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Savannah River Site Environmental Report for 1993

Editors

Margaret W. Arnett

Linda K. Karapatakis

Albert R. Mamatey

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Westinghouse Savannah River Company
Savannah River Site, Aiken, SC 29808

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Manager, Environmental Publications
Westinghouse Savannah River Company
Building 735-16A
Aiken, South Carolina 29808
Telephone: 803-725-3556

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Preface

Savannah River Site (SRS) conducts effluent monitoring and environmental surveillance to ensure the safety of the public and the well-being of the environment. DOE Order 5400.1, "General Environmental Protection Program," requires the submission of an environmental report that documents the impact of facility operations on the environment and on public health.

SRS has had an extensive environmental surveillance program in place since 1951 (before site startup). At that time, data generated by the on-site surveillance program were reported in site documents. Beginning in 1959, data from off-site environmental monitoring activities were presented in reports issued for public dissemination. Separate reporting of SRS's on- and off-site environmental monitoring activities continued until 1985, when data from both surveillance programs were merged into a single public document.

The *Savannah River Site Environmental Report for 1993* is an overview of effluent monitoring and environmental surveillance activities conducted on and in the vicinity of SRS from January 1 through December 31, 1993.^a For complete program descriptions, consult the "SRS Environmental Monitoring Plan" (WSRC-3Q1-2-1000). It documents the rationale and design criteria for the monitoring program, the frequency of monitoring and analysis, the specific analytical and sampling procedures, and the quality assurance requirements.

Variations in the report's content from year to year reflect changes in the routine program or difficulties encountered in obtaining or analyzing some samples. Examples of such problems include adverse environmental conditions (such as flooding or drought), malfunctioning sampling or analytical equipment, and the compromising of samples in the preparation laboratories or counting room.

Unless otherwise indicated, the figures and tables in this report are generated using information about the routine monitoring program. No attempt has been made to include all data from environmental research programs.

A more complete listing of data can be found in *Savannah River Site Environmental Data for 1993* (WSRC-TR-94-077).

The following items should aid the reader in interpreting data in this report:

- Analytical results and their corresponding uncertainty terms are reported with up to three significant figures. The last significant figure of a result is determined by the quantification of the uncertainty term. EMS attempts to report the appropriate confidence in the result with the correct number of significant figures.
- The reported uncertainty reflects only the counting error—not other components of random and systematic error present in the measurement process. For this reason, some results may imply a greater confidence than the determination would suggest.
- Uncertainties quoted with means represent the deviation of measurements about the mean value. This number is calculated from the results themselves and is not weighted by the uncertainties of the individual results.
- For gamma-emitting radionuclides, less-than-detectable (LLD) values are not reported or considered in the averages. Detection limits based on typical sample parameters are not reported.
- A value is reported for all other analyses, although it may be below the LLD value. Negative values also are reported. Averages were calculated using both positive and negative results.
- The generic term "dose," as used in the report, refers to the committed effective dose equivalent (50-year committed dose) from internal deposition of radionuclides and to the effective dose equivalent attributable to penetrating radiation from sources external to the body.

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Westinghouse Savannah River Company
Building 735-16A
Aiken, SC 29808 Telephone: 803-725-3556

^a The reader should note that the purpose of this report is to document effluent monitoring and environmental surveillance for a calendar year; no attempt has been made to produce a comprehensive report of all environmental activities conducted at SRS.

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Executive Summary

Introduction

In 1993, effluent monitoring and environmental surveillance were conducted within a 30,000-square-mile area in and around the Savannah River Site (SRS) that includes neighboring cities, towns, and counties in Georgia and South Carolina and extends up to 100 miles from the site. Thousands of samples of air, surface water, groundwater, foodstuffs, drinking water, wildlife, rainwater, soil, sediment, and vegetation were collected and analyzed for radioactive constituents and nonradiological contaminants.

1993 Dose Estimates

The radiation protection standards followed by SRS are outlined in U.S. Department of Energy (DOE) Order 5400.5, "Radiation Protection of the Public and the Environment," and include U.S. Environmental Protection Agency (EPA) regulations on the doses from airborne releases and treated drinking water.

Unless otherwise noted, the generic term "dose" used in this report includes both the committed effective dose equivalent (50-year committed dose) from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body. The effective dose equivalent, which is a risk-equivalent value, is used to express dose in terms of the potential health impact. Use of the effective dose equivalent allows doses from different types of radiation and doses to different parts of the body to be expressed on the same basis.

Regulations state that the dose to an individual shall not exceed 10 mrem/yr (0.10 mSv/yr) from releases of radioactivity to the air, and 4 mrem/yr (0.04 mSv/yr) from releases of radioactivity to drinking water. The

maximum limit for all types of exposures to the public from DOE facilities is 100 mrem/yr (1.0 mSv/yr).

As shown in table 1, all estimated doses attributed to SRS in 1993 were below required standards. Doses to the maximally exposed individual contributed less than 1 percent of the average annual radiation dose received by a Central Savannah River Area (CSRA) resident (figures 1 and 2). Figure 3 shows SRS's all-pathway doses (airborne pathway plus liquid pathway doses to the maximally exposed individual) for the past five years.

Doses from Airborne Releases

For 1993, the dose to the maximally exposed individual from airborne releases of radioactive materials was 0.11 mrem (0.0011 mSv). This estimated dose, based on a hypothetical individual residing at the SRS boundary, is 1.1 percent of the 10-mrem/yr (0.1-mSv/yr) limit for exposure to airborne releases from a DOE facility.

The collective dose (population dose) to the 620,100 persons living within 50 miles (80 kilometers) of the center of the site was estimated to be 7.6 person-rem (0.076 person-Sv), which is less than 1 percent of the collective dose received from naturally occurring sources of radiation (about 195,000 person-rem).

Tritium comprised approximately 90 percent of the estimated doses from SRS airborne releases. The 1993 doses from airborne releases are approximately 25 percent higher than the 1992 doses because of increases in airborne tritium releases from the site.

Doses from Liquid Releases

The dose to the maximally exposed individual from liquid releases of radioactivity to the Savannah River was estimated to be 0.14 mrem (0.0014 mSv). More than 50 percent of this calculated dose resulted from

Dose to the Maximally Exposed Individual

When calculating doses to the public, SRS uses the concept of the maximally exposed individual; however, no such person is known to exist. The parameters for the dose calculations are

For airborne releases: Someone who lives at the SRS boundary 365 days per year and consumes milk, meat, and vegetables produced at that location

For liquid releases: Someone who lives immediately downriver from SRS 365 days per year, drinks 2 liters of water per day from the Savannah River, consumes a large amount of fish, and spends the majority of time on the river

the intake of cesium-137, which came primarily from Savannah River fish. More than 40 percent of the dose resulted from tritium releases.

Two changes were implemented in 1993 to the liquid release dose determination methodology for the maximally exposed individual. Based on a survey, freshwater shellfish no longer are considered an exposure pathway, and the maximum consumption of

untreated river water at the site boundary was changed from 1 liter per day to 2 liters per day. The net result of these changes caused about a 10-percent increase in the dose reported for the maximally exposed individual, even though liquid radioactive releases decreased during 1993.

The 1993 collective dose from liquid releases was estimated to be 1.5 person-rem (0.015 person-Sv).

Table 1 1993 Estimated Doses to Maximally Exposed Individuals from SRS Releases, compared with Applicable Standards and Natural Radiation

Exposure Pathway	Maximum Dose from SRS Releases ^a	Applicable Standard ^b	% of Standard	% of Natural ^c
Airborne Releases				
Inhalation	0.05 mrem			
Other	0.06 mrem			
Total Airborne	0.11 mrem	10 mrem^d	1.10	0.04
Liquid Releases				
Fish consumption	0.08 mrem			
Other	0.06 mrem			
Total Liquid	0.14 mrem	N/A^e	N/A^e	0.05
All pathways^f	0.25 mrem	100 mrem	0.25	0.08
Treated Drinking Water				
Beaufort-Jasper	0.04 mrem	4 mrem ^g	1.00	0.01
Port Wentworth	0.05 mrem	4 mrem ^g	1.25	0.02
Sportsman				
Deer and hog consumption				
On-site hunter	57.30 mrem	100 mrem	57.30	19.10
Off-site hunter	4.05 mrem	100 mrem	4.05	1.35
Fish consumption	1.30 mrem	100 mrem	1.30	0.43

a Committed effective dose equivalent.

b All the standards listed are given in DOE Order 5400.5, February 8, 1990, "Radiation Protection of the Public and the Environment."

c Estimate of average dose received from naturally occurring radiation is 300 mrem per year [NCRP, 1987].

d The standard for airborne effluents applies to the sum of the doses from all airborne pathways: inhalation, submersion in a plume, exposure to radionuclides deposited on the ground surface, and consumption of foods contaminated as a result of the deposition of radionuclides.

e There is no separate standard for all liquid pathways alone; liquid releases are included in the 100-mrem standard for all pathways.

f The total airborne and liquid exposure pathways are added in order to compare maximum calculated doses from SRS releases with the DOE "all pathways" standard. This total includes the maximum airborne dose of 0.11 mrem (0.0011 mSv) and the maximum liquid dose of 0.14 mrem (0.0014 mSv).

g The drinking water standard applies to public community drinking water systems and to drinking water supplies operated by DOE or DOE contractors.

Doses from Treated Drinking Water

Off-site doses were calculated for persons consuming drinking water from two water treatment plants approximately 100 miles downriver of SRS near Beaufort, South Carolina, and Port Wentworth, Georgia. The maximum doses were 0.04 mrem (0.0004 mSv) at Beaufort and 0.05 mrem

(0.0005 mSv) at Port Wentworth. These estimated doses are based on an individual who consumes 2 liters per day of treated drinking water from the Savannah River. These doses are 1.0 percent and 1.25 percent, respectively, of the drinking water standard of 4 mrem/yr (0.04 mSv/yr). Tritium releases from SRS accounted for approximately 87 percent of the off-site doses at Beaufort and Port Wentworth.

Figure 1 Contributions to the Average Individual Dose

As shown in the graph, the major contributor to the average individual dose in the United States, including residents of the CSRA, is naturally occurring radiation [NCRP, 1987].

Figure 2 Comparison of Doses from SRS to Background and Federal Standards
SRS's dose contribution estimate of 0.25 mrem was 0.25 percent of the 100-mrem federal limit and 0.08 percent of the 300-mrem average dose from background radiation. (300 mrem is an average for the U.S. population [NCRP, 1987].)

Leaf Graph

Figure 3 SRS All-Pathway Doses (airborne and liquid pathways) since 1989

Sportsman Dose

Nontypical exposure pathways, not included in the standard calculations of the doses to the maximally exposed individual, are considered and quantified separately. This is because they apply to relatively low-probability scenarios, such as consumption of fish caught exclusively from the mouths of SRS streams, or to unique scenarios, such as volunteer deer hunters.

During 1993, the maximum dose to an actual on-site hunter could have been as high as 57 mrem (0.57 mSv), which is 57 percent of DOE's 100-mrem all-pathway dose standard. This individual harvested seven animals—the edible portion totaled approximately 162 kilograms (360 pounds)—during the controlled deer hunts held on site and was assumed to have eaten all the meat himself. This dose was based on the actual concentration of cesium-137 measured in the seven harvested animals.

If a hypothetical off-site hunter living near the site boundary consumed 81 kilograms (180 pounds) of meat—the annual maximum adult consumption rate for meat—taken from deer living on site prior to being harvested, the individual's maximum dose would have been 4.1 mrem (0.041 mSv). This dose was based on the average concentration of cesium-137 measured in all animals harvested during 1993.

The hypothetical maximum dose for a fisherman was based on the consumption of 19 kilograms (42 pounds) of Savannah River fish having the highest measured concentrations of radionuclides. In 1993, a composite of bass caught at the mouth of Steel Creek had the

highest concentrations. Consumption of this bass would result in a dose of 1.3 mrem (0.013 mSv), which is 1.3 percent of DOE's 100-mrem all-pathway dose standard.

Radiological Effluent Monitoring

During 1993, SRS monitored process effluents and the surrounding environment to determine the effect site operations had on the environment. Tritium was the major contributor to air and liquid releases. In fact, it accounted for more than 99 percent of the total radioactivity released in 1993.

Airborne Releases

Tritium was the primary radionuclide released to the atmosphere [191,000 Ci (7.1E+15 Bq)] in 1993; this compares with 156,000 Ci (5.8E+15 Bq) released in 1992. The 22-percent hike is attributed to increased tritium reservoir loading and unloading operations in the tritium facilities.

Liquid Releases

Total liquid radioactive releases (direct and migration releases) included 11,300 Ci (4.2E+14 Bq) of tritium in 1993, compared to 13,800 Ci (5.1E+14 Bq) in 1992. The decrease in direct releases is attributable to the shutdown and lay-up of all reactor facilities. Approximately 87 percent of the liquid releases were a result of seepage basin and Solid Waste Disposal Facility migration. Direct discharges of process effluents resulted primarily from operations in the reactor and separations areas.

Radiological Environmental Surveillance

The radiological environmental surveillance program at SRS is designed to survey and quantify any effects routine and nonroutine operations may have on the site itself, the surrounding area, and the population living in the site's vicinity. Sampled media include air, surface water (seepage basins, site streams, and the Savannah River), drinking water, rainwater, sediment, soil, vegetation, foodstuffs, and aquatic and terrestrial wildlife (fish, deer, hogs, turkeys, beavers, and turtles).

In 1993, approximately 105,000 radiological analyses were performed on 27,000 samples, and measurements of gamma radiation levels were made at 392 locations on and off site. Activity levels generally were consistent with 1992 levels.

Nonradiological Effluent Monitoring

Nonradioactive airborne emissions of sulfur dioxide, oxides of nitrogen, carbon monoxide, and total particulate matter less than 10 microns released from SRS stacks were within applicable South Carolina Department of Health and Environmental Control (SCDHEC) standards.

Since 1986, SRS has maintained a National Pollutant Discharge Elimination System compliance rating above 99 percent for liquid releases. Of the 8,000 analyses performed in 1993, only 10 exceeded permit limits.

Nonradiological Environmental Surveillance

The nonradiological environmental surveillance program at SRS involves the sampling and analysis of surface waters (SRS streams and the Savannah River), drinking water, sediment, groundwater, and fish.

In 1993, more than 20,000 analyses for specific chemicals and metals were performed on more than 7,000 samples, not including groundwater. Approximately 600,000 nonradiological analyses were performed on groundwater samples collected from more than 1,600 monitoring wells.

Groundwater

SRS monitors groundwater quality for radioactive and nonradioactive constituents to identify contamination that may have occurred because of site operations. Groundwater beneath 5 to 10 percent of the site has been contaminated by industrial solvents, tritium,

metals, or other constituents used or generated by SRS operations. Seven wells were abandoned during 1993, and 44 new or replacement wells were monitored for the first time.

Wells monitor the volatile organic plume beneath A-Area and M-Area. In 1993, as in the past, trichloroethylene and tetrachloroethylene exceeded standards in many upper saturated zone and Congaree-Fourmile zone wells monitoring the plume. Through September 1993, the site's groundwater remediation program had removed about 300,000 pounds of volatile organic compounds from approximately 1.75 billion gallons of groundwater beneath A-Area and M-Area.

Tritium, total radium, gross alpha, nonvolatile beta, lead, trichloroethylene, and tetrachloroethylene are the most common contaminants exceeding standards in monitoring wells on site.

Nonroutine Occurrences

One nonroutine occurrence contributed to unplanned releases of radioactive materials to the environment from SRS operations in 1993. (When sufficient information is available, release values from nonroutine occurrences are incorporated into final off-site dose estimates.)

On December 27, 1993, alpha monitors on the 291-F stack indicated elevated levels of activity. An initial investigation by field personnel determined that the resulting alarm was not caused by elevated natural activity, but rather that it likely was the result of a release. Subsequent investigations determined that a transfer of liquid between two underground tanks had, in fact, caused a release. The activity released appears to have been confined to within the SRS boundary. No elevated activity was observed at the site perimeter or off site.

Special Surveys

In the 1960s, a portion of the Savannah River Swamp was contaminated with approximately 25 Ci (9.3E+11 Bq) of cesium-137 and 1 Ci (3.7E+10 Bq) of cobalt-60 from failed fuel elements. Ten sampling trails were established in the swamp in 1974 so that specific locations could be monitored routinely. In 1993, a cursory survey was conducted that consisted of gamma radiation measurements and sampling at selected locations.

In 1992, a survey of the Pen Branch system was conducted as part of the routine environmental surveillance program and was designed to characterize the Pen Branch system prior to the restart of K-Reactor. The results indicate that, because of previous

operations at K-Reactor, radioactive material is present in the Pen Branch system.

In 1993, seven total residual chlorine exceedances occurred at the K-018 outfall. Further investigation revealed sample interference as a possible cause for the elevated total residual chlorine. Procedures for removing possible interference are being developed.

Since 1951, the Academy of Natural Sciences of Philadelphia has conducted biological and water quality surveys of the Savannah River. The surveys, which study the effects of SRS effluent discharges on general river health, include studies of algae, rooted aquatic plants, protozoa, insects and other macroinvertebrates, fish, and basic water chemistry. The Academy's 1993 studies included

- biweekly diatometer monitoring throughout the year
- comprehensive surveys near SRS in May, June, September, and December (algae, protozoa, noninsect macroinvertebrates, insects, and fish)
- sampling near Vogle Electric Generating Plant in September (algae, protozoa, noninsect macroinvertebrates, insects, and fish)
- sediment-core studies in the SRS vicinity in June

Compliance Activities

SRS remains committed to operating in a manner that protects the surrounding environment and ensures the health of its employees and the general public. The site's record of compliance in 1993 reflects its ongoing dedication to these principles. More than 1,000 SRS employees participate in projects that help the site comply with all state and federal regulations, as well as with applicable DOE orders. The following paragraphs briefly describe some of the major compliance-related activities with which SRS was involved in 1993.

Waste Minimization The SRS Waste Minimization Program, a comprehensive plan to minimize waste from all SRS operations, is designed to meet the requirements of the Resource Conservation and Recovery Act (RCRA), of DOE orders, and of applicable executive orders. The program, which has saved the site more than \$13 million, focuses primarily on source reduction, on recycling, and on increasing employee awareness of and participation in waste minimization.

Among new initiatives for 1993 were the implementation of a paper recycling program and the initiation of an affirmative procurement program to purchase products made from recycled materials. SRS was one of six DOE sites that received a Recycling and

Affirmative Procurement Award from DOE in 1993 for its efforts in this area.

The site continued its support of community pollution prevention activities in 1993 through regional Earth Day activities for the CSRA, communitywide telephone book recycling, and the sponsorship of workshops and presentations to schools and civic groups on recycling and source reduction.

Federal Facility Agreement In accordance with Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), DOE, EPA Region IV (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee), and SCDHEC entered into a Federal Facility Agreement (FFA), which was executed by the three parties January 15, 1993, and declared effective by EPA Region IV August 16, 1993. Declaration of the effective date results in the FFA being an enforceable agreement. The FFA, which sets the terms of environmental remediation at SRS, coordinates site cleanup activities into one comprehensive strategy.

Land Disposal Restrictions Federal Facility Agreement The land disposal restrictions Federal Facility Compliance Agreement (LDR FFCA) was amended April 23, 1993, to modify schedules associated with the hazardous waste/mixed waste disposal facility treatment building. During 1993, the full impact of the Federal Facility Compliance Act (FFCA) was determined, and further modifications to the LDR FFCA were discussed beginning in August to provide alignment with the FFCA. Following these negotiations, an LDR FFCA bridging amendment is expected to provide the commitments necessary for SRS to continue a program of responsible mixed waste management while the Site Treatment Plan is being developed.

Federal Facility Compliance Act The FFCA was signed into law in October 1992 as an amendment to the Solid Waste Disposal Act to clarify provisions concerning the application of certain requirements and sanctions to federal facilities. DOE's Savannah River Operations Office (DOE-SR) has begun developing a site-specific plan—with State of South Carolina involvement—that addresses SRS mixed wastes, as required by the FFCA. DOE-SR submitted the first phase of the Site Treatment Plan to the state October 28, 1993. This phase, known as the conceptual Site Treatment Plan, will be followed by further refinements. SRS is working on the draft Site Treatment Plan, due in August 1994, and will submit a final Site Treatment Plan in February 1995.

NESHAP Radionuclide Program The SRS National Emission Standards for Hazardous Air Pollutants

(NESHAP) radionuclide program continues to change to incorporate sampling, monitoring, and dose assessment practices that meet or exceed the requirements of 40 CFR 61, Subpart H. The first amendment to the FFCA for Radionuclide NESHAP was signed by EPA Region IV August 16, 1993. The amendment will provide SRS an extension to the original FFCA through February 10, 1995, in order to accomplish monitoring upgrades to several additional sources.

Air Emissions Inventory SRS personnel conducted a comprehensive air emissions inventory of all site facilities in 1993 to ensure that all radiological and nonradiological sources have been accounted for and to better characterize waste streams from site processes. SRS uses many chemicals identified as toxic or hazardous air pollutants. As required by SCDHEC Air Pollution Control Regulation 62.5, Standard No. 8 (toxic air pollutants), SRS completed and submitted the air emission inventory and air dispersion modeling data for all site sources by June 28, 1993. The submitted data demonstrated compliance by computer modeling the accumulated ambient concentration of individual toxic air pollutants at the property line and comparing them to the Standard No. 8 maximum allowable concentrations.

Environmental Compliance Issues Among key SRS compliance issues addressed during 1993 were

- the concerns of Georgia officials that tritium may be migrating under the Savannah River to groundwater in that state
- the Par Pond drawdown

Regional groundwater and Georgia tritium studies were continued in 1993 to address the concerns of Georgia officials about tritium in groundwater. The first phase of the Georgia tritium project essentially was completed with the September 1993 release of a Georgia Department of Natural Resources (GDNR) report to the Governor of Georgia. The 1991 study has shown that 1) flow patterns are toward the river from

both sides, 2) tritium concentrations are higher in shallower wells, and 3) tritium concentrations mimic rainfall concentrations. The report's data are completely consistent with airborne tritium transport and do not support transriver migration of tritium. The GDNR has received \$500,000 from DOE for a second phase of the study.

A design for repair of the Par Pond dam was finished May 7, 1993; completion of the repairs is scheduled for August 1994. The final special environmental analysis assessing the potential environmental impact associated with management and maintenance of—and repair activities on—the dam was issued by DOE-SR in April 1992, with subsequent updates in 1993. This document fulfilled a commitment made by DOE Headquarters (DOE-HQ) to the President's Council on Environmental Quality regarding the Par Pond issue. A CERCLA Interim Action Proposed Plan, which assesses and screens environmental impacts and costs of remediation alternatives, has been completed, with DOE-SR comments incorporated. The plan was sent to EPA Region IV and SCDHEC December 3, 1993.

Environmental Research

In 1972, the Atomic Energy Commission designated the site as the nation's first National Environmental Research Park. The park provides a variety of unique opportunities to study the interaction between a nuclear industrial site and the environment. In addition, thousands of acres of SRS land are specifically protected for research. Designated as set-aside areas, they provide undisturbed land for comparison with areas affected by site operations and forest management. Because public access to the site is limited, opportunities exist for long-term research programs because many of the natural habitats on the site are virtually undisturbed. Environmental research projects at the site covered a variety of sciences in 1993. Groups participating included the Savannah River Technology Center, the Savannah River Ecology Laboratory, the U.S. Forest Service Savannah River Forest Station, and the Savannah River Archaeological Research Program.

Chapter 1

Site and Operations Overview

Linda K. Karapatakis
Environmental Protection Department

Introduction

On June 12, 1950, the U.S. Atomic Energy Commission asked E.I. du Pont de Nemours and Company to design, construct, and operate what was to become the Savannah River Plant. On July 25, President Harry S. Truman wrote to Du Pont President Crawford H. Greenewalt, urging him to undertake the project. President Truman wrote, "I want you to know that I consider this project as one of highest urgency and vitally important to our national security and defense" [Bebbington, 1990].

Du Pont accepted the assignment August 2 and appeared before the Joint Committee on Atomic Energy of the U.S. Congress August 4 to negotiate terms for a contract. On October 17, Du Pont executed a letter contract with the Atomic Energy Commission and Greenewalt replied to President Truman's letter of July 25: "I hope that we will be able to justify the confidence you were kind enough to express in your letter to me. In any event I can assure you that the du

Pont Company will, as always, put forth its best efforts" [Bebbington, 1990].

Site surveys had begun July 15, 1950. On November 22, the Atomic Energy Commission approved the present site and purchased the land for approximately \$19 million, and, by February 1, 1951, construction had started [Bebbington, 1990]. The first facility to begin operating, the heavy water plant, started up August 17, 1952; the first production reactor achieved criticality December 28, 1953. By March 1958, all five reactors had achieved criticality [Bebbington, 1990].

In less than five years, initial construction—consisting of five reactors, two chemical separations facilities, a heavy water extraction plant, a nuclear fuel and target fabrication facility, and waste management facilities—was complete. It was one of the nation's largest construction projects at that time, with a peak work force of 38,500 in 1952. By the time the basic site was completed in 1956, the project had used a third of the country's concrete supply and half of its stainless steel supply. The total cost was \$1.1 billion, including the

The Savannah River Site: A Brief Chronology

- 1950** An area for the site is chosen.
- 1953** R-Reactor, the first production reactor, goes critical.
- 1954** P-Reactor, L-Reactor, and K-Reactor go critical; the first irradiated fuel is discharged from R-Reactor.
- 1955** C-Reactor goes critical; the first plutonium shipment leaves the site.
- 1956** Construction of the basic plant is complete.
- 1971** K-Reactor becomes the first production reactor automatically controlled by computer.
- 1972** The site is designated as the first National Environmental Research Park.
- 1983** Ground is broken for construction of the Defense Waste Processing Facility.
- 1989** The site is officially included on the National Priority List and becomes regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund).
- 1990** Construction of a cooling tower for K-Reactor begins.
- 1993** Nonradioactive test runs of the Defense Waste Processing Facility begin.

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A barge transports sections of R-Reactor up the Savannah River. The SRS reactor tanks were fabricated by the New York Shipbuilding Company at Camden, New Jersey, and shipped to the site by barge.

cost for the land. Several other facilities necessary to support operations have been constructed since that time, including test reactors, uranium fuel processing facilities, and a process development laboratory to support production operations [WSRC, 1990c].

Until it was disbanded by the Energy Reorganization Act of 1974, the Atomic Energy Commission oversaw and regulated site activities. In 1975, its functions were transferred to two newly established agencies: the Energy Research and Development Administration, overseeing government operations, and the Nuclear Regulatory Commission, overseeing commercial operations. By 1977, the Energy Research and Development Administration had evolved into the U.S. Department of Energy (DOE). Since that time, DOE has overseen all facility activities.

Du Pont operated the plant until March 31, 1989. On April 1, 1989, Westinghouse Savannah River Company (WSRC) became the prime operating contractor, and the Savannah River Plant became the Savannah River Site (SRS).

Description of Site Locale

Several criteria were developed for possible sites: a large land area for safety and security; a buffer zone large enough to provide land around each operating

facility for protection of human health and the environment; land somewhat isolated yet near communities that could handle construction and operations personnel; land not subject to floods and major storms; millions of gallons of available water, low in mineral content; and suitable terrain and topography. Du Pont, the Atomic Energy Commission, and the U.S. Army Corps of Engineers considered 114 sites in 18 states before making a recommendation. The current site met all the established criteria.

At the time the site was acquired, it was home to several thousand people. Almost 200,000 acres (roughly 310 square miles) were purchased from about 1,600 landowners (1,711 separate tracts of land were purchased and 699 were acquired through condemnation procedures) [SRFS, 1982; SRFS, 1991]. The residents of the surrounding towns and farms, including Ellenton, Dunbarton, Hawthorne, Meyers Mill, Robbins, and Leigh, were relocated. In all, 6,000 people, or approximately 1,500 families, were moved, along with many houses and 122 cemeteries (36 cemeteries remain on site) [Bebbington, 1990; SRFS, 1991]. Of the almost 200,000 acres, approximately 68,000 were farm fields; 29,000 were swamp and stream bottom; and 103,000 were mixed pine and scrub oak [SRFS, 1982].

Location

SRS covers 198,344 acres adjacent to the Savannah River in Aiken (72,686 acres), Allendale (4,155 acres), and Barnwell (121,503 acres) counties of South Carolina (figure 1-1). The average population density in the counties surrounding SRS is 85 people per square mile, with the largest concentration in the Augusta, Georgia, metropolitan area. Based on 1990 U.S.

Census Bureau data, the population within a 50-mile (80 km) radius of SRS is approximately 620,100.

Various industrial, manufacturing, medical, and farming operations are conducted around the site. Major industrial and manufacturing facilities in the area include textile mills; polystyrene foam and paper product plants; chemical processing plants; and a commercial nuclear power plant. Farming is diversified and includes crops such as cotton, soybeans, corn, and small grains.

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Figure 1-1 Regional Location of SRS

SRS is about 25 miles southeast of Augusta, Georgia, and 12 miles south of Aiken, South Carolina. The site, approximately 310 square miles in area, covers about 1 percent of the state of South Carolina.

Climate

The climate is mild, with an average frost-free season of approximately 246 days. The average annual rainfall, about 48 inches, is fairly evenly distributed throughout the year. There is no strongly prevailing wind direction. However, there is a relatively high frequency of east and northeast winds during the summer and fall. During the late fall, winter, and spring, there is a relatively high frequency of south through northwest winds [Hunter, 1990]. With the exception of the Savannah River, no unusual topographic features exert significant influence on the general climate.

Water Resources

SRS is bounded on its southwestern border for about 35 miles by the Savannah River, approximately 160 river miles from the Atlantic Ocean. Five major streams at SRS feed into the Savannah River: Upper Three Runs Creek, Four Mile Creek (also referred to as Fourmile Branch), Pen Branch, Steel Creek, and Lower Three Runs Creek. These streams, which receive effluents from various on-site operations, are not used as commercial sources of water.

The two main bodies of water located on site are Par Pond and L-Lake, both of which are man-made. Constructed in 1958 to provide cooling water for P-Reactor and R-Reactor (hence the name P A R Pond), Par Pond covers 2,640 acres and is approximately 60 feet deep. L-Lake, covering 1,000 acres, was constructed in 1985 to receive heated cooling water from L-Reactor.

The Savannah River is used as a drinking water supply for approximately 65,000 persons downriver in Port Wentworth, Georgia, and near Beaufort, South Carolina (Beaufort and Jasper counties) [Hamby, 1991]. The Cherokee Hill Water Treatment Plant intake, at Port Wentworth, is approximately 130 river miles from SRS; the Beaufort-Jasper Water Treatment Plant intake, near Beaufort, is approximately 120 river miles from SRS. The Savannah River also is used for commercial and sport fishing, boating, and other recreational activities. There is no known use of the Savannah River for irrigation by farming operations downriver of SRS [Hamby, 1991]. SRS uses water from the river for some site operations.

Geology and Hydrology

SRS is on the Upper Coastal Plain of South Carolina. The Coastal Plain at SRS consists of 500 to 1,400 feet of sands, clays, and limestones of Tertiary and Cretaceous age. These sediments are underlain by

Typical Climate at SRS

- ♦ **Summer**
Hot and humid
Temperatures reach upper 90s (°F)
33 percent of annual rainfall
- ♦ **Fall**
Cool mornings, warm afternoons
Temperatures range from 50 to 76 °F
19 percent of annual rainfall
- ♦ **Winter**
Mild; lasting November through March
Temperatures normally above 32 °F
21 percent of annual rainfall
- ♦ **Spring**
Most variable; cold snap often in March
Temperatures average 65 °F
27 percent of annual rainfall

sandstones of Triassic age and by older metamorphic and igneous rocks.

The sandy sediments of the Coastal Plain contain several productive aquifers, separated by clay-rich units, that drain to the Savannah River, its tributaries, and the Savannah River Swamp. The older, underlying rocks are nearly impermeable and do not constitute a major water source.

Land Resources

The SRS region is part of a wetlands area called the Southern Bottomland Hardwood Swamp region. The main features are river swamps, rarely more than five miles wide, which occur on the Coastal Plain that extends from Virginia south to Florida and west along the Gulf of Mexico to the Mississippi River drainage basin.

Plant and Animal Life

Except for timber, the area of the site not used for production and related activities—more than 100,000 acres—has remained virtually untouched for several decades. In 1951, the U.S. Forest Service in Atlanta, Georgia, was asked to establish a reforestation and forest management plan, and reforestation plans were written in 1952. In 1953, SRS had the largest mechanized planting in the United States, with 28 planting machines capable of planting 400,000 seedlings a day [SRFS, 1991]. During that year, 10 million trees were planted, and by 1968, the one hundred millionth tree had been planted [SRFS, 1982]. In all, the Forest Service has planted more than 300 million trees, mainly pines, which now cover almost 80 percent of the site. SRS maintains a forest management

program to contribute to environmental protection and research.

In 1972, SRS was designated as the first National Environmental Research Park. These parks are used as outdoor laboratories for the study of the impact of human activity on the natural environment. This designation has created a unique environment for the preservation and study of vegetation and wildlife.

To help maintain the site as a National Environmental Research Park, several areas have been designated as set-aside areas. Thirty areas covering 14,288 acres have been set aside to protect rare, threatened, and endangered biota, as well as unique habitats.

Vegetation

Most of the site's environs are rural, with approximately 40 percent of the countryside forested with longleaf and loblolly pines and sweet gum, maple, birch, and various oak-hickory hardwood trees.

Major plant communities at SRS include cypress-gum and lowland hardwood swamps, sandhills, and old agricultural fields, as well as aquatic and semiaquatic

areas. These habitats range from very sandy, dry hilltops to continually flooded swamps.

Wildlife

SRS is populated with more than 50 species of mammals, including deer, feral hogs, beavers, rabbits, foxes, raccoons, bobcats, river otters, and opossums. In 1952, there were less than three dozen white-tail deer on site. Since that time the population has increased dramatically, and the site now is home to several thousand white-tail deer [SRFS, 1982]. In 1965, managed public deer hunts were initiated to reduce the increasing number of deer-vehicle accidents and to maintain the health of the herd.

The site also is home to more than 100 species of reptiles and amphibians—including turtles, alligators, lizards, snakes, frogs, and salamanders—and more than 200 species of birds.

The area provides refuge for endangered and threatened species: the red-cockaded woodpecker, the American alligator, the southern bald eagle, the wood stork, and the smooth purple coneflower. Many research projects conducted at the site are designed to protect and increase the populations of these species.

National Environmental Research Park

In 1972, the federal government designated SRS as the nation's first National Environmental Research Park. The park provides a unique outdoor laboratory to study the interaction between managed and natural systems.

The Savannah River Swamp is 7,500 acres of natural swampland adjacent to the Savannah River. In the deep water areas of the swamp, two types of trees are dominant: the bald cypress and the water tupelo. These trees cover 50 percent of the swamp. The other 50 percent consists of islands that support bottom land hardwood forests, including oaks, red maples, and sweet gum trees. The swamp also is home to waterfowl and alligators. Studies conducted at the swamp track subtle long-term effects of land use changes on ecosystems [WSRC, 1990c].

SRS serves as a refuge for the endangered species such as the southern bald eagle.

The southern bald eagle is a subspecies of the bald eagle. When fully mature, it is about 40 inches long with dark brown plumage, a white head and tail, and yellow eyes, beak, and feet. Eagles reach full maturity in 3 to 7 years. They are monogamous, mate for life, and tend to use the same nest every year.

In 1993, two nesting pairs of southern bald eagles at SRS produced three offspring; one pair used a wind-damaged nest prepared by humans. Wildlife officials believe there are about 100 active eagle nests in South Carolina, most located near the coast.

White plumage covers the head of a mature southern bald eagle.

Description of Site Operations and Facilities

The SRS production process begins with the manufacture of fuel and target assemblies produced from raw materials such as enriched uranium. The assemblies are transported by rail to the reactors, where they are loaded into a reactor tank and used to produce a controlled nuclear reaction. During the reaction, neutrons from the fuel bombard the target to produce the desired product.

The irradiated target assemblies and spent fuel assemblies are shipped by rail to an on-site chemical separations facility, where the desired products are separated. Finally, waste products are processed.

Until 1988, SRS produced plutonium and tritium for national defense; now, additional nuclear materials produced at the site, such as californium-252, americium-243, uranium-233, curium-244, polonium-210, and cobalt-60, are used for other government programs (e.g., plutonium-238 is used as an energy source in the U.S. space program) and for some civilian purposes (e.g., medical procedures).

SRS is divided into several areas based on its production process (figure 1-2):

- reactor areas (C, K, L, P, and R)
- the Reactor Materials Area (M)
- separations areas (F and H)
- waste management areas (E, F, H, S, and Z)
- the heavy water reprocessing area (D)
- the Administration Area (A)
- other areas (B, N, G, TNX)

Each area performs a specific function for the site. The following sections provide brief descriptions of the primary operations conducted within each area.

Reactor Areas

Production reactors are in five areas: C, K, L, P, and R. Each area houses one of the site's five heavy water reactors. The basis for the design of the reactors was derived in large part from experience and data generated at the Argonne National Laboratory in Argonne, Illinois. Argonne was the focal point for heavy water reactor research and development, and the facility had built and operated two such reactors by 1950 [Bebbington, 1990].

All the reactors at SRS are similar to each other. The building housing the reactor tank is 200 feet high at its tallest point. This section often is referred to as the

The First Man-made Nuclear Reactor: Chicago Pile One

Construction of the first man-made nuclear reactor began November 7, 1942, under the University of Chicago's Stagg Field. The structure was made up of 40,000 graphite bricks, each 4 1/8 inches wide and deep and 16 1/2 inches long. Layers of solid graphite bricks were stacked alternately with graphite bricks in which holes had been bored every 8 1/4 inches to hold pellets of uranium. The completed reactor, called Chicago Pile One (CP-1), contained approximately 400 tons of graphite, 6 tons of uranium metal, and 58 tons of uranium oxide.

