6.76	.80	±6.74	2.56	-
North Augusta (river)	2	0.94	±6.74	.24	±5.63	0.59	-
Sardis (deep well)	2	2.81	±6.82	.00	±6.56	1.41	-
Waynesboro (stream)	2	0.72	±5.65	.00	±6.63	0.36	-
Williston (deep well)	2	2.28	±5.71	0.27	±6.68	1.28	-
Avg →						1.24	±3.11
Treatment Plants							
Savannah treated	12	7.09	±7.03	0.00	±5.21	2.80	±4.98
Beaufort treated	12	5.90	±6.83	0.00	±7.04	3.66	±3.68
			Tritium, $\times 10^{-6}$ µCi/ml				
Aiken (stream & well)	2	0.73	±0.30	0.25	±0.30	0.49	-
Allendale (deep well)	2	.21	± .30	.00	± .30	.11	-
Augusta (river)	2	.31	± .30	.22	± .02	.27	-
Barnwell (deep well)	2	.21	± .30	.00	± .30	.11	-
Bath (deep well)	2	.39	± .30	.17	± .01	.28	-
Clearwater (lake)	2	.92	± .06	.37	± .30	.65	-
Jackson (deep well)	2	.48	± .03	.28	± .30	.38	-
Langley (deep well)	2	.05	± .30	.00	± .30	.03	-
New Ellenton (deep well)	2	.18	± .30	.17	± .30	.18	-
North Augusta (river)	2	.21	± .30	.09	± .30	.15	-
Sardis (deep well)	2	.35	± .30	.09	± .30	.22	-
Waynesboro (stream)	2	.39	± .03	.21	± .30	.30	-
Williston (deep well)	2	0.97	±0.30	0.00	±0.30	0.49	-
Avg →						0.26	±0.52
Treatment Plants							
Savannah treated	12	5.70	±0.34	2.10	±0.13	3.30	±2.22
Beaufort treated	12	10.00	±0.60	0.00	±0.08	2.12	±5.60

- Insufficient data.

TABLE B-13
CONCENTRATION AND DEPOSITION OF RADIOACTIVITY IN SOIL

(Pu, 0-5 cm depth; ^{137}Cs, 0-15 cm depth)

	Concentration, $\times 10^{-6}$ µCi/g			Deposition, $\times 10^{-3}$ µCi/m^2		
	^{239}Pu	^{238}Pu	^{137}Cs	^{239}Pu	^{238}Pu	^{137}Cs
Plant perimeter						
NW quadrant	0.0119 ± 0.0011	0.0006 ± 0.0003	0.343 ± 0.027	0.91 ± 0.08	0.047 ± 0.022	78.5 ± 6.2
NE quadrant	.0177 ± .0012	.0010 ± .0003	.697 ± .032	1.35 ± .09	.077 ± .024	98.6 ± 6.4
SE quadrant	.0136 ± .0014	.0007 ± .0004	.433 ± .029	1.04 ± .11	.057 ± .030	98.0 ± 6.6
SW quadrant	.0160 ± .0016	.0011 ± .0005	.345 ± .029	1.22 ± .12	.083 ± .037	78.9 ± 6.6
Distant locations, ∿100 miles						
Clinton, SC	.0110 ± .0015	.0004 ± .0003	.392 ± .033	0.84 ± .11	.028 ± .025	89.6 ± 7.5
Savannah, GA	.0070 ± .0009	.0002 ± .0002	.238 ± .027	.53 ± .07	.016 ± .016	54.4 ± 6.2
Offplant						
Springfield, SC	.0033 ± .0011	.0005 ± .0004	-	0.25 ± .08	.040 ± .030	-
Aiken Airport, SC	0.0132 ± 0.0013	0.0009 ± 0.0004	-	1.01 ± 0.10	0.072 ± 0.031	-

- No analysis.

APPENDIX C. METHODS FOR CALCULATING ENVIRONMENTAL RADIATION DOSE

Releases to the Atmosphere

Radiation dose to man in the vicinity of SRP is calculated for the radioactive gases and particulates unavoidably released to the atmosphere from the Savannah River Plant operations. Although SRP has an extensive environmental monitoring system, a mathematical model is needed to estimate potential radiation dose commitment from the atmospheric releases. The mathematical model is needed because the majority of releases lead to very low concentrations not detectable (exception: tritium oxide) by current monitoring techniques.