On December 2, 1942, at 9:45 a.m., Enrico Fermi withdrew the first cadmium control rod from CP-1. He continued to withdraw control rods until, at 3:20 p.m., a self-sustaining chain reaction was recorded. CP-1 had gone "critical." Within minutes, increased radiation in the room required Fermi to insert a control rod and end the reaction.

Arthur Compton, director of the University of Chicago's Metallurgical Lab, called James Conant, president of Harvard, to report: "the Italian navigator has just landed in the new world" [Hewlett and Anderson, 1962; Groueff, 1967].

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Figure 1-2 The Savannah River Site

SRS includes several areas plus the Savannah River Ecology Laboratory (SREL), the Savannah River Forest Station (SRFS), and the Savannah River Technology Center (SRTC). Production areas are primarily in the interior of the site. Production and waste management activities use about 10 percent of the site; the remaining acreage provides a protected area for scientific study.

“high hat.” The top of the tank housing the reactor is at ground level and extends 40 feet below the surface. The reactor tank is half-inch-thick stainless steel and is approximately 20 feet tall and 20 feet in diameter. The walls of the process area containing the tank are 6-foot-thick steel-reinforced concrete, buttressed to resist seismic stress.

Each reactor is made up of about 600 fuel and target rods, plus safety and control rods. When the safety and controls rods are lifted up into the high hat, the nuclear reaction begins. Heavy water moderates the reaction and cools the fuel rods.

Of the five SRS production reactors, four, R-Reactor, P-Reactor, L-Reactor, and C-Reactor, are permanently shut down; the fifth, K-Reactor, has been placed in cold standby.

R-Reactor went critical in December 1953 and has been permanently shut down because of reduced production demands.

P-Reactor was started in February 1954 and was shut down in August 1988 for maintenance. In February 1991, it was placed in cold standby and was to be used to provide spare parts for L-Reactor and K-Reactor. P-Reactor has been permanently shut down.

L-Reactor went critical in August 1954 and was placed in cold standby in 1968. It was restarted in October 1985, after upgrading, and shut down for maintenance and safety upgrades in August 1988. It was placed in warm standby in December 1991 to be put into operation as a backup to K-Reactor if necessary. L-Reactor has been permanently shut down.

C-Reactor went critical in March 1955 and was shut down in 1985 for maintenance. It was placed in cold standby in 1987, when cracking was observed in the reactor vessel. C-Reactor has been permanently shut down.

K-Reactor went critical in October 1954 and was shut down in August 1988 for maintenance. Initial steps to restart K-Reactor began in December 1991. Successful power ascension testing was completed in July 1992. Following ascension testing, the reactor was taken offline to allow for the tie-in of the cooling tower. The tie-in of the cooling tower was completed, and the operating permit was issued in December 1992. In 1993, the cooling tower was tested; however, the reactor was never restarted. K-Reactor has since been placed in cold standby.

Reactor Materials Area

The Reactor Materials Area (M-Area) consists of a fuel and target fabrication facility, three analytical

laboratories, and the Effluent Treatment Facility (ETF).

The fuel fabrication facility produced fuel and target elements to be used in the reactors. Control rods and other reactor components also were manufactured in the facility.

Three laboratory facilities in M-Area provide analytical support for reactor facilities, heavy water facilities, fuel fabrication facilities, and the ETF.

The Liquid Effluent Treatment Facility (LETf) treats wastewater generated by various M-Area processes for discharge to Tims Branch, which feeds into Upper Three Runs Creek. It also consolidates low radioactivity residues from M-Area processes for eventual disposal.

Separations Areas

Reactor-generated products are processed in the separations facilities in F-Area and H-Area. Operations in the separations areas also include chemical separations, receipt of off-site fuel for processing, and tritium processing. Facilities include the canyon buildings, the FB-Line, the HB-Line, the Receiving Basin for Offsite Fuel (RBOF), the Extraction/Separation Facility, and the Replacement Tritium Facility (RTF).

Complex chemical and physical processes in the F-Area and H-Area facilities separate uranium, plutonium, and fission products. The irradiated fuel and target assemblies are separated into products and waste by a series of complex chemical operations. Plutonium is converted into metal, and uranium is converted to dry powdered uranium trioxide, which is later reprocessed [WSRC, 1990c]. The separations activities take place in the canyon buildings. The buildings are called canyons because of their long, narrow shape: approximately 850 feet long, 65 feet high, and 120 feet wide, with 5-foot-thick concrete walls. The F-Area canyon began operations in November 1954. The H-Area canyon began operations eight months later, in July 1955 [Bebbington, 1990]. The separated plutonium and uranium are transferred to other facilities in F-Area and H-Area and processed into solid form.

The FB-Line, in the F-Area canyon building, is used to process purified plutonium solution. The plutonium is concentrated, precipitated, and reduced to metal form [Fact Sheet, 1990].

The HB-Line, in the H-Area canyon building, is used for Pu-238 separation. The Pu-238 is shipped to Los Alamos National Laboratory in Los Alamos, New Mexico, for encapsulation into fuel for the space

program. The fuel will power an upcoming space probe, Cassini, to the planet Saturn. Pu-238 provides a good source of power for satellites because it has a high specific heat. This allows satellite designers to keep the overall weight of the satellite at a minimum and still have a power supply that is effective for many years [Fact Sheet, 1991c].

Off-site fuel to be processed in the H-Area canyon building is stored and packaged in the RBOF. Other operations conducted at RBOF include cleaning lithium-aluminum targets for processing in the tritium facilities and processing deionizers used in the reactor areas. Most radioactive waste generated from RBOF operations is contained in liquid waste transferred to the high-level waste storage tanks in F-Area and H-Area.

Facilities in H-Area extract and separate tritium—from targets irradiated in SRS reactors and from military reservoirs—to be processed and packaged for shipment to other DOE facilities. Because tritium decays with a half-life of 12.3 years, the nation's supply must be continuously replenished to meet defense needs.

The Extraction/Separation Facility handles tritium produced in SRS reactors. Irradiated targets are processed to separate tritium and other useful hydrogen isotopes, namely deuterium, from waste gases. The tritium and deuterium are used to replenish current military reservoirs of tritium gas. Handling of these reservoirs takes place in several facilities, many of which have been in operation since the 1950s. The RTF will house the processes in one facility.

Construction of the RTF, a 1-acre underground facility in H-Area, began in late fall 1986. The underground location increases safety and security by offering protection against natural disasters, such as earthquakes and tornados. The RTF will handle unloading, separating, mixing, and loading operations now performed in existing tritium facilities. It is designed to minimize tritium losses to the environment and to reduce waste generation. In mid-1993, tritium gas was introduced into the facility. That began the final phase of testing before the facility becomes operational. The RTF and the existing tritium facilities will operate concurrently for approximately one year.

The Replacement Tritium Facility and Tritium Recycling

There are two sources of tritium at SRS: irradiated fuel targets that have not yet been through the separations process and the recycling of gas from existing weapons reservoirs. One of the jobs of the RTF will be to separate, or enrich, the useful hydrogen isotopes (tritium and deuterium) from the existing reservoirs.

In the past, gas to be recycled was unloaded in one facility, pumped to another for separation, then pumped back for reloading into shipping containers. The RTF will perform all these activities in one underground location designed to ensure that tritium releases to the environment are minimal.

Waste Management Areas

Waste management activities are conducted in the following areas: E, F, H, S, and Z. E-Area, between F-Area and H-Area, eventually will include all the site's disposal and storage facilities.

Facilities in waste management areas are designed to store or treat waste generated from on-site operations. These facilities include waste tank farms, the ETF, the Defense Waste Processing Facility (DWPF), the Solid Waste Disposal Facility (SWDF)—formerly the Radioactive Waste Burial Grounds—and the Consolidated Incineration Facility (CIF).

Historically, seepage basins were used to dispose of wastewater from the separations facilities in F-Area and H-Area. Six were placed in operation in 1955, and a seventh was constructed in 1962 to replace a basin that had stopped seeping. The three F-Area basins cover about 6.5 acres; the four H-Area basins cover about 15.5 acres. Annually, an average of about 80 million gallons of wastewater was discharged into the basins. Most basins contained between 1 million and 3 million gallons; however, one basin held 15.8 million gallons and another, 22.6 million gallons. Use of the basins was discontinued in 1988, when the ETF was brought online [Fact Sheet, 1991a].

Construction of the ETF began in January 1987 and was completed in November 1988; it replaced the F-Area and H-Area seepage basins. The facility, on the south side of H-Area, collects and treats routine process wastewater, contaminated canyon facility cooling water, and tank farm stormwater from F-Area and H-Area. The ETF removes radioactive and nonradioactive contaminants, except tritium, from process effluents and allows the water to discharge to Upper Three Runs Creek. The facility is designed to process 100,000 to 250,000 gallons of low-level wastewater daily, with a maximum capacity of 430,000 gallons per day [Fact Sheet, 1991b].

The F-Area and H-Area waste tank farms consist of large underground storage tanks that hold high-level liquid radioactive waste and evaporated saltcake. Installation of the tanks was preceded by a drilling exploration designed to characterize the type of earth, its load-bearing capacity, the presence of cavities, and a profile of the water table. A 4- to 6-inch concrete slab was placed over the entire bottom of the excavation. On that foundation, individual base slabs for the support of each tank were constructed [Dukes, 1984].

There are four types of waste tanks with capacities of 750,000 to 1.3 million gallons. All are constructed of carbon steel and reinforced concrete. Three of the types consist of a stress-relieved inner container, or primary

tank, surrounded by a steel container, the secondary tank. This dual tank assembly is surrounded by a 30-inch-thick reinforced concrete wall and has a forced-water cooling system. These tanks are used for high-level waste. The fourth type has a single wall directly supported by the encasing-reinforced concrete, has no forced cooling, and is used primarily for low-level waste [Dukes, 1984]. The waste, contained in 29 tanks in H-Area and 22 tanks in F-Area, eventually will be removed and processed in the DWPF.

The DWPF is made up of two facilities: the Saltstone Facility and the Vitrification Building. High-level waste will be processed in the Vitrification Building. Low-level waste will go to the Saltstone Facility.

The 360-foot-long Vitrification Building in S-Area will accept high-level radioactive waste stored in the F-Area and H-Area waste tanks and mix the waste with glass frit. The mixture is fed into a melter and heated until it becomes molten glass. It then is poured into stainless steel canisters and allowed to cool and form a solid inert glass suitable for storage in off-site geologic repositories. The glass form and the geologic repository will effectively isolate the nuclear waste from the environment. In March 1993, cold chemical runs to test the facility began. During these runs, nonradioactive chemicals simulating the chemical and physical properties of radioactive liquid waste are used to test the facility's ability to receive and process liquid waste. In April, the testing was suspended following the unintentional transfer of 1,300 gallons of water into the melter and melter cell. Cold chemical runs were resumed in July after implementation of corrective actions. Radioactive runs are scheduled for late 1995.

The Saltstone Facility, constructed in Z-Area between February 1986 and July 1988, is designed to process and dispose of decontaminated salt solution supernatant from the storage tanks in F-Area and H-Area and from ETF concentrate. Since startup in June 1990, the Saltstone Facility has operated successfully and, as of June 17, 1992, had stabilized 1 million gallons of low-level radioactive waste. The decontaminated salt solution, or sludge, is immobilized with solidifying agents, such as slag, fly ash, or cement, and disposed of in concrete vaults. After being filled, the vault is capped with clean concrete.

Solid radioactive waste generated at SRS and other DOE facilities is buried in the SWDF. The storage site occupies 195 acres in E-Area, approximately 6 miles from the nearest site boundary. The original 76 acres, which began to receive waste in 1953, were filled in 1972, and operations were shifted to a 119-acre site contiguous to the original area [Dukes, 1984]. The SWDF consists of separate trenches for waste with

The Saltstone Facility

High-level waste is stored in underground tanks. Although the waste is classified as high level, approximately 93 percent of the volume is a low-level salt solution (primarily sodium nitrate, which is similar to fertilizer).

Pretreatment of high-level waste will separate the salt solution from the other waste. After the separation, the salt solution contains highly radioactive cesium and strontium. The solution is treated in tanks to remove the cesium and strontium, which become part of the high-level sludge sent to the Vitrification Building for processing. The remaining salt solution, now a low-level waste containing less than 0.01 percent of the waste's total radioactivity, goes to the Saltstone Facility.

At the Saltstone Facility, the decontaminated salt solution is immobilized by being mixed with cement slurry, blast furnace slag, and fly ash to create a grout. The grout is pumped into aboveground concrete vaults and solidifies to form a stable concrete-like substance called saltstone. Once filled, the vaults are capped with weatherproof concrete to isolate the saltstone from the elements. Final closure includes covering vaults with a clay cap and backfilling with earth.

The Saltstone Facility is designed to process approximately 9 million gallons of waste per year into 70,000 cubic yards of saltstone (approximately 270 tons of saltstone per day) [Fact Sheet, 1991e]. The one millionth gallon of low-level waste was processed in June 1992.

high-level radioactivity and waste with low-level radioactivity. The trenches are approximately 20 feet deep and 20 feet wide. The bottom 6 to 12 inches are covered with gravel. Monitoring wells are installed in each trench, and dikes are constructed to prevent surface water from running into the open trenches [Dukes, 1984]. Accurate records are kept of the contents, radiation level, radionuclide content, and storage location of each package of waste. The exact location of the burial trenches is defined by a 100-foot grid system laid out in 1962 [Dukes, 1984]. Waste buried in the SWDF includes contaminated equipment, items from laboratory operations (e.g., gloves, beakers), and scrap and tools used in the reactor areas.

Also located in E-Area are the waste storage vaults being built to replace the SWDF. Low-activity waste is placed in the low-activity waste vaults. Construction of

the vaults began in 1990 and will continue for the next 20 years. Each concrete vault is 650 feet long by 150 feet wide by 30 feet tall and contains 12 cells. Each cell will hold 1,000 standard B-25 boxes (carbon steel boxes, 6 feet wide by 4 feet high by 4 feet deep). When the cell is full, the door is sealed with concrete [Fact Sheet, 1992a].

Intermediate-level vaults are used to dispose of intermediate-level waste, with tritium-contaminated waste disposed of separately from waste without tritium. Construction of the vaults began in 1990 and will continue over the next 20 years. Each tritium vault is 25 feet wide by 43 feet long by 27 feet deep and contains two cells with open tops. Vaults for waste without tritium are identical but contain seven cells. To load waste into the vaults, a crane straddles the vault and lowers the waste box into the cell. A rain cover

protects the open cell until it is filled. When the cell is full, the door is sealed with concrete [Fact Sheet, 1992a].

Construction of the CIF began in 1993 with plans to have the facility operating by January 1996. The facility will be located on 3 acres near the center of the site, adjacent to H-Area, and should take two years to complete. The CIF will treat and reduce the volume of specific combustible SRS hazardous, mixed, and low-level waste by 90 percent. Examples of waste to be treated include sludges, oils, paint solids, solvents, rags, and protective clothing.

Heavy Water Reprocessing Area

A heavy water production plant in D-Area began operations in 1953 to produce heavy water to moderate and cool the site's reactors. The plant separated heavy water, present in all water, from Savannah River water. The facility stopped production in 1981 because of a sufficient supply of heavy water.

The facilities operating in D-Area include a coal-fired power plant, a laboratory facility that analyzes process effluent samples, and the Heavy Water Rework Facility. Through normal reactor operations, heavy water becomes diluted with light (ordinary) water. This degraded heavy water is sent to the Heavy Water Rework Facility, where light water is removed, and the heavy water is reconcentrated to a 99.75 percent purity [Fact Sheet, 1991d].

Administration Area

The Administration Area contains organizations that provide direct support for SRS operations. DOE's Savannah River Operations Office and WSRC administrative offices are located in A-Area. The Savannah River Technology Center performs research and development activities and provides analytical support for on-site operations, and the University of Georgia's Savannah River Ecology Laboratory conducts independent environmental research projects.

Other Areas

Other on- and off-site facilities support SRS operations. On-site areas include training facilities (B-Area), central shops (N-Area), the Savannah River

Heavy Water

Heavy water, or deuterium oxide, is water made up of oxygen and deuterium (an isotope of hydrogen).

Deuterium and deuterium oxide were discovered by Harold Urey, F.G. Brickwedde, and G.M. Murphy in 1931. (Urey, an American chemist, received the 1934 Nobel Prize for Chemistry for the discovery of deuterium.)

Heavy water (D_2O) is present in all natural water (H_2O). In fact, ordinary water contains one part D_2O for every 6,760 parts H_2O . In other words, ordinary water is about 0.01 percent heavy water. There is approximately one ounce of heavy water in every 52 gallons of ordinary water.

Heavy Water and SRS Reactors

At SRS, heavy water was extracted from Savannah River water and used as moderator and primary coolant for the reactors. Heat generated in the reactors was removed by recirculating heavy water through 12 heat exchangers. The heavy water flowed through 9,000 thin tubes in each heat exchanger and was cooled by ordinary water flowing around the outside of the thin tubes.

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Chapter 2

Environmental Compliance

Compiled by Al Mamatey
Environmental Protection Department

Introduction

Savannah River Site's (SRS) work force continued operations in 1993 that involved hundreds of processes and a vast array of chemicals subject to regulatory compliance with a growing number of environmental statutes, regulations, and policies. Compliance is required to ensure that SRS employees, the public, and the surrounding environment are fully protected. This chapter addresses environmental compliance issues involving the site during 1993.

The goal of the site and the U.S. Department of Energy (DOE) continues to be zero violations and full compliance, and SRS employees maintained progress toward achievement of that goal during 1993. Two Notices of Violation (NOVs) were issued to the site in 1993—both by the South Carolina Department of Health and Environmental Control (SCDHEC). One alleged storage and disposal of hazardous waste without a Resource Conservation and Recovery Act (RCRA) permit; the other, under the Clean Air Act (CAA), resulted from failed biennial source compliance tests for two coal-fired boilers in H-Area. No consent orders had been issued and no fines levied against SRS by the end of 1993 as a result of the potential violations.

Compliance Activities

Compliance with environmental regulations and DOE orders related to environmental protection is a critical part of the operations at SRS. Assurance that on-site processes do not impact the environment adversely is a top priority, and management of the environmental programs at SRS is a major task, with more than 1,000 people devoted full-time to environmental activities. All site activities are overseen by one or more regulators, including the U.S. Environmental Protection Agency (EPA) and SCDHEC. During the past few years, the number of regulations affecting site operations has increased dramatically, and significant effort has been devoted to bringing all site facilities and operations into compliance with them.

Resource Conservation and Recovery Act

RCRA was passed in 1976 to address the problem of solid and hazardous waste management. The law requires that EPA regulate spent solvents, batteries, and many other discarded substances deemed potentially harmful to human health and the environment. Amendments to RCRA regulate nonhazardous solid waste, biohazardous medical waste, and some underground storage tanks.

RCRA is responsible for controlling every aspect of the generation, treatment, storage, and disposal of hazardous waste; this is referred to as "cradle-to-grave control." Hazardous waste generators, including SRS, must follow specific requirements for handling these wastes. RCRA requires that owners and operators of operating or post-closure care hazardous waste management facilities have a permit for many waste management activities.

EPA is responsible for all hazardous waste regulations. However, EPA can delegate this authority to a state when the state passes laws and regulations that meet or exceed EPA regulations and the state plan is approved by EPA. SCDHEC has authority for all aspects of RCRA except some of the rules associated with the 1984 Hazardous and Solid Waste Amendments to RCRA. Also, SCDHEC has been authorized by Congress to administer the Federal Facility Compliance Act (FFCA) and will be the lead regulatory agency for development of the Site Treatment Plan, which is discussed on page 14. For more information on waste management at SRS, refer to chapter 4, "Environmental Restoration and Waste Management."

Land Disposal Restrictions

The 1984 RCRA amendments established land disposal restrictions (LDR), often referred to as "land ban." LDR allow storage of restricted hazardous wastes solely for the purpose of accumulating such quantities as are necessary to facilitate proper recovery, treatment, or disposal of untreated waste in land disposal units. The amendments require that, prior to land disposal, all wastes meet treatment standards based on the best demonstrated available technology.

The same restrictions apply to mixed wastes, which are composed of a mixture of radioactive and hazardous wastes. Because LDR apply to mixed wastes and SRS does not have adequate mixed waste treatment capacity, regulatory agreements are required to achieve compliance. Therefore, a Federal Facility Compliance Agreement (FFCA) was signed in March 1991 between DOE's Savannah River Operations Office (DOE-SR) and EPA Region IV (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee) to address SRS mixed waste compliance with LDR. The LDR FFCA has been amended twice—in April 1992 to include additional mixed wastes and in April 1993 to modify schedules associated with the "Hazardous Waste/Mixed Waste Disposal Facility Treatment Building" project.

The full impact of the FFCAct was determined during 1993, and further modifications to the LDR FFCA were discussed beginning in August 1993 to provide alignment with the FFCAct. Following these negotiations, an LDR FFCA bridging amendment is expected to provide the commitments necessary for SRS to continue a program of responsible mixed waste management while the Site Treatment Plan is being developed. Also, the site is preparing treatability variances for some mixed wastes to allow appropriate RCRA treatment while minimizing worker exposure to radioactivity.

Treatability variances are an option available to facilities for particular waste streams that either cannot be treated at the level specified in the regulations or for which the treatment technology is inappropriate for the waste. SRS has identified several mixed waste streams that are potential candidates for a treatability variance. One variance—for in-tank precipitation filters—was granted in October 1993 by EPA Region IV. Other variances will be prepared and submitted as appropriate.

Federal Facility Compliance Act

The FFCAct was signed into law in October 1992 as an amendment to the Solid Waste Disposal Act to clarify provisions concerning the application of certain requirements and sanctions to federal facilities. With respect to DOE and other federal agencies, the FFCAct waives sovereign immunity from all civil and administrative penalties and fines to include both coercive and punitive sanctions for violations of the Solid Waste Disposal Act. The FFCAct will continue to provide sovereign immunity for mixed waste storage as long as DOE-SR prepares inventories and—by October 1995—develops treatment schedules and enters into a compliance order with the State of South Carolina.

DOE-SR has begun developing a site-specific plan—with State of South Carolina involvement—that addresses SRS mixed wastes, as required by the FFCAct. DOE-SR submitted the first phase of the Site Treatment Plan to the state on October 28, 1993. This phase, known as the conceptual Site Treatment Plan, will be followed by further refinements. SRS is working on the draft Site Treatment Plan, due in August 1994, and will submit a final Site Treatment Plan in February 1995. A meeting was held November 17, 1993, with SCDHEC and state representatives to discuss the conceptual Site Treatment Plan, and SRS is keeping SCDHEC, EPA Region IV, and the state up-to-date on the development status of the draft Site Treatment Plan.

Also in association with the FFCAct, Westinghouse Savannah River Company (WSRC) submitted a mixed waste inventory report January 13, 1993, and DOE Headquarters (DOE-HQ) issued a complexwide report—"U.S. Department of Energy Interim Mixed Waste Inventory Report: Waste Streams, Treatment Capacities, and Technologies"—April 21, 1993, to state governors and to regulatory agencies in states that host DOE sites. This was followed by a comment period for the regulators and states. DOE-HQ is expected to provide an update to the mixed waste inventory report in April 1994.

Underground Storage Tanks

Underground storage tanks at SRS house petroleum products—such as gasoline and diesel fuel—and hazardous substances (as defined by the Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA). All the tanks are regulated under Subtitle I of RCRA.

Underground storage tank regulations require that all regulated existing tanks be closed or upgraded to new tank standards by 1998. In 1993, WSRC closed five tanks by removal and performed tightness testing on 26 existing tanks that remained in use, as required by SCDHEC regulations. Every tank that was tested passed.

In areas where underground tanks are still needed, WSRC will replace single-walled tanks with double-walled tanks that have leak detection systems. To complete this project, removal or abandonment is required for 23 remaining tanks, including 15 of the 26 that were tested; this action is slated for completion by 1998.

RCRA Facility Investigation Program

The hazardous waste permit issued to SRS in September 1987 requires that the site institute a program for investigating solid waste management

Key Regulations that SRS Must Follow

Legislation	What it Regulates/SRS Compliance Posture
RCRA Resource Conservation and Recovery Act	<ul style="list-style-type: none"> Management of hazardous, nonhazardous, and medical wastes and of underground storage tanks containing hazardous substances and petroleum products.
FFCA Act Federal Facility Compliance Act	<ul style="list-style-type: none"> Requires that DOE develop schedules meeting LDR requirements for mixed waste to avoid waiver of sovereign immunity.
CERCLA; SARA Comprehensive Environmental Response, Compensation, and Liability Act; Superfund Amendments and Reauthorization Act	<ul style="list-style-type: none"> Establish liability, compensation, cleanup, and emergency response for hazardous substances released to the environment. SRS was placed on the National Priority List in December 1989.
CERCLA (TITLE III); EPCRA Emergency Planning and Community Right-to-Know Act	<ul style="list-style-type: none"> Requires that hazardous substances used on site be reported to EPA, state, and local planning units and that releases be reported.
NEPA National Environmental Policy Act	<ul style="list-style-type: none"> Evaluates potential environmental impact of federal activities and alternatives. In 1993, WSRC conducted 412 reviews for proposed activities.
SDWA Safe Drinking Water Act	<ul style="list-style-type: none"> Enacted in 1974 to protect public drinking water systems; it was amended in 1980 and 1986.
CWA; NPDES Clean Water Act; National Pollutant Discharge Elimination System	<ul style="list-style-type: none"> Regulates liquid discharges at the outfall (e.g., drain or pipe) that carries effluents to streams.
CAA; NESHAP Clean Air Act; National Emission Standards for Hazardous Air Pollutants	<ul style="list-style-type: none"> Sets air quality standards for hazardous air emissions, such as radionuclides and benzene.
TSCA Toxic Substances Control Act	<ul style="list-style-type: none"> Regulates the use and disposal of PCBs. Because there is no disposal facility in the country, radioactive PCBs generated at SRS are stored on site.

units. The RCRA Facility Investigation program permits the investigation and remediation (if necessary) of contamination caused by releases of hazardous waste/constituents from solid waste management units at the site.

The RCRA Facility Investigation program plan was expanded in 1992 to address CERCLA hazardous

substances and was renamed the RCRA Facility Investigation/Remedial Investigation program plan. The integration of RCRA and CERCLA regulatory requirements will provide a more cost-effective and focused investigation and remediation process. The RCRA/CERCLA program status is detailed under the CERCLA section of this chapter.

Waste Minimization

The SRS Waste Minimization Program, a comprehensive plan to minimize waste from all SRS operations, is designed to meet the requirements of RCRA, of DOE orders, and of applicable executive orders. The program, which has saved the site more than \$13 million dollars, focuses mainly on source reduction, on recycling, and on increasing employee awareness of and participation in waste minimization.

Source reduction opportunities are identified through formal facility process waste assessments and through informal reviews of facility operations and activities. Process waste assessments, conducted by all major waste generators, identify and prioritize key areas for eliminating waste. They are supplemented by additional efforts to eliminate hazardous materials through improved housekeeping and maintenance practices, chemical inventory controls, and identification of nonhazardous alternatives. Typical source reduction programs include reduction of Radiologically Controlled Area size; improved labeling and consolidation of maintenance materials; and replacement of chlorofluorocarbon (CFC)-based automotive maintenance cleaners with nonhazardous, CFC-free products. Waste reduction is reported annually to state and federal agencies.

SRS has an aggressive program to recycle and reuse excess/waste materials. The site continually seeks to identify new materials for inclusion in the program, which includes the recycling of materials such as computer toner cartridges, office and computer paper, antifreeze, tires, furniture, construction chemicals, metals, paint solvents, aluminum cans, oil, lead, treated lumber, and wood pallets. Among new initiatives for 1993 were the implementation of a paper recycling program and the initiation of an affirmative procurement program to purchase products made from recycled materials. SRS was one of six DOE sites that received a Recycling and Affirmative Procurement Award from DOE in 1993 for its efforts in this area.

The site continued its support of community pollution prevention activities in 1993 through regional Earth Day activities for the Central Savannah River Area (CSRA), communitywide telephone book recycling, and sponsorship of workshops and presentations to schools and civic groups on recycling and source reduction.

Notice of Violation (RCRA)

SCDHEC issued an NOV to SRS on October 14, 1993, alleging storage and disposal of mixed waste without a RCRA permit. The NOV was based on information reported to SCDHEC by SRS in September 1993. SRS

representatives met with SCDHEC on November 17 to discuss the issue and present clarifying information. At the meeting, SCDHEC requested additional information, which was provided by SRS on December 16. The issue had not been resolved as of December 31, but a settlement agreement being negotiated between DOE and SCDHEC is expected to be finalized in 1994.

Comprehensive Environmental Response, Compensation, and Liability Act

SRS was placed on the National Priority List—or Superfund List—in December 1989, thereby making the site subject to CERCLA (Public Law 96-510), as amended by the Superfund Amendments and Reauthorization Act (SARA, Public Law 99-499). CERCLA assigns liability and provides for compensation, cleanup, and emergency response for hazardous substances released to the environment.

In accordance with Section 120 of CERCLA, DOE, EPA Region IV, and SCDHEC entered into a Federal Facility Agreement (FFA), which was executed by the three parties January 15, 1993, and declared effective by EPA Region IV August 16, 1993. Declaration of the effective date results in the FFA being an enforceable agreement. Additionally, EPA Region IV prepared responses to public comments on the FFA for inclusion in the CERCLA Administrative Record. The FFA, which sets the terms of environmental remediation at SRS, coordinates site cleanup activities into one comprehensive strategy.

Remediation under CERCLA imposes requirements in addition to existing RCRA requirements. SRS complies with all applicable or relevant and appropriate requirements when performing CERCLA activities. For example, additional training may be necessary for people working in RCRA/CERCLA units, depending on the specific activity. CERCLA also requires remedial decisions to be based on the results of the Baseline Risk Assessment, which examines present and future risk to human health and the environment from the waste unit, using conservative, EPA-approved exposure scenarios.

CERCLA also requires public participation in the selection of remediation alternatives. A significant step in this process is the development of a Proposed Plan, which highlights key aspects of the remedial investigation and feasibility study, provides a brief analysis of remedial alternatives under consideration, identifies the preferred alternative, and tells the public how it can participate in the remedy selection process. After public comment is received, a Record of Decision is issued that presents the selected remedy and provides the rationale for that selection. Also

included in this process is the establishment of an administrative record file that documents the remediation alternatives and provides for public review of them. The SRS Public Involvement Plan addresses the requirements of CERCLA, RCRA, and the National Environmental Policy Act (NEPA) of 1969.

All SRS releases to the environment, including those from the identified RCRA/CERCLA units, must be evaluated under the FFA. Work plans detailing the proposed investigations for the RCRA/CERCLA units must be approved by both EPA and SCDHEC prior to implementation. During 1993, 11 work plans were revised to incorporate regulatory comments and were resubmitted for approval as Revision 2 work plans. EPA and SCDHEC approved 11 work plans in 1993 that previously had been resubmitted.

Proposed Plans and final Records of Decision issued in 1993 documented the RCRA closure of the F-Area and the H-Area hazardous waste management facilities.

Two Interim Action Proposed Plans were submitted for review in 1993:

- The D-Area Oil Seepage Basin Interim Action Proposed Plan details an interim response to remove drums and debris from the basin.
- The Par Pond proposal details plans for refilling the Par Pond reservoir.

The FFA also identifies more than 300 on-site locations being evaluated to determine if they are subject to the integrated RCRA/CERCLA process. Site evaluation reports for 12 areas were submitted to EPA and SCDHEC during 1993.

As the mission for selected facilities at the SRS progresses from a national defense initiative to one of cleanup and environmental restoration, efforts and activities are under way to implement a transition of selected site facilities to the environmental division of DOE and to perform decontamination and decommissioning (D&D). Transition and D&D activities performed or initiated during 1993 are briefly described as follows:

- WSRC, in cooperation with DOE, requested and received written approval from SCDHEC to remove the cadmium control and safety rods from four reactors—K, L, P, and C. After removal, the rods will be packaged to meet the regulatory requirements for macroencapsulation and shipped to Waste Management for storage and disposal. This project is expected to be completed in 1994.
- Activities were initiated to stabilize and remove the L-Area hot-shop facility. This project also is targeted for completion in 1994.

- DOE appropriated additional funds in late 1993 that will be used to perform demonstration D&D activities in R-Area and the 232-F facility. Five support buildings were selected in R-Area for demolition. R-Area buildings that are not radiological areas and are not impacted by CERCLA and that have a minimal potential for RCRA impact were chosen. Plans are being developed to proceed with the demolition, which should be completed in 1994. Work, to be performed in the administration area of the 232-F facility, will include removal of loose equipment and materials, nonload-bearing walls, and asbestos. The gutted administration area will become the staging area for D&D work associated with the process and process support areas.
- Three support buildings of the heavy water component test reactor were selected for 1994 D&D.
- At the request of DOE-HQ, WSRC has initiated an effort to identify all surplus facilities and to assess their environmental and health and safety risk. Phase I of this effort was completed in December 1993. Phases II and III are to be completed during 1994.
- Separations equipment development facility characterization was initiated and 90 percent completed during 1993. Remaining activities to complete the characterization include trap removal and assay. Following completion of the characterization, activities will be initiated leading to D&D of the facility.

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 was enacted as a provision to SARA. EPCRA requires businesses to notify state and local emergency planning units about the hazardous chemicals used at their facilities, including inventories of these chemicals. Industries also must report releases of hazardous chemicals, such as CERCLA-reportable releases.

Under Section 312 of EPCRA, SRS completes an annual Tier II Inventory Report for all hazardous chemicals present at the site in excess of specified quantities during the calendar year. Hazardous chemical storage information is submitted to state and local authorities by March 1 for the previous calendar year.

Under Section 313 of EPCRA, SRS must file an annual Toxic Release Inventory (TRI) report by July 1. SRS calculates chemical releases to the environment and reports aggregate quantities for each regulated chemical that exceeds established threshold amounts. The Pollution Prevention Act of 1990 expanded the TRI reports to include source reduction and recycling

activities. Pollution prevention information has been reported annually since 1991. The compilation of data for 1993 had begun by the end of the year, but 1992 is the last year for which complete data are available. It is anticipated that compilation of the 1993 data will be finished by July 1994.

Eight chemicals, with releases totaling 76,763 pounds, were reported to EPA for 1992. This compares—following revisions to the original release estimates—with 118,963 pounds of nine chemicals released during 1991 and 131,130 pounds of 11 chemicals released during 1990. A breakdown of the comparison between the three years is presented in table 2-1. Figure 2-1 shows the overall reduction in total toxic chemical releases at SRS from 1987 to 1992.

33/50 Pollution Prevention Program

In September 1992, DOE formally became the first federal agency to agree to participate in EPA's 33/50 Pollution Prevention Program. Under the agreement, DOE voluntarily strives to reduce the use and release of 17 priority chemicals by 50 percent by the end of 1995 for government-owned, contractor-operated facilities that already report the releases under EPCRA. By the end of 1997, DOE will strive to achieve a 33 percent reduction in releases of the chemicals from facilities that do not report their releases but do meet the reporting thresholds.

SRS has been submitting release reports since 1988. The site's TRI reports indicate that releases of six of the 17 priority chemicals have exceeded a reporting threshold at least once since 1988. Three such chemicals—lead, toluene, and xylene—exceeded the threshold during 1992, accounting for 41,420 pounds released to the environment or transferred off site. A breakdown of the three chemicals and their associated releases in 1992 is presented in table 2-2.

Executive Order 12856

On August 3, 1993, President Bill Clinton signed Executive Order 12856, which requires that all federal facilities comply with right-to-know laws and pollution prevention requirements. Prior to establishment of the executive order, only private industries in Standard Industrial Classification codes 20-39 were required to comply with EPCRA. The executive order requires that federal facilities meet EPCRA reporting requirements and develop voluntary goals to reduce releases of toxic chemicals 50 percent by the end of 1999. SRS is meeting compliance requirements for EPCRA and is well ahead of many other federal facilities in establishing EPCRA programs.

The new executive order will have an impact on the site in terms of pollution prevention. The reduction in toxic chemical releases will go beyond the voluntary 33/50 program and will mean that SRS must incorporate all the toxic chemicals on the TRI report into the site's pollution prevention efforts.

National Environmental Policy Act

NEPA provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. Although implemented on site by the Energy Research and Development Administration during the 1970s, a formal maintenance and operations NEPA compliance group was not established at SRS until 1982. The ongoing mission of this group is to make recommendations regarding the level of NEPA review of a site-proposed action and to prepare draft documentation in support of DOE compliance with NEPA at SRS. In 1993, 412 reviews of new proposed actions were conducted at SRS and formally documented through categorical exclusions (CXs), notices of NEPA approval, special environmental analyses (SEAs) and associated supplements, or environmental assessments (EAs). WSRC also provided technical support to DOE-SR for the preparation of Environmental Impact Statements (EISs).

The types and numbers of NEPA activities conducted at SRS during 1993 are presented in table 2-3. Among the specific activities were the following:

- The revised draft EA on the remaining construction and operation of the uranium solidification facility in Building 221-H was submitted to DOE-SR in September 1993. The document is undergoing further revisions based on comments from DOE-HQ.
- The Finding of No Significant Impact (FONSI) for the EA on the natural resource management activities at SRS was approved in July 1993. This EA assesses the impacts associated with the ongoing efforts of the Savannah River Forest Station (SRFS) and other site contractors to ensure the environmental protection and responsible stewardship of natural resources at SRS.
- The final EA on construction and operation of a health protection instrument calibration facility was in August 1993. The FONSI for the proposed facility was approved in late August. The facility will be located in B-Area.
- The final EA on construction and operation of the proposed conference center by the University of Georgia's Savannah River Ecology Laboratory (SREL) at SRS was issued in July 1993. The FONSI was issued later that month. This proposed action will provide SREL with DOE permission to

Table 2-1 Releases of Toxic Chemicals—In Pounds—by SRS During 1990, 1991, 1992 Reporting Years (Reported Under EPCRA Section 313)

1990				
Chemical	Air Emissions	Water Discharges	Land Disposal	Off-site Transfers
Ammonia	430	1639	7700	0
Benzene	2,850	0	0	3,900
Chlorine	0	158	0	0
Freon 113	17,200	0	260	18,660
Lead	12	2	14,000	0
Manganese compounds	150	0	9972	6
Nitric Acid	8,000	0	0	0
Sulfuric Acid	0	180	76	0
Toluene	1,909	0	8	1,640
Trichloroethane, 1,1,1-	18,290	0	230	52
Xylene	17,004	0	2	6,800
Totals	65,845	1,979	32,248	31,058

1991				
Chemical	Air Emissions	Water Discharges	Land Disposal	Off-site Transfers
Ammonia	14,500	894	89	0
Chlorine	0	211	0	0
Freon 113	36,000	0	3	0
Freon 114	15,000	0	0	0
Halon 1301	11,064	0	0	0
Nitric Acid	3,601	0	0	333
Sulfuric Acid	4	0	0	9,009
Toluene	2,863	0	18	10,100
Xylene	5,530	0	44	9,700
Totals	88,562	1,105	154	29,142

1992				
Chemical	Air Emissions	Water Discharges	Land Disposal	Off-site Transfers
Ammonia	8,300	654	32	110
Chlorine	1	16	0	0
Freon 113	22,500	960	6	611
Lead	29	1	10,000	18
Nitric Acid	790	0	0	643
Sulfuric Acid	0	0	0	720
Toluene	3,560	0	4	5,403
Xylene	15,370	0	26	7,009
Totals	50,550	1,631	10,068	14,514

Figure 2-1 Total Toxic Chemical Releases at SRS, 1987-1992

The graph shows a distinct downward trend in toxic chemical releases at SRS between 1987 and 1992, with the sharpest drop occurring between 1988 and 1990.

Leaf Graph

construct and operate the conference center as part of its applied research mission at SRS.

- The final EA and FONSI on the proposed centralization and upgrading of the sanitary wastewater system at SRS were approved and issued in September 1993. This project will enable the site to comply with newly promulgated and proposed EPA and SCDHEC sanitary wastewater regulation by replacing or upgrading existing site sanitary wastewater facilities.
- The final EA and FONSI for the new whole body counter facility at SRS were issued in January 1993. This EA enables SRS to construct and operate a new in-vivo counting facility for monitoring employees for internal radionuclides.
- The final EA and FONSI for nonnuclear consolidation within the DOE complex were issued in June 1993. The purpose of this proposed action is to effect better management of nonnuclear manufacturing activities within the complex and to decrease the long-term operating costs of this aspect of the complex. This action includes transfer of the tritium handling facilities from DOE's Mound facility in Ohio to SRS.
- The final SEA assessing the potential environmental impact associated with management and maintenance of—and repair activities on—the Par Pond dam was issued by DOE-SR in April 1992, with subsequent updates in 1993. This document fulfilled a commitment made by DOE-HQ to the President's Council on Environmental Quality regarding the Par Pond issue.
- A supplement analysis for the revised process components of the Defense Waste Processing Facility (DWPF) was sent to DOE-HQ in November 1993. This supplement analysis will be used to determine if there is a need for preparation of a Supplemental Environmental Impact Statement for that SRS facility.
- A draft Notice of Intent to prepare an EIS on the waste management operations at SRS was pre-

Table 2-2 Summary of 33/50 Chemicals Exceeding Reporting Threshold for 1992 (In Pounds)

Chemical	Amount Used/ Processed	Air Emissions	Water Discharges	Land Disposal	Off-site Transfers
Lead/Compounds	11,306	29	1	10,000	18
Toluene	11,651	3,560	0	4	5,403
Xylene	30,520	15,370	0	26	7,009
Totals	53,477	18,959	1	10,030	12,430

Table 2-3 Types of NEPA Activities at SRS During 1993

Type of NEPA Documentation	Number
Categorical Exclusion Recommendation	18
Recommended Tiering to Existing NEPA Documentation	6
Sitewide Categorical Exclusion/Routine Insignificant Actions	409
Environmental Assessment	23
Special Environmental Analysis	1
Programmatic Environmental Assessment	3
Supplement Analysis	2
Environmental Impact Statement	3
Programmatic Environmental Impact Statement	3
Total	468

pared in December 1993. This EIS will assess the environmental consequences associated with the generation, management, and minimization of low-level waste, liquid high-level waste, nonradioactive hazardous waste, mixed waste, and transuranic waste at SRS.

- The Mitigation Action Plan for the K-Reactor, L-Reactor, and P-Reactor is updated annually. The plan identifies commitments made in the final EIS and in the record of decision for the referenced reactors regarding wetlands restoration. A related Program Implementation Plan also is updated annually. This document outlines the administrative controls and organizational structure established to ensure efficient and timely implementation of commitments addressed in the Mitigation Action Plan.

For a complete list of NEPA documentation activities at SRS during 1993, refer to table 2-4.

A total of 433 CXs were documented for the site during 1993. A new sitewide procedure for implementation of the revised DOE regulations (10 CFR 1021) concerning NEPA compliance within the DOE complex became effective in June 1993. The SRS Department NEPA Coordinator (DNC) certification program was officially implemented with the issuance of this procedure. DOE-SR approved the use of 47 sitewide CXs for routine insignificant actions at SRS. These CXs require documentation only at the DNC

level prior to project implementation. SRS was the first site in the DOE complex to be granted such authority within the NEPA compliance process. A DOE-SR/Environmental and Laboratory Programs Division surveillance of the DNC documentation of these CXs found the sitewide program to be well organized and the direct lines of communication well established. Based on the 1993 site self-assessment results, the NEPA final regulations (i.e., 10 CFR 1021) were successfully implemented at SRS through the following:

- Revision of the 3Q site procedure
- Issuance of an implementation plan
- Training
- The DNC training and certification program

The SRS NEPA program is recognized as a leader and model within the DOE complex.

Safe Drinking Water Act

The federal Safe Drinking Water Act (SDWA) was enacted in 1974 to protect public drinking water systems; it was amended in 1980 and 1986. SRS provides drinking water to its employees through 13 major treatment/distribution systems. Previously, there were 14 such systems, but on June 11, 1993, the Railroad Yard system was reclassified as a "small" system because of a population decrease.

The site continues to work toward upgrading these 13 systems. Approval of the SRS Domestic Water Consolidation Preliminary Engineering Report was issued by SCDHEC May 24, 1993. The report included the recommendation to consolidate 11 of the major site drinking water systems into three systems through the installation of three elevated storage tanks, looped distribution piping, and a centralized water treatment facility. Plans had been to consolidate all 14 of the major systems, but it subsequently was decided to reclassify the systems in L-Area and P-Area as small systems by 1997—also because of population decreases. Drinking water system consolidation, scheduled for completion by September 1997, replaces the upgrade plan submitted to SCDHEC in October 1991.

The D-Area drinking water system upgrade was completed and placed into operation July 22, 1993. This project consists of two wells, distribution system piping, chemical treatment facilities, and an elevated storage tank, which replaces the existing surface water treatment plant for drinking water service. Operation of the new system coincided with implementation of the SDWA Surface Water Treatment Rule.

SRS satisfactorily completed lead and copper compliance monitoring under the SDWA Lead and

Table 2-4 SRS Project NEPA Documentation Activities During 1993

Project Name	Level of NEPA Documentation
Environmental Restoration and Waste Management	PEIS ^a
Nuclear Weapons Complex Reconfiguration	PEIS
Domestic Spent Nuclear Fuel/INEL Environmental Restoration and Waste Management	PEIS
F/H Canyon Exhaust System	EIS ^b
Foreign Research Reactor Spent Nuclear Fuel	EIS
SRS Waste Management Operations	EIS
Waste Management Activities for Groundwater Protection	SA ^c
DWPF Process Revision	SA
Nonnuclear Consolidation	PEA ^d
Import of Russian Plutonium-238	PEA
Urgent-Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel	PEA
Par Pond Repair and Maintenance Activities	SEA ^e
Plutonium Storage in Building 247-F Vault	EA ^f
New Whole Body Counter Facility	EA
Upgrade Site Road System	EA
Uranium Solidification Facility in Building 221-H	EA
Natural Resources Management Activities	EA
Health Physics Site Support Facility	EA
Separations Engineering Development I and II Decommissioning and Decontamination	EA
Health Protection Instrument Calibration Facility	EA
Processing Plutonium Materials in F Canyon and Associated Facilities	EA
HB-Line Phases I and III	EA
Replacement High-Level Waste Evaporator	EA
HB-Line Phase II	EA
New Sanitary Landfill	EA
Plutonium Storage in 221-F Vault	EA
Centralization/Upgrading of Sanitary Wastewater System at SRS	EA
Domestic Water System Upgrade	EA
Nuclear Incident Monitor Upgrade	EA
400 D-Area Powerhouse Upgrade	EA
300 M-Area Vendor Treatment Process	EA
Radiological Equipment Maintenance Facility	EA
SREL Conference Center	EA
Commercial Cleaning of Regulated Laundry	EA
Sanitary Sludge Land Application Site	EA
^a Programmatic Environmental Impact Statement ^b Environmental Impact Statement ^c Supplement Analysis ^d Programmatic Environmental Assessment ^e Special Environmental Analysis ^f Environmental Assessment	

Copper Rule in 1993 for the A-Area/M-Area drinking water system. More than 90 percent of the samples collected were under the lead action level of 0.015 mg/L and copper action level of 1.3 mg/L. The National Primary Drinking Water Regulations specify that treatment technique requirements are triggered by exceedances of the lead and copper action levels measured in the 90th percentile. Therefore, the A-Area/M-Area drinking water system was in compliance for the 1993 sampling period. The remaining 12 SRS drinking water systems—all small domestic water systems—were sampled for lead and copper by December 31, 1993, as required by the Lead and Copper Rule. Except for the SRFS system, each system had less than 10 percent of all collected samples exceed the lead and copper action levels. A corrective plan of action has been developed for the SRFS system (see the Drinking Water section of chapter 9, “Nonradiological Environmental Surveillance”).

EPA issued approval July 16, 1993, for a reduced monitoring schedule for the A-Area/M-Area domestic water system under the Lead and Copper Rule. The National Primary Drinking Water Regulations specify that all public water systems that meet the lead and copper action levels or maintain optimal corrosion control treatment for two consecutive six-month monitoring periods may reduce the number of tap water sampling sites—and may reduce their collection frequency to once per year. Based on this approval, SRS plans to continue compliance sampling for the A-Area/M-Area system under a reduced monitoring schedule of 20 samples per year.

Clean Water Act

The Clean Water Act (CWA) of 1972 created the National Pollutant Discharge Elimination System (NPDES) program, which is regulated by SCDHEC under EPA authority. The program is designed to protect surface waters by limiting all nonradiological releases of effluents into streams, reservoirs, and other wetlands. Radiological effluents are covered under other acts. Discharge limits are set for each facility to ensure that SRS operations do not impact aquatic life adversely or decrease water quality.

SRS has three NPDES permits—two for industrial wastewater discharge (SC0000175 and SC0044903) and one for general stormwater discharge (SCR000000). Permit SC0000175 regulated 76 active NPDES outfalls at SRS during 1993. Five additional NPDES outfalls are regulated under permit SC0044903. Of these 81 industrial wastewater outfalls, 67 discharged (operated) during 1993, 10 did not discharge, and four were not in service. All the operational outfalls were sampled, while the 10 that

were not in operation continued to be monitored [SRS Data, 1994]. All analytical results, including those that indicated zero discharges at the 10 nonoperational outfalls, were reported to SCDHEC in the monthly discharge monitoring reports, per the NPDES permit requirements.

NPDES permit compliance at SRS has steadily improved during the past 10 years. In October and November 1993, SCDHEC personnel conducted a two-week audit of SRS wastewater facilities and found no deficiencies. This marked the fourth consecutive SCDHEC audit of wastewater facilities in which no deficiencies were noted. The compliance rate for 1993 was 99.9 percent, based on 8,000 analyses. Ten analyses exceeded NPDES permit limits. A list of exceedances, including the outfall locations, probable causes, and corrective actions, can be found in chapter 8, “Nonradiological Effluent Monitoring.”

Forty-eight stormwater-only point sources are covered under permit SCR000000 for stormwater discharges associated with industrial activity. Of the 48 point sources, 11 representative outfalls have been selected for monitoring. The outfalls represent a wide range of SRS activities, including

- storage, use, or disposal of EPCRA Section 313 chemicals
- land disposal units
- steam electric generation
- chemical and allied product manufacturing

As required by the general permit, a pollution prevention plan was developed and implemented for the identified stormwater outfalls. The plan identifies facility areas where best management practices and/or best available technology should be implemented to prevent or mitigate the release of pollutants with stormwater runoff.

SCDHEC issued a wastewater permit-to-operate for the high-level waste tank farms in March 1993. Receipt of the operating permit completes the transition of the entire high-level waste system from RCRA permitting authority to coverage under the CWA. Certain RCRA regulatory requirements, such as LDR provisions, will continue to be in effect for the tank farm operations. The high-level waste system includes the high-level waste tanks, the in-tank precipitation facility, the extended sludge processing facility, the DWPF, and the Effluent Treatment Facility (ETF).

SCDHEC also issued SRS a “no discharge” permit allowing land application of sanitary treatment plant biosolids to SRS pine forests. This permit allows beneficial reuse of biosolids by providing nutrients that enhance the growth rate of pine trees. Beneficial reuse is a concept highly promoted by EPA.

Under the federal Oil Pollution Prevention regulation (40 CFR 112), SRS must report petroleum product discharges of 1,000 gallons or more into or upon the navigable waters of the United States, or petroleum product discharges in harmful quantities that result in oil sheens. No such incidents occurred at the site during 1993.

SRS has an agreement with SCDHEC to report petroleum product discharges of 25 gallons or more to the environment. There was one such occurrence—approximately 250 gallons—during 1993 (table 2-6, page 29).

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act restricts the application of pesticides through a state-administered certification program. WSRC's pesticide procedure provides guidelines for pesticide use at SRS and requires that applicators be state certified. A pesticide use task group evaluates planned pesticide programs to ensure that they are acceptable and that appropriate pesticides are used so that any impact on the environment is minimal. The task group also

- maintains records of pest control activities
- assists in communicating information about pesticide use to other site contractors
- contacts off-site utility companies to determine what pesticide applications they plan on SRS property for their right-of-way maintenance

SRS pesticide programs typically include such activities as the maintenance of roadways and fence lines through the use of herbicides.

On or about May 26, 1992, a property owner adjacent to SRS found dead fish in a pond and dead bluebirds in several bird boxes. The owner, who had noticed that an SRS subcontractor had recently sprayed herbicides along an SRS fence line, was concerned that the spraying may have caused the fish and bluebird kill. An investigation was performed, with various samples taken and provided to SCDHEC and Clemson University for analysis. Analyses of the results, completed in 1993, concluded that herbicides applied along the SRS fence line did not cause the fish/bluebird kill.

Clean Air Act

The CAA provides the basis for protecting air quality and regulating air pollution. Except for radioactive sources, which are regulated by EPA, regulation of air

emissions under the CAA has been delegated to SCDHEC. SRS has several air quality control permits; they are identified by individual permit numbers for each area, with each individual source identified separately on the area permit. Several construction permits have been issued by SCDHEC's Bureau of Air Quality Control. Under the CAA, SRS is classified as a "major source" and, as such, has been assigned one permit number for the site by SCDHEC. The bureau is in the process of renewing SRS operating permits with the new site permit number (0080-0041) and with each permitted source identified by the area designation, by a point identification number, and by a source description. These permits regulate 172 point sources for criteria and toxic air pollutant emissions. Of the 172 sources, 62 are diesel generators, which are exempt from regulatory requirements for operations of less than 250 hours per year.

During 1993, SCDHEC conducted 100 source compliance inspections at SRS. These include biennial stack tests, initial operation inspections following completion of construction, and annual compliance inspections.

National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) is a CAA-implementing regulation that sets air quality standards for air emissions containing hazardous constituents, such as radionuclides (40 CFR 61, Subpart H), benzene, asbestos, and other hazardous pollutants. Regulation of hazardous air pollutants, except radionuclides, has been delegated to SCDHEC.

SRS, like most South Carolina industrial complexes, uses a number of chemicals identified by SCDHEC as toxic air pollutants and by EPA as hazardous air pollutants. These include many common consumer products—off-the-shelf bug sprays, correction fluids, paints, sealers, janitorial cleaning supplies, gasoline for vehicles, etc.—as well as a number of typical industrial chemicals, such as degreasers, solvents, metals, batteries, diesel fuel, etc. But SRS has at least one category, radionuclides, not found in typical industrial settings. During the course of normal operations, some radionuclides are released to the air. The air emissions are regulated by SCDHEC and EPA Region IV.

NESHAP Radionuclide Program The SRS NESHAP radionuclide program continues to change to incorporate sampling, monitoring, and dose assessment practices that meet or exceed the requirements of 40 CFR 61, Subpart H. Work is proceeding on schedule under the radionuclide FFCA signed October 31, 1991.

The first amendment to the FFCA for Radionuclide NESHAP was signed by EPA Region IV on August 16,

1993. The amendment will provide SRS with an extension to the original FFCA through February 10, 1995, in order to accomplish monitoring upgrades to several additional sources.

A comprehensive analysis of all SRS radionuclide emission sources, both point and nonpoint, was completed in late 1991. Because of modifications in the dose modeling, the analysis was repeated in 1992. Results of the 1992 analysis indicated that only four of 260 point sources would require monitoring equipment upgrades—not because they emit significant doses, but because of their proximity to the site boundary. The upgrades were added to the FFCA, which requires that monthly progress reports be submitted to EPA. During 1993, the maximally exposed individual effective dose equivalent, calculated using the NESHAP-required CAP88 computer code, was estimated to be 0.18 mrem (0.0018 mSv), which is 1.8 percent of the 10-mrem/yr (0.10-mSv/yr) EPA standard (chapter 7, "Dose").

NESHAP Nonradionuclide Program As previously indicated, SRS uses many chemicals identified as toxic or hazardous air pollutants. As required by SCDHEC Air Pollution Control Regulation 62.5, Standard No. 8 (toxic air pollutants), SRS completed and submitted an air emission inventory and air dispersion modeling data for all site sources by June 28, 1993. The submitted data demonstrated compliance by computer modeling the accumulated ambient concentration of individual toxic air pollutants at the property line and comparing them to the Standard No. 8 maximum allowable concentrations. Under Title III of the federal Clean Air Act Amendments (CAAA) of 1990, EPA will publish a list of hazardous air pollutant-emitting source values potentially subject to maximum available control technology standards. The list includes all radionuclides as a single item, along with 188 toxic air pollutants.

Air Emissions Inventory The CAAA also include, under Title V, a major new permitting section expected to have a significant impact on the site. Title V will require that SRS submit new application packages for some new air sources and for some already-permitted sources. The full impact on the site is not yet known, however, because the implementation plan submitted to EPA by the State of South Carolina has not been approved.

To meet these standards, SRS personnel conducted a comprehensive air emissions inventory of all site facilities in 1993 to demonstrate compliance with Standard No. 8, to ensure that all radiological and nonradiological sources have been accounted for, and to better characterize waste streams from site processes. A database and a series of data collection

forms were developed, and site employees—assisted by two off-site subcontractors—mobilized to accomplish this effort. Guidelines and procedures were written to ensure documentation of all vents and stacks for each building and to calculate design emissions, maximum potential emissions, and actual emissions for a selected period of time.

The inventory data for 1990 was used to support the SCDHEC Standard No. 8 requirements and will be used for future permitting needs. The inventory identified approximately 5,300 radiological and nonradiological air emissions sources. The site is expected to record the remaining data, for the years 1991 through 1993, by February 1994.

Ozone-Depleting Substances The CAAA of 1990 contained a chapter under Title VI addressing stratospheric ozone protection. This new law requires that EPA promulgate a number of regulations to phase out the production and consumption of ozone-depleting substances (ODS). The substances commonly are used as refrigerants in air conditioning and cooling systems (Freon); degreasers and cleaners; spray can propellants; fire suppressants (Halon); and many other common consumer products. The phaseout of these substances is likely to have a significant impact on the site and across the United States—on industry and on everyday consumer items.

Several sections of Title VI of the CAAA, along with recently promulgated regulations from EPA, apply to the site. The ODS are regulated in two general categories: Class I substances, or CFCs, and Class II substances, or hydrochlorofluorocarbons (HCFCs). CFCs are about 10 times more ozone-depleting than HCFCs, and thus are more strictly regulated. As required by the CAAA, most CFCs will be phased out of production by January 1, 1996, and Halon (a subgroup of Class I ODSs) will be phased out by January 1, 1994. This means that several very important refrigerants (Freon 11, 12, 114, and 502) used on site essentially will be nonexistent after 1995. Many of the large chillers on site that use these refrigerants are being scheduled for retrofits with chemical substitutes or for total replacement. The site also is scheduling fire suppression (Halon) system replacements. Many common degreasers are CFCs and have been targeted for replacement for several years. Most major degreasing applications already have been eliminated or replaced with HCFCs or non-ODS. Smaller ODS degreasing applications, such as those in maintenance and electrical shops, are being targeted for phaseout.

DOE-HQ has requested from each DOE site an annual report describing progress made toward the phaseout of ODS. The first report, which contained a detailed

Table 2-5 Equipment Affected by ODS Phaseout at SRS

Refrigeration Units	>8,000
Fire Suppression Units	371
Laboratory Applications	6
Degreasing Applications	Consumer Products

description of SRS's ODS program and its progress to date, was submitted to DOE-HQ prior to the December 31, 1993, deadline.

The site has set up a CFC steering committee comprised of participants from all the major users of these substances. A number of technical subcommittees also were initiated to address particular applications, such as refrigeration, fire suppression, degreasers, laboratory applications, and environmental compliance. Initial inventories of equipment have been completed and some of the general results appear in table 2-5.

The site program includes regular environmental compliance surveillance by DOE-SR and WSRC of site facilities for compliance with 40 CFR 82, Subparts B (Servicing of Motor Vehicle Air Conditioners), E (Labeling of Products Using ODS), and F (Recycling and Emissions Reduction). The site has purchased appropriately certified recycling equipment, trained and certified technicians where required, begun recordkeeping and leak-tracking for large cooling systems, and implemented proper labeling and other recordkeeping requirements.

NESHAP Asbestos Removal Program Asbestos insulation, considered one of the best boiler and piping insulators, can be found in older buildings throughout SRS. This is because people were unaware of the danger of airborne asbestos fibers in the early 1950s, when SRS was constructed. Today, however, it is known that asbestos can cause cancer in humans.

Through its asbestos removal program, SRS has contracted certified instructors to teach employees the correct way of performing asbestos abatement projects. In 1993, the site identified and trained a number of specialists on the proper methods of asbestos removal. This paved the way to a 50 percent reduction in the program's training costs, with no loss of efficiency, and in its respirator-fit testing and medical recordkeeping costs.

SRS continues to maintain two trained professionals who coordinate permitting and approvals from SCDHEC for all departments working under WSRC.

Asbestos is removed during maintenance and renovations of equipment and buildings. During 1993, SRS removed 12,372 linear feet and 4,384 square feet of asbestos pipe and surface insulation. An additional 79,548 square feet of transite panel, which contains asbestos, also was removed. It is estimated that 24 percent of the friable asbestos—a form that can be crumbled or pulverized with hand pressure when dry—has been removed from the site since a program of removal was begun in 1988. The site will continue to identify and remove such asbestos according to state (SCDHEC R.61-86.1) and federal (40 CFR 61, Subpart M) regulations and best management practices.

Notice of Violation

Two inspections involving stack tests resulted in an NOV being issued on October 20 to SRS by SCDHEC under the CAA. The NOV was the result of failed biennial source compliance tests for two coal-fired boilers in H-Area. The particulate matter emission rates for the two boilers, calculated from stack test results, exceeded the maximum permitted limit. The excess emissions, which occurred during regulatory compliance testing in January and June 1993, did not pose a threat to public health or to the environment, and corrective actions have been taken. One of the two boilers passed a compliance retest in September 1993; the other, in December 1993. An enforcement conference for this NOV was conducted November 30, 1993. However, no consent order or monetary penalty had been imposed by the end of the year.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) gives EPA comprehensive authority to identify and control chemical substances manufactured, imported, processed, or used in the United States. Reporting and recordkeeping are mandated for new chemicals and for any chemical that may present a substantial risk of injury to human health or the environment. WSRC's Environmental Protection Department (EPD) and Industrial Hygiene Section coordinate reporting and recordkeeping requirements under TSCA.

Polychlorinated biphenyls (PCBs) are chemicals specifically regulated under 40 CFR 761 of TSCA. PCBs have been used in the past in various SRS processes. PCBs on site are in pre-1979 electrical equipment in the form of transformers, small capacitors, and fluorescent light ballasts. The site has a well-structured PCB program that complies with TSCA regulation 40 CFR 761, with DOE orders, and

with WSRC policies. Also, the EPD surveillance program is in place to help site organizations comply with the regulations. The 1992 PCB Annual Document Log was completed prior to the July 1, 1993, deadline in full compliance with the regulations. Disposal of PCBs from SRS is conducted at EPA-approved disposal facilities within the regulatory time frame.

In August 1993, PCBs were confirmed to be present as a component of dense nonaqueous phase liquids in samples from two groundwater monitoring wells around the M-Area hazardous waste management facility. Regulators were notified and a modification to the Part B Permit Application to address the discovery of PCBs was submitted to SCDHEC. Any waste generated was handled according to the appropriate TSCA and RCRA requirements. Savannah River Technology Center (SRTC) continues to study ways to remediate the dense nonaqueous phase liquids.

SRS has some PCBs—radioactively contaminated during a spill—that have been stored on site since 1978. TSCA regulations call for annual disposal of PCB waste, but there is insufficient capacity for disposal of radioactive PCB waste off site. These radioactive PCB materials are stored on site in a facility that meets storage requirements under 40 CFR 761.65 (b) (1). SRS continues to seek disposal technologies and facilities that can handle radioactive PCB waste. A task team is investigating the possibility of treating the waste with a dechlorination process, and a treatability study is being considered to demonstrate this process. Additionally, the site is investigating the possibility of sending this waste to another DOE facility.

Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of wildlife, fish, and plants in danger of becoming extinct. The act also conserves the ecosystems on which such species depend.

Several endangered species exist at SRS. The site conducts research on the wood stork, the red-cockaded woodpecker, the bald eagle, the smooth purple coneflower, and the shortnose sturgeon. Studies of the bald eagle on Par Pond are being formulated to comply with the Endangered Species Act, as requested by the U.S. Fish and Wildlife Service. Programs designed to enhance habitat also are in place. NEPA reviews of new projects at SRS in 1993 found no activities of significant impact.

National Historic Preservation Act

The National Historic Preservation Act of 1966, Section 106, governs the protection of archaeological and historical resources. SRS ensures that the site is in compliance with this act through the site-use process. All sites being considered for activities such as construction are evaluated by the University of South Carolina's archaeology group to ensure that archaeological or historic sites are not impacted. NEPA reviews of new projects at SRS in 1993 found no activities of significant impact.

Floodplains and Wetlands

Under DOE General Provisions, 10 CFR, Part 1022 ("Compliance with Floodplains/Wetlands Environmental Review Requirements"), establishes policies and procedures for implementing DOE's responsibilities in terms of compliance with Executive Orders 11988 ("Floodplain Management") and 11990 ("Protection of Wetlands"). Part 1022 includes DOE policies regarding the consideration of floodplains/wetlands factors in planning and decision making. It also includes DOE procedures for identifying proposed actions involving floodplains/wetlands, providing early public reviews of such proposed actions, preparing floodplains/wetlands assessments, and issuing statements of findings for actions in floodplains.

Executive Order 11988, "Floodplain Management"

Executive Order 11988, "Floodplain Management," was established to avoid long- and short-term impacts associated with the occupancy and modification of floodplains. Evaluation of impacts to SRS floodplains is ensured through the NEPA Evaluation Checklist and the site-use system. Site-use applications are reviewed for potential impacts by WSRC, DOE-SR, SRFS, and SREL, as well as by professionals from other organizations. NEPA reviews of new projects at SRS in 1993 found no activities of significant impact.

Executive Order 11990, "Protection of Wetlands"

Executive Order 11990, "Protection of Wetlands," was established to mitigate adverse impacts to wetlands caused by destruction and modification of wetlands and to avoid new construction in wetlands wherever possible. Avoidance of impact to SRS wetlands is ensured through the site-use process, various departmental procedures and checklists, and project reviews by the SRS Wetlands Task Group. Many groups and individuals, including scientists at SRTC, SREL, and EPD, review site-use applications to ensure that proposed projects do not impact wetlands. NEPA

reviews of new projects at SRS in 1993 found no activities of significant impact.

Occurrences Reported to Regulatory Agencies

CERCLA requires notification of the National Response Center if a nonpermitted release of a reportable quantity (RQ) or more of a hazardous substance (including radionuclides) is released to the environment. The CWA requires that the National Response Center be notified if an oil spill causes a "sheen" on navigable waters of the United States, such as rivers, lakes, or streams. Reporting of oil spills was reinforced with liability provisions in CERCLA's National Contingency Plan.

Other CERCLA provisions allow exemptions from reporting a release of an RQ or more of a hazardous substance if the release is covered by a continuous-release notification or if it is "federally permitted." A continuous-release notification provides an exemption from reporting each release of a specific hazardous substance greater than an RQ. Rather, releases of the substance are reported annually.

Federally permitted releases comply with a legally enforceable license, permit, regulation, or order. Under the Atomic Energy Act, for example, releases of SRS radionuclides are federally permitted as long as public dose standards in DOE orders are not exceeded.

EPCRA (40 CFR 355.40) requires that reportable releases of extremely hazardous substances or CERCLA hazardous substances be reported to any local emergency planning committees and state emergency response commissions likely to be affected by the release.

Other regulations and agreements require that SCDHEC be notified when regulatory thresholds are exceeded. Also, it is SRS policy to notify SCDHEC and the Georgia Department of Natural Resources (GDNR) of any occurrence that may interest state regulatory agencies. Although not required by law, these "courtesy notifications" enhance environmental protection objectives by providing state regulatory agencies the opportunity to review occurrences that may degrade the on-site environment.

SRS submitted two continuous-release notifications to regulatory agencies during 1992. The first was for releases of ethylene glycol (antifreeze), which has a statutory RQ of one pound. Since many vehicles and a significant amount of equipment at SRS require ethylene glycol, releases of one pound or more occur routinely.

The second notification was for friable (crushable) asbestos. Routine asbestos releases in excess of the one-pound RQ occur at nonoperational facilities likely to be dismantled in the future. The upper limit for reporting a single asbestos release is 100 pounds.

Follow-up annual reports were submitted in 1993 for both of the 1992 continuous-release notifications. The reports indicate that the annual continuous releases are 210 pounds of ethylene glycol and 315 pounds of asbestos.

Table 2-6 lists the occurrences reported to regulatory agencies during 1993 (excluding ethylene glycol and asbestos). None of the five notifications represent spills or releases of a CERCLA RQ. This compares with three CERCLA-reportable releases during 1992 and four during 1991.

Appraisals and Surveillances of Environmental Programs

The SRS environmental program is overseen by a number of organizations, both outside and within the DOE complex. Each year, this involves numerous appraisals and surveillances of various aspects of the program. In 1993, within the DOE complex, 12 appraisals, 134 WSRC surveillances, and 40 DOE-SR surveillances were conducted. Also, SCDHEC performed three comprehensive compliance inspections in 1993: an air compliance inspection, an NPDES compliance inspection, and a RCRA comprehensive monitoring evaluation inspection.

Appraisals

The appraisals, which are formal evaluations of environmental programs, included nine DOE-SR comprehensive compliance assurance reviews, two DOE-SR comprehensive environmental reviews, and one WSRC management appraisal. The 12 appraisals conducted by DOE-SR and WSRC assessed SRS environmental programs and its compliance with environmental regulations. Among programs reviewed in 1993 were the

- Federal Insecticide, Fungicide, and Rodenticide Act Implementation Program
- Meteorological and Atmospheric Release Tracking and Monitoring Program
- Unplanned Environmental Release Response and Emergency Notification Program
- NPDES Data Management Program
- Regulatory Commitment Tracking Program
- Hazardous Waste Management Training Program
- Stormwater Management Program

Table 2-6 SRS Releases Reported to Regulatory Agencies In 1993

Date	Applicable Regulation/ Reason for Notification	Agencies Notified	Description
March 4	Courtesy notification	SCDHEC	Approximately 5 pounds of hydrochloric acid/charcoal absorber leaked from a drum to the ground.
March 14	Agreement to report sewage releases of greater than 100 gallons	SCDHEC	Six portable toilets were blown over, releasing approximately 250 gallons of sewage to the ground.
March 17	Courtesy notification	SCDHEC	Approximately 5 gallons of kerosene overflowed from a drum to the ground.
September 11	Agreement to report petroleum product releases of greater than 25 gallons	SCDHEC	Approximately 250 gallons of fuel oil spilled to the ground when a pump switch failed.
October 22	Courtesy notification	SCDHEC	A Department of Transportation shipping package containing sodium hypochlorite cracked, releasing fumes to the air (no material released).

- Groundwater Sampling Program
- Environmental Compliance Management Program

Surveillances

The 134 WSRC surveillances and 40 DOE-SR surveillances were conducted to investigate compliance-related concerns associated with emergencies, to randomly evaluate site programs and facilities, and to supplement and follow up on DOE-SR's Comprehensive Environmental Protection Assessment Program evaluations. The 1993 surveillances were conducted on spills and releases, drinking water systems, water treatment systems, and waste handling and storage.

SRS Tiger Team Environmental Assessment

In 1989, Energy Secretary James D. Watkins announced a plan to strengthen the Environmental, Safety, and Health (ES&H) activities within the DOE complex. During the first quarter of 1990, the DOE Tiger Team assessed SRS environmental, safety, health, and management areas to determine the site's compliance with applicable DOE orders and federal, state, and local requirements. The environmental assessment subteam concentrated on 10 areas: air; soils and sediments; surface water; hydrogeology; waste management; toxic and chemical materials; quality assurance; radiation; inactive waste sites; and NEPA.

WSRC prepared a Tiger Team Action Plan to address the findings from all areas evaluated. The original plan

identified 211 actions required to correct findings from the environmental portion of the assessment; however, additional actions were identified as some of the findings were closed, boosting the total number of actions required to 238. Most of the findings were administrative in nature, and none represented a threat to public health or the environment. As of November 12, 1993, all 238 of the actions had been completed; by December 31, DOE-SR had validated 194 of them. Though DOE-SR will not formally validate the remaining actions, WSRC is expected to continue to close and validate them on schedule and to notify the appropriate DOE-SR office—as well as DOE-SR's Quality Programs Division—of all closure/validations. DOE-SR will monitor WSRC's progress on the actions through its continuing oversight activities.

More on specific Tiger Team Assessment findings and on plans to correct the findings can be found in the following publications: *Tiger Team Assessment of the Savannah River Site Environment, Safety, and Health* [DOE, 1990a] and *Savannah River Site Action Plan in Response to the Department of Energy Environmental Health and Safety Compliance Assessment of the Savannah River Site* [WSRC, 1990a].

The DOE Progress Assessment Team conducted an on-site assessment of the ES&H programs at SRS during February and March 1993. The assessment represents a follow-up to the March 1990 visit from DOE's Tiger Team. Overall, the assessment team found that a significant number of actions had been taken since the 1990 visit, and that these actions resulted in considerable progress in all aspects of the ES&H program at SRS.

Table 2-7
SRS Construction and Operating Permits

Type of Permit	Number of Permits		
	1991	1992	1993
Air	133	134	172
C.O.E. 404 (Dredge & Fill)	1	1	1
Domestic Water	111	127	146
Industrial Wastewater	79	75	79
NPDES—Discharge	2	2	2
NPDES—No Discharge	0	0	1
NPDES—Stormwater	0	1	2
RCRA	1	1	1
Sanitary Wastewater	112	119	120
SCWRC (Stream Crossing)	1	1	1
Solid Waste	6	6	6
Underground Storage Tank	11	11	13
Totals	457	478	544

The Progress Assessment Team's final report identified several strengths, concerns, and weaknesses noted during its assessment. Of these findings, one strength, two concerns, and two weaknesses were attributed to WSRC environmental programs. The strength discussed WSRC's implementation of a comprehensive program for managing hazardous and mixed waste satellite accumulation areas, resulting in the significant reduction of risk regarding the management of waste at the point of generation. The concerns and weaknesses involved minor deficiencies in WSRC's environmental monitoring, quality assurance, and waste management facility inspection programs. WSRC prepared response sheets providing corrective action plans to address each of the concerns and weaknesses, and 13 action items were developed to address them. Eight of the 13 action items were completed as scheduled during 1993. The five remaining items are scheduled for completion during 1994.

Environmental Permits

SRS has 544 construction and operating permits that specify operating levels for each permitted source. This compares with 478 such permits in 1992 and 457 in 1991. Table 2-7 summarizes the permits held by the site during the last three years. Appendix B provides a comprehensive list of the permits, including the permit number, type of permit, and permitted source.

Environmental Training

Documented as Employee Education, the SRS environmental awareness and training programs play an important role in achieving environmental goals at the site.

SRS is committed—as a matter of policy—to maintaining its facilities and conducting its operations in full compliance with all applicable laws and regulations for the protection of the environment and of the health and safety of its employees and the general public. The awareness program is designed to communicate SRS environmental philosophy and policy to the employees.