The model is based on measured and calculated releases and on dispersion by measured meteorology. The meterorological data were obtained over a two-year period (1966-1968) from instrumentation installed at eleven elevations on a 1200-foot television transmitting tower 30 kilometers (18.8 miles) northwest of the geometric center of SRP. Data collected at three-minute intervals over the two-year period provided information on wind speed, wind direction, wind variability, and thermal stability. Sufficient data were collected to include meteorological variations typical of the SRP site. Adequacy of this meteorological data base and calculational model is verified annually with measured dispersion of tritium released during normal operations to the atmosphere at SRP.

Annual averaged concentration factors in air and external gamma dose rate factors from a plume were calculated for each radionuclide individually by processing the meteorological data assuming a 1-curie release for each data period (15-minute averages). Ground level concentrations and external gamma dose were accumulated for each azimuth (16 sectors) and radial distance from the point of release for each meteorological data period according to a polar grid overlay of SRP and environs (see figure 8). After all meteorological data for the two-year period had been processed, the accumulated concentrations and gamma doses were divided by the total number of data periods represented. The result was a quantity representing a yearly integrated concentration (curie-seconds per cubic meter) and gamma dose associated with each grid point for a curie release over the year. These quantities were corrected for decay according to radionuclide and measured meteorology for each data period. For each of the 320 grid points, the integrated air concentration and gamma dose factor for a curie release is multiplied by the number of curies of each radionuclide released in a year to obtain integrated air concentrations and gamma cloud dose for subsequent calculations of dose commitment to individuals (and to the population).

The grid overlay was divided into sixteen 22.5° sectors and twenty 5-kilometer radial increments. Population distribution for each sector and radial increment was determined from the 1970 census and is shown in figure 8. Integrated air concentration and gamma plume dose is calculated at the center of each areal increment and is assumed to be representative of average conditions for the increment. The integrated air concentration and gamma dose are used for calculating radiation dose commitment to all persons within the areal increment.

Major pathways of radiation exposure from radioactive materials released to the atmosphere are:

- o External dose from radioactive materials in the atmosphere
- o External dose from radioactive materials deposited on earth's surface
- o Internal dose from inhalation of radioactive materials in the air
- o Internal dose from ingestion of food and water containing radioactive materials deposited from the atmosphere.