The training program is designed to identify training activities needed to teach job-specific skills that protect the environment and satisfy regulatory training requirements. The SRS Environmental Training Plan, WSRC-RP-92-282, issued in February 1992, is a documented framework for implementing and managing an integrated environmental training system at the site. The plan addresses federal and state environmental regulations. Emphasis initially is on federal regulations, with state regulations added as requirement validation is completed. The focus is on the required training and the recommended education courses for workers, supervisors, and managers involved with environmental oversight, hazardous materials, and waste management at SRS. The training program includes formal delivery (classroom, self-paced, computer-based, etc.) as well as documented, supervised on-the-job experience, when appropriate. All training activities are documented, and programmatic and individual records are maintained.

The SRS Environmental Training Plan represents a centralized, total quality approach to environmental training, with a primary objective of training and developing employees into "partners in environmental excellence."

A number of achievements were marked in environmental training during 1993:

- SRS Environmental Training Plan HAZWOPER courses (29 CFR 1910.120) that had been developed and implemented in 1992 continued to provide employee health and safety training in 1993 for those involved in hazardous waste cleanup activities and in performing work at RCRA treatment, storage, and disposal facilities.
- The Consolidated Annual Training Program was developed.
- SRS began procuring environmental courses from off-site locations for on-site delivery to provide up-to-date information on environmental regulations in the most cost-effective manner possible.

- The Environmental, Safety, Health, & Quality Assurance Division's training program continued to maintain and enhance relations with other government owned, contractor-operated organizations to facilitate the exchange of environmental training courses and programs that can be adapted to meet SRS needs.
- SRS continued to provide instructors and students to the DOE/Westinghouse School for Environmental Excellence, which will be hosted by the site in January 1994.
- The Central Environmental Committee Executive Committee used the SRS 1993 Total Quality Days Conference to identify training needs and levels and establish core and advanced training for SRS environmental coordinators. The first core environmental coordinator training class is scheduled for early 1994.
- DOE-SR completed a comprehensive compliance assurance review of the SRS Hazardous Waste Management Training Program (Report No. 07-01-93-0014) in August, noting three proficiencies, one deficiency, and seven recommendations, three of which required responses. Corrective action plans and/or responses have been submitted and are being implemented.
- No training deficiencies were cited or recommendations made on the 1993 SCDHEC Comprehensive Monitoring Evaluation Audit.

Other Major Environmental Issues and Actions

Key SRS compliance issues addressed during 1993 included

- the concerns of Georgia officials that tritium may be migrating under the Savannah River to groundwater in that state
- the Par Pond drawdown
- lawsuits involving the K-Reactor cooling tower and the HB-Line restart

Tritium Migration

The Georgia officials' concerns about the migration of tritium in groundwater are being addressed by two studies—one on regional groundwater flow and the other on tritium in and around Burke County, Georgia. These studies are reviewed quarterly by technical advisory committees that consist of representatives from the U.S. Geological Survey (USGS), GDNR, DOE, WSRC, the South Carolina Geological Survey, and several area universities.

Regional Groundwater Study

Work began on a USGS study in 1991 to determine groundwater flow patterns in the CSRA. Formulation of the study approach had begun in 1988. The original scope of the study was revised several times in response to congressional inquiries regarding the SRS groundwater monitoring program and to Georgia officials' concerns that tritium may be migrating under the Savannah River to groundwater in that state.

The USGS study, also known as the Trans-River Flow Project, is developing a computerized model of the groundwater flow in the CSRA. The model involves a detailed three-dimensional representation of the area's topography, stratigraphy, and rock properties. An unusually large database is involved because of the area's size and because of the amount of detail available from more than 400 monitoring wells, geophysical surveys, aquifer pump tests, and groundwater analyses. The model will quantitatively relate the groundwater flows of the area's aquifers to each other and to surface discharge into the area's streams.

In addition to its size and detail, the model is unique in that it defines the hydrologic interrelationship of two large areas on either side of a major river. This requires an unusual level of data collection along the Savannah River, including geophysical surveys and, on the Georgia side, five new monitoring well clusters. Preliminary data from seismic lines and auger borings along three river transects indicate the depth to which the Savannah River valley is incised into the coastal plain aquifers and the thickness of the river bottom sediments.

Tritium in Burke County

The GDNR began a study, also in 1991, to determine the extent of tritium discovered in several domestic water supply wells in Burke County. A September 1993 GDNR report ("An Investigation of Tritium in the Gordon and Other Aquifers in Burke County, Georgia") to the Governor of Georgia offers a summary of historical tritium releases at SRS, of the natural background of tritium in the environment, and of tritium in rainfall that enters surface waters and the water table aquifer. The water table aquifer drains directly into the bottoms of the local creeks and also enters them through visible springs and seeps. Based on three years of study by GDNR, the concentration of tritium, equivalent to that found in average rainfall in the area, is well below EPA's maximum contaminant level for tritium in drinking water.

Figure 2-2 is a water table surface contour map that shows dendritic patterns of depression where the water table is lowered by drainage into the creeks. At any point, the direction of groundwater flow is perpendicular to the contour lines.

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Figure 2-2 Jacksonian Aquifer

A contour map of the water table surface in eastern Burke County, Georgia, shows the direction of groundwater flow [Summerour, 1993 (modified)].

lar to the contours and from the adjacent higher contour toward the lower contour. Thus, the groundwater flow is from the highlands toward the Savannah River to the northeast and its tributaries. There is no direct groundwater flow that can move tritium from SRS to the water table aquifer in Georgia.

The highest tritium result found in a well was less than 2,000 pCi/L, which is 10 percent of the EPA drinking water standard. The highest tritium concentration seen in water from 110 supply wells was 1,500 pCi/L (at Delaigle Trailer Park Well No. 3), and the highest concentration seen in groundwater monitoring wells was 1,700 pCi/L (at Cluster Site No. 2, near River and Hancock Landing roads).

No tritium has been confirmed in any of the wells drawing water from the Gordon aquifer—a confined aquifer below the water table aquifer—which serves as a drinking water source for several Georgia counties. The 10 anomalous wells that showed evidence of tritium in the 1991 study subsequently were found to be producing water from the near-surface water table aquifer—not from the Gordon aquifer.

The tritium values found in well waters match those found in springs and the smallest streams (figure 2-3). The highest value—from about two miles northwest of Vogle Electric Generating Plant—may be interpreted as the western side of the rainfall pattern around SRS (figure 2-4). A comparison of the tritium measurements from springs and the smallest creeks in eastern Burke County for 1991, 1992, and 1993 indicates that the tritium is decreasing with time.

The first phase of the Georgia tritium project essentially was completed with the September 1993 release of the GDNR report to the Governor of Georgia. The 1991 study has shown that 1) flow patterns are toward the river from both sides, 2) tritium concentrations are higher in shallower wells, and 3) tritium concentrations mimic rainfall concentrations. The report's data are completely consistent with airborne tritium transport and do not support trans-river migration of tritium.

The GDNR has received \$500,000 from DOE for a second phase of the study. Some of the key items this phase is expected to provide are

- electric logs of existing domestic wells

Figure 2-3 Tritium in Surface Water

A contour map shows tritium in the surface water of eastern Burke County, Georgia, in October 1993. Values are in pCi/L (picoCuries per liter). The illustration was provided by GDNR.

- a new monitoring well cluster on the southwest side of the Savannah River near the Pen Branch fault
- a high-resolution seismic line to aid in the selection of the well cluster site
- measurement of the tritium distribution in the unsaturated zone above the water table at the well cluster site
- establishment of rainfall monitoring stations from which tritium will be measured
- continued measurement of tritium mainly from springs and seeps during a dry spell in the fall
- continued measurement of 110 domestic wells for tritium
- a master's thesis to conduct a hydraulics study

Par Pond Drawdown

Par Pond, a 2,640-acre reservoir constructed in 1958 on Lower Three Runs Creek, served as a recirculating cooling reservoir for P-Reactor and R-Reactor.

In March 1991, an inspection of the Par Pond dam revealed a depression on the downstream face. Subsequent investigations revealed piping (erosion around the outside of buried conduits) and erosion of fill materials within the dam. Although the investigation revealed no imminent potential for dam failure, precautionary measures were taken. To minimize the potential for failure and to decrease the magnitude of associated flooding, the reservoir was drawn down to the 181-foot elevation, representing a reduction of the original volume by about two-thirds; normal reservoir elevation is 200 feet above mean sea level. The drawdown exposed approximately 1,300 acres of contaminated sediments (radioactive cesium and mercury) and led to notable impacts on the ecosystem. SRTC and SREL are conducting extensive radioecological and water quality studies on the effects and impact of the drawdown.

In March 1992, the exposed sediment area of Par Pond was declared a unit to be addressed under CERCLA, and—at EPA's request—a baseline risk assessment was conducted using existing data. The assessment indicated there was no significant risk to off-site or on-site personnel. A Focused Feasibility Study was

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Figure 2-4 Tritium in Rainfall

The map shows the distribution of tritium in rainfall around SRS, based on rainfall samples from 1982 through 1986 [Murphy et al, 1991 (modified)].

conducted to identify interim remedial alternatives to address human health and environmental concerns associated with the exposed sediment.

A public involvement notice, press release, and administrative record were issued in June 1992, per CERCLA requirements. An SEA and updates have been performed to satisfy NEPA requirements, which included an evaluation of the environmental impact of the drawdown, the repairs, and the refill.

WSRC's Site Services Engineering and Environmental Protection departments have recommended that DOE repair and refill the dam as quickly as possible to its original level. Congressional funding has been authorized to repair the dam at an estimated cost of \$10 million, with completion of the repairs scheduled for August 1994.

Several additional studies have been completed, including seismic studies, a probable maximum flood study, and a probabilistic risk assessment.

A CERCLA Interim Action Proposed Plan, which assesses and screens environmental impacts and costs of remediation alternatives, has been completed, with DOE-SR comments incorporated. The plan was sent to EPA Region IV and SCDHEC on December 3, 1993.

Lawsuits

Two lawsuits filed in the U.S. District Court of South Carolina in 1990 and 1993 resulted in 1993 dismissals without prejudice.

K-Reactor Cooling Tower

On June 11, 1990, the Natural Resources Defense Council and the Energy Research Foundation filed a lawsuit in the U.S. District Court of South Carolina requesting that K-Reactor not be restarted without a cooling tower in place. Connection of the cooling tower to K-Reactor was completed December 31, 1992, as required by the consent order between South Carolina and SRS. A joint stipulation settling the case was filed February 2, 1993, with the district court, which subsequently issued an order dismissing the complaint without prejudice.

HB-Line Restart

The Energy Research Foundation filed a complaint January 4, 1993, against DOE in the U.S. District Court of South Carolina, alleging that an EA issued in 1991 on operations at HB-Line was inadequate and that an EIS was required instead. The foundation contended that DOE would be in violation of NEPA by restarting HB-Line (which was restarted on January 5, 1993) prior to preparation of the EIS. A joint stipulation settling the case was filed with the court on November 18, 1993. In the settlement, DOE and the Energy Research Foundation agreed to the preparation of another EA and to the continued operation of HB-Line to process plutonium-238 in support of the NASA Cassini mission. On November 22, the court issued an order dismissing the complaint without prejudice.

Chapter 3

Environmental Program Information

Linda K. Karapatakis
Environmental Protection Department

Introduction

The Savannah River Site (SRS) has an extensive environmental program of radiological and nonradiological monitoring and surveillance at and around the site. Westinghouse Savannah River Company (WSRC) conducts most radiological and nonradiological monitoring for SRS. However, other groups, including the Savannah River Technology Center (SRTC), the Savannah River Ecology Laboratory (SREL), the Savannah River Forest Station (SRFS), and the Savannah River Archaeological Research Program (SRARP) also conduct various environmental and monitoring activities. Other environmental programs at SRS include waste management, environmental restoration, research, waste minimization, and awareness programs.

Environmental Monitoring and Surveillance

Because SRS handles plutonium, tritium, and other special nuclear materials, much of the environmental monitoring effort is directed toward collecting and analyzing samples of radioactive materials in airborne and liquid effluents released during routine operations (figure 3-1). Radioactive materials are regulated at the point of discharge and tracked as they disperse into the

surrounding environment. However, most radionuclides are released in such small amounts that it is not possible to detect them in a sampling medium, such as water, soil, or vegetation. For this reason, SRS must use mathematical models to estimate the transport and dispersion of radionuclides into the environment.

Basically, this involves monitoring the source of the contamination (i.e., the discharge stack or pipe), where higher concentrations may be more readily obtained. Modeling then can be used to calculate the expected concentrations of contaminants in environmental media. Refer to chapter 7, "Dose," for a complete discussion of SRS modeling.

These models also are used to optimize the existing radiological monitoring program. For example, predictions of models can be very beneficial in deciding where to place measuring devices and in identifying important pathways and contaminants that should be given priority. Modeling can contribute to the best use of resources available for sampling and analysis and can verify that a sampling network performs adequately.

While the radiological program is extensive, monitoring also is conducted for nonradioactive contaminants. The nonradiological monitoring program is designed to ensure that the physical and chemical properties of

Monitoring versus Surveillance

Per DOE Order 5400.5, "Radiation Protection of the Public and the Environment":

Effluent monitoring is the collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying contaminants, assessing radiation exposure to members of the public, and demonstrating compliance with applicable standards.

Environmental surveillance is the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from DOE sites and their environs and the measurement of external radiation for purposes of demonstrating compliance with applicable standards, assessing radiation exposures to members of the public, and assessing effects, if any, on the local environment.

Monitoring occurs at the point of discharge, such as an air stack or drainage pipe; surveillance involves looking for contaminants in the environment.

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Figure 3-1 Typical Atmospheric Effluent Monitoring

Radioactive materials are regulated at the point of discharge and tracked as they disperse into the surrounding environment.

atmospheric and liquid discharges comply with state and federal standards.

Monitoring requirements vary for each outfall—or discharge point—for liquids, depending on the type of facility and the known characteristics of the wastewater. In addition to the monitoring conducted at the point of discharge, surveillances are conducted by the collection and analysis of samples from site streams and the Savannah River. This nonradiological surveillance is designed to provide verification of the outfall sampling and to ensure that materials that could adversely affect the environment are detected and characterized.

Monitoring of nonradioactive constituents in SRS atmospheric releases is designed to ensure compliance with permits issued by the South Carolina Department of Health and Environmental Control (SCDHEC). The major nonradiological emissions of concern from SRS stacks include sulfur dioxide, oxides of nitrogen, and total particulate matter. Ambient air quality near SRS is monitored by South Carolina and Georgia as part of a network associated with the federal Clean Air Act. Clean Air Act Amendments, implemented in 1990, require federal facilities such as SRS to comply with provisions of the Act. In 1993, an inventory was conducted to quantify emissions of air pollutants on site. For complete information on the air emissions inventory, see chapter 2, "Environmental Compliance."

Goals

The SRS environmental program is designed to identify and to quantify the site's effect on the environment. This is accomplished by collecting and analyzing samples and comparing the results to defined standards. These results are used by the operating departments to assess operations, to determine ways to make work more productive, and to reduce emissions.

Objectives

Implicit in many environmental regulations are a number of objectives relating to protection of the environment and of human health. The SRS monitoring program's objectives incorporate recommendations of the International Commission on Radiological Protection (*Principles of Monitoring for the Radiation Protection of the Public*, ICRP Publication 43), as well as requirements of U.S. Department of Energy (DOE) Order 5400.1, "General Environmental Protection Program," and DOE's *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE/EH-0173T). The objectives include the following:

- To assess actual or potential exposures to critical groups and populations from the presence of radioactive and nonradioactive materials from normal site operations and accidents

- To demonstrate the degree of compliance with authorized limits, regulatory requirements, and environmental commitments made under official documents
- To verify the adequacy of facility containment of radioactivity and the effectiveness of effluent treatments and controls
- To notify the proper officials of unusual or unforeseen conditions and, where appropriate, to implement a special monitoring program
- To communicate accurately and effectively the results of the monitoring program to DOE, other government agencies, and the general public
- To maintain an accurate and continuous record of the effects of SRS operations on the environment
- To determine concentrations of radioactive and nonradioactive contaminants in environmental media to assess the immediate and long-term consequences of normal and accidental releases
- To distinguish between contributions to environmental contamination and environmental effects from the operation of SRS and contributions from other sources
- To evaluate and revise the environmental monitoring program in response to changing conditions in releases, transfer pathways, and regulatory orders
- To provide site-specific data for risk assessment and uncertainty analysis for human populations in the vicinity of SRS
- To conduct scientific studies of the transfer pathways of radioactive and nonradioactive contaminants in the environment
- To assess the validity and effectiveness of models used to predict the concentration of pollutants in the environment
- To determine the long-term buildup and prediction of environmental trends from site-released contaminants
- To establish baselines of environmental quality so that trends in the physical, chemical, and biological condition of environmental media can be characterized
- To identify and quantify new or existing environmental quality problems and to evaluate the need for remedial actions or mitigation measures

To meet these objectives, approximately 50,000 samples are collected and 700,000 analyses performed annually for radioactive and nonradioactive contaminants.

Rationale

The justification of sampling locations, sample media, sampling frequencies, and analyses is called the rationale for monitoring. Environmental regulations, critical pathways analysis, public concerns, and measurement capabilities also must be considered when designing a monitoring program. Following is a brief discussion of the rationale and justification for the site's environmental monitoring and surveillance programs; complete justification and rationale can be found in the "SRS Environmental Monitoring Plan" (WSRC-3Q1-2-1000).

Environmental Regulations

Numerous state and federal regulations encompassing radiological and nonradiological programs drive much of the monitoring at SRS. These include U.S. DOE orders in the 5400 series, specifically 5400.1, "General Environmental Protection Program," and 5400.5, "Radiation Protection of the Public and the Environment"; the National Emission Standards for Hazardous Air Pollutants (NESHAP); the National Pollutant Discharge Elimination System (NPDES); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA—also known as the Superfund); the Resource Conservation and Recovery Act (RCRA); and the National Environmental Policy Act (NEPA). Compliance with these programs is overseen by a number of regulators, including SCDHEC and the U.S. Environmental Protection Agency (EPA). A complete discussion of the site's compliance activities can be found in chapter 2, "Environmental Compliance."

Radioactive materials and nonradioactive contaminants are monitored at their point of discharge, per federal regulations. Regulations for nonradioactive substances generally specify discharge or emission limits. However, regulations for radioactive materials generally specify limits for dose to the public. As discussed earlier in this chapter and in chapter 7, "Dose," SRS uses mathematical models to determine the transport of radioactive contaminants into the environment and to estimate the resulting doses to the off-site population. Therefore, the radiological effluent monitoring program is designed and operated to provide data to effectively develop and use these models.

Critical Pathways Analysis

Airborne and liquid releases of radioactivity reach people in many ways. The routes radioactivity takes to get from a facility to the environment and then to a person are referred to as pathways. Figure 3-2 illustrates some of the pathways radioactivity uses to move through the environment.

Although many different radionuclides are released from SRS facilities each year, fewer than 10 are significant contributors to off-site doses. Information from the 1986-1993 SRS environmental reports was examined to determine which radionuclides and exposure pathways are most important in terms of the quantity of radionuclides released, the dose to the maximally exposed individual, and the collective dose to the population. This type of analysis, called a critical pathways analysis, provides an indication of the important radionuclides and pathways for a particular site. A detailed discussion of this critical pathways analysis is found in appendix A, "Critical Pathways Analysis."

Public Concerns

While the actual amount of a substance released is of great concern to the public, the effect of the substance on the environment and on public health is of even greater concern. Apprehensions can arise when a release may be transported to neighborhoods or schools. One aspect of the surveillance program that addresses these concerns is the placement of thermoluminescent dosimeters (TLDs). Many TLDs are positioned in off-site locations and provide a quick and reliable method of determining the dose within an 8,000-square-mile area of SRS in the event of an unplanned release of radioactivity.

Measurement Capabilities

Many materials released from SRS exist in such low concentrations in the environment that they cannot be readily measured. Thus, measurement capabilities become factors in the rationale for monitoring certain materials. In these cases, modeling, as previously discussed, is used to determine concentration levels.

Figure 3-2 Exposure Pathways

People can be exposed to radioactivity released from SRS in many ways. Radioactivity can leave the facility in airborne or liquid effluents and end up in the food people eat or in the air they breathe.

1993 Program Changes

The types, frequencies, and locations of environmental measurements are reviewed to determine if a need for monitoring remains. If a clear rationale for a measurement no longer exists, it is deleted from the program. Likewise, the program is modified as new methods and needs evolve. Program changes in 1993 included the following:

- Savannah River sampling locations were moved. There are now five, instead of seven, sampling locations at 10-mile intervals. In 1993, old and new locations were sampled. In 1994, the new locations become the official sampling points.
- A global positioning system was put in place. This system is used for pinpointing sample locations and transferring this location data to the Geographic Information System. This information is used to generate maps and to analyze data from various sources.
- Air monitoring stations were upgraded. The changes include new air sample pumps, new gas volume totalizers to monitor the volume of air sampled, and improved sampling lines to minimize leaks in the system. In addition, larger silica gel tubs, used for tritium sampling, are now in place. This allows the tubes to be changed every two weeks instead of every week.
- TLD sampling locations were assessed, and the indoor locations were deleted. Additionally, a tracking system using bar codes was introduced. This system greatly improves quality assurance efforts for tracing TLDs and the resulting data.
- The foodstuffs program was expanded to include sampling points along a 50-mile radius from the center of the site. Products collected include pork, beef, milk, and seasonal produce, such as corn, soybeans, wheat, peaches, watermelons, cantaloupes, peanuts, and other truck crops.

A comprehensive review of the monitoring program began in 1990. The result was the "SRS Environmental Monitoring Plan" (WSRC-3Q1-2-1000). The plan, required by DOE Order 5400.1, "General Environmental Protection Program," was approved by DOE's Savannah River Operations (DOE-SR) in 1991. It documents the effluent monitoring and environmental surveillance activities conducted at SRS by identifying the rationale and design criteria for the monitoring program, the frequency of monitoring and analysis, specific analytical and sampling procedures, quality assurance requirements, and guidance on preparing and distributing reports. The plan is reviewed annually and will be updated every three years.

Waste Management

For the past 40 years, SRS activities have focused on the manufacture of plutonium, tritium, and other nuclear materials required to support national defense. This has resulted in the generation of numerous waste byproducts. The goal of waste management is to safely manage all types of waste from generation through treatment and disposal. The long-term goal is the safe disposal of all the waste on site. For more information on waste management at SRS, see chapter 4, "Environmental Restoration and Waste Management."

Environmental Restoration

Research at SRS and other facilities has resulted in increased knowledge of waste disposal and its impact on the environment. This research also has shown instances of localized contamination of soil and water at some of the site's previously used waste disposal locations that could have an impact on the environment. To protect the surrounding groundwater, surface water, and soil, an aggressive program for remediating these sites is in place [Fact Sheet, 1992b]. For more information on environmental restoration at SRS, see chapter 4, "Environmental Restoration and Waste Management."

Environmental Research

DOE designated SRS as the first National Environmental Research Park in 1972. Since then, scientists from universities and other organizations have used the site as an outdoor laboratory to study the impact of human activities on the environment. The protected boundaries of the site provide land suitable for long-term research projects. Thirty areas covering 14,288 acres have been set aside to protect rare, threatened, and endangered biota as well as unique habitats. These areas, designated as set-aside areas, provide undisturbed land for comparison with areas affected by SRS operations and forest management. As a result of the research park program, scientists have compiled detailed information on many aspects of the SRS environment, including soil development and inventories of plant and animal species. National Environmental Research Park activities are conducted by and coordinated through SRTC, SREL, SRFS, and SRARP.

SRTC, a research and development facility at SRS, provides support to many on-site operations. Numerous research and development activities conducted by SRTC are designed to meet environmental and other compliance requirements. Projects include the radiation assessment program, the calculation of dose uncertainties, the meteorological monitoring program, and the development and testing of new equipment.

SREL is operated by the University of Georgia under contract with DOE. SREL has conducted independent environmental studies of SRS, surrounding streams and ponds, and the Savannah River since 1951. Studies focus on research activities involving freshwater and terrestrial ecosystems in natural and disturbed habitats, as well as on biological inventories, competition in plant and animal communities, and the use of radioactive tracers to determine food chains. For more information, contact SREL at 803-725-2472.

SRFS was formed in 1952, when the Atomic Energy Commission and the U.S. Department of Agriculture's Forest Service formed an interagency agreement to create a forest management organization at SRS. SRFS has expanded from strictly timber management to the management of all site natural resources. This includes wildlife, fish, and botany studies; management for threatened, endangered, or sensitive wildlife and plant species; protection of soil and watershed quality; and efforts to maintain a healthy forest for environmental research. For more information, contact SRFS at 803-725-2441.

SRARP began in 1973 under a cooperative agreement with DOE and the South Carolina Institute of Archaeology and Anthropology, University of South Carolina. The primary function of SRARP is to provide DOE with recommendations concerning archaeological matters to facilitate the management of archaeological resources at SRS. Other functions of SRARP include cultural resource management, research, and public education, as well as compliance activities involving reconnaissance surveys, general intensive watershed surveys, specific intensive surveys, data recovery, and coordination with major land users. For more information, contact SRARP at 803-725-3623.

Waste Minimization

SRS actively develops and implements waste reduction and minimization programs to decrease the amount of solid waste generated by site operations. The sitewide Waste Minimization Plan is revised annually to identify objectives, goals, and activities for the programs. SRS facilities update facility-specific waste minimization plans each year.

The SRS Excess and Salvage program finds on-site users and off-site buyers or recyclers for products that otherwise would be thrown out. Items that previously would have been considered trash but now are recycled or sold include office furniture, laserwriter toner cartridges, aluminum cans, stainless steel, miscellaneous electrical equipment, tires, spent lead/acid

batteries, and wooden pallets. Site waste minimization efforts save landfill space and other disposal costs and recover funds for excess stock.

Environmental Awareness

Awareness programs are created to inform and educate individuals about site efforts to protect and restore the environment. Many of the programs also fulfill regulatory public notice requirements. Awareness activities include information exchange, public outreach, and employee programs.

Information Exchange

In an effort to improve and update its environmental monitoring and research programs, SRS has opened several avenues of exchange with state and federal regulators, other government-owned, contractor-operated (GOCO) facilities, and scientists.

DOE-SR representatives attend DOE Headquarters (DOE-HQ)-sponsored technical information exchange workshops. These workshops represent a method of enhancing the exchange of technical information among DOE sites.

Environmental awareness and information exchange tours are conducted for many groups with special interests, such as visitors from other GOCOs, DOE-HQ, Westinghouse Corporate, EPA, SCDHEC, and environmental activists. Tours are designed to meet the needs of the particular group. For example, EPA and SCDHEC tours might focus on regulatory issues. Visitors from other GOCOs might be interested in site activities that have applications for their environmental programs.

The Environmental Advisory Committee, which consists of several nationally recognized consultants from the fields of biology, ecology, hydrogeology, health physics, environmental restoration, and economics, meets quarterly to review site environmental programs and make recommendations.

Representatives from SCDHEC, the Georgia Department of Natural Resources, Georgia Power Company, Chem-Nuclear Systems, DOE, and WSRC have met quarterly since 1987 in a data exchange program to share technical environmental program information and data. These meetings provide an open forum in which to review and possibly to improve each organization's monitoring program. The program is known as the Central Savannah River Area Radiological Environmental Monitoring Plan.

Public Outreach

The numerous public outreach activities at SRS include tours, presentations to civic clubs and school groups, forums and workshops, public involvement projects, and various publications. The programs are designed for a two-way flow of information: the site presents its plans and the public presents its comments and concerns regarding site operations.

The SRS Visitors Program provides the public a firsthand look at the site and its activities. SRS visitors may take a drive-by tour of site facilities and may enter some facilities. Each tour is designed to meet the needs and interests of the visiting group. The tour program, begun in 1989, has grown each year.

The SRS Speakers Bureau is an integral part of the site's efforts to increase dialogue with the public. The bureau arranges for speakers to address all types of audiences, including civic, professional, and educational organizations. Another component of the Speakers Bureau is the Traveling Lecturer Program,

designed for colleges and universities. Through this program, SRS professionals lecture, present seminars, and participate in institution-sponsored activities throughout the Southeast.

SRS informs and involves the public on environmental issues through a program called "Public Involvement and Regulatory Public Notice." This program, which began in 1988, offers site tours and stewardship talks to the general public about environmental activities.

In 1991, the site began a series of public meetings called Environmental Forums. These are informal evening meetings designed to promote dialogue between SRS and its neighbors regarding environmental and public health issues. The decision on topics, location, date, time, and moderator are made by local representatives before each meeting. The meetings include poster and display sessions, brief presentations on various subjects by SRS personnel, and a question-and-answer period.

When topics are unusually complex, DOE may conduct a workshop. These are designed to allow

Environmental Awareness and Earth Day

The first Earth Day was celebrated April 22, 1970, by 10,000 schools, 2,000 colleges and universities, and many communities. In all, more than 20 million people in the United States participated. The celebration was nationwide: automobiles were banned from New York's Fifth Avenue by the mayor and 100,000 people attended an eco-fair in Union Square; Congress adjourned for the day so members could attend local teach-ins; the three major television networks at the time (ABC, CBS, and NBC) devoted their entire daytime programming to Earth Day coverage; and many publications dedicated issues exclusively to the environment [Earth Day, 1989].

Since 1970, Earth Day and the entire environmental awareness movement have grown and taken on international importance. In a 1989 speech addressing a global scientific conference on holes in the ozone layer, Prince Charles, heir to the British throne, was frank: "Human beings can be rightly proud of their inventiveness. We thought the world belonged to us. Now we are beginning to realize that we belong to the world. We are responsible to it, and to each other. Our creativity is a blessing, but unless we control it, it will be our destruction" [Earth Day, 1989].

In 1988, SRS began its environmental awareness program by participating in Earth Day. The theme was "Savannah River Plant; Protecting the Future through Environmental Awareness." The first celebration included a spill response team open house and a guest environmental speaker. It since has grown to a week-long celebration featuring events in several areas around the site plus participation in off-site activities.

The 1993 celebration centered around the DOE theme "A Good Planet is Hard to Find." Events included sponsorship of a poster contest for local schoolchildren, the creation and distribution of environmental resource and awareness packets for teachers, a trash pick-up day in a local community, Earth Day festivals at five on-site locations, and participation in the Central Savannah River Area Earth Day at Lake Olmstead in Augusta, Georgia.

The 1993 SRS Earth Day Logo

citizens with special interests an opportunity to engage in in-depth discussions with site representatives.

CERCLA requires that a site develop a community relations plan once it is placed on the National Priority List (CERCLA Superfund cleanup). SRS was placed on the list in December 1989. The site Public Involvement Plan, released to the public in 1992, goes a step beyond CERCLA to include public involvement in other environmental regulations.

One of the most significant comments on the Public Involvement Plan was a request for a citizens advisory group that would participate in decisions on environmental restoration and waste management. As a result, SRS announced in November 1992 that it would establish such a group. A planning workshop for the SRS Citizens Advisory Board was held in February 1993, and—after a public-comment period—a final charter for the board was issued on October 26, 1993. In December, a seven-member selection panel chose 25 citizens (and 11 alternates), from more than 230 applicants, to serve on the advisory board, which is scheduled to be in place in early 1994.

Information sheets called *Environmental Bulletin* are published several times a year to fulfill regulatory requirements for public notice of site activities. Publication has been expanded to include a quarterly newsletter, also titled *Environmental Bulletin*, that features a variety of articles on environmental and restoration issues.

Other forms of publication include newspaper advertising (legal notices and display advertising) and fact sheets that provide information on specific topics. Compliance documents, background information on the site, newsletters, and other reference materials can

be found in DOE public reading rooms in local libraries.

Employee Awareness

SRS strives to educate employees about environmental protection. The awareness program was enhanced in 1988 when the site held its first Environmental Awareness Day to celebrate Earth Day. Environmental Awareness Day continues to be an annual event at SRS and is observed each April in connection with Earth Day festivities. The event is observed sitewide to increase waste minimization and environmental and pollution prevention awareness. The 1993 program included numerous displays on varied topics, literature on endangered species, tips on recycling, and free saplings for employees.

The awareness program has grown to include other activities designed to educate employees about environmental issues. The *Environmental Exchange* newsletter provides information to field personnel about new and existing environmental regulations, as well as guidance received from the regulatory community. Environmental information is distributed to all site personnel via the *SRS News*—a newspaper published for employees, their families, and retirees—and the site's monthly video magazine, *Update*.

SRS also provides environmental training programs to increase employee awareness of environmental activities and to enhance the knowledge and qualifications of personnel performing tasks associated with environmental assessment, planning, and restoration. This training is designed to ensure compliance with all applicable requirements. The program includes on- and off-site classroom instruction, on-the-job training, seminars and video conferences, and specialized workshops and courses.

Chapter 4

Environmental Restoration and Waste Management

Marilyn Garcia and Donna Martin
Environmental Restoration Department

Linda Karapatakis
Environmental Protection Department

Environmental Restoration

Determining the most environmentally sound method of cleaning up waste units is a major component of the Savannah River Site (SRS) environmental restoration program. The U.S. Department of Energy (DOE) uses the term "environmental restoration" to refer to the assessment and cleanup of facilities (decontamination and decommissioning) and of inactive waste units and groundwater (remediation). "Cleanup" means actions taken to deal with the release or potential release of hazardous substances. This may mean complete removal of a substance; it also may mean stabilizing, containing, or otherwise treating the substance so it does not affect human health or the environment [DOE EM, 1991f].

SRS began its cleanup program in 1981, before many of the regulations requiring environmental restoration were written. Two major federal statutes now govern the site's restoration activities: the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). RCRA addresses the management of regulated hazardous waste and requires that permits be obtained for DOE facilities that treat, store, or dispose of hazardous or mixed waste and that DOE facilities perform corrective action as appropriate. CERCLA (also known as Superfund) addresses the uncontrolled releases of hazardous substances and the cleanup of inactive waste sites. This act establishes a National Priority List of sites targeted for assessment and, if necessary, restoration. SRS was placed on this list December 21, 1989 [Fact Sheet, 1992b]. For complete information on SRS compliance activities, see chapter 2, "Environmental Compliance."

Decontamination and Decommissioning

Decontamination and decommissioning (D&D) is the safe decontamination, dismantling, and/or removal of facilities that no longer are active [DOE EM, 1991g]. No D&D work has been completed at SRS; however, more than 600 site facilities are being assessed. They are categorized as containing chemicals, radionuclides, asbestos, or a combination of these. Facilities include reactors, chemical separation facilities, metal forming facilities, office buildings, diesel generator houses, and power substations and transformers.

Remediation

Remediation, or the correction of a problem, may be required for inactive waste units or groundwater. Remediation identifies and contains contamination to prevent it from spreading [DOE EM, 1991g]. The SRS Federal Facility Agreement directs the comprehensive remediation of SRS by establishing the framework and schedule for remediation activities at the site. (See chapter 2, "Environmental Compliance," for a complete discussion of the SRS Federal Facility Agreement.) More than 400 waste units, including groundwater, have been identified at SRS. They include seepage and settling basins, pits and piles, tanks, and landfills, all of which must be evaluated and, if necessary, cleaned up. Waste types found in these units include radioactive, hazardous, and mixed wastes. For a definition of waste terms, see page 46. These inactive waste units, located throughout the site, range in size from several yards, such as the site of a small spill, to tens of acres, such as the Low-Level Radioactive Waste Disposal Facility.

Waste Units

A broad overview of the typical evaluation and cleanup process of a waste unit is as follows:

- If preliminary evaluations show that a waste unit may be a candidate for cleanup, it undergoes investigation and characterization. The investigation phase begins with an examination of existing unit data, followed by the development of a work plan that prescribes how to characterize the unit.
- This investigation may find that a waste unit does not pose a risk to human health or the environment. If the U.S. Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC) agree with this finding, with acceptance by the public, no further action is needed on that waste unit.
- When a unit has been fully characterized, cleanup alternatives are evaluated and a preferred method is selected. SRS holds a public comment period to solicit input. After the public input has been considered, a record of decision is issued, specifying the remediation method.
- This entire process typically requires about five to seven years. Each step is approved by EPA and/or SCDHEC, with public involvement in the process.

- Once a record of decision is issued and remedial design plans are developed and submitted to EPA and SCDHEC for approval, remediation of the waste unit begins.

The first step in the remediation process is to determine the most efficient characterization techniques with which to assess a waste unit. Lysimeters measure leaching and migration of contaminants; borehole wells determine physical characteristics of subsurface layers; vibracoring collects soil samples in wetland areas; ground-penetrating radar locates buried wastes; cone penetration tests for physical properties; soil gas measures volatile organic compounds; and aerial photography determines overall site layout.

Next, the extent of contamination is investigated, and cleanup alternatives for waste site remediation are developed. Closure technologies vary based on a waste unit's characteristics and needs. While each site's closure is customized, the closures often share common characteristics. For example, the overall closure plan for the F-Area basins includes techniques commonly used in basin closures:

- Each basin is dewatered.
- Layers of protective materials, such as granite aggregate, limestone and blast furnace slag, soil, clay,

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Dynamic compaction is a method used during the physical closure of a waste unit to stabilize solid waste buried in trenches. A 20-ton concrete or steel weight is dropped from a height of about 42 feet. The resulting force reduces the void space in the trench, which in turn reduces the occurrence of subsidence, or settling, once a clay closure cap is placed over the trench.

and geotextile fabric, are provided to fill the dewatered basin.

- A low-permeability kaolin cap layer is built over the layers of protective material to isolate wastes from rainwater.
- The entire filled and capped basin area is covered with topsoil and vegetation, such as sodding or seeding.

Once a closure is completed and certified, monitoring continues for the next 30 years.

Six waste units, totaling over 80 acres, have been successfully cleaned up and closed under the RCRA permit at SRS. These closures, among the largest in the world, include a 58-acre burial ground containing mixed, hazardous, and radioactive wastes, seepage and settling basins, and a large restored lake. Specific closures include

- **Mixed Waste Management Facility Burial Ground** – The Mixed Waste Management Facility Burial Ground is a 58-acre waste unit that officially was closed in 1991. It is the largest mixed waste closure in the country and the first SRS facility closed and certified under RCRA (figure 4-1).
- **M-Area Settling Basin** – SRS used the M-Area settling basin from the 1950s to the 1980s to dispose of wastewater contaminated with chemicals. The

basin was closed safely in 1991. Lost Lake, a Carolina bay adjacent to the settling basin, was restored.

- **F-Area and H-Area Seepage Basins** – The F-Area and H-Area seepage basins officially were closed in 1991. The basins were used to dispose of radioactive wastewater until 1988, when the Effluent Treatment Facility replaced them. The three F-Area basins cover about 6.5 acres, and the four H-Area basins cover about 15.5 acres.
- **Tritiated Waste Oil Storage Tank and 105-C Hazardous Waste Management Facility** – The underground storage tank contained 8,400 gallons of low-level radioactive water, which was treated and safely discharged in the successful tank closure process.
- **The Metallurgical Laboratory Basin** – The Metallurgical Laboratory Basin contained trace metals from prior operations and was closed safely in 1992. An adjacent Carolina bay was protected with the completion.

Groundwater

Groundwater contamination at SRS varies by area. Comprehensive groundwater monitoring data indicate that contaminant plumes have not migrated into groundwater beyond the site's boundaries. Shallow groundwater flows toward streams on SRS; deeper groundwater flows toward the Savannah River. Natural factors, such as the numerous clay layers under the site, act as barriers and impede flow of contaminated

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Figure 4-1 Mixed Waste Management Facility Burial Ground Closure Cap Cross Section

The Mixed Waste Management Facility Burial Ground was capped as mandated by a RCRA agreement between SRS and SCDHEC and officially was closed in April 1991. The cap will be monitored and maintained for 30 years.

groundwater. More than 1,600 monitoring wells continuously monitor contamination near known waste sites.

Subsurface sedimentary layers are characterized through soil core samples and electrical resistivity measurements in an ongoing program to provide subsurface data necessary to assess and remediate waste units. Three-dimensional mapping is used to study and report the extent of groundwater contamination at the site.

This information, along with groundwater sampling results, is used to conduct baseline risk assessments involving four major steps: data collection and evaluation, exposure assessment, toxicity assessment, and risk characterization.

Once the groundwater and waste site have been characterized and assessed, a strategy for remediation must be determined. An example of a technology used at SRS to remediate contaminated groundwater is the air stripper pump-and-treat method, which cleans volatile organic compounds from groundwater. About 306,000 pounds of solvent have been removed from approximately 1.75 billion gallons of contaminated groundwater through 1993 by this method. Because removal efficiency of the air stripper pump-and-treat method declines over time, other technologies are being studied. For a complete discussion of the SRS groundwater monitoring program, see chapter 10, "Groundwater."

Waste Management

Waste has been generated as a result of SRS operations, including the manufacture of plutonium, tritium, and other nuclear materials. Proper handling of this waste requires first that the waste be categorized. Categories for waste are transuranic, high level, low level, hazardous, mixed, and sanitary.

Transuranic Waste Transuranic waste is radioactive waste contaminated with alpha-emitting isotopes that have decay rates and concentrations exceeding specified levels. It contains man-made elements heavier than uranium, thus the name trans (or beyond) uranium. Transuranic waste decays slowly and requires isolation for thousands of years. Equipment, tools, and protective clothing, such as laboratory coats and gloves, can become contaminated with transuranic radionuclides [DOE EM, 1991b]. In 1993, SRS generated 13,668 cubic feet of solid transuranic waste.

High-level Waste High-level waste is highly radioactive material resulting from the reprocessing of spent nuclear fuel. (Spent nuclear fuel is nuclear reactor fuel that has been irradiated to the extent that it no longer

can effectively sustain a chain reaction.) High-level waste includes liquid waste produced during reprocessing and highly radioactive solid waste derived from liquid that contains a combination of transuranic waste and fission products in concentrations high enough to require permanent isolation. It contains elements that decay slowly and remain radioactive for thousands of years [DOE EM, 1991b]. It also includes other highly radioactive material that the Nuclear Regulatory Commission, consistent with existing law, determines will require permanent isolation [DOE EM, 1991f].

Low-level Waste Low-level waste is any radioactive waste not classified as high-level waste or transuranic waste. It is generated by reactor operations, isotope production, medical procedures, and research and development projects. It typically has small amounts of radioactivity dispersed in large amounts of material. Examples of low-level waste include rags, papers, filters, tools, and protective clothing, such as laboratory coats [DOE EM, 1991b]. In 1993, SRS generated 501,567 cubic feet of solid low-level waste.

Hazardous Waste Hazardous waste, as defined by RCRA, is any toxic, corrosive, reactive, or ignitable material that could negatively affect human health or could damage the environment. Environmental laws also list specific materials as hazardous waste and describe specific characteristics that classify a material as a hazardous waste [DOE EM, 1991c]. In 1993, SRS generated 2,596 cubic feet of solid hazardous waste.

Mixed Waste Mixed waste is a combination of radioactive and hazardous waste, as defined by the Atomic Energy Act of 1954 and RCRA [DOE EM, 1991f]. Mixed waste is subject to RCRA, which regulates the hazardous component, and to additional regulations governing the radioactive component [DOE EM, 1991d]. In 1993, SRS generated 137 cubic feet of solid low-level mixed waste.

Sanitary Waste Sanitary waste is neither radioactive nor hazardous. Solid sanitary waste basically is garbage and is disposed of in landfills; liquid sanitary waste includes sewage and industrial waste treated in on-site sewage treatment plants [DOE EM, 1991e].

SRS has approximately 34 million gallons of high-level radioactive waste containing about 600 million curies of radioactivity. An integrated approach has been developed to address the treatment, storage, and/or disposal of all site-generated waste [DOE EM, 1991a].

Program emphasis for the near term has been placed on the construction and startup of new facilities for the solidification of high-level waste, the treatment of stored transuranic waste in preparation for future permanent storage at a federal repository, and the

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Figure 4-2 High-level Waste Tanks

Waste tanks for high-level waste are constructed of carbon steel and reinforced concrete. The tanks consist of a primary tank surrounded by the secondary tank. This entire dual assembly is surrounded by 30-inch-thick reinforced concrete.

incineration of low-level, hazardous, and mixed wastes. See chapter 1, "Site and Operations Overview," for a discussion of waste management facilities and operations.

All high-level liquid waste produced at SRS to date is stored in tanks on site (figure 4-2). The waste is kept in the tanks while the radioactivity is given time to decay prior to evaporation. Nearly 90 million gallons of high-level waste have been concentrated by evaporation to the present volume (about 34 million gallons). The 34 million gallons will be pretreated further, which concentrates all but a small amount of the radioactivity into a fraction (about 10 percent) of the original volume [DOE EM, 1991a]. The remaining high-level waste will be processed, or vitrified, in the Defense Waste Processing Facility; the low-level waste will be processed in the Saltstone Facility.

The liquid low-level waste generated as a by-product of the separations and tank farm operations is treated in the Effluent Treatment Facility (ETF). Chemical and radioactive contaminants are removed from the

wastewater of the sites' two separations facilities before release of the water—which meets federal drinking water standards—into Upper Three Runs Creek.

Solid low-level waste has been buried in the low-level waste burial ground. This is the centrally located, fenced, 195-acre Solid Waste Disposal Facility (SWDF). Here, waste is separated by the type and amount of radioactivity it contains. Records are kept of the contents, radiation level, and storage location of each type of waste. The burial ground is monitored to detect radioactivity in the soil and any migration of radioactivity or hazardous waste from storage areas.

Disposal of solid low-level waste is moving from burial to storage in engineered vaults that ensure compliance with groundwater protection standards [DOE EM, 1991a]. Disposal vaults for low-level waste are under construction. In addition to vault disposal, the Consolidated Incinerator Facility (CIF) is under construction and will treat low-level, hazardous and mixed wastes.

Chapter 5

Radiological Effluent Monitoring

Timothy Jannik
Environmental Protection Department

Introduction

This chapter presents a brief description of the Savannah River Site (SRS) radiological effluent monitoring program and the 1993 effluent monitoring results. Refer to chapter 3, "Environmental Program Information," for a discussion of the objectives and rationale for the SRS effluent monitoring program.

Radiological effluent monitoring results are a major component in the determination of compliance with applicable dose standards (see chapter 7, "Dose"). In addition to this, SRS maintains a management philosophy and objective "that potential exposures to members of the public be as far below regulatory standards as is reasonably achievable." This is better known as the as low as reasonably achievable (ALARA) process.

Radioactive airborne emissions are monitored (by a combination of direct measurement and/or sample extraction and analysis) at their points of discharge.

Monitoring activities of radioactive liquid effluents encompass sampling and analysis and are performed by the Environmental Protection Department's Environmental Monitoring Section (EMS) and the Savannah River Technology Center (SRTC).

Of the more than 7,000 effluent samples scheduled for collection and analysis during 1993, five were not collected and/or analyzed because of sampling equipment failure or inadvertent loss of/damage to the sample media. However, the radioactive releases attributed to these samples were accounted for in the annual release totals by using either historical process knowledge or less sensitive on-line monitoring results.

A complete description of the EMS sampling and analytical procedures used for radiological effluent monitoring can be found in the "SRS Environmental Monitoring Plan" (WSRC-3Q1-2-1000). A summary of data results is presented in this chapter; however, more complete data can be found in *SRS Environmental Data for 1993* (WSRC-TR-94-077).

Air Effluents

Process area discharge stacks that release or have the potential to release radioactive materials are continuously monitored by applicable on-line monitoring (for tritium and noble gases) and/or sampling systems [EMP, 1993]. Filter paper samples, used to monitor radioactive particulates, are collected daily and screened initially for radioactivity by Radiological Control Operations personnel. Charcoal canisters (used to monitor radioiodines) are collected weekly. Radiological Control Operations personnel routinely transfer the charcoal canisters and filter paper samples on a weekly, composited basis to EMS sampling personnel for transport to and analysis in the EMS laboratory.

Depending on the processes involved, effluent stacks also may be monitored by area operations and/or Radiological Control Operations personnel with "real-time" instrumentation to determine instantaneous and cumulative atmospheric releases to the environment. Tritium is one of the radionuclides monitored with continuous real-time instrumentation.

Applicable Regulations

U.S. Department of Energy (DOE) Order 5400.1, "General Environmental Protection Program," requires that effluent monitoring be conducted at all DOE sites. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," sets annual dose standards to members of the public—as a consequence of routine DOE operations—of 100 mrem through all exposure pathways and 10 mrem from airborne releases.

DOE Order 5400.5 also establishes Derived Concentration Guides (DCGs) for radionuclides in air. DCGs, calculated by DOE using methodologies consistent with recommendations found in International Commission on Radiological Protection (ICRP) publications 26 and 30, are used as reference concentrations for conducting environmental protection programs at DOE sites and for making dose comparisons. DCGs are not to be considered release limits.

Radiological airborne releases also are regulated by U.S. Environmental Protection Agency (EPA) regulations in 40 CFR 61, Subpart H, National Emission Standard for Hazardous Air Pollutants (NESHAP). The SRS NESHAP radionuclide program continues to change to incorporate sampling, monitoring, and dose assessments practices that meet or exceed the EPA requirements. Effluent monitoring assessments and improvements continue on schedule under the radionuclide Federal Facility Compliance Agreement signed October 31, 1991. (see chapter 2, "Environmental Compliance").

Description of Monitoring Program

The SRS radiological air effluent monitoring program is described briefly in the following paragraphs.

Sample Collection Systems

Sample collection systems vary from facility to facility, depending on the nature of the radionuclides being discharged. In general, Radiological Control Operations personnel are responsible for ensuring that the sampling systems are maintained and for collecting the filter papers and charcoal filter samples.

Continuous Monitoring Systems

SRS reactor and tritium facilities use real-time instrumentation to determine instantaneous and cumulative atmospheric releases of tritium and noble gas radioisotopes. All other monitored radionuclides are sampled using filter papers, charcoal filters, or other air effluent sampling media.

Laboratory Analysis

EMS provides most of the necessary radioanalytical laboratory functions required to conduct the site airborne emissions monitoring program. However, the SRTC environmental laboratory performs iodine-129 and carbon-14 analyses on certain air effluent samples because of their low radiation energies and radioanalytical difficulty.

Effluent Flow Rates

Stack effluent flows generally are determined with hot-wire anemometers, pitot tubes, or fan capacity calculations. Sample line flow rates usually are determined with in-line rotameters or hot-wire anemometers. Flow rates are used to determine the total quantity of radioactivity released.

Diffuse and Fugitive Sources

An estimate of radionuclide releases from unmonitored diffuse and fugitive sources also is included in the SRS release totals. These unmonitored sources include

ponds, contaminated land areas, and structures without ventilation—or with ventilation that does not result in a well-defined release point. These sources were included in the overall SRS source terms for the first time in 1991.

The specific sources and methods used to estimate these emissions are described in *Calculated Release Levels from Phase III Installations*, WSRC-RP-92-542.

Monitoring Results

Data obtained from continuously monitored airborne effluent release points are used in conjunction with calculated release estimates of unmonitored radionuclides (fission product tritium and isotopes of krypton) to quantify the total amount of radioactive material released to the environment. In addition, an estimate of radionuclide releases from unmonitored diffuse and fugitive sources is included in the SRS release totals. Total SRS atmospheric releases for 1993 are shown by source in table 5-1, page 60.

For dose calculation purposes, releases of unidentified beta-gamma emitters were summed with total strontium (strontium-89,90) releases and accounted for more than 77 percent of the total strontium-89,90 reported. Likewise, unidentified alpha emitters were summed with plutonium-239 releases and accounted for more than 35 percent of the total plutonium-239 releases reported. Strontium-90 and plutonium-239 have the highest dose factors of the common alpha- and beta-emitting radionuclides. Therefore, summing the unidentified alpha and beta emissions this way maintains conservatism of the highest dose being represented. In addition, some of the unidentified alpha and beta activity probably originates from naturally occurring radionuclides, such as potassium-40 and radon-222 progeny. This also adds a degree of conservatism to the dose calculations.

Even though they have relatively short half-lives, iodine-131, iodine-133, and xenon-135, which are fission product radionuclides, again were detected in SRTC effluents during 1993 [Kantelo and Crandall, 1993]. These releases occur because californium-252, which decays by spontaneous fissioning, is stored in small quantities at SRTC. Realizing this, EMS began analyzing the air effluent samples from SRTC much more quickly than normally (less than one day) during 1992 and continued this regime through 1993. This is why these short-lived radionuclides were detected.

The release totals shown in table 5-1, page 60, are a major component in the determination of off-site dose estimations from SRS operations. The calculated individual and collective doses from atmospheric releases are presented in chapter 7, "Dose," as is a

comparison of these off-site doses to EPA and DOE dose standards.

Tritium, in both the elemental and oxide form, constitutes more than 99 percent of the total radioactivity released to the atmosphere from SRS operations. Because tritium is an isotope of hydrogen, it behaves chemically and physically the same as hydrogen and thus is extremely difficult to filter or remove from atmospheric waste streams.

During 1993, approximately 191,000 Ci ($7.1\text{E}+15$ Bq) of tritium were released from SRS, compared to approximately 156,000 Ci ($5.8\text{E}+15$ Bq) in 1992. This 22 percent increase is attributed to increased loading and unloading of tritium reservoirs in the tritium facilities. These increased operations, especially the reservoir unloading operations, were a result of the country's nuclear weapons reduction program following the end of the Cold War.

Throughout the history of SRS, changes in the site's mission and continual improvements in facilities, processes, and operations have reduced the amount of tritium and other atmospheric radionuclide releases. During the early years at SRS, large quantities of tritium were discharged to the atmosphere. The maximum yearly release of 2.4 million Ci ($8.9\text{E}+15$ Bq) of tritium occurred during 1958. More recently (except for 1993), the amount of tritium released from SRS has been decreasing approximately 20 percent per year since 1987 (figure 5-1). In the near future, atmospheric releases of tritium are expected to decrease substantially as a result of 1) the shutdown

and lay-up of all reactor facilities and 2) the anticipated startup of the Replacement Tritium Facility (RTF), a state-of-the-art tritium processing facility.

Comparison of Average Concentrations in Airborne Emissions to DOE Derived Concentration Guides

Average concentrations of radionuclides in airborne emissions are calculated by dividing the yearly release total of each radionuclide from each stack by the yearly stack flow quantities. These average concentrations then can be compared to the DOE DCGs (found in DOE Order 5400.5) for each radionuclide.

DCGs are used as reference concentrations for conducting environmental protection programs at all DOE sites. DCGs, which are based on a 100-mrem exposure, are applicable at the point of discharge (prior to dilution or dispersion) under conditions of continuous exposure (assumed to be an average inhalation rate of 8,400 cubic meters per year). This means that the DOE DCGs are based on the highly conservative assumption that a member of the public has direct access to and continuously breathes (or is immersed in) the actual air effluent 24 hours a day, 365 days a year. However, because of the large distance between most SRS operating facilities and the site boundary, and because the wind rose at SRS shows no strong prevalence (see chapter 7, "Dose"), this scenario is improbable.

Average annual radionuclide concentrations in SRS air effluents can be referenced to DOE DCGs as a

Curies

leaf Graph

Figure 5-1 SRS Annual Atmospheric Tritium Releases since 1987

screening method to determine if existing effluent treatment systems are proper and effective.

Most of the SRS radiological stacks/facilities released small quantities of radionuclides at concentrations far below the DOE DCGs [SRS Data, 1994]. However, certain radionuclides—such as tritium (in the oxide form) from the tritium, heavy water rework, and reactor facilities and uranium, americium, and plutonium isotopes from the F-Area and H-Area separations facilities—are emitted at concentration levels above the DCGs. Because of the extreme difficulty in filtering or mitigating tritium and because of current facility designs, site missions, and operational considerations, this situation is unavoidable. However, it must be noted that the dose consequences from all SRS atmospheric releases was much less during 1993 than the DOE and EPA annual atmospheric pathway dose standard of 10 mrem (0.1 mSv) (see chapter 7, “Dose”).

Liquid Effluents

Each process area liquid effluent discharge point that releases or has the potential to release radioactive materials is sampled routinely and analyzed for radioactivity [EMP, 1993].

Site streams also are sampled upgradient and downgradient of seepage basins (see chapter 6, “Radiological Environmental Surveillance”) to calculate the amount of radioactivity migrating from the basins. These results are important in calculating the total amount of radioactivity released to the Savannah River as a result of SRS operations.

The general site locations of the radiological liquid effluent points at SRS are shown, along with the surface water sampling locations, in figure 6–3, page 71.

P-Reactor (pictured), like the other four reactors at SRS, is shut down, but except for R-Area, the monitoring of air and liquid effluents from all the site's reactor areas continues because of the spent fuel and/or tritiated moderator stored within the facilities. Effluent Monitoring no longer is conducted at R-Reactor because it has been shut down for more than 30 years.

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Applicable Regulations

DOE Order 5400.1 requires that effluent monitoring be conducted at all DOE sites. DOE Order 5400.5 sets annual dose standards to members of the public—as a consequence of routine DOE operations—of 100 mrem through all exposure pathways and 4 mrem from the drinking water pathway. Effluent monitoring results are a major component in the determination of compliance with these dose standards.

DOE Order 5400.5 also establishes DCGs for radionuclides in water. DCGs were calculated by DOE using methodologies consistent with recommendations found in ICRP Publications 26 and 30. They are used

- as reference concentrations for conducting environmental protection programs at DOE sites
- as screening values for considering best available technology for treatment of liquid effluents
- for making dose comparisons

DOE Order 5400.5 exempts aqueous tritium releases from best available technology requirements but not from ALARA considerations.

EPA drinking water standards (40 CFR 141) for radionuclides apply at the water treatment plants serving Beaufort and Jasper counties in South Carolina and Port Wentworth in Georgia [EPA, 1975]. Drinking water standards for specific radionuclides are listed in appendix D, "Drinking Water Standards."

DOE Order 5400.5, chapter II, para. 3a(4), requires that settleable solids in process waste streams be tested to ensure that no buildup of radionuclides occurs in the sediments of the receiving streams.

Description of Monitoring Program

The SRS radiological liquid effluent monitoring program is briefly described in the following paragraphs.

Sample Collection Systems

Liquid effluents are sampled continuously at, or very near, their points of discharge to the receiving streams. Three primary systems are used—paddlewheel samplers, Brailsford motor pumps, and Isco samplers. EMS personnel normally collect the liquid effluent samples weekly and transport them to the EMS laboratory for analysis.

The following effluent sampling and monitoring changes were made during 1993:

- The 291-F isokinetic sampling system replaced the old F-Area main-stack sampling system.
- The 291-H isokinetic sampling system replaced the old H-Area main-stack sampling system.
- The 772-4F stack and isokinetic sampling system replaced the temporary 772-F stack and sampling system.
- The Replacement Tritium Facility stack and monitoring system was added to the Tritium Facility stack and monitoring system.

Continuous Monitoring Systems

Depending on the processes involved, liquid effluents also may be monitored by area operations and/or Radiological Control Operations personnel with real-time instrumentation to ensure that instantaneous releases stay within established limits. However, because of instrumentation detection capabilities, on-line monitoring systems are not used to quantify liquid radioactive releases from SRS.

Laboratory Analysis

EMS provides most of the necessary radioanalytical laboratory functions to conduct the site liquid effluent monitoring program. Specific low-level analysis for selected radioisotopes is performed by the SRTC environmental laboratory.

Flow Rate Measurements

Liquid effluent flows generally are determined by one of four methods: U.S. Geological Survey (USGS) flow stations, stream velocity measurements, Isco sampler flow meters, or pump capacity calculations. Effluent flow rates are used to determine the total radioactivity released.

Settleable Solids

Settleable solids are defined as material settling out of suspension within a defined period.

To comply with the section of the DOE order pertaining to settleable solids (which requires the site to prevent the buildup of radioactivity in stream sediments), the Environmental Protection Department presented a sampling and analytical plan to DOE in 1991 [Eldridge, 1991].

The SRS settleable solids program was implemented in 1992 and continued throughout 1993 in order to ascertain whether or not radionuclides are being deposited in the sediments of site streams.

The program involves the collection and analysis of water samples (from process waste discharges) for settleable solids; this is performed in EMS's water

quality laboratory. The settleable solids then are analyzed for radionuclides in EMS's radiological laboratory.

Monitoring Results

Data from continuously monitored liquid effluent discharge points are used in conjunction with site seepage basin and Solid Waste Disposal Facility (SWDF) migration release estimates to quantify the total radioactive material released to the Savannah River from SRS operations. SRS liquid effluent releases for 1993 are shown by source in table 5-2, page 61.

For dose calculation purposes, releases of unidentified beta-gamma emitters were summed with strontium-89,90 releases, and they accounted for nearly 55 percent of the total strontium-89,90 reported. The combined strontium-89,90 and unidentified beta-gamma release total for 1993 ($4.77\text{E}-01$ Ci) showed a 40 percent decrease from the 1992 ($7.90\text{E}-01$ Ci) total. Also, unidentified alpha emitters were summed with plutonium-239 releases, and they accounted for more than 96 percent of the total plutonium-239 releases reported.

As with airborne releases, strontium-90 and plutonium-239 have the highest dose factors of the common alpha- and beta-emitting radionuclides found in liquid releases. Therefore, summing the unidentified alpha and beta emissions this way maintains conservatism of the highest dose being represented. In addition, some of the unidentified alpha and beta activity probably originates from naturally occurring radionuclides. This also adds a degree of conservatism to the dose calculations.

The radioactive liquid release totals are a major component in the determination of off-site dose consequences from SRS operations. The calculated individual and collective doses from site liquid releases are presented in chapter 7, "Dose," as a comparison of these off-site doses to EPA and DOE dose standards.

Tritium constitutes well over 99 percent of the radioactivity released to the Savannah River from direct discharges and from seepage basin and SWDF migration discharges. In 1993, approximately 11,300 Ci ($4.2\text{E}+14$ Bq) of tritium were released from SRS, compared to approximately 13,800 Ci ($5.1\text{E}+14$ Bq) released in 1992 [SRS Data, 1994].

Direct Discharges of Liquid Effluents

As discussed previously, tritium is the major radionuclide released in SRS liquid effluents. The total amount of tritium released directly from process areas

to site streams during 1993 was 1,670 Ci ($6.2\text{E}+13$ Bq), which was more than 30 percent less than the 1992 total of 2,390 Ci ($8.80\text{E}+13$ Bq). This large decrease is directly attributable to the shutdown and lay-up of all reactor facilities. The separations areas showed the largest decrease (from 1,040 Ci in 1992 to 426 Ci in 1993); however, liquid tritium releases from separations depend almost entirely on how much reactor-area-originated waste is sent to and processed in the Effluent Treatment Facility (ETF), which is located within the separations areas. ETF cannot remove tritium from the waste streams it processes.

Direct releases of tritium to site streams for the years 1988 through 1993 are shown in figure 5-2.

Comparison of Average Concentrations in Liquid Releases to DOE Derived Concentration Guides

In addition to dose standards, DOE Order 5400.5 imposes other control considerations on liquid releases. The DOE order lists DCG values for most radionuclides. DCGs are used as reference concentrations for conducting environmental protection programs at all DOE sites. These DCG values are not release limits, but rather are screening values for best available technology investigations and for determining whether existing effluent treatment systems are proper and effective.

Per DOE Order 5400.5, exceedance of the DCGs at any discharge point may require that an investigation be performed of best available technology waste treatment for the liquid effluents. Tritium in liquid effluents is specifically excluded from best available technology requirements; however, it is not excluded from other ALARA considerations. DOE DCG compliance is demonstrated when the sum of the fractional DCG values (based on consecutive 12-month average concentrations) for all radionuclides detectable in the effluent is less than 1.00.

DCGs, which are based on a 100-mrem exposure, are applicable at the point of discharge from the effluent conduit to the environment (prior to dilution or dispersion). They are based on the highly conservative assumption that a member of the public has continuous, direct access to the actual liquid effluents and consumes 2 liters of the effluents every day, 365 days a year. However, because of security controls and the large distance between most SRS operating facilities and the site boundary, this scenario is improbable.

For each site facility that releases radioactivity, EMS compares the monthly liquid effluent concentrations and 12-month average concentrations against the DOE DCGs [Releases, 1993].

Figure 5-2 Direct Releases of Tritium to Site Streams

The 1991 total includes an accidental release in December of 5,700 Ci from K-Reactor.

The 1993 liquid effluent 12-month average concentrations, their comparisons against the DOE DCGs, and the quantities of radionuclides released are provided, by discharge point, in *SRS Environmental Data for 1993* (WSRC-TR-94-077).

The U3R-2A (ETF outfall) discharge point exceeded the DCG guide for 12-month average tritium concentrations during 1993. However, as stated previously, DOE Order 5400.5 specifically exempts tritium from best available technology waste treatment investigation requirements. This is because there is no practical technology available for removing tritium from dilute liquid waste streams.

The K-Area purge to containment basin (K-percolation field) also exceeded the tritium DCG during 1993, but tritium again is exempted from the best available technology requirements.

No other discharge points exceeded the DOE DCGs during 1993.

Seepage Basin and SWDF Migration Results

To incorporate the migration of radioactivity to site streams into total radioactive release quantities, EMS monitors and quantifies the migration of radioactivity from site seepage basins and SWDF. During 1993, only tritium and strontium were detectable in migration releases [SRS Data, 1994].

Figure 5-3 is a graphical representation of releases of tritium via migration to site streams for the years 1988 through 1993. During 1993, the total quantity of tritium migrating from the seepage basins and SWDF was 9,630 Ci ($1.6\text{E}+14$ Bq), compared to 11,400 Ci ($4.2\text{E}+14$ Bq) in 1992. This 15 percent decrease is consistent with the reductions seen during 1988, 1989, 1990, and 1992. The reason for the larger than normal increase in migration during 1991 has not been determined with absolute certainty. However, it may be attributed to increased rainfall, which could have caused a more rapid migration of contaminants through the seepage basin into the groundwater.

Figure 5-4 shows the total combined tritium releases from direct discharges and seepage basin and SWDF migration from 1988 through 1993. During 1993,

Figure 5-3 Tritium Migration from Seepage Basins and SWDF to Site Streams

leaf Graph

direct releases of tritium from process areas accounted for 13 percent of the total tritium released to the Savannah River.

Refer to chapter 2, "Compliance Summary," for a discussion of SRS seepage basin closures.

Migration of Radioactivity from the K-Area Drain Field and Seepage Basin Liquid purges from the K-Area disassembly basin were released to the K-Area seepage basin in 1959 and 1960. Since 1960, purges from the K-Area disassembly basin have been discharged to a percolation field below the K-Area retention basin. A total tritium migration of 1,100 Ci ($4.1\text{E}+13$ Bq) was calculated from weekly flow measurements and tritium concentrations measured in Indian Grave Branch (a tributary of Pen Branch) during 1993. This migration represents a 28 percent decrease from the 1992 total of 1,530 Ci ($5.7\text{E}+13$ Bq).

Migration of Radioactivity from F-Area and H-Area Seepage Basins Although seepage basins in F-Area and H-Area no longer are used, radioactivity previously deposited in them continues to migrate via the groundwater and to outcrop into Four Mile Creek.

Migration of radioactivity from F-Area and H-Area seepage basins is measured with continuous samplers and flow recorders in Four Mile Creek. Groundwater

from the F-Area seepage basins enters Four Mile Creek between sampling locations FMC-3A, FMC-2B, and FMC-A7. Four Mile Creek sampling locations are shown in figure 6-3, page 71.

Most of the outcropping from H-Area seepage basins 1, 2, and 3 occurs between FMC-1C and FMC-2B. Outcropping from H-Area seepage basin 4 and SWDF occurs between FMC-3 and FMC-3A. Radioactivity from H-Area seepage basin 4 and SWDF mixes during groundwater migration to Four Mile Creek. Therefore, radioactivity from the two sources cannot be distinguished at the outcrop point.

Measured migration of tritium from F-Area seepage basins was 2,180 Ci ($8.1\text{E}+13$ Bq) in 1993, a 49 percent decrease from the 1992 total of 4,260 Ci ($1.6\text{E}+14$ Bq). The measured migration from H-Area seepage basin 4 and SWDF was 5,330 Ci ($2.0\text{E}+14$ Bq), a 30 percent increase from the 1992 total of 4,090 Ci ($1.5\text{E}+14$ Bq). The measured migration from H-Area seepage basins 1, 2, and 3 was 1,020 Ci ($3.8\text{E}+13$ Bq), a 31 percent decrease from the 1992 total of 1,470 Ci ($5.4\text{E}+13$ Bq) [SRS Data, 1994].

Past, current, and computer model-projected tritium migration releases from F-Area and H-Area seepage basins and SWDF are shown in figure 5-5. In general, and as the data show, tritium migration from the F-Area and H-Area seepage basins, which were closed in 1988,

has been declining and is projected to continue to decline. However, tritium migration from SWDF has remained relatively stable over the past 10 years. Furthermore, based on the operational history of SWDF and the geology and hydrology of the site, it is anticipated that, with no corrective actions, SWDF tritium migration to Four Mile Creek will remain at approximately 4500 Ci ($1.7\text{E}+13$ Bq) per year for at least the next 10 to 20 years [Looney et al, 1993].

As required by the Resource Conservation and Recovery Act (RCRA), SRS, in conjunction with the South Carolina Department of Health and Environmental Control (SCDHEC), is developing groundwater corrective action plans for SWDF. Portions of SWDF also are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA characterization and assessment also are under way. Reduction of tritium migration releases is one of the factors being considered during the development of these RCRA/CERCLA groundwater corrective action plans. Low permeability caps, waste form stabilization, groundwater barriers, groundwater pump-treat-reinjection, and other technologies are under consideration as relevant components of SWDF remediation.

In 1993, the amount of strontium-89,90 entering Four Mile Creek was estimated to be 150 mCi ($5.6\text{E}+09$ Bq) from the F-Area seepage basins. This was a 23 percent decrease from the 1992 level of 194 mCi ($7.2\text{E}+09$ Bq). In addition, 65 mCi ($2.4\text{E}+09$ Bq) of strontium-89,90 were estimated to have migrated from the H-Area seepage basins. This was a 17 percent decrease from the 1992 level of 78 mCi ($2.9\text{E}+09$ Bq) [SRS Data, 1994]. Like tritium migration, strontium migration is expected to continue to decline from these closed seepage basins.

In 1993, no cesium-137 migration was detected from the F-Area or H-Area seepage basins. However, 160 mCi ($5.9\text{E}+09$ Bq) of cesium-137 were detected at the sampling location near the Four Mile Creek mouth over and above the 246 mCi ($9.1\text{E}+09$ Bq) cesium-137 detected in direct process discharges. This additional cesium-137 is attributed to desorption of past cesium releases from the stream bed.

An estimated 22 mCi ($8.2\text{E}+08$ Bq) of iodine-129 were projected to have migrated from the F-Area and H-Area seepage basins during 1993. Because iodine-129 emits very low energy beta/gamma radiation, it cannot be detected—using common radioanalytical methods—in dilute streams. However, as releases of other radionuclides from SRS continue to decrease, the

Figure 5-4 Total Tritium Releases to Site Streams (Direct Discharges and Migration)

percentage of the maximum individual off-site dose attributed to iodine-129, which has a long half-life of 1.57×10^7 years, is likely to increase in future years. Therefore, beginning in 1994, the SRTC environmental laboratory, which has the sensitive instrumentation capable of detecting iodine-129, will be analyzing for iodine-129 in the F-Area and H-Area seepage basin migration samples.

Migration of Radioactivity from P-Area, C-Area, and L-Area Seepage Basins Liquid purges from the P-Area, L-Area, and C-Area disassembly basins have been released periodically to their respective seepage basins since 1978. Purge water is released to the seepage basins to allow a significant part of the tritium to decay before the water outcrops to surface streams and flows into the Savannah River. The delaying action of the basins reduces the dose that users of water from downriver water treatment plants receive from SRS tritium releases. The seepage basins were used for purging the disassembly basins from the 1950s until 1970, but disassembly basin purge water was released directly to SRS streams between 1970 and 1978. The earlier experience with seepage basins indicated that the extent of radioactive decay during the holdup was

sufficient to recommend that the basins be used again in P-Area, L-Area, and C-Area. However, because these reactor areas have been shut down, no purges to the basins occurred during 1993.

Results of samples taken from Twin Lakes and Castor Creek near C-Area indicated that no radionuclide migration could be attributed to the C-Area seepage basin in 1993. The failure of the Twin Lakes Dam in 1991 made the determination of migration more difficult in this area. Results from a sampler installed on Steel Creek above L-Lake indicated that 382 Ci (1.4×10^{13} Bq) of tritium migrated from the P-Area seepage basin during 1993, an increase of 65 percent from 1992 [SRS Data, 1994]. The reason for this increase has not been determined. Migration of radionuclides from the L-Area seepage basin has not been detected in site streams.

Settleable Solids Results

During 1993, the process waste streams chosen for testing in the Radionuclides in Settleable Solids Program were analyzed for settleable solids and radionuclides [SRS Data, 1994].

leaf Graphic

Figure 5-5 Past, current, and projected tritium migration releases to Four Mile Creek from the F-Area and H-Area Seepage Basins and SWDF.

For most locations, radionuclide analyses revealed the presence of only naturally occurring radionuclides, such as potassium and daughter products associated with the uranium and thorium decay chains. However, the December 1993 sample from the Four Mile Creek 3 location had detectable quantities of unidentified alpha activity. This activity was measured to be approximately 31.4 pCi/g (1.2 Bq/g), which is near the detection limit of the radioanalytical method used. Neither the duplicate sample taken from this location nor the

unsettleable portion of the original sample had alpha activity levels above the radioanalytical detection limit. Future sampling and analysis should reveal if a problem exists at this location. For all other samples, no man-made radionuclides were detected in quantifiable amounts, as defined by the minimum detectable activity for each analysis [SRS Data, 1994].

The analytical results, therefore, indicate no significant quantities of radionuclides accumulating from settleable solids in the sediments of site streams.

Table 5-1
1993 Atmospheric Radioactive Releases by Source

Page 1 of 1

Radio-nuclide	Half-life	Curies ^a						Diffuse and Fugitive ^b	Total	
		Reactors	Separations	Reactor Materials	Heavy Water	SRTC				
GASES AND VAPORS										
H-3 (oxide)	12.3 y	3.85E+04	9.39E+04		4.48E+02		4.31E+01	1.33E+05		
H-3 (elem)	12.3 y		5.82E+04					5.82E+04		
H-3 Total	12.3 y	3.85E+04	1.52E+05		4.48E+02		4.31E+01	1.91E+05		
C-14	5.7E3 y		1.69E-02				4.00E-06	1.69E-02		
I-129	1.6E7 y		4.96E-03				6.88E-07	4.96E-03		
I-131	8 d		8.89E-05			5.92E-05		1.48E-04		
I-133	20.8 h					1.96E-03		1.96E-03		
Xe-135	9.1 h					3.19E-02		3.19E-02		
PARTICULATES										
S-35	87.2 d						2.00E-06	2.00E-06		
Co-60	5.3 y		5.89E-09				3.34E-17	5.89E-09		
Ni-63	100 y						2.00E-07	2.00E-07		
Sr-89,90 ^c	29.1 y	1.81E-04	1.88E-03	8.32E-05	7.19E-06	1.19E-05	1.11E-04	2.27E-03		
Zr-95	64 d						2.39E-14	2.39E-14		
Ru-106	1.0 y	3.99E-06	5.76E-09				4.96E-12	4.00E-06		
Sb-125	2.8 y						7.27E-15	7.27E-15		
Cs-134	2.1 y		1.49E-06				1.40E-17	1.49E-06		
Cs-137	30.2 y	1.04E-04	5.28E-04			1.51E-06	4.33E-11	6.34E-04		
Ce-144	285 d						1.13E-13	1.13E-13		
Eu-154	8.6 y						3.44E-13	3.44E-13		
Eu-155	4.7 y						1.63E-13	1.63E-13		
U-235,238	4.5E9 y		1.86E-03	1.55E-05		2.89E-08	4.74E-05	1.92E-03		
Pu-238	87.7 y		1.21E-03			1.00E-08	4.63E-12	1.21E-03		
Pu-239 ^d	2.4E4 y	4.11E-06	1.06E-03	3.50E-06	8.42E-07	9.41E-06	4.70E-07	1.08E-03		
Am-241,243	7.4E3 y		1.42E-04			1.34E-06	8.86E-13	1.43E-04		
Cm-242,244	18.1 y		4.96E-05			6.83E-06	7.33E-12	5.64E-05		

^a One curie equals 3.7E+10 Becquerels.