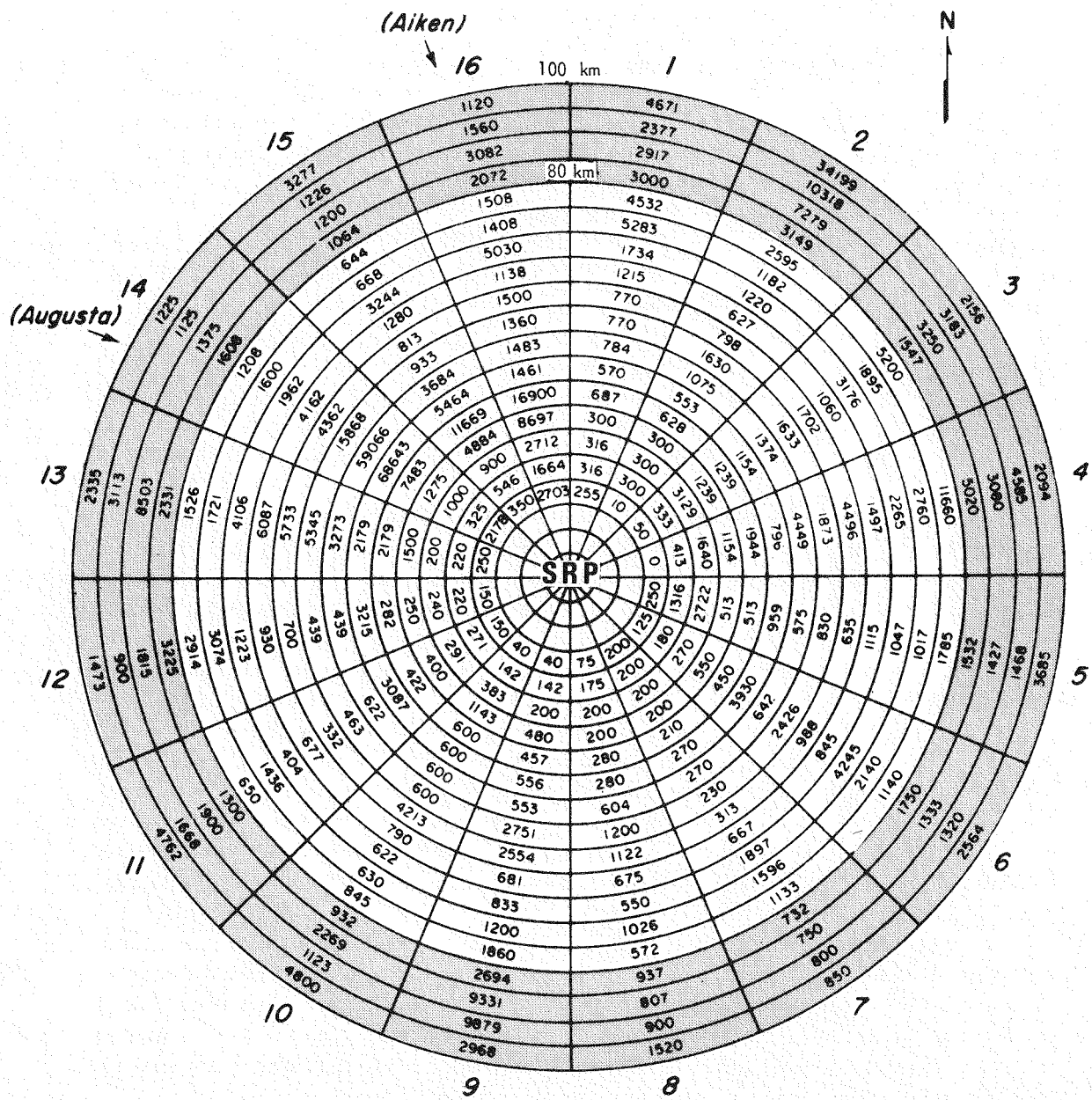

FIGURE 8. DISTRIBUTION OF POPULATION IN REGION SURROUNDING SRP
(Radial Increments = 5 km, 22.5° Sector)
1970 Census

Factors were calculated for converting integrated air concentrations of each radionuclide to a 70-year lifetime dose commitment via each exposure pathway. Techniques for calculating dose were patterned after methods used by the ICRP [2,12,17]. Standard man data were used for deriving dose factors for the general population; factors are also provided for calculating dose to infants when they are critical members of the population for specific pathways of exposure (example: iodine-131 in air → pasture grass → cow → milk → infant thyroid gland). Body dose, as calculated with dose factors, is summarized with gamma plume dose to obtain whole body dose.

Recycling of noble gases and tritium oxide in the global environment is not included in the mathematical dose model. If noble gases are assumed to be diluted by the world's atmosphere and tritium oxide is diluted by the world hydrological cycle, subsequent 70-year dose commitment to the population groups considered in this report will be a small fraction of 1% of the first pass dose from release of all radionuclides.

The external dose from gamma-emitting radionuclides deposited on the earth's surface are calculated assuming the nuclides are on the surface of soil and on surfaces of vegetation during the first year following release, and in succeeding years are distributed exponentially with depth in the soil as a result of washoff and infiltration into the soil with rainwater. Lifetime dose from these deposited nuclides is calculated with the assumption that each person is exposed throughout life only at the location of his residence. No corrections are made for surface runoff, surface roughness factors, or shielding by buildings.

Releases to the Savannah River

Radionuclides in liquid effluents from SRP are analyzed at the point of release, in surface streams on the SRP site before entry into the Savannah River swamp, and in the Savannah River upstream and downstream from SRP. Many radionuclides that are measurable at the point of release are below the analytical limit of sensitivity after being diluted with river water; only tritium oxide and trace amounts of cesium-137 and strontium-90 are routinely measurable in the river, and only tritium oxide at the two downstream water treatment plants. Dose commitments to downstream consumers of river water are based on the release inventory and the following assumptions.