^b Estimated releases from minor unmonitored diffuse and fugitive sources

^c Includes unidentified beta-gamma emissions

^d Includes unidentified alpha emissions

Table 5-2
1993 Liquid Radioactive Releases by Source
(Including Direct and Seepage Basin Migration Releases)

Page 1 of 1

Radio-nuclide	Half-life	Curies ^a					Total
		Reactors	Separations	Reactor Materials	Heavy Water	SRTC/TNX	
H-3 (oxide)	12.3 y	2.29E+03	9.88E+03		4.99E+02	1.29E-01	1.27E+04
Sr-89,90 ^b	29.1 y	1.87E-01	2.41E-01		4.65E-02	2.02E-03	4.77E-01
I-129	1.6E7 y		2.20E-02				2.20E-02
Cs-137	30.2 y	1.29E-02	2.33E-01				2.46E-01
Pm-147	2.6 y		7.03E-03				7.03E-03
U-235,238	4.5E9 y		1.14E-05				1.14E-05
Pu-239 ^c	2.4E4 y	5.97E-04	8.65E-03	7.64E-05		2.66E-04	9.59E-03

a One curie equals 3.7E+10 Becquerels.

b Includes unidentified beta-gamma

c Includes unidentified alpha

Chapter 6

Radiological Environmental Surveillance

Jason Chappell, Brian Crandall, Pete Fledderman, Craig Hetrick, and Roger Wong
Environmental Protection Department

Introduction

The radiological environmental surveillance program conducted at the Savannah River Site (SRS) is designed to survey and quantify any effects that routine and nonroutine operations might have on the site and on the surrounding area and population. The program, in conjunction with the radiological effluent monitoring program (see chapter 5, "Radiological Effluent Monitoring"), enables SRS to monitor ambient radiological conditions and determine site contributions of radioactive materials to the environment.

The SRS radiological surveillance program is an extensive network covering 30,000 square miles and extending up to 100 miles from the site. The program is designed to detect and quantify the effects of site operations on the surrounding population and environment.

Surveillance activities are performed by the Environmental Protection Department's Environmental Monitoring Section (EMS) and the Savannah River Technology Center (SRTC). The Savannah River also is monitored by other groups, including the South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Department of Natural Resources (GDNR).

As part of the radiological surveillance program, routine surveillance of all radiation exposure pathways (ingestion, inhalation, immersion, and submersion) is performed on all environmental media that may lead to a measurable annual dose at the site boundary. Included in this surveillance are analyses of the atmosphere, surface waters, drinking water, rainwater, sediment and soil, vegetation, food products, and wildlife. Also, extensive monitoring of ambient gamma radiation levels is performed on site, at the site boundary, and in population centers (surrounding communities).

All results discussed in this chapter are based on available sample analyses. Because of sampling and/or analytical difficulties, some sample analyses may be

missing. Problems may have arisen with sample collection, such as loss of power to the sampling site or inaccessibility to the sampling site (locked gates, flooding, etc.) Results for collected samples can be rejected after analysis for such reasons as insufficient sample volume, low chemical yield, or equipment failure. Details about the number of samples analyzed and the results of those analyses appear in *SRS Environmental Data for 1993* (WSRC-TR-94-077). Information on the rationale for the radiological environmental surveillance program can be found in chapter 3, "Environmental Program Information."

This chapter summarizes surveillance results of the following: air, gamma radiation, surface water, drinking water, rainwater, sediment, soil, vegetation, terrestrial foodstuffs, and aquatic and terrestrial wildlife. For complete program descriptions, see the "SRS Environmental Monitoring Plan" (WSRC-3Q1-2-1000) (EMP).

Applicable Regulations

The radiological surveillance program is driven by U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) regulations. DOE orders 5400.1, "General Environmental Protection Program," and 5400.5, "Radiation Protection of the Public and the Environment," require that an environmental surveillance program be conducted at all DOE sites to monitor the effects, if any, of DOE activities on the surrounding population and environment. Drinking water is governed by the South Carolina primary drinking water regulations, which establish water quality criteria and incorporate EPA drinking water standards for radionuclides. These standards apply to all public drinking water systems and are based on an annual whole-body dose of 4 mrem, assuming the consumption of 2 liters of water per day. SRS has voluntarily adopted EPA and South Carolina drinking water standards for on-site water supplies [CFR, 1976.; SCDHEC, 1990]. Table 6-1 lists the EPA drinking water standards for radionuclides.

Air

The SRS atmospheric surveillance program consists of 35 stations: 5 on site, 14 along the site perimeter, 12 at approximately a 25-mile radius, and 4 approximately 100 miles from the site. Figure 6-1 shows all the surveillance locations except the 100-mile stations.

Several changes were made to the air surveillance program during 1993 to improve sample quality. The changes represent a reconfiguration of the surveillance system to include replacement of old equipment and

the addition of new features. These changes include the following:

- Gas totalizing meters were installed. These provide a more accurate measurement of the total volume of air sampled than the timer and flow rate meter system previously used. The timer and flow rate meter system remains in use as a backup.
- New air pumps and flow meters were installed.
- Vacuum hoses and rubber tubing were replaced by hard piping with appropriate air-tight fittings.
- New tritium oxide silica gel collection columns were designed and installed. These columns have

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Figure 6-1 Air Surveillance Stations

The SRS atmospheric surveillance program consists of 31 stations located within 25 miles of the site and four stations (not shown) approximately 100 miles from the site

Table 6-1 EPA Drinking Water Standards for Radionuclides

Gross Alpha	1.5E-08 $\mu\text{Ci/mL}$
Nonvolatile Beta	5.0E-08 $\mu\text{Ci/mL}$
Tritium	2.0E-05 $\mu\text{Ci/mL}$
Strontium-89	2.0E-08 $\mu\text{Ci/mL}$
Strontium-90	8.0E-09 $\mu\text{Ci/mL}$

a more secure end cap than rubber stoppers used on the old columns, and they contain sufficient silica

gel for a 2-week sample. In addition, flow rate was standardized at 150 cubic centimeters per minute.

Surveillance Results

As discussed earlier, some analyses have fewer results than expected by the sampling and analysis information presented in the EMP because of sampling and/or analytical difficulties. Also, the changes discussed previously for tritium oxide sampling frequency were implemented over several months, resulting in the collection of fewer samples after the change at a given station.

Gross Alpha and Nonvolatile Beta Gross alpha and nonvolatile beta analyses are performed on glass fiber filters used to sample particulates in the air. These

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EMS upgraded its environmental surveillance air monitoring stations in 1993. In the EMS air sampling system, air is moved by a rotary vane pump (1). Two trains are used to sample the air. In the first train, air is drawn through a sampling head (2) containing a glass fiber filter and an activated charcoal canister. Sampling flow rate is indicated by a rotameter (3), and the integrated volume is indicated by a bellows-type gas meter (4). The second train consists of a clear column (5) that contains indicating silica gel and is used to sample atmospheric moisture for tritium. Flexible, hard tubing (6) and air-tight, quick-disconnect fittings (7) connect system components. Also shown is a rainwater ion column (8). Items 4, 5, 6, and 7 were added to the system to improve sample quality, while items 1, 2, 3, and 8 replaced old equipment as part of the monitoring program upgrade.

Table 6-2
Average 1991-1993 Gross Alpha and Nonvolatile Beta Measured in Air ($\mu\text{Ci}/\text{mL}$)

Locations	No. of Locations	Average Gross Alpha			Average Nonvolatile Beta		
		1991	1992	1993	1991	1992	1993
On site	5	2.5E-15	1.8E-15	1.9E-15	1.8E-14	1.9E-14	1.8E-14
Site perimeter	14	2.6E-15	1.8E-15	1.8E-15	1.8E-14	1.9E-14	1.9E-14
25-mile radius	12	2.5E-15	1.7E-15	1.8E-15	1.8E-14	1.8E-14	1.8E-14
100-mile radius	4	2.6E-15	1.7E-15	2.0E-15	1.8E-14	1.7E-14	2.0E-14

analyses do not provide isotope-specific characterization of activity, but they are used for screening purposes and do provide information for trending.

As detailed in chapter 5, "Radiological Effluent Monitoring," site operations resulted in the release of 2.8 mCi of beta particulate and 4.27 mCi of alpha particulate activity in 1993. This released activity was not detected at the site boundary. A summary of the average gross alpha and nonvolatile beta analytical results for 1991-1993 appears in table 6-2. These results show no difference in average concentrations observed near operating facilities (on-site locations) and those found at the site perimeter and beyond, indicating that the released activity was effectively dispersed by atmospheric transport.

The 1993 average gross alpha and nonvolatile beta levels were consistent with those from 1992. However, as indicated in the 1992 annual report, an unexplained increase in gross alpha activity was observed between 1990 and 1991. This level dropped somewhat in 1992 and remained unchanged in 1993. As previously indicated, changes in EMS analytical techniques in early 1991 are believed to be responsible for these changes.

The maximum single on-site concentration of gross alpha activity in air was $(4.06 \pm 0.77)\text{E}-15 \mu\text{Ci}/\text{mL}$ at the Burial Ground North location, while the highest average on-site concentration was $(2.12 \pm 0.87)\text{E}-15 \mu\text{Ci}/\text{mL}$, also observed at the Burial Ground North location. Likewise, the maximum single site perimeter or off-site concentration of gross alpha activity in air was $(5.11 \pm 0.84)\text{E}-15 \mu\text{Ci}/\text{mL}$ at the Olar, South Carolina, location, while the highest average off-site concentration was $(2.09 \pm 0.94)\text{E}-15 \mu\text{Ci}/\text{mL}$ at the Darkhorse (Williston Gate) location. These concentrations are consistent with historical levels.

The maximum single on-site concentration of nonvolatile beta was $(4.11 \pm 0.12)\text{E}-14 \mu\text{Ci}/\text{mL}$ of air, measured at the F-Area location, while the highest average on-site concentration was $(1.92 \pm 0.57)\text{E}-14 \mu\text{Ci}/\text{mL}$, also observed at the F-Area location. The maximum single site perimeter/off-site concentration of nonvolatile beta was $(6.30 \pm 0.15)\text{E}-14 \mu\text{Ci}/\text{mL}$ measured at the Barnwell Gate location, while the highest average concentration was $(2.21 \pm 0.74)\text{E}-14 \mu\text{Ci}/\text{mL}$, observed at the Greenville, South Carolina, location. The Barnwell Gate measurement is considerably higher than the average nonvolatile beta concentrations observed at other site perimeter locations and somewhat higher than the single sample maximum nonvolatile beta concentration observed at those locations. This increase was measured in the same sample that showed detectable levels of gamma-emitting radionuclides—identified as cobalt-60 and manganese-54—and is attributable to those nuclides.

Gross alpha and nonvolatile beta results from two additional on-site locations (Par Pond bubble-up and Par Pond pump house) were reported for part of the year. These were temporary sampling locations installed and operated to support the 1991 drawdown of Par Pond; they were removed from service in February 1993. Because these stations were not part of the routine atmospheric surveillance program, their results are not discussed in this chapter.

Gamma-Emitting Radionuclides Glass fiber filters and charcoal cartridges were analyzed for gamma-emitting radionuclides. Two weekly perimeter composite samples of glass fiber filters indicated detectable gamma activity. It was determined in both cases that a filter from the Barnwell station was responsible for the detectable activity. The only two nuclides quantified were low levels of manganese-54 and cobalt-60, which are activation products normally associated with reactor operations. Examination of SRS source term

data indicated that only $5.9\text{E}-9$ Ci of cobalt-60 was released from SRS during 1993; this occurred during October. The SRS samples showing the activity were collected during the November time period and indicated a higher cobalt-60 concentration than was measured at the release location. The exact cause of these elevated results is unknown.

Plutonium and Strontium Composite samples were analyzed for plutonium-238 and plutonium-239. These nuclides are released in small amounts from routine operations. In 1993, plutonium isotopes were released primarily from the separations areas, with much smaller amounts released from SRTC. Consistent with this source term, the routine surveillance results indicate that the highest levels of plutonium were observed at the F-Area and H-Area locations, with the Burial Ground North and Burial Ground South locations also showing higher concentrations near the point of release. Concentrations decrease at the site perimeter and 25-mile locations as a result of dispersion and diffusion. In general, the 1993 results are slightly higher than the 1992 results.

Both the maximum average and maximum single plutonium-238 concentrations were observed at the H-Area location; the maximum average plutonium-238 concentration was $(3.59 \pm 5.59)\text{E}-17$ $\mu\text{Ci/cc}$, and the maximum single concentration was $(1.93 \pm 0.12)\text{E}-16$ $\mu\text{Ci/cc}$. Both the maximum average and maximum single plutonium-239 concentrations were observed at the F-Area location; the maximum average plutonium-239 concentration was $(2.27 \pm 3.29)\text{E}-17$ $\mu\text{Ci/cc}$, and the maximum single concentration was $(1.19 \pm 0.02)\text{E}-16$ $\mu\text{Ci/cc}$.

Composites also were analyzed for total strontium (strontium-89,90). In 1993, a small amount of strontium was released from the separations areas as part of normal operations. Surveillance results showed levels that generally were at or near the detection limit. As in 1992, both the maximum average and the maximum single strontium-89,90 concentrations were observed at the Burial Ground North location; the maximum average strontium-89,90 concentration was $(2.42 \pm 4.36)\text{E}-16$ $\mu\text{Ci/cc}$, and the maximum single concentration was $(1.27 \pm 0.54)\text{E}-15$ $\mu\text{Ci/cc}$. The total strontium concentrations at the site perimeter and off-site locations were similar to each other and were less than those observed on site.

Tritium As previously discussed, the sampling protocol for atmospheric tritium oxide was changed in 1993. Collection frequency of the silica gel samplers was changed from 1 to 2 weeks. Because of this change, analytical results are not directly comparable but may be compared to observe gross trends.

For the year, average concentrations were similar to 1992 levels. As in previous years, H-Area showed the highest single measurement, $(5.26 \pm 0.08)\text{E}-9$ $\mu\text{Ci/cc}$, and the highest annual average concentration, $(1.06 \pm 1.13)\text{E}-9$ $\mu\text{Ci/cc}$. This is expected, given the proximity of the sampling location to the tritium facilities in H-Area. Sampling locations at F-Area, Burial Ground North, and Burial Ground South also showed tritium concentrations higher than at the site perimeter and off site; this also is due to the proximity of these locations to the tritium facilities. Generally, the site perimeter monitoring locations showed slightly higher concentrations—11 of 14 showed an increase—and the average concentration of the 14 locations also increased. These increases are attributable to higher tritium releases in 1993. Meanwhile, the 25-mile stations showed slightly lower concentrations—eight of 11 locations with a change showed a decrease—and their average concentration also decreased.

Gamma Radiation

Ambient gamma exposure in and around SRS is monitored by an extensive environmental thermoluminescent dosimeter (TLD) program. TLDs have been used by SRS since 1965 to monitor ambient gamma levels and to provide an accurate and reliable method of quantifying gamma exposure.

The gamma surveillance program consists of 392 surveillance locations within an 8,000-square-mile area of SRS. The information provided by this program is used to determine and document ambient gamma exposure levels, evaluate trends in environmental exposure levels, and support dose calculation actions in the event of an unplanned release of gamma-emitting radionuclides.

The routine TLD surveillance network is divided into five areas: on-site locations, site perimeter locations, air monitoring locations (designated as 614 buildings), population centers, and Nuclear Regulatory Commission (NRC)/Vogtle Electric Generating Plant stations. (Plant Vogtle is a nuclear power facility on the Georgia side of the Savannah River.) Monitored population centers are within a 50-mile radius of the site boundary (figure 6-2). The numbers of surveillance locations in each program area are as follows:

- On site, 94 locations
- Site perimeter, 179 locations
- Air monitoring stations, 39 locations
- Population centers, 62 locations
- NRC/Vogtle, 18 locations

Every three months, the TLDs are collected for analysis and replaced.

In late 1992, EMS implemented a series of program changes designed to improve the quality of TLD data. These changes consisted of the following actions:

- New TLDs were purchased.
- Packaging of TLDs was changed from plastic zippered bags to thicker, heat-sealed plastic bags.
- Individual element correction factors were determined for each thermoluminescent element. Prior to this, each badge was assigned to one of eight categories, and a general correction factor was applied based on the category.
- Blank and fade badges were placed at each surveillance location. All such badges on a run are averaged and applied to all field (indicator) badges on the entire run. Prior to this, a set of blank and fade badges was placed at one of two control locations. The new method provides a more representative measure of run-specific external factors affecting results.
- Badges were labeled with an individual bar code. These badges are placed using a portable bar code reader to record the location, date, and time of badge placement and retrieval. At the completion of a run, this information is downloaded into a computer database for subsequent processing.
- Data entry and processing routines were automated.
- Monitoring of the inside of public buildings at population centers was discontinued. Monitoring outside of these buildings continued.

Surveillance Results

Surveillance results are expressed in mrem per day. Although the TLD is an integrating device, this derived unit is used to facilitate data comparison between locations or through time at a single location.

The monitoring results indicate values that appear consistently higher than those observed in previous years. However, the program changes described earlier resulted in many improvements to the quantification of gamma exposure rates. Chief among these changes was the replacement of old stressed badges with new badges—each with an individual element correction factor—and the addition of new field packaging. Because of these changes, the exposure levels measured in 1993 were more accurate than those from previous years.

Table 6-3 shows the maximum exposure observed from each surveillance area; a wide range of exposures was observed. Gamma radiation fields vary significantly from one location to another because of differences in the terrestrial, cosmic, and man-made components of natural background radiation. The EPA estimates an average outdoor dose in Augusta, Georgia, of 84 mrem per year from cosmic and terrestrial radiation [Oakley, 1972].

The program improvements make it impossible to directly compare 1993 data to that of previous years. However, trends of the relative exposure rate at all monitoring locations may be compared from year to year. Within normal data fluctuation, these trends in 1993 were similar to those observed in 1992; that is,

Measuring Gamma Radiation in the Environment

Gamma radiation levels at and around SRS are measured continuously with TLDs. TLDs provide a quick and reliable method for determining doses to population groups within an 8,000-square-mile area of SRS in the event of an unplanned release of radioactivity.

Bar Coding

SRS uses bar coding technology to identify TLDs and monitoring locations.

When TLDs are placed in the field, bar codes corresponding to the monitoring location and badge ID number are read by a portable, hand-held scanner.

An individual badge's history can be tracked using the bar code identification.

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Figure 6-2 Off-Site TLD Surveillance Locations

areas of elevated exposure rates in 1992 also showed elevated exposure rates in 1993.

On-site TLD measurements are taken along the fence line surrounding the various SRS operating areas. Most on-site exposure rates were no greater than levels observed on the site perimeter or off site. However, some on-site measurements were above background levels, including those at F-Area and H-Area near their respective tank farms, at the Solid Waste Disposal Facility (SWDF), and at N-Area (formerly Central Shops). The maximum daily exposure rate observed on site was in N-Area.

Surface Water

The radiological surveillance program for surface water is designed to collect and analyze samples from

on- and off-site control locations, from locations downstream of the process area, from seepage basins, and from Savannah River locations.

Seepage Basins

During previous years of operation, SRS discharged liquid effluent to seepage basins to allow for the decay and natural removal of radioactivity in the water before it reached on-site streams. The practice of discharging water to the seepage basins was discontinued in 1988, but water accumulating in the basins from other sources continues to be monitored by EMS because of potential contamination from the basin soil. In 1993, samples were collected monthly from the SWDF and TNX seepage basins, and quarterly from the C-Area, L-Area, and P-Area basins. As part of the E-Area expansion plan, EMS also began monitoring two

Table 6-3
TLD Surveillance Results Summary for 1993

Surveillance Area	Maximum Exposure (mrem/year)	Location
On site	506	N-Area
Site perimeter	102	Mile 20.0
Population centers	138	West Columbia, S.C.
Surveillance	126	Highway 301
NRC/Vogtle	79	NRC #1

basins, E Basin North and E Basin South. Because of dry conditions, no samples were pulled from the A-Area seepage basins during 1993.

Seepage basin water is analyzed for gross alpha, nonvolatile beta, and tritium content. Analyses for specific radionuclides are determined by the make-up of previous releases to the basins.

Surveillance Results

Sampling results from 1993 for seepage basin water were similar to those from 1992, largely because liquid effluents no longer introduce new activity to the basins. As in 1992, the C-Area and P-Area basins contained the highest beta activity, the majority of which was identified as cesium-137. The tritium concentration in the P-Area basins, which had reached a maximum of $1.04\text{E-}03 \mu\text{Ci/mL}$ in 1992, registered only a $2.00\text{E-}05 \mu\text{Ci/mL}$ high in 1993. The newly monitored E Basin North and E Basin South showed only tritium at detectable levels [SRS Data, 1994].

Site Streams

Continuous surveillance is used on several SRS streams, including Tims Branch, Upper Three Runs Creek, Four Mile Creek (also known as Fourmile Branch), Pen Branch, Steel Creek, and Lower Three Runs Creek. Stream water sampling locations that monitor below process areas serve to detect and quantify levels of radioactivity in liquid effluents that are being transported to the Savannah River. In 1993, 23 samplers on SRS streams served as environmental surveillance points. Stream surveillance locations are shown in figure 6-3.

Stream samples are collected every week and analyzed as either weekly, biweekly, or monthly composites. Frequency and types of analyses performed on each sample are based on the potential quantity and type of

radionuclides likely to be present in the water at that surveillance station. Generally, tritium determinations, gamma spectroscopy, and gross alpha and nonvolatile beta screening are performed on stream water. Monthly composites also are analyzed for strontium, another likely byproduct of SRS operations. The choice of analytical schemes for particular stream locations is a dynamic one documented in the EMP.

Surveillance Results

The average gross alpha, nonvolatile beta, and tritium concentrations at downstream locations near the creek mouths are presented in table 6-4. A graph showing the average concentration over a 5-year period is presented in figure 6-4. The location of these stations, well below all points at which radioactivity is introduced into the respective streams, ensures that adequate mixing has taken place and that a representative sample is being analyzed. Concentrations at surveillance station U3R-1A (above process effluents and runoff locations on Upper Three Runs Creek) and at an Edisto River surveillance station in the Aiken State Park above the site are listed for comparison purposes. The following sections contain discussions of surveillance results from each of the major SRS creeks.

Tims Branch (TB) A tributary of Upper Three Runs Creek, Tims Branch receives effluents from M-Area and SRTC. A surveillance point on Tims Branch, TB-5, is located downstream of all release points and before entry into Upper Three Runs Creek. Tritium and gamma emitters were not detected in Tims Branch in 1993, and gross alpha and nonvolatile beta measurements, while above the detection limit, are comparable to levels seen above SRS at the U3R-1A and the Edisto sampling locations.

Upper Three Runs Creek (U3R) Upper Three Runs Creek receives discharges from the Effluent Treatment Facility (ETF), flow from Tims Branch, effluent from

the Naval Fuels Facility, and stormwater runoff from F-Area and H-Area. Tritium, the predominant radionuclide detected in Upper Three Runs Creek, is discharged primarily from the ETF. The average concentration of tritium in 1993 at U3R-4, located at Road A on SRS, was $(3.58 \pm 3.55)E-06$ $\mu\text{Ci/mL}$,

which was 18 percent of the $2.00E-05$ $\mu\text{Ci/mL}$ EPA drinking water standard for tritium. Gross alpha concentrations in Upper Three Runs Creek were slightly above the detection limit, with the highest concentrations occurring at U3R-1A, above the site. Gross alpha concentrations at this station are similar to

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Figure 6-3 Surface Water Sampling Locations

Surveillance and effluent sampling points are located on SRS streams and seepage basins and on the Savannah River.

those observed at the Edisto River above SRS in the Aiken State Park. The highest concentrations are believed to be caused by naturally occurring radium, thorium, and/or uranium from heavy mineral deposits common to waters in these sampling areas.

Four Mile Creek (FMC) Four Mile Creek receives effluents from F-Area, H-Area, and C-Area, as well as from waters that have migrated from seepage basins and are outcropping into the stream. Four Mile Creek transported the majority of radioactivity present in SRS streams in 1993, mostly in the form of nonvolatile beta-gamma activity and tritium. The nonvolatile beta-gamma activity is made up of strontium outcropping from retired seepage basins, as well as cesium-137 from direct releases and resuspension of activity deposited in the streambed. The amount of tritium transported in Four Mile Creek was approximately 75 percent of the total amount reaching the Savannah River in 1993. Because the highest tritium concentrations are present at surveillance points along Four Mile Creek, and not at the stations monitoring direct releases, most of the tritium transport is due to outcropping activity from retired seepage basins and from the SWDF. This activity is expected to decrease in the coming years as a result of the closure of the F-Area and H-Area seepage basins in 1988.

Pen Branch (PB) Pen Branch receives discharges from K-Area and flow from a tributary, Indian Grave Branch. Levels of gross alpha and nonvolatile beta activity in Pen Branch were below detection limits. Because K-Reactor did not operate in 1993, tritium detected in Pen Branch was due to water entering from Indian Grave Branch, which carries tritium outcropping from the K-Area percolation field and seepage basins. The average tritium concentration at PB-3 was $(4.02 \pm 1.14)E-05$ $\mu\text{Ci/mL}$ in 1993, virtually unchanged from the level observed in 1992.

Steel Creek (SC) Steel Creek receives releases from L-Area effluents and tritium migration from P-Area seepage basins. When P-Area diverts water away from Par Pond to Steel Creek, the area's discharges are transported in the stream. All releases enter L Lake. Water from L Lake overflows into Steel Creek and is monitored at SC-4. Gross alpha and nonvolatile beta concentrations at SC-4 were below detection limits, with tritium being detected at an average concentration of $(5.15 \pm 0.53)E-06$ $\mu\text{Ci/mL}$. Because the highest tritium concentration, $(1.62 \pm 0.86)E-04$ $\mu\text{Ci/mL}$, is measured at the surveillance station at SC-2A, and not at the direct-release monitoring stations in L-Area and P-Area, activity being transported in Steel Creek is

Ileaf Graphic

Figure 6-4 Average Tritium Concentration Site Streams from 1988 to 1993

Analysis of stream water shows a fairly steady decrease in the concentration of tritium in on-site streams.

Table 6-4
Average Concentration of Radioactivity in Off-Site and SRS Stream Waters ($\mu\text{Ci/mL}$)

Location ^a Lower Limits of Detection	Gross Alpha 6.23E-10	Nonvolatile Beta 1.55E-09	Tritium 1.30E-06
Tims Branch (TB-5)	(1.54 $\pm$ 1.01)E-09	(2.48 $\pm$ 1.23)E-09	(9.88 $\pm$ 3.15)E-07
Upper Three Runs (U3R-4)	(1.77 $\pm$ 0.97)E-09	(1.50 $\pm$ 1.01)E-09	(3.58 $\pm$ 3.55)E-06
Four Mile Creek (FMC-6)	(3.50 $\pm$ 3.08)E-10	(1.41 $\pm$ 0.37)E-08	(2.22 $\pm$ 0.55)E-04
Pen Branch (PB-3)	(2.59 $\pm$ 3.45)E-10	(1.22 $\pm$ 0.54)E-09	(4.02 $\pm$ 1.14)E-05
Steel Creek (SC-4)	(0.46 $\pm$ 3.05)E-10	(1.49 $\pm$ 0.55)E-09	(5.15 $\pm$ 0.53)E-06
Lower Three Runs (L3R-3)	(1.26 $\pm$ 1.89)E-10	(2.74 $\pm$ 1.09)E-09	(9.03 $\pm$ 3.89)E-07
Above the site			
Edisto River	(1.06 $\pm$ 0.49)E-09	(1.40 $\pm$ 0.49)E-09	(1.66 $\pm$ 1.37)E-07
Upper Three Runs (U3R-1A)	(2.26 $\pm$ 1.27)E-09	(1.41 $\pm$ 0.89)E-09	(5.48 $\pm$ 4.47)E-07

^a Site surveillance locations are near mouths of streams.

attributed to outcropping from the P-Area seepage basins.

Lower Three Runs Creek (L3R) Lower Three Runs Creek receives overflow from Par Pond, a man-made pond that receives discharges from P-Area. Nonvolatile beta concentrations in Par Pond and Lower Three Runs Creek are above detection limits; this is attributed to low concentrations of cesium-137 from previous releases during P-Area and R-Area operations. Gross alpha and tritium concentrations in Lower Three Runs Creek are at background levels.

Savannah River

Continuous surveillance is performed along the Savannah River at points above and below SRS, in the vicinity of the river entry points of SRS streams, and above and below the point at which Plant Vogtle liquid discharges enter the Savannah River. In 1993, seven locations along the river served as environmental surveillance points. River sampling locations are shown in figure 6-5.

The Savannah River, which provides SRS its western boundary for a 35-mile stretch, is analyzed to determine what effect the site's effluents have on the river water. Gross screening for alpha and beta emitters—along with determinations of specific isotopes, such as tritium, plutonium, strontium, and

gamma emitters—is performed on weekly, biweekly, and monthly composites.

Surveillance Results

The average concentrations of gross alpha, nonvolatile beta, and tritium at river locations are presented in table 6-5. The order of the locations begins above the site with R-2 and ends with R-10 (below SRS after all site stream entries into the Savannah River). Samplers situated between R-2 and R-10 are located along the SRS boundary, where various creek mouths and discharges feed into the river.

Tritium Tritium is the predominant radionuclide detected in the Savannah River above background levels. The highest average concentration in 1993, (1.24 $\pm$ 0.46)E-06 $\mu\text{Ci/mL}$, was measured at R-10, located at Highway 301 below SRS. The average concentration above SRS, measured at R-2 at Shell Bluff, was (0.70 $\pm$ 1.73)E-07 $\mu\text{Ci/mL}$. The R-10 concentration was 6 percent of the 2.00E-05 $\mu\text{Ci/mL}$ drinking water standard set by the EPA for tritium in drinking water. Figure 6-6 shows weekly concentrations of tritium at R-2 and R-10 in 1993.

Other Radionuclides Gross alpha, nonvolatile beta, plutonium, and strontium concentrations in the Savannah River along SRS were at background levels for surface water. There is no statistical difference between the concentrations of these radionuclides above and below the site.

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Figure 6-5 Savannah River Water Sampling Locations

River water samples are collected from several locations along the Savannah River—upriver of, adjacent to, and downriver of SRS.

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Figure 6-6 Tritium Concentrations in the Savannah River Above and Below SRS

Tritium concentrations in the Savannah River below SRS, although higher than concentrations detected above the site, were well below the EPA Drinking Water Standard of 20,000 pCi/L in 1993.

Table 6-5
Average Concentration of Radioactivity in the Savannah River ($\mu\text{Ci/mL}$)

Location Lower Limits of Detection	Alpha $6.23\text{E-}10$	Nonvolatile Beta $1.55\text{E-}09$	Tritium $4.07\text{E-}07$
R-2, above SRS	$(0.39 \pm 2.00)\text{E-}10$	$(1.72 \pm 0.63)\text{E-}09$	$(0.70 \pm 1.73)\text{E-}07$
R-3A, above Vogtle discharge	$(0.73 \pm 2.01)\text{E-}10$	$(1.78 \pm 0.67)\text{E-}09$	$(2.82 \pm 3.36)\text{E-}07$
R-3B, below Vogtle discharge	$(1.11 \pm 1.79)\text{E-}10$	$(1.85 \pm 0.50)\text{E-}09$	$(6.11 \pm 8.97)\text{E-}07$
R-8A, below Steel Creek	$(0.55 \pm 20.3)\text{E-}10$	$(1.77 \pm 0.50)\text{E-}09$	$(9.37 \pm 5.11)\text{E-}07$
R-8C, below Little Hell Landing	$(0.60 \pm 20.5)\text{E-}10$	$(1.71 \pm 0.63)\text{E-}09$	$(1.22 \pm 0.58)\text{E-}06$
R-10, below SRS	$(0.09 \pm 1.44)\text{E-}10$	$(1.76 \pm 0.51)\text{E-}09$	$(1.24 \pm 0.46)\text{E-}06$

Tritium Transport in Streams and River

Tritium is introduced into SRS streams and the Savannah River via production areas on site. Because of the mobility of tritium in water and the quantity of the radionuclide released during the years of SRS operations, a tritium balance has been performed annually since 1960. The balance is evaluated among the following alternative methods of calculation:

- Tritium releases from effluent release points and calculated seepage basin migration (direct releases)
- Tritium transport in SRS streams and the last sampling point before entry into the Savannah River (stream transport)
- Tritium transport in the Savannah River downriver from SRS after subtraction of any measured contribution above the site (river transport)

Figure 6-7 and table 6-6 show graphic and numeric summaries of the last 34 years of direct releases, stream transport, and river transport determined by EMS.

In 1993, tritium transport continued a downward trend from the highs registered in the mid-1960s. The decrease is attributed to a slowdown in production activities on site.

General agreement between the three calculational methods of annual tritium transport—measurements at the source, stream transport, and river transport—serves to validate SRS sampling schemes and counting results. Differences between the various methods can be attributed to uncertainties arising in the collection and analytical processes, including determinations of water flows and varying transport times. For each SRS stream flowing to the Savannah River, the higher of the two estimates, direct release or stream transport, is used for environmental dose calculations.

leaf Graph

Figure 6-7 SRS Tritium Transport Summary, 1960-1993

SRS has maintained a tritium balance of direct releases, stream transport, and river transport since 1960 in an effort to account for and trend tritium releases in liquid effluents from the site. The general downward slope over time indicates that tritium transport has decreased as production has slowed and effluent controls have been developed.

Table 6-6
Summary of SRS Tritium Transport, 1960-1993

Year	Estimated Tritium Transport (Ci)		
	Based on Point-of-Release Concentrations and Flow Rates ^a	Based on Stream Concentrations and Flow Rates	Based on Savannah River Concentrations and Flow Rates
1960	64,000 ^b	69,600	73,700
1961	69,000 ^b	83,000	77,000
1962	58,000 ^b	64,000	63,000
1963	97,000 ^b	96,900	122,800
1964	111,000 ^b	131,600	143,000
1965	108,400	109,200	100,200
1966	84,900	97,800	78,300
1967	70,600	77,000	68,500
1968	63,800	67,200	61,800
1969	64,600	64,000	58,100
1970	36,900	43,200	31,800
1971	38,200	44,700	39,100
1972	46,800	47,300	45,300
1973	71,100	62,800	61,100
1974	59,900	54,600	46,000
1975	55,600	50,000	49,500
1976	59,600	47,400	51,100
1977	43,800	39,700	42,500
1978	37,600	35,300	36,600
1979	29,400	27,100	30,600
1980	24,900	28,800	30,700
1981	23,900	22,100	25,100
1982	32,200	31,300	30,600
1983	34,200	33,000	33,000
1984	32,800	32,600	33,200
1985	25,000	22,300	24,100
1986	27,800	22,300	22,100
1987	22,700	20,500	26,200
1988	19,300	18,300	14,600
1989	17,300	17,800	15,600
1990	16,100	15,600	14,500
1991	27,400	26,600	26,300
1992	13,800	13,100	13,800
1993	11,300	12,700	12,200

a Includes direct releases to streams and migration from F-Area, H-Area, K-Area, and P-Area seepage basins and the SWDF to streams

b Includes heat exchanger cooling water (of Par Pond origin) released from P-Area to Steel Creek

Drinking Water

EMS collects drinking water samples from locations at SRS, in surrounding towns and communities, and at water treatment facilities using Savannah River water. Potable water from surrounding communities is analyzed to ensure that SRS operations are not adversely affecting the water supply and to provide voluntary assurance that drinking water is below EPA drinking water standards for radionuclides.

Sampling on site consists of monthly grab samples collected at production areas and quarterly pulls at nonproduction and perimeter stations. Semiannual collection is performed at towns within a 30-mile radius of the site. Collected monthly are samples from two water treatment plants downriver of SRS that supply treated Savannah River water to Beaufort and Jasper counties in South Carolina and to Port Wentworth, Georgia, as well as samples from the North Augusta Water Treatment Plant and the D-Area treatment facility on site. At all these facilities, raw and finished water samples are collected daily personnel and composited in preparation for analysis by EMS. All drinking water samples are screened for alpha and beta emitters and analyzed specifically for tritium. Drinking water samples also are analyzed at least once

a year for strontium. Drinking water sampling locations are shown in figure 6-8.

Surveillance Results

Analytical results of radionuclides monitored in drinking water samples collected by EMS are discussed in the following paragraphs.

Gross Alpha and Nonvolatile Beta All drinking water samples collected by EMS are screened for gross alpha and nonvolatile beta concentrations to determine if activity levels warrant further analysis. No samples collected in 1993 exceeded EPA's $1.50\text{E}-08$ $\mu\text{Ci/mL}$ alpha activity limits or $5.00\text{E}-08$ $\mu\text{Ci/mL}$ beta activity limits. The highest average alpha concentration, $(1.32 \pm 0.10)\text{E}-08$ $\mu\text{Ci/mL}$ at the 701-5G Aiken Barricade (Talatha Gate), has been characterized for specific alpha activity, with at least a partial source of activity due to radium-226. This location currently is served by bottled water. A few on-site sample locations exceeded $8.00\text{E}-09$ $\mu\text{Ci/mL}$ of beta activity, which is the EPA limit for strontium-90, a beta emitter. None of the samples that exceeded this beta level showed detectable levels of strontium-90.

Strontium No drinking water samples collected and analyzed for strontium-90 by EMS exceeded the $1.90\text{E}-09$ $\mu\text{Ci/mL}$ detection limit of the EMS

Figure 6-8 Drinking Water Sampling Locations
SRS collects drinking water samples from 14 surrounding towns and cities within a 30-mile radius and from two water treatment plants (not shown on map) that supply treated Savannah River water to Beaufort-Jasper and Port Wentworth consumers.

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laboratories. This detection limit is approximately 25 percent of the EPA drinking water standard for strontium-90.

Tritium No drinking water samples collected and analyzed by EMS exceeded the $2.00\text{E}-05$ $\mu\text{Ci/mL}$ EPA tritium limit. Detectable levels of tritium were present in the drinking water samples collected monthly from the Beaufort-Jasper and Port Wentworth water treatment facilities. These levels reflect the introduction of tritium from SRS operations into the Savannah River. The average tritium concentration in finished water at Beaufort-Jasper in 1993, $(7.12 \pm 4.63)\text{E}-07$ $\mu\text{Ci/mL}$, was 4 percent of the EPA drinking water limit. The average tritium concentration at Port Wentworth, $(9.67 \pm 2.48)\text{E}-07$ $\mu\text{Ci/mL}$, was 5 percent of the limit.

Rainwater

SRS maintains a network of rainwater sampling stations to measure deposition from worldwide fallout and emissions from the site. Rainwater can be a source of dose to man through the ingestion pathway (foodstuffs and drinking water) and by direct external exposure. Rainwater data are used to assist in the detection and quantification of unplanned releases and as an important indicator of environmental atmospheric trends.

Rainwater collection pans are located atop each air surveillance station (figure 6-1, page 64). Ion-exchange resin columns are placed at four of these stations—H-Area (on-site), Barnwell Gate and Darkhorse (site perimeter), and Olar (off-site)—to determine radionuclide deposition. Rainwater passes from the pans through the ion columns and into collection bottles. The ion columns, to be analyzed for deposition, and water from the collection bottles are returned to the laboratory. Rainwater at all other locations, which do not have ion columns, passes directly from the pans to the collection bottles and also is returned to the laboratory.

Ion-exchange and rainwater samples from the previously mentioned four stations were collected monthly. Rainwater samples from the four 100-mile-radius control stations were collected and analyzed quarterly.

EMS began biweekly collection and tritium analysis of rainwater samples from every station in 1993 in response to state and public concerns about tritium in groundwater used for drinking water, and in an effort to improve the quality of the program.

In general, ion column samples are analyzed for gross alpha, nonvolatile beta, gamma-emitting radionu-

clides, strontium, and plutonium. Rainwater samples are analyzed for tritium.

Surveillance Results

Because of the differences in sampling frequency, data from the 100-mile-radius stations are not comparable to those from other stations. The quarterly frequency allows more activity to collect on the 100-mile-radius ion columns; the levels of this activity typically exceed those measured at locations on site, at the site perimeter, and at the 25-mile-radius stations.

Gross Alpha and Nonvolatile Beta The average concentration of gross alpha at the H-Area station, $(1.92 \pm 2.57)\text{E}+00$ pCi/m^2 , exceeded the averages at the site perimeter and 25-mile-radius stations. Although the gross alpha measurement gave no indication of specific radionuclides present in the sample, the increase may reflect the increased deposition of alpha-emitting isotopes from F-Area and H-Area separations facilities. The highest average nonvolatile beta concentration of the monthly samples— $(7.27 \pm 7.95)\text{E}+01$ pCi/m^2 measured at Barnwell Gate—represented a typical numerical distribution of nonvolatile beta measurements seen at each station and did not reflect contributions from SRS operations. As expected, the longer sampling interval at the 100-mile-radius stations resulted in increased gross alpha and nonvolatile beta measurements, with the maximum average gross alpha concentration of $(6.53 \pm 4.11)\text{E}+00$ pCi/m^2 measured at Columbia, South Carolina, and the maximum average nonvolatile beta concentration of $(3.62 \pm 3.20)\text{E}+02$ pCi/m^2 measured at Greenville, South Carolina.

Gamma-Emitting Radionuclides One sample, the March ion column collected at the H-Area station, showed a detectable level of a man-made radionuclide, cesium-137, at $(5.11 \pm 5.13)\text{E}+01$ pCi/m^2 . This station is in the vicinity of separations and tank farm atmospheric releases that contain small quantities of cesium-137.

Plutonium Detectable levels of plutonium were observed only at the H-Area station, with both plutonium-238 and plutonium-239 concentrations averaging less than 0.1 pCi/m^2 . The proximity of the station to the F-Area and H-Area separations facilities, which contain small amounts of plutonium in their atmospheric effluent, explains the positive identification.

Strontium Measurements of strontium in rain are below detectable levels because of the absence of a large strontium-bearing effluent on site.

Tritium For the first time since 1986, and as discussed earlier, biweekly samples from all atmo-

spheric surveillance stations were analyzed for tritium in rain. Not surprisingly, the highest concentration of rainwater tritium, located in H-Area and averaging $(4.25 \pm 3.05)E-05 \mu\text{Ci/mL}$, is collected at the station nearest the tritium facilities, which routinely release tritium in their atmospheric effluent (figure 6-9).

Sediment

Collection and radiological analysis of sediment samples monitor the deposition and accumulation of long-lived radionuclides in SRS streambeds and in the Savannah River riverbed. Although the data gathered from the radiological sediment surveillance program are not used to directly show compliance with any dose standard, they can be used to verify dose models and are used for determination of environmental trends [EMP, 1993].

Sediment samples are collected annually from 15 locations on the Savannah River or on SRS streams. Seven of the locations are on site streams and eight are on the Savannah River upriver from, adjacent to, and downriver of SRS. This is a change from 1992, when there were nine locations on the site streams and six on the Savannah River. The change resulted from the renaming of two site stream locations to two river locations. These two locations, Upper Three Runs Mouth (River Mile 157.2) and Lower Three Runs Mouth (River Mile 129), are at the mouths of streams that interface with the Savannah River. Sediment sampling locations are shown in figure 6-10.

Collection of sediment samples is conducted annually because sediment usually is not in a critical exposure pathway. Sediment sample results indicate the quantity and type of radionuclides released by liquid effluents. Because liquid effluents are considered an exposure pathway leading to ingestion, while sediment deposits are not, the liquid effluents are monitored on a monthly or weekly basis.

Sediment is analyzed for gamma-emitting radionuclides and strontium-90, which are fission/activation products, and for plutonium-238 and plutonium-239, which are transuranics.

Surveillance Results

Concentrations of radionuclides in sediment may vary from year to year because the exact collection points in the streambeds and riverbeds may vary. An ecosystem, such as a river or a stream, periodically is subjected to turbulent water and suspended debris. This can create mobilization and resuspension of sediment on the riverbeds and streambeds and thus cause variations in radionuclide concentrations. Because sediment samples normally are analyzed to detect the buildup of radionuclides by sedimentation, it is more appropriate to use sediment analytical results as long-term trending indicators rather than year-to-year indicators.

Gamma-Emitting Radionuclides Cesium-137 was the only man-made, gamma-emitting radionuclide detected in river sediment. Chemically, cesium has a high tendency to attach to clay minerals and organic materials. In 1993 the maximum cesium-137 concentration detected in river sediment was

Figure 6-9 Average Concentration of Tritium in Rainwater

Tritium concentrations in rainwater generally decrease as the distance from the site increases.

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Figure 6-10 Sediment Sampling Locations

Sediment samples were collected in 1993 at eight Savannah River locations—upriver of, adjacent to, and downriver of SRS—and seven site stream locations.

(1.17 ± 0.06)E-00 pCi/g, which occurred at Lower Three Runs Mouth. This location was listed as a stream sediment in 1992. As indicated earlier, exact collection points for riverbed locations vary from year to year, and turbulent water—along with suspended debris—can mobilize and resuspend sediment in the riverbed. This may be responsible for the differences in the 1993 and 1992 analytical results, which could not be attributed to any known contributions from Par Pond or Lower Three Runs Creek.

As expected, higher concentrations of gamma emitters were measured in stream sediment than in river sediment. The site streams, which eventually lead to the Savannah River, generally receive any liquid effluents on site. Most radionuclides settle out and deposit onto streambed sediment before they reach the river. In 1993, the maximum cesium-137 concentration detected in stream sediment was (3.68 ± 0.03)E+01 pCi/g, which occurred at Steel Creek/Pen Branch Mouth. The mouth of a stream is an area where deposition of sediment is likely because water flow rate decreases as the stream channel widens. This deposition—combined with mobilization and resuspension of sediment, as well as with varying collection points—could account for the differences in the 1993 and 1992 analytical results at Steel Creek/Pen Branch Mouth.

Cobalt-60 also was detected in stream sediment at four collection points. Cobalt-60 was detected in Four Mile Creek, Pen Branch, and Steel Creek. The maximum cobalt-60 concentration of (1.02 ± 0.05) pCi/g was detected in sediment at Steel Creek/Pen Branch Mouth. As indicated earlier, the stream mouth is an area where deposition, mobilization, and resuspension of sediment can occur, and these factors contribute to year-to-year concentration variations. At all other streambed and riverbed collection points, the sample results were below the lower limits of detection (LLD) for the radioanalytical method used.

Plutonium Plutonium-239 and plutonium-238 were the two radioisotopes of plutonium observed in the Savannah River and in SRS streams during 1993. The maximum plutonium-238 concentration, (7.50 ± 0.41)E-02 pCi/g, was detected at Four Mile Creek Road A-7, and the maximum plutonium-239 concentration, (8.15 ± 0.36)E-02 pCi/g, was detected at Steel Creek/Pen Branch Mouth. Both samples represent SRS streambed sediments, which should be expected to have higher concentrations than riverbed sediments.

On average, the riverbed sediment concentrations for plutonium-239 and plutonium-238 were an order of magnitude less than the streambed sediment concentra-

tions. The maximum plutonium-238 concentration in river sediment (3.24 ± 0.65)E-03 pCi/g, was detected at Upper Three Runs Mouth, as was the maximum plutonium-239 concentration in river sediment (1.52 ± 0.14)E-02 pCi/g. Mobilization and resuspension of sediment, as well as deposition rates at a stream mouth, may have contributed to differences in the 1993 and 1992 results at the Upper Three Runs Mouth location. Specifically, two SRS stream locations, Four Mile Creek Road A-7, and Four Mile A-7 (beaver pond), produced sediment results a magnitude of ten lower in 1993 than in 1992.

Strontium The maximum detected strontium-90 concentration of (2.47 ± 0.26)E-01 pCi/g was at Four Mile Creek at Road A-7. This result is less than the 1992 result by approximately a magnitude of ten. Year-to-year variations in radionuclide concentrations due to the previously mentioned factors could cause this difference. The rest of the stream sediment results were less than the LLD for strontium-90 sediment analysis. All strontium-90 river sediment results were less than the LLD for strontium-90 sediment analysis.

Soil

Soil samples are collected and analyzed to determine the deposition and accumulation of long-lived radionuclides at SRS and on the surrounding terrain. Routine and nonroutine atmospheric releases from SRS, as well as worldwide fallout, are monitored by this program. Rainfall and dry deposition contribute to the presence of radionuclides in soil. Data from the soil surveillance program are not used to directly show compliance with any dose standard. However, the data can be used, as required, to verify dose models and are used to determine environmental trends.

Soil samples are collected annually from 24 locations at either on- or off-site areas of undisturbed and uncultivated land. Radionuclide concentrations in soil can vary due to phenomena, such as physical decay, leaching, resuspension or dissolution, or spatial reallocations. Because of this, it is more appropriate to collect annual soil samples for long-term trending purposes than for year-to-year comparisons.

In 1993, samples were collected on site from 16 locations—in H-Area, F-Area, S-Area, and Z-Area—and off site from four locations around the site perimeter and two locations 100 miles from the site. For trending purposes, two additional E-Area locations, Burial Ground 643-26E-1 and Burial Ground 643-26E-2, were sampled in 1993 to determine a baseline activity. Located between F-Area and H-Area, E-Area is a newly designated area where low-level wastes eventually will be stored.

Soil is analyzed for gamma emitters (primarily cesium-137), strontium-90, plutonium-238, and plutonium-239.

Surveillance Results

Concentrations of the radionuclides detected in the soil samples showed minor variations from previous years, but these variations could be attributed to several different factors. Different radionuclides have various rates of migration through soil. For example, strontium binds more weakly to soil and travels more freely through soil than cesium. The retention and transport characteristics of radionuclides in soil can affect concentration values. The presence of organic material in soil affects the solubility of radionuclides. Strontium and plutonium move more freely in soil with a high content of organic matter because of its increased solubility. Worldwide fallout contributes to the presence of man-made radionuclides in soil. Nuclear reactor accidents—such as the one that occurred at Chernobyl—and, to a lesser extent, nations that do not abide by the nuclear test-ban treaty—China, for example—can introduce nuclear fallout to the environment in unpredictable patterns, causing variations in radionuclide soil concentrations. Capillary conduction can play an important role in the transportation of radionuclides through soil. If soil is saturated by precipitation, the moisture gradient flow direction is downward. As evaporation occurs and surface soil dries out, the moisture gradient flow reverses and moves upward. Soluble radionuclides can move according to this gradient flow by means of capillary conduction.

Gamma-Emitting Radionuclides Cesium-137 was detected at 16 of the 18 on-site locations, at all four site perimeter stations, and at the two 100-mile locations. The maximum on-site cesium-137 soil concentration, (1.26 ± 0.07) pCi/g, was found south of F-Area. No detectable cesium-137 was observed at the S-Area 5 and S-Area 7 stations. The differences in 1993 and 1992 results were not unexpected because of the phenomena previously discussed, which can affect radionuclide concentrations in soil. The maximum site perimeter soil cesium-137 concentration, (6.52 ± 0.34) E-01 pCi/g, was found in the northwest quadrant. The maximum 100-mile-radius soil cesium-137 concentration, (3.52 ± 0.28) E-01 pCi/g, was detected at the Clinton, South Carolina, location. At this concentration level, the Clinton result could be attributed to a different collection point in 1993, as well as to a buildup of nuclear fallout from previous years.

Plutonium Plutonium-238 and plutonium-239 were detected in soil samples collected for plutonium analysis in 1993. The results generally show that the

plutonium-238 concentrations are an order of magnitude less than the plutonium-239 concentrations. This could be due to two factors. First, plutonium-239 and plutonium-240 are not distinguishable by alpha spectroscopy analysis because the energies of the alpha particles emitted by both radioisotopes are practically the same. Because plutonium-239 and plutonium-240 dose consequences are the same and the majority of plutonium releases are plutonium-239, measured radioactivity is reported as all plutonium-239. Also, as a result of nuclear weapons testing, more plutonium-239 and plutonium-240 are present in soils than plutonium-238. This difference could reach up to one or two orders of magnitude when comparing plutonium-238 results to those of plutonium-239.

The maximum on-site soil plutonium-238 concentration, (7.84 ± 0.39) E-02 pCi/g, was observed south of F-Area. The maximum on-site soil plutonium-239 concentration, (3.60 ± 0.09) E-01 pCi/g, was found east of F-Area. The differences in the 1993 and 1992 results were not unexpected because of the previously discussed phenomena, which can affect radionuclide concentrations in soil. It should be noted that samples from two locations, Burial Ground 643-26E-1 and Burial Ground 643-26E-2, were not analyzed for plutonium.

As expected, plutonium concentrations off site and along the site perimeter were lower than those on site. The maximum site perimeter plutonium-238 concentration, (1.87 ± 0.72) E-03 pCi/g, was observed in the southwest quadrant. The maximum site perimeter plutonium-239 concentration, (2.01 ± 0.10) E-02 pCi/g, was found in the southeast quadrant. The maximum off-site plutonium-238 concentration, (1.05 ± 0.45) E-03 pCi/g, was found at the Savannah, Georgia, location. The maximum off-site plutonium-239 concentration, (8.35 ± 1.45) E-03 pCi/g, was observed at the Clinton location.

Strontium-90 The maximum soil strontium-90 concentration, (1.33 ± 0.27) E-01 pCi/g, was observed south of F-Area. All other soil samples collected and analyzed were below the LLD for strontium-90 (9.45 E-02 pCi/g).

Vegetation

The radiological program for vegetation is designed to routinely collect and analyze samples from on- and off-site locations to determine radionuclide concentrations. Vegetation samples are obtained to complement the soil and sediment samples as a means of determining the environmental accumulation of radioactivity and to help confirm the dose models used by WSRC. Furthermore, the program provides

information that can be used to determine the effect, if any, of SRS operations on the surrounding vegetation.

On-site samples, collected on a seasonal or quarterly basis, are obtained from areas with predicted maximum annual ground concentrations and from areas receiving water that might have been contaminated. These on-site collection locations are inside and around SWDF, F-Area, H-Area, Z-Area, S-Area, and the site's many seepage and retention basins. Off-site vegetation generally is collected in close proximity to the environmental air monitoring stations, which are designated as 614 buildings.

Vegetation samples are analyzed for gross alpha and nonvolatile beta, gamma-emitting radionuclides, strontium-89,90, and tritium. These radionuclides, once deposited on the surface of the ground or vegetation, are prone to both vertical and horizontal transfer and can contaminate local vegetation. EMS recognizes that vegetation can be contaminated externally by the deposition of airborne activity and internally by water runoff or by precipitation that contains radioactivity. While the program makes no attempt to differentiate between the contributions of external and internal contamination, the contributions can be approximated if the local soil radionuclide concentrations are available.

Typically, grasses are the vegetation of choice because of their year-round availability. Bermuda grass is preferred because of its importance as a pasture grass for dairy herds.

Surveillance Results

The vegetation surveillance program can be divided into three broad areas: quarterly samples, annual seepage and retention basin samples, and annual SWDF samples. Each area is discussed in this section. All results are based on dry weight.

Quarterly Samples

Vegetation samples are collected quarterly from 40 locations on and off site. Eighteen locations are on site, 14 are on the site perimeter, four are 25 miles from the site, and four are 100 miles from the site. On-site locations are shown in figure 6-11. Analytical results are summarized in table 6-7.

The F-Area and H-Area locations are 2,000 feet from each of the areas' atmospheric discharge stacks. This distance was chosen to avoid production and construction activities in the areas. Also, the distance places most of the sampling sites outside high-security areas, where they can be maintained more easily.

Sampling around S-Area and Z-Area was initiated in 1989 to obtain baseline information before the start of radioactive operations at these waste processing facilities. The locations continue to be sampled to determine the effect of the activities on the surrounding vegetation.

Two of the 18 on-site locations were added to the burial ground perimeter in 1993. These locations are sampled quarterly to develop baseline information prior to the startup of the 643-26E burial ground expansion, which will contain the E-Area vaults. Their locations were selected along the north and east perimeter fencing, which represents the direction of the expansion of the existing burial grounds.

The site perimeter locations circle SRS and are located to permit sampling within each 30-degree sector around the site.

The 25-mile locations are used for the accumulation of trending data. The 100-mile-radius locations serve as control locations and provide historical baseline information.

EMS was able to obtain a quarterly sample from every location except Talatha Gate. Only three samples were collected from this location during 1993 because there was an insufficient amount of grass during the fall collection run.

Gross Alpha and Nonvolatile Beta The 1993 data indicate that the gross alpha levels for the F-Area and H-Area composites were elevated when compared to the 100-mile-radius composites. This was not unexpected because these facilities were involved with the production and isolation of materials that are alpha emitters. An examination of the nonvolatile beta values shows there was no significant difference between the on-site surveillance locations and the surrounding control locations.

Many of the gross alpha results (both on and off site) were at or below the LLD. Variations in worldwide fallout patterns and in concentrations of naturally occurring radionuclides in the soil contributed to the differences in the nonvolatile beta concentrations.

Gamma-Emitting Radionuclides Most vegetation samples are composited for analysis of gamma-emitting radionuclides. Samples are composited by area (F-Area and H-Area) and by radius (perimeter, 25-mile, and 100-mile). Samples from E-Area, S-Area, and Z-Area are not composited but are analyzed individually.

Cesium-137 was present in at least one sample from every location. Although not present in all samples analyzed, cesium-137 was the only man-made gamma-emitting radionuclide detected. Because ce-

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Figure 6-11 On-site Quarterly Vegetation Sampling Locations

sium-137 was not detected in a large number of samples, inferences are difficult. When detected at on-site locations, cesium-137 is present at a slightly higher level than at the perimeter and off-site locations. The concentrations detected represent a committed dose—using 1983 Food and Drug Administration (FDA) forage conversion factors—that is less than 1 mrem and 10,000 times less than the FDA's 1982 preventive protective action guide of 1.3 $\mu\text{Ci/kg}$.

Strontium The strontium-89,90 levels for the F-Area and H-Area composites were elevated when compared to the 100-mile-radius composites. Because strontium is a long-lived radionuclide present in the F-Area and H-Area tank farms, the results of this comparison were not unexpected. As with the gross alpha results, many of the strontium levels were at or below the LLD.

Tritium On-site and perimeter tritium concentrations generally were higher than the concentrations in vegetation samples collected from the 25- and 100-mile-radius locations. These higher on-site and perimeter concentrations were attributed to atmospheric tritium releases from SRS.

Seepage and Retention Basins

Seepage and retention basin vegetation samples are collected at 18 locations. Vegetation is collected annually, and all samples from a specific operating area are composited for measurements of gross alpha, nonvolatile beta, and gamma-emitting radionuclides, as well as for strontium-89,90. Maximum concentrations are presented in table 6-8. No grass was available in two areas of the H-Area retention basin, so no

samples were obtained from locations HRB-4 and HRB-5.

As in previous years, low levels of gross alpha activity were detected in a number of basins, although a large analytical uncertainty is associated with most of these measurements. Generally, the seepage and retention basins' gross alpha levels were consistent with background levels observed off site and on the site perimeter.

Nonvolatile beta activity was detected in all vegetation samples analyzed. In general, the nonvolatile beta

activity was at or near background levels observed off site and on the site perimeter. The data were comparable to those of previous years, with the A-Area seepage basin vegetation having the highest nonvolatile beta result.

As in 1992, cesium-137 was the only man-made, gamma-emitting radionuclide detected. This nuclide was present in samples from all locations except the F-Area seepage basin. Generally, the cesium-137 concentrations were present at levels at or near the off-site and perimeter levels. The cesium-137

Table 6-7
Maximum Radionuclide Concentrations in Vegetation from Quarterly Surveillance Samples (pCi/g)

Surveillance Ring	Maximum	Location
Gross Alpha		
On Site	$(4.30 \pm 1.36)E+00$	Z-Area 8
Perimeter	$(3.52 \pm 1.45)E+00$	Jackson ^a
25-Mile	$(1.34 \pm 0.75)E+00$	Allendale
100-Mile	$(1.95 \pm 1.04)E+00$	Greenville
Nonvolatile Beta		
On Site	$(70.3 \pm 0.31)E+01$	S-Area 3
Perimeter	$(41.8 \pm 0.26)E+01$	Talatha
25-Mile	$(3.84 \pm 0.25)E+01$	Waynesboro
100-Mile	$(3.91 \pm 0.26)E+01$	Macon
Cs-137		
On Site	$(6.25 \pm 0.58)E-01$	Z-Area 7
Perimeter	$(2.98 \pm 0.40)E-01$	Z-Area 7
25-Mile	$(1.75 \pm 0.27)E-01$	Z-Area 7
100-Mile	$(1.48 \pm 0.42)E-01$	Z-Area 7
Strontium		
On Site	$(2.84 \pm 0.14)E+00$	H-Area
Perimeter	$(1.92 \pm 0.13)E+00$	H-Area
25-Mile	$(5.75 \pm 0.83)E-01$	H-Area
100-Mile	$(2.56 \pm 0.74)E-01$	H-Area
Tritium		
On Site	$(2.28 \pm 0.04)E+01$	S-Area 4
Perimeter	$(1.20 \pm 0.05)E+00$	Jackson
25-Mile	$(5.97 \pm 0.24)E-01$	Langley
100-Mile	$(3.46 \pm 0.63)E-01$	Macon

^a Multiple samples were collected during the year at this location; of those samples, one had the highest concentration and another the lowest.

Table 6-8

Maximum Radionuclide Concentrations in Vegetation from Seepage and Retention Basins (pCi/g)

	Maximum	Location
Gross Alpha	$(1.54 \pm 0.70)E+00$	H-Area Retention
Nonvolatile Beta	$(6.09 \pm 0.24)E+01$	A-Area Seepage
Cs-137	$(2.77 \pm 0.12)E+00$	H-Area Retention
Strontium	$(1.16 \pm 0.05)E+01$	A-Area Seepage

concentrations usually were higher for locations with higher nonvolatile beta activities.

Strontium was detected in all samples. The A-Area seepage basin vegetation continued to increase in concentration of strontium-89,90; however, most other basins exhibited concentrations comparable to previous years. No strong relationship between nonvolatile beta and strontium-89,90 was noted in samples at or near background levels.

Solid Waste Disposal Facility

When they are available, vegetation samples are collected annually inside and outside the SWDF to determine if there is a significant uptake of radioactivity occurring from the buried waste. Samples

were collected successfully from 46 of the 48 existing sites. Samples were not obtained from locations IBG-28 and IBG-32 because of lack of vegetation. All SWDF samples are analyzed for gross alpha, nonvolatile beta, and gamma-emitting radionuclides. Maximum concentrations are presented in table 6-9. SWDF interior sample locations are shown in figure 6-12.

Because of a high gross alpha concentration in 1992, location IBG-14 was sampled twice during 1993. Both values were comparable to the off-site control locations and indicated that this location may not be trending high for alpha activity. Generally, the gross alpha activities for the SWDF samples were at or near the levels present at the site perimeter and off-site control

Table 6-9

Maximum Radionuclide Concentrations in Vegetation from inside and Outside the Solid Waste Disposal Facility (pCi/g)

	Maximum	Location
Gross Alpha	$(0.62 \pm 1.28)E+01$	OBG-5
Gross Beta	$(1.18 \pm 0.04)E+02$	IBG-4A & IBG-17
Cs-137	$(3.39 \pm 0.13)E+00$	IBG-9

Figure 6-12 SWDF Interior Vegetation Sampling Locations

Vegetation samples are collected inside the SWDF, which houses buried waste, to determine whether uptake of radioactivity by vegetation has occurred.

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locations. This would suggest that there is no appreciable uptake of gross alpha activity in the SWDF vegetation.

Thirty-four of the 46 inside-location samples showed minor reductions in gross nonvolatile beta concentrations from 1992 to 1993. The 12 samples that showed increased concentrations in 1993 could represent some floral uptake; however, many factors other than floral uptake could influence the nonvolatile beta concentrations, including soil composition, turnover, leaching, and adsorption. The higher cesium-137 concentrations generally occurred at the locations with elevated nonvolatile beta.

Foodstuffs

The foodstuff surveillance program consists of radiological analyses of foodstuff samples typically found in the Central Savannah River Area (CSRA). Radioactive materials can be transported to humans through the consumption of milk and other food products containing radioactivity. Therefore, foodstuff samples are analyzed to determine what effect, if any, SRS operations have on them. Data from the food product surveillance program are not used to directly show compliance with any dose standard. However, the

data can be used, as required, to verify dose models and to determine environmental trends.

Description of Program

Farm products, including milk, poultry, beef, pork, fruit, wheat, corn, soybeans, peanuts, and other crops, are collected throughout the year from 20 locations surrounding SRS. Six of these locations are near the site perimeter, and eight are approximately 25 miles from the site. EMS also attempts to collect eggs on a quarterly basis from the perimeter and 25-mile locations. Collards are collected annually from the Columbia area and used as control samples. Figure 6-13 shows the sampling locations at the perimeter and 25-mile locations.

In 1993, four new food sample areas were added to the foodstuffs surveillance program. These areas, designated as the northeast, southeast, northwest, and southwest quadrants, are approximately 50 to 60 miles from the site (figure 6-14). If possible, all foodstuffs from each area were collected within a several-mile radius of the same location in the quadrants. The foodstuffs collected are the same as previously listed, except for eggs and poultry.

Food samples are analyzed for gamma-emitting radionuclides, uranium and plutonium (nonspecific),

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Figure 6-13 Foodstuffs Perimeter and 25-Mile Sampling Locations

Foodstuffs collection points correspond to general geographic areas because exact locations vary from year to year and crop to crop. Food samples are collected annually, except for eggs, which are collected quarterly, and milk, which is collected quarterly and monthly.

plutonium-238, plutonium-239, strontium-89,90, and tritium.

During 1993, milk samples were collected monthly at five dairies within a 25-mile radius of SRS, at four dairies within a 50-mile radius, and from locally produced inventories of a major distributor.

The milk samples were analyzed for gamma-emitting radionuclides—primarily cesium-137 and io-

dine-131—and for tritium. Additional milk samples are collected quarterly for strontium-90 analysis.

Surveillance Results

The following paragraphs present the 1993 surveillance results for foodstuffs and milk.

Gamma-Emitting Radionuclides The only man-made gamma-emitting radionuclide detected in food was cesium-137. The maximum cesium-137 concentration, $(5.10 \pm 0.62)E-02$ pCi/g, was measured in

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Figure 6-14 Foodstuffs 50-Mile Sampling Locations

In 1993, the foodstuffs sampling program was expanded to include 50-mile-radius locations. The collection points correspond to general geographic areas because exact locations vary from year to year and crop to crop.

beef taken from the Talatha area, which is near the site. Concentrations of cesium-137 were not detected in control samples.

Cesium-137 also was the only man-made gamma-emitting radionuclide detected in milk samples during 1993. The mean concentrations measured in 1993 were similar to those measured in 1992.

Uranium/Plutonium Most concentrations of total uranium and plutonium in foodstuffs were not detectable. The highest concentration, $(5.11 \pm 1.18)E-02$ pCi/g, was measured in collards taken from the Gracewood (Georgia) School vicinity. This was higher than the 1992 maximum concentration

of $(8.48 \pm 5.53)E-03$ pCi/g, which was measured in collards taken from the Allendale barricade vicinity.

Plutonium The maximum concentration of plutonium-238 found in foodstuffs during 1993 was $(7.55 \pm 0.64)E-04$ pCi/g, measured in chicken collected from the Gracewood School vicinity. Plutonium-239 concentrations were below the LLD for foodstuffs. Plutonium-238 and plutonium-239 concentrations measured in foodstuffs during 1993 were similar to the 1992 concentrations.

Strontium Except in collards, all concentrations in foodstuffs were below the LLD of $1.0E-01$ pCi/g. The strontium-89-90 concentrations measured in foodstuffs were within the ranges observed in past years.

Strontium analysis also was performed on milk taken from the perimeter and 25-mile sampling locations. The mean concentrations measured in 1993 were similar to those measured in 1992.

Tritium During 1993, concentrations of tritium ranged from less than the LLD to a maximum of $(2.47 \pm 0.34) \text{E-01 pCi/g}$ in eggs from the Allendale, South Carolina, barricade vicinity below the site. Tritium concentrations were similar to those measured in 1992.

Tritium in milk was attributed to SRS releases. Milk from all sampled dairies showed detectable concentrations of tritium during 1993. The maximum concentration for the perimeter and 25-mile-radius locations, $(1.17 \pm 0.13) \text{E-06 } \mu\text{Ci/mL}$, was observed at the Jackson, South Carolina, station. Tritium concentrations measured in milk in 1993 were similar to those measured in 1992 and generally reflected atmospheric releases from the site.

The maximum tritium concentration detected in milk from the 50-mile-radius locations, $(3.74 \pm 1.16) \text{E-07 } \mu\text{Ci/mL}$, was measured in a sample from the northeast quadrant. As expected, the concentrations of tritium in milk measured at the 50-mile locations were lower than those observed at the perimeter and 25-mile locations.

Aquatic and Terrestrial Wildlife

The protective boundary of SRS provides refuge for an abundance of wildlife. One objective of the site's environmental surveillance program is to assess the potential radiation dose to humans from the consumption of wildlife harvested on and in the vicinity of the site.

Fish

Nine surveillance points for the collection of fish are located on the Savannah River. These include

- five areas where site streams enter the Savannah River
- the Augusta Lock and Dam area upriver of the site
- the U.S. 301 bridge
- Stokes Bluff Landing
- the U.S. 17A bridge area below the site.

In addition to these nine locations, two points on the Edisto River are used as control locations—one for freshwater fish and the other for saltwater fish.

Nine surveillance points for fish collection also are located within the SRS boundary. These points include

Par Pond, L Lake, Pond B, Lower Three Runs Creek, Upper Three Runs Creek, Beaver Dam Creek, Pen Branch, Steel Creek, and Four Mile Creek.

Fish from all the surveillance points are grouped into one of three categories: predatory fish, panfish, or bottom-dwelling fish. Largemouth bass were placed in the predatory group; bluegill, red-breast, and crappie in the panfish group; and catfish in the bottom-dwelling group. The fish are grouped in this manner because they are the most sought-after fish in the Savannah River, according to the latest creel survey conducted by the Fisheries Management Section of the Georgia Department of Natural Resources Wildlife Resources Division.

Surveillance Results

Table 6-10 presents the average nonvolatile beta and cesium-137 activity measured in the edible portion of fish taken during 1993 from the Savannah River, from on-site streams and ponds, and from the freshwater control location on the Edisto River.

In the following surveillance results discussion, uncertainty values are provided because most measurements were at or near the LLD.

Savannah River Fifty edible composites and 42 nonedible composites of fish from the Savannah River were analyzed in 1993 for gross alpha and nonvolatile beta.

The maximum gross alpha activity of $(6.03 \pm 0.74) \text{E+00 pCi/g}$ was measured in the edible portion of a catfish composite from the U.S. 301 bridge area. The maximum gross alpha activity in a nonedible composite, $(9.27 \pm 1.34) \text{E+00 pCi/g}$, was in a catfish composite from Lower Three Runs Mouth.

The maximum edible nonvolatile beta activity from the Savannah River, $(5.15 \pm 1.08) \text{E+00 pCi/g}$, was measured in a bream composite from Four Mile Creek Mouth. This concentration was slightly higher than the maximum edible nonvolatile beta activity from the freshwater Edisto River control location, $(2.71 \pm 1.25) \text{E+00 pCi/g}$, which was measured in a crappie composite.

In 1993, composites of fish from the Savannah and Edisto rivers were analyzed for gamma-emitting radionuclides. Figure 6-15 shows surveillance locations on the Savannah River and the control locations on the Edisto. Cesium-137 was the only man-made, gamma-emitting radionuclide detected. The maximum cesium-137 activity in fish taken from the Savannah River, $(5.75 \pm 0.02) \text{E+00 pCi/g}$, was measured in edible composites of catfish from the Stokes Bluff Landing area. The maximum cesium-137 concentration in edible portions of fish from the freshwater

Edisto River control location was $(4.50 \pm 0.60)E-01$ pCi/g.

The maximum strontium-90 concentration measured in an edible composite from the Savannah River was in a bream composite from Lower Three Runs Mouth. The concentration, $(4.45 \pm 2.24)E-02$ pCi/g, was lower than that measured at the freshwater Edisto River control location. The maximum concentration of strontium-90 in the edible composite from the control location, $(6.69 \pm 1.55)E-02$ pCi/g, was in a crappie composite.

Maximum tritium concentrations were similar at all locations, with two exceptions. Four Mile Creek Mouth and Steel Creek Mouth edible composites yielded concentrations of $(1.12 \pm 0.02)E+00$ pCi/g and $(1.47 \pm 0.02)E+00$ pCi/g, respectively. The maximum tritium concentration measured at the freshwater Edisto River control location was below the LLD.

On-Site Surveillance Gross alpha and nonvolatile beta analyses were performed on edible fish composites collected from SRS streams and ponds. The maximum gross alpha activity,

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Figure 6-15 Fish Sampling Locations

SRS collects fish on the Savannah River above the site, adjacent to the site, and near the river mouth, as well as on the Edisto River at two control locations.

Table 6-10
Radioactivity in Edible Fish Composites (Average Concentration, pCi/g)

Location	Nonvolatile Beta	Cs-137
Savannah River Below SRS^a		
Bass	$(2.80 \pm 0.08)E+00$	^d
Bream	$(1.83 \pm 0.63)E+00$	$(8.60 \pm 2.43)E-02$
Catfish	$(1.65 \pm 1.37)E+00$	$(1.11 \pm 0.55)E-01$
Steel Creek Mouth^b		
Bass	$(8.49 \pm 4.63)E-01$	$(1.26 \pm 0.23)E+00$
Bream	$(4.40 \pm 0.41)E+00$	$(1.36 \pm 0.31)E-01$
Catfish	$(1.71 \pm 0.86)E+00$	$(1.46 \pm 0.71)E-01$
Edisto River (control location)^c		
Bass	^d	$(2.54 \pm 0.32)E-01$
Bream	$(2.12 \pm 1.18)E+00$	^d
Crappie	$(1.79 \pm 1.29)E+00$	$(4.50 \pm 0.60)E-01$

a River Mile 12 \ (Highway 301 Bridge)

b Creek adjacent to site

c West Bank Landing

d Less than detection limit

$(8.45 \pm 6.03)E-01$ pCi/g, was measured in a bass composite from Pond B. The maximum on-site nonvolatile beta activity, $(1.36 \pm 0.04)E+02$ pCi/g, also was measured in an edible bass composite from Pond B.

Cesium-137 was the only man-made, gamma-emitting radionuclide detected in fish from on-site streams and ponds. The maximum cesium-137 concentration in an on-site edible composite, $(1.16 \pm 0.01)E+02$ pCi/g, came from a Pond B bass composite. The maximum cesium-137 activity measured in a edible composite from the freshwater Edisto River control location was $(4.50 \pm 0.60)E-01$ pCi/g. Pond B fish typically contain higher cesium-137 concentrations than fish from other on-site locations because R-Reactor effluents were discharged through this body of water to Par Pond. R-Reactor was operated from the late 1950s until 1964, when it was shut down permanently. During this period, R-Reactor released approximately 170 Ci of cesium-137. Resuspension of this cesium-137 from the pond's sediments probably is the cause for the higher concentrations found in the Pond B fish.

Deer and Hogs

Annual hunts are conducted at SRS to control the site's deer and hog populations and reduce animal-vehicle accidents. Before any animal is released to a hunter, EMS performs field analyses for cesium-137 on all

deer and hogs at the hunt site using portable NaI (TI) detectors.

Surveillance Results

During the 1993 hunts, 1,553 deer and 147 hogs were harvested from the site. This compares to 1,519 deer and 147 hogs harvested in 1992. However, the number of hunts decreased from 18 in 1992 to 14 in 1993.

Gamma-Emitting Radionuclides In deer muscle tissue, the 1993 maximum cesium-137 field measurement was 43 pCi/g and the average was 4.7 pCi/g. For hogs, the maximum was 26 pCi/g and the average was 5.6 pCi/g.

The field measurements are supplemented by EMS laboratory analyses of muscle samples from approximately 10 percent of the animals harvested. These analyses are conducted to verify field measurements and determine the presence of other gamma-emitting radionuclides.

During 1993, 199 muscle samples were collected from 183 deer and hogs for EMS laboratory analysis of gamma-emitting radionuclides. The only man-made radionuclide detected by gamma analysis of the laboratory samples was cesium-137. The levels of cesium-137 detected by laboratory analysis ranged from $(2.2 \pm 0.5)E-01$ pCi/g to $(5.77 \pm 0.04)E+01$

pCi/g, compared to field measurement ranges of 1 pCi/g to 43 pCi/g.

The measured laboratory concentrations of cesium-137 in deer from SRS were compared to those in deer taken from off site. The off-site locations were approximately 50 miles from the center of the site from areas southeast and northwest of SRS. Because of unavailability, no deer were taken from the areas northeast or southwest of the site.

Muscle samples were collected from 24 deer from two off-site control locations and analyzed in the laboratory for gamma-emitting radionuclides. Of those deer, five were from the northwest quadrant and 19 from the southeast quadrant. The cesium-137 measurements were consistent with levels observed in 1992. The maximum cesium-137 concentration was 1.76 pCi/g, and the minimum was 0.06 pCi/g—both observed in samples from the northwest quadrant.

Strontium Samples from 37 animals (29 deer and eight hogs) were analyzed for strontium-89,90. Muscle samples were taken from all 37 of the animals and bone samples from 16 deer.

The muscle sample results in the 29 deer ranged from below detectable levels to 0.049 pCi/g; results from the eight hogs ranged from below detectable levels to 0.076 pCi/g. The bone sample results ranged from 4.09 to 13.40 pCi/g.

Higher concentrations of strontium occur in bone than in muscle because of the chemical similarity between strontium and calcium.

Turkeys

Wild turkeys are trapped live on site by the South Carolina Wildlife and Marine Resources Department and used to repopulate South Carolina game areas. All turkeys are monitored for cesium-137 with portable

NaI (TI) detectors before leaving SRS. EMS monitored 33 turkeys in 1993, and all concentrations of cesium-137 were similar to those measured in the past. The maximum concentration measured in 1993 was 5 pCi/g; the minimum, 1 pCi/g. This compares with a 1992 maximum of 2 pCi/g and minimum of 1 pCi/g.

Beavers

The U.S. Forest Service administers a contract for the trapping of beavers in selected areas within the SRS perimeter. The purpose of trapping is to reduce the beaver population in specific areas of the site and thereby minimize dam-building activities that can result in flood damage to timber stands, primary and secondary roads, and railroad beds. All beavers are monitored for cesium-137 with a portable NaI (TI) detector and disposed of in the SRS sanitary landfill. EMS monitored 127 beavers in 1993. The maximum cesium-137 concentration was 47 pCi/g, measured in an animal trapped at Meyers Branch near Old Dunbarton Road. The minimum concentration was 1 pCi/g. This compares with a 1992 maximum of 14 pCi/g and minimum of 1 pCi/g.

Turtles

Although no turtles were trapped in 1993 as part of the EMS monitoring program, the Savannah River Ecology Laboratory (SREL) trapped 818 turtles on and off site as part of other research projects. The turtles were monitored for gross beta-gamma with portable Geiger-Mueller detectors. Twenty-nine of them had radioactivity levels greater than the background reading of 100 counts per minute. Of these, 25 were pond sliders from Pond B; two were pond sliders from Four Mile Creek; one was a pond slider from Steel Creek; and the remaining turtle was a river cooter from the D-Area ash basin. The highest level recorded was 400 counts per minute in a pond slider from Pond B.

Chapter 7

Dose

Timothy Jannik
Environmental Protection Department

Bill Carlton
Environmental Technology Section

Introduction

This chapter presents the estimated doses to individuals and the surrounding population from Savannah River Site (SRS) atmospheric and liquid radioactive releases. The methodologies used to calculate these doses are described briefly.

Additionally, potential doses from special-case exposure scenarios, such as deer meat and goat milk consumption and crops irrigated with Savannah River water, are estimated and documented in this chapter.

Unless otherwise noted, the generic term "dose" used in this chapter includes both the committed effective dose equivalent (50-year committed dose) from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.

Many parameters—such as radioactive release quantities, population distribution, meteorological condi-

tions, radionuclide dose factors, human consumption rates of food and water, and environmental dispersion—should be considered in the dose models used to estimate off-site doses at SRS. For descriptions of the effluent monitoring and environmental surveillance programs discussed in this chapter, refer to chapter 5, "Radiological Effluent Monitoring," and chapter 6, "Radiological Environmental Surveillance." Additional information about dose and dose calculations can be found in the "SRS Environmental Monitoring Plan" (WSRC-3Q1-2-1000) and in *SRS Environmental Data for 1993* (WSRC-TR-94-077).

Applicable Regulations

Table 7-1 presents the dose standards for atmospheric and liquid pathways referenced in this report. U.S. Department of Energy (DOE) radiation dose standards for protection of the public in the SRS vicinity are specified in DOE Order 5400.5, "Radiation Protection of the Public and the Environment." These dose standards are based on recommendations of the

Table 7-1
Dose Standards for Exposure of the Public to Radioactive Releases from DOE Facilities^a

Mode of Public Exposure	Effective Dose Equivalent	
	mrem/year	mSv/year
All effluents and pathways from routine DOE operations ^b	100	1
Air effluents ^c	10	0.1
Treated-drinking-water pathway ^d	4	0.04

a All the limits listed are incorporated into DOE Order 5400.5, February 8, 1990, "Radiation Protection of the Public and the Environment."

b "Routine DOE Operations" means normal planned operations and does not include nonroutine releases.

c The standard for air effluents applies to the sum of the doses from all airborne pathways: inhalation, submersion in a plume, exposure to radionuclides deposited on the ground surface, and consumption of foods contaminated as a result of deposition (40 CFR 61, Subpart H).

d The drinking water standard applies to public community drinking water systems and to drinking water supplies operated by DOE or DOE contractors (40 CFR 141).

International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).

The U.S. Environmental Protection Agency (EPA) dose limit of 10 mrem (0.1 mSv) for the atmospheric pathway, which is contained in 40 CFR Part 61, Subpart H, is included in DOE Order 5400.5.

The DOE dose standard enforced at SRS for drinking water consumed from DOE drinking water systems, community drinking water systems, and downriver water treatment plants is consistent with the criteria contained in 40 CFR 141, "National Interim Primary Drinking Water Regulations." Under these regulations, persons consuming drinking water shall not receive an annual whole body dose—DOE Order 5400.5 interprets this dose as committed effective dose equivalent—of more than 4 mrem (0.04 mSv). Both of these dose standards are based on a consumption of 2 liters of water per day. However, some radionuclide

dose conversion factors (including tritium) differ between EPA and DOE. Because SRS must use DOE-provided, ICRP-based dose conversion factors, a direct comparison of the estimated drinking water doses in this chapter to the EPA drinking water dose standard cannot be made. However, radionuclide concentrations found in drinking water are directly compared to the EPA drinking water concentration standards in chapter 6.

Individual and collective doses for 1993 SRS releases are compared with doses from natural background and medical sources in the Executive Summary of this report.

Calculating Dose

Off-site doses from SRS releases of radioactive materials (atmospheric and liquid) are calculated for the scenarios listed in table 7-2 for adults residing near SRS or at downriver locations. Because DOE has adopted dose factors only for adults, SRS calculates

Table 7-2
Off-Site Dose Calculations for SRS Releases: Receptors and Assumptions

Description	Assumptions about Receptors
	Airborne Effluents ^a
Maximum Site Boundary	Lives at site boundary where highest air concentrations occur. Maximum exposure and consumption rates of food produced at residence.
Average Site Boundary	Lives at a location of average boundary air concentration ^b . Average exposure and consumption rates.
Whole Population	Actual distribution of population within 50 miles of center of SRS. Average exposure and consumption rates for all pathways.
	Waterborne Effluents ^a
Maximum Exposure Case #1	Lives on shore of Savannah River. Maximum consumption rate of river water. Maximum consumption rate of fish.
Maximum Exposure Case #2	Maximum consumption of water from downriver water treatment plants.
Average Exposure	Average consumption of water from downriver water treatment plants.
Whole Population	Average consumption of water from downriver water treatment plants. Average consumption of fish from Savannah River. River recreational activity exposure based on survey data.

a Refer to *SRS Environmental Data for 1993* (WSRC-TR-94-077) for specific values of the maximum and average adult consumption rates used in the calculations.

b Determined by averaging the predicted concentrations at 320 locations along the site perimeter.

Figure 7-1 Radionuclide Movement Comparisons
Depicted in the illustration are comparisons between mathematical models of radionuclide movement and actual measurements.

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collective, or population, doses as if the entire population consists of adults [DOE, 1988].

In 1989, the ICRP, in its Publication #56, issued age-specific dose factors for six age groups ranging from 3-month-old infants to adults. However, dose factors for only 19 radioisotopes were published and they are applicable to only the ingestion pathway. In general, for most radioisotopes, the dose to an infant is higher than to an adult. For the radioisotopes that constitute most of SRS's radioactive releases (i.e., tritium and cesium), the dose to infants would be approximately two to three times higher than to adults. The dose to older children becomes progressively closer to the adult dose.

When the ICRP completes age-specific dose factors for all radioisotopes and develops an age-specific lung model for inhalation, and when DOE adopts these factors and models, doses will be calculated for the various age groups.

SRS also uses adult consumption rates for food and drinking water and adult usage parameters to estimate intakes of radionuclides [SRS Data, 1994]. These intake values and parameters were developed specifically for SRS based on an intensive regional survey [Hamby, 1991]. The survey includes data on agricultural production, consumption rates for food products, and the use of the Savannah River for drinking water and recreational purposes.

Dose Calculation Models

Figure 7-1 shows how computer models can be used to calculate concentrations that are too small to measure. These models use known transport mechanisms for atmospheric and liquid releases and known major pathways of exposure to man.

To calculate annual off-site doses, SRS uses radiation transport and dose models developed for the commercial nuclear industry [NRC, 1977]. The models are implemented at SRS in the following computer programs [EMP, 1993]:

- **MAXIGASP:** calculates maximum and average doses to off-site individuals from atmospheric releases.
- **POPGASP:** calculates collective doses from atmospheric releases.
- **LADTAPII:** calculates both maximum and average doses to off-site individuals and the population from liquid releases.
- **CAP88:** calculates doses to off-site individuals from atmospheric releases to demonstrate compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) under the Clean Air Act.

The CAP88 computer code is required under 40 CFR 61 to calculate off-site doses from atmospheric releases from existing and proposed facilities. SRS uses the CAP88 dose estimates to show NESHAP compliance, but not for routine dose calculations.

Both the CAP88 and the MAXIGASP codes use modeling based on Nuclear Regulatory Commission Regulatory Guide 1.109. Differences in the implementation of the tritium-in-food model in the codes are responsible for most of the differences in the calculated doses. Even with these differences, the doses calculated by the two computer codes are in reasonable agreement. This comparison is discussed further in the Dose Calculation Results section of this chapter (page 101).

Meteorological Database

Meteorological data are used as input for the atmospheric transport and dose models.

For 1993, all off-site doses from release of radioactivity to the atmosphere were calculated with a quality-assured meteorological database for H-Area (located near the center of the site), determined for the period 1987-1991 [SRS Data, 1994]. A five-year average database is used instead of the actual annual data because of the manpower and time requirements of compiling and inputting all the data into the main frame computer program in time to be used for the current-year dose calculations, and because there is little year-to-year variation in the meteorology at SRS.

Figure 7-2 compares wind direction frequency from the 1982-1986 database with that of the 1987-1991 database. Both databases show that there is no prevailing wind at SRS, which is typical for the lower midlands of South Carolina. The maximum frequency that the wind blew in any one direction was 9.1 percent of time, which occurred in the southwest direction. The

wind rose developed from the 1987-1991 database is shown in figure 7-3.

The meteorological measurements include all dispersion conditions observed during the five-year period, ranging from unstable (much turbulence, which leads to good dispersion) to very stable (very little turbulence, which produces a narrow plume exhibiting poor dispersion). The data for 1987-1991 indicate that the SRS area experiences stable conditions (atmospheric stability classes E, F, G) about 21 percent of the time.

In the *SRS Annual Environmental Report for 1992* (WSRC-TR-93-075), the doses reported for the maximally exposed individual and the collective dose due to atmospheric releases were calculated using an intermediate version of the final 1987-1991 meteorological database. Had the final version been used, the maximum individual dose would have been

Leaf Graphic

Figure 7-2 Percent of Time Wind Blows Toward Sector
H-Area Meteorological Databases

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Figure 7-3 Wind Rose for SRS (1987-1991)

The wind rose plot shows the percent of occurrence frequencies of wind direction and speed at SRS. It is based on a composite of hourly averaged wind data from the SRS meteorological tower network for the five-year period 1987-1991. Measurements were taken from 200 feet above the ground. Directions indicated are from which the wind blows.

0.083 mrem (0.00083 mSv), a reduction of 5 percent. The collective dose would have been 5.7 person-rem (0.057 person-Sv), a reduction of 14 percent. The 1993 doses documented in this report were calculated using the final version of the 1987-1991 meteorological database.

Population Database and Distribution

Collective, or population, doses from atmospheric releases are calculated for the population within a 50-mile (80-km) radius of SRS.

For 1993 dose calculations, a 1990 population database prepared by the University of South Carolina was used. This database distributes the population into a grid of cells one second latitude by one second longitude (i.e., 120×120 cells, or 14,400 cells). Thus, each cell covers an area of approximately one square mile. This database is transformed by the POPGASP Code into polar coordinates of 16 compass sectors and varying radial distances out to 50 miles. The POPGASP Code can prepare a polar coordinate database for any release point input into the code in polar coordinates. A separate, fixed-polar-coordinate database was prepared

for use with the CAP88 Code, which does not have the capability of transforming the 14,400-cell grid into polar coordinates. The population database generated by the POPGASP Code is centered on the geographical center of SRS [SRS Data, 1994].

Within the 50-mile radius, the total population for 1990 was 620,100, compared to 555,200 for 1980, a 12-percent population growth in 10 years.

Collective doses from liquid releases are calculated for the population served by the Cherokee Hill Water Treatment Plant near Port Wentworth, Georgia (15,000 persons), and for the population served by the Beaufort-Jasper Water Treatment Plant near Beaufort, South Carolina (50,000 persons).

River Flow Rate Data

Off-site dose from liquid releases varies each year with the amount of radionuclides released and the amount of dilution (flow rate) in the Savannah River. Although flow rates are recorded at United States Geological Survey (USGS) gauging stations at the SRS Boai Dock and at River Mile 120 (Highway 301 bridge), these data are not directly used in dose calculations. This is

Bidirectional vanes (bivanes) are installed on each of the 10 towers used to monitor meteorological conditions at SRS. Bivanes are designed to simultaneously measure horizontal and vertical wind directions. They also provide direct, accurate, and reliable measurements of turbulence. Turbulence is an important factor in dose calculations.

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because weekly flow rates fluctuate widely (i.e., short-term dilution varies from week to week). Instead, flow rates for dose calculations are based on weekly measured tritium releases and concentrations in river water. The USGS-measured flow rates are used only for comparison to these calculated values.

The 1993 calculated flow rates determined for the Beaufort-Jasper (19,974 cubic feet per second) and Port Wentworth (14,707 cubic feet per second) water treatment facilities are "effective" flow rates that account for widely varying short-term flow rates and additional dilution in the water treatment facilities' pumping systems. These "effective" flow rates, used in calculating doses to customers of the water treatment facilities, are based on continuously measured releases of tritium, on measured concentrations of tritium in river water, and on measured concentrations in water used at the downstream water treatment plants.

The calculated River Mile 120 flow rate (11,469 cubic feet per second) is used in determining doses to maximally exposed individuals, population doses from recreation and fish consumption, and potential doses from crops irrigated with river water. For comparison, the measured flow rate at River Mile 120 was 14,788 cubic feet per second. Therefore, the calculated value accounts for less dilution.

The calculated Savannah River estuary flow rate (16,268 cubic feet per second) is used only for calculation of dose from consumption of salt water invertebrates.

Uncertainty in Dose Calculations

Radiation doses are calculated using the best available data. If adequate data are unavailable, then site-specific input parameters are selected that would result in a conservative estimate of the maximum dose.

All radiation data and input parameters have an uncertainty associated with them, which causes uncertainty in the dose determinations. For example, there is uncertainty in the assumption that an individual eats 81 kilograms (178 pounds) of meat each year. Obviously, a few people will eat more than 81 kilograms, but most probably will eat less. Uncertainties can be combined mathematically to create a distribution of doses rather than a single number. While the concept is simple, the calculation is quite difficult. A detailed technical discussion of the method of estimating uncertainty at SRS was published in the July 1993 issue of *Health Physics*.

An example of a dose distribution resulting from data uncertainty was calculated from the annual releases of tritium to the atmosphere. The dose distribution from

one radioisotope (tritium) was calculated for a single location (the Talatha Gate sampling station) and for the measured site boundary average.

The PREDICT computer model was developed to calculate the dose distributions. Figure 7-4 shows the range of possible doses from tritium for the Talatha Gate location and for the site boundary average.

For the Talatha Gate location (solid line), dose values ranged from 0.008 to 0.16 mrem. The most likely value (50th percentile) was 0.040 mrem. The probability distribution indicates that only 1 percent of possible values are greater than 0.12 mrem. For the site boundary average (dotted line) possible doses ranged from 0.002 to 0.15 mrem. The most likely value was 0.033 mrem.

For 1993, the maximum dose from tritium at the site boundary was determined by the MAXIGASP code to be 0.096 mrem (Max/Max in figure 7-4), which is 140 percent higher than the most likely value at the Talatha Gate location, as estimated by PREDICT. This example shows that the doses calculated using the MAXIGASP code are conservative.

Dose Calculation Results

Air and liquid pathway doses are calculated for the maximally exposed individual and for the surrounding population. In addition, a sportsman dose is calculated separately for consumption of fish, deer, and wild hogs, which are nontypical exposure pathways. Finally, a dose is calculated for the aquatic biota found in SRS streams.

Air Pathway

This section describes the atmospheric source terms and concentrations used for dose determinations and presents the calculated dose to the maximally exposed individual, as well as the calculated collective population dose. Also included is a discussion about how SRS demonstrates NESHAP compliance.

Atmospheric Source Terms

The 1993 radioactive atmospheric release quantities used as source terms in SRS dose calculations are presented in chapter 5. Releases of unidentified beta-gamma emitters were summed with strontium-90 releases and unidentified alpha emitters were summed with plutonium-239 releases for dose calculation purposes [SRS Data, 1994].

Estimates of unmonitored diffuse and fugitive source terms again were considered, as required for demonstrating compliance with NESHAP regulations. These sources were included in the overall SRS source terms for the first time in 1991. No fugitive source

Percent of Probability

Leaf Graphic

Figure 7-4 Analysis of Dose Uncertainty

The graph illustrates the relative probability of atmospheric tritium dose using 1993 concentration data.

terms were included for exposed sediments at Par Pond because limited air sampling in the vicinity of the sediments indicates there was no significant resuspension into the atmosphere in 1993. Most of the estimated diffuse and fugitive releases occurred in the reactor and separations areas and in the Burial Grounds.

Atmospheric source terms are grouped by major release points for dose calculations. For MAXIGASP calculations of doses to average and maximally exposed off-site individuals at the site perimeter, five release locations with specific release heights were used [SRS Data, 1994].

The CAP88 dose code can calculate doses from collocated release heights but cannot combine calculations for releases at different geographical locations. Therefore, for CAP88 calculations, source terms were grouped for elevated releases (61 m) and ground-level releases (0 m), and the geographical center of the site was used as the release location for both.

Atmospheric Concentrations

The MAXIGASP and CAP88 codes calculate average and maximum concentrations of all released radionuclides at the site perimeter. These calculated concentrations are used for dose determinations instead of measured concentrations. This is because most radionuclides released from SRS cannot be measured, using standard methods, in the air samples collected at the site perimeter and off-site locations. However, the concentrations of tritium oxide at the site perimeter locations can be measured and are compared with calculated concentrations as a verification of the dose models [SRS Data, 1994].

The average tritium concentration in air measured at the 14 site perimeter locations during 1993 was 30 pCi/m³ (1.1 Bq/m³). This value compares favorably with the MAXIGASP and CAP88 computer code values of 37 pCi/m³ (1.4 Bq/m³) and 34 pCi/m³ (1.3 Bq/m³), respectively. The maximum tritium concentration measured in air at the site perimeter was 60 pCi/m³ (2.2 Bq/m³), which occurred at the D-Area location. This value also compared favorably with the MAXIGASP

Table 7-3

1987-1993 SRS Atmospheric Tritium and Tritium Oxide Releases and Average Measured Tritium Oxide Concentrations in Air

Year	Total Tritium Released (Ci)	Tritium Oxide Released ^a (Ci)	Average Measured Tritium Oxide Concentrations in Air			
			On-Site (5 sites) (pCi/m ³)	Site Perimeter (14 sites) (pCi/m ³)	25-mile (12 sites) (pCi/m ³)	100-mile (4 sites) (pCi/m ³)
1987	595,000	270,000	10.0E+02	8.1E+01	2.5E+01	9.9E+00
1988	462,000	288,000	8.4E+02	5.4E+01	1.7E+01	12.0E+00
1989	309,000	218,000	6.4E+02	3.7E+01	1.4E+01	9.0E+00
1990	253,000	175,000	4.3E+02	3.2E+01	1.2E+01	8.8E+00
1991	200,000	137,000	2.5E+02	2.1E+01	1.1E+01	8.5E+00
1992 ^b	156,000	100,000	3.4E+02	2.7E+01	1.1E+01	8.3E+00
1993	191,000	133,000	3.7E+02	3.0E+01	0.9E+01	4.7E+00

a The tritium oxide releases are included with elemental tritium releases in the "Total Tritium Released" column.

b During May 1992, the methodology for determining tritium oxide concentrations in air was changed to the use of measured humidity values instead of a single generic value. The listed concentrations are for May through December 1992.

computer code value of 60 pCi/m³ (2.2 Bq/m³). However, the CAP88 code calculated a maximum site perimeter concentration of 50 pCi/m³ (1.9 Bq/m³). This lower value is attributed to the fact that the CAP88 code assumes that all releases occurred from only one release point, which is located at the center of the site.

The average measured tritium concentrations in air for the years 1987-1993 are shown in table 7-3. Also shown are the total tritium and tritium oxide releases from SRS for the same years. As can be seen, there is a correlation between the quantity of tritium oxide released and the measured concentration of tritium oxide in air at all monitoring locations.

Dose to the Maximally Exposed Individual

The calculated dose by pathway and radionuclide to a hypothetical individual located at the site perimeter, which is considered the point of maximum off-site exposure, was determined based on average and maximum consumption rates [SRS Data, 1994]. The MAXIGASP computer code was used to calculate these doses. For 1993, the MAXIGASP code determined that the north-northwest sector of the site was the location of the maximally exposed individual. The parameters used for the calculations were discussed earlier in this chapter.

In 1993, using a maximum dietary intake, the estimated dose to the maximally exposed individual was 0.11 mrem (0.0011 mSv), which is 1.1 percent of the DOE Order 5400.5 standard of 10 mrem/year. This dose was approximately 25 percent higher than the

1992 dose of 0.09 mrem (0.0009 mSv) mainly because there was a 33-percent increase in tritium oxide releases from 1992 to 1993 (see chapter 5). Tritium oxide releases accounted for 89 percent of the dose to the maximally exposed individual. Table 7-4 compares the dose to the maximally exposed individual with the DOE standard.

The major pathways contributing to the dose to the maximally exposed individual from atmospheric releases were from inhalation (47 percent) and from consumption of vegetation (35 percent), cow milk (12 percent), and meat (5 percent).

In response to public concerns, additional calculations of the dose to the maximally exposed individual were performed substituting a goat milk pathway for the normal cow milk pathway. The maximum dose using the maximum-consumption goat milk pathway was estimated to be 0.13 mrem (0.0013 mSv), which is 16 percent higher than the cow milk pathway dose. Most of this difference is from tritium because the transfer factor (fraction of daily intake of nuclide that appears in each liter of milk) for tritium is 17 times higher for goat milk than for cow milk [NRC, 1977]. Because goat milk consumption is less common, the dose calculated with consumption of cow milk will continue to be the primary dose reported.

Collective Dose (Population Dose)

Doses also were calculated, by pathway and radionuclide, using the POPGASP computer code for the population (620,100 people) residing within 50 miles of the center of SRS [SRS Data, 1994]. In

1993, the collective dose was estimated to be 7.6 person-rem (0.076 person-Sv), which is less than 0.01 percent of the collective dose received from natural sources of radiation (about 195,000 person-rem). The 1993 collective dose was approximately 19 percent higher than the 1992 collective dose of 6.4 person-rem (0.064 person-Sv), again because of the 33-percent increase in tritium oxide releases from 1992 to 1993. Tritium oxide releases accounted for 91 percent of the 1993 collective dose.

NESHAP Compliance

To demonstrate compliance with NESHAP (Clean Air Act, 40 CFR 61, Subpart H) regulations, maximum individual and collective doses were calculated, and a percentage of dose contribution from each radionuclide was determined, using the CAP88 computer code [SRS Data, 1994].

The dose to the maximally exposed individual, calculated with CAP88, was estimated to be 0.18 mrem (0.0018 mSv), which is 1.8 percent of the 10-mrem/yr EPA standard, as shown in table 7-4. Tritium oxide releases accounted for more than 98 percent of this dose.

The CAP88 collective dose was estimated to be 20 person-rem (0.20 person-Sv). Tritium oxide releases accounted for 98 percent of this dose.

As the data show, the CAP88 code estimates a higher dose than do the MAXIGASP and POPGASP codes. Most of the differences occur in the tritium dose estimated from food consumption. The major cause of this difference is the CAP88 code's use of 100-percent equilibrium between tritium in air moisture and tritium in food moisture, whereas the MAXIGASP and POPGASP codes use 50-percent equilibrium values as recommended by the Nuclear Regulatory Commission [NRC, 1977]. A recent publication indicates that the 50-percent value is correct for the atmospheric conditions at SRS. [Hamby and Bauer, 1994].

Liquid Pathway

This section contains information on liquid release quantities used as source terms in SRS dose calculations, including a discussion about radionuclide concentrations in Savannah River fish. The calculated dose to the maximally exposed individual, the calculated collective (population) dose, and the potential dose from irrigation are presented.

Liquid Release Source Terms

The 1993 radioactive liquid release quantities used as source terms in SRS dose calculations are presented in chapter 5 and summarized by radionuclide in table 7-5. In order to maintain conservatism, the stream transport tritium release total of 12,700 Ci ($4.7\text{E}+14$ Bq), which was the highest value of the three alternative tritium release calculation methods employed at SRS (see chapter 6), was used in the dose calculations instead of the 11,300-Ci ($4.2\text{E}+14$ Bq) direct-release plus migration-release total.

As discussed in chapter 5, for dose calculations releases of unidentified beta-gamma emitters were summed with strontium-89,90 releases, and unidentified alpha emitters were summed with releases of plutonium-239.

For use in dose determinations and model comparisons, concentrations of radionuclides in Savannah River water and fish were measured at several locations along the river. Measured concentrations of tritium oxide, cesium-137, unidentified beta/gamma (reported as strontium-89,90), and unidentified alpha (reported as plutonium-239) in the Savannah River at Highway 301, and at the Beaufort-Jasper and Port Wentworth water treatment facilities, also are shown in table 7-5, as are LADTAPII computer code concentrations of iodine-129, promethium-147, and uranium-235,238.

The 12-month average tritium oxide concentrations measured in the Savannah River at Highway 301 (1,240 pCi/L), and at the Beaufort-Jasper (712 pCi/L)

Table 7-4
Dose to the Maximally Exposed Individual from SRS Atmospheric Releases in 1993

	MAXIGASP	CAP88 (NESHAP)
Calculated dose	0.11 mrem	0.18 mrem
Standard	10.0 mrem ^a	10.0 mrem ^b
Percent of Standard	1.1%	1.8%

a DOE: DOE Order 5400.5, February 8, 1990.
b EPA: (NESHAP) 40 CFR 61 Subpart H, December 15, 1989.

Table 7-5

**Radioactive Liquid Releases from SRS and Comparison of Downriver Concentrations
(Calculated Concentrations Based on Adjusted River Flow Rates)**

Nuclide	Curies Released	Concentration ($\mu\text{Ci/mL}$)		
		Below SRS ^a	Beaufort-Jasper ^b	Port Wentworth ^c
H-3 ^d	1.3E+04	1.2E-06 ^e	7.1E-07 ^e	9.7E-07 ^e
Sr-89,90 ^{d,f}	4.8E-01	1.9E-09 ^e	2.3E-09 ^e	1.8E-09 ^e
I-129 ^d	2.2E-02	2.2E-12	1.2E-12	1.7E-12
Cs-137	2.5E-01	4.1E-11 ^e	1.4E-11	1.9E-11
Pm-147	7.0E-03	6.9E-13	3.9E-13	5.4E-13
U-235,238	1.1E-05	1.1E-15	6.4E-16	8.7E-16
Pu-239 ^g	9.6E-03	8.5E-12 ^e	5.4E-13	7.3E-13

a Savannah River Mile 120 (River-10 location), just downriver from SRS at the Highway 301 bridge

b Beaufort-Jasper, South Carolina, drinking water

c Port Wentworth, Georgia, drinking water

d Includes direct releases and groundwater migration from seepage basins

e Measured concentrations; all other concentrations calculated using models verified with tritium measurements

f Includes unidentified beta/gamma releases

g Includes unidentified alpha releases

and Port Wentworth (967 pCi/L) water treatment plants, remained below the EPA and DOE concentration standards of 20,000 pCi/L and 80,000 pCi/L, respectively.

Radionuclide Concentrations in River Fish A major dose pathway for the maximally exposed individual at the site perimeter is from the consumption of fish, which readily bioaccumulate cesium-137.

The dose from cesium-137 in fish flesh to the hypothetical maximally exposed individual is based on the radioanalysis of fish collected from the Savannah River Mile 120 (River-10) location [SRS Data, 1994]. During 1992, cesium-137 was the only SRS-released radionuclide, other than tritium, detectable in River-10 location fish flesh. The 50-year committed dose to a maximally exposed individual is based on a maximum consumption rate of 19 kilograms (42 pounds) of fish per year [Hamby, 1991]. Some fraction of this estimated dose is due to cesium-137 present from worldwide fallout; however, that amount is difficult to determine and is not subtracted from the total.

The dose determinations are accomplished in the LADTAPII code by substituting a cesium-137 release value that would result in the measured concentration in river fish, assuming a site-specific bioaccumulation factor of 3000. A weighted average concentration (based on number of fish composites analyzed) of cesium-137 in River 10 fish was used for maximum

individual and population dose determinations. Using the above factors, the cesium-137 release value used for LADTAPII input was 0.26 Ci (9.6E+09 Bq). This is 1.1 times higher than the measured-release value of 0.25 Ci (9.3E+09 Bq). This indicates either some migration of fish from SRS streams to the main channel of the river or a source of release to the river other than measured direct liquid effluents, possibly from streambed and swamp desorption and/or migration. This phenomenon is seen every year but was slightly lower in 1993 than in 1992, when the ratio of measured to calculated concentrations was 1.2.

Dose to the Maximally Exposed Individual

The calculated dose to the hypothetical maximally exposed individual living just downriver of SRS, which is considered the point of maximum off-site exposure, was determined based on intake parameters discussed earlier in this chapter.

Two changes were made in the 1993 calculation of dose to the maximally exposed individual: 1) the freshwater-shellfish pathway was eliminated after a survey indicated no known consumption of freshwater shellfish [Hamby, 1994], and 2) The maximum consumption of untreated river water was changed from 1 liter to 2 liters per day to be consistent with calculations for water treatment plants. The net result of these changes was a 10-percent increase in the dose to the maximally exposed individual.

Table 7-6
Calculated Maximum Individual Dose Commitment from SRS Liquid Releases in 1993

	Committed Dose	Applicable Standard	Percent of Standard
Maximally Exposed Individual			
At Site Boundary (untreated river water)	0.14 mrem	100 mrem ^a	0.14%
At Port Wentworth (public water supply only)	0.05 mrem	4 mrem ^b	1.25%
At Beaufort-Jasper (public water supply only)	0.04 mrem	4 mrem ^b	1.00%

a All-Pathway Dose Standard: 100 mrem/year (DOE Order 5400.5)

b Drinking Water Pathway Standard: 4 mrem/year. (DOE Order 5400.5 and EPA, 1975)

As shown in table 7-6, for 1993, the highest potential dose to the maximally exposed individual from liquid releases was estimated to be 0.14 mrem (0.0014 mSv). This dose is 0.14 percent of DOE's 100-mrem all-pathway dose standard for annual exposure.

The 1993 maximum dose was 8 percent higher than the 1992 maximum dose of 0.13 mrem (0.0013 mSv). This increase is due primarily to the changes in the dose calculation methods previously described.

Approximately 51 percent of the dose to the maximally exposed individual at the site perimeter resulted primarily from the consumption of cesium-137 in fish, and more than 40 percent resulted from tritium releases.

Drinking Water Pathway Persons downriver from SRS may receive a radiation dose by consuming drinking water that contains radioactivity as a result of liquid releases from the site. Tritium present in downriver drinking water is attributed to SRS operations and represents the majority of the dose (87 percent) received by persons at downriver water treatment plants (figure 7-5).

The calculated doses to maximally exposed individuals whose entire daily intake of water is supplied by the Beaufort-Jasper and Port Wentworth water treatment facilities, which are located downriver of SRS, were determined based on average (1 liter per day for a year) and maximum (2 liters per day for a year) water consumption rates [SRS Data, 1994].

At the Beaufort-Jasper Water Treatment Plant, the dose for maximum water consumption rates (2 liters per day for a year) was 0.04 mrem (0.0004 mSv). At the Cherokee Hill Water Treatment Plant near Port Wentworth, the dose for maximum water consumption rate (2 liters per day for a year) was 0.05 mrem (0.0005 mSv).

As shown in table 7-6, the maximum dose of 0.05 mrem (0.0005 mSv) is 1.25 percent of the DOE and EPA standard of 4 mrem/yr from public water supplies. This maximum drinking water dose is approximately 41 percent less than the 1992 dose of 0.087 mrem (0.00087 mSv). This decrease in dose is attributed to decreases in liquid tritium releases and to greater dilution in the Savannah River due to increased river flow during 1993.

Collective Dose (Population Dose)

The collective dose from drinking water consumption occurs to the discrete population groups at Beaufort-Jasper and Port Wentworth. The collective dose from other pathways occurs to a diffuse population that cannot be described as being in a specific geographical location.

Collective doses were calculated, by pathway and radionuclide, using the LADTAPII computer code [SRS Data, 1994]. In 1993, the collective dose from SRS liquid releases was estimated to be 1.5 person-rem (0.015 person-Sv). This was 40 percent lower than the 1992 collective dose of 2.5 person-rem (0.025 person-Sv) because of 1) decreases in liquid tritium releases and 2) greater dilution in the Savannah River due to increased river flow during 1993.

Figure 7-5 Downriver Tritium Dose
Tritium accounts for 86.7 percent of the treated-drinking-water dose from two water treatment facilities downriver from SRS.

Leaf Graph

Potential Dose from Irrigation

The 1990 update of land- and water-use parameters [Hamby, 1991] revealed that there is no known use of river water withdrawn downstream from SRS for irrigation purposes. However, a potential off-site dose of 0.08 mrem (0.0008 mSv) to the maximally exposed individual and a collective dose of 6.1 person-rem (0.061 person-Sv) were estimated for this exposure pathway. As in previous years, collective doses from irrigation were calculated for 1,000 acres of land devoted to each of the four major food types, i.e., vegetation, leafy vegetation, milk, and meat [SRS Data, 1994].

Sportsman Dose

As noted previously, DOE Order 5400.5 specifies radiation dose standards for individual members of the public. The dose standard of 100 mrem per year, which applies to all members of the public, includes doses a person receives from routine DOE operations through all exposure pathways. Nontypical exposure pathways, not included in the standard calculations of the doses to the maximally exposed individual