- All radionuclides, as measured at the point of release, move down the Savannah River during the year of release.
- No depletion in the quantity of radionuclides occurs except for natural radioactive decay. Approximately five days elapse between time of release of radionuclides and entry into the two water treatment plants approximately 100 miles downstream. For the radionuclides released in 1975, no decay corrections were made.
- The flow rate of the river at the water treatment plants in 1975 averaged about 15,340 cubic feet per second (annual flow = 1.4×10^{16} ml).
- No allowance is made for removal of radionuclides in the water treatment plants.
- Dose commitment from tritium is based on measured concentrations at the water treatment plants.
- Individuals served by the water treatment plants consume an average of 1200 ml of water per day (standard man).

Dose factors were calculated for converting concentration of each radionuclide in water to a 70-year lifetime dose commitment. Techniques for calculating dose were patterned after methods used by the ICRP [2,12,17].

APPENDIX D. SAVANNAH RIVER WATER QUALITY

Savannah River Health

The Limnology Department of the Academy of Natural Sciences of Philadelphia (ANSP), under contract to Du Pont, has performed a continuing survey of aquatic environment and water quality of the Savannah River upstream and downstream from SRP since 1951. The purpose of this survey is to determine the effect, if any, of SRP effluent discharges on general river health.

Diatometers are positioned in the river at three locations (one above and two below the SRP site) to provide a continuous monitor of the effects of plant effluents on one major group of river organisms. The diatometers contain glass slides on which diatoms accumulate. The slides are replaced biweekly, and the slides containing dried diatoms are sent to ANSP for analysis.

In rivers adversely affected by pollution, the number of species will be reduced in varying amounts corresponding to the degree of pollution. The less tolerant species are eliminated while the more tolerant species grow more rapidly. Thus, while total populations may increase in size, the number of different species will be reduced. Detailed readings and summaries of the diatometer surveys are issued quarterly by ANSP. There is no evidence that the operation of the Savannah River Plant affected the diatom flora of the Savannah River.

Quarterly surveys of other algae, insects, invertebrates, and fish are also conducted by ANSP. Specialists in entomology, algology, invertebrate zoology, and ichthyology sample river biota during times of the year most suitable to their specialty. An algologist or entomologist accompanies every survey to provide continuity of collecting and methodology and to observe environmental conditions. Results of the quarterly surveys are summarized and published annually. No detrimental effects upon aquatic life in the Savannah River results from operation of SRP.

Periodically, or as a result of major changes in the physiography of the river, ANSP makes comprehensive surveys of the biota and chemical water quality above, adjacent to, and below SRP to ascertain effects of SRP operations on river conditions. In general, the Savannah River stations were found in a healthy enriched condition during the last comprehensive survey (1972). Although among some faunistic groups there were indications of minor deterioration at all river locations, no changes could be found in the river that could be attributed to the Savannah River Plant.

Pesticides in the Savannah River

Arrangements were made in 1971 for the United States Geological Survey (USGS) Water Quality Laboratory, Washington, DC (now located in Atlanta, GA), to analyze water and sediment from SRP streams and the Savannah River for pesticides. Water samples were previously analyzed for pesticides by the Federal Water Pollution Control Administration [now Environmental Protection Agency (EPA)] at Athens, GA, and all results were less than sensitivity of analyses. Gas chromatographic water analyses show only trace quantities of pesticides (<0.05 μg/l), primarily Dieldrin in the river upstream and downstream from SRP. Quantities of pesticides detected in river sediment by the USGS laboratory are shown in the following table. The pattern of concentrations detected in sediment indicates that offplant sources are the primary contributors.

TABLE D-1
PESTICIDES IN SAVANNAH RIVER SEDIMENT
(μg/kg or ppb)

	River 2 (Upstream)				River 10 (Downstream)			
	1972	1973	1974	1975	1972	1973	1974	1975
Aldrin	1.1	-	-	-	1.5	0.9	1.5	-
DDD	7.1	1.6	0.2	1.0	6.8	3.0	11.0	3.4
DDE	3.1	2.3	-	1.2	2.8	2.6	4.2	3.4
DDT	1.8	1.2	-	1.3	-	0.5	1.2	4.1
Dieldrin	-	2.4	0.1	0.5	-	2.4	1.5	1.4
Chlordane	5.0	-	-	-	-	1.0	-	-

- Less than sensitivity of analyses.

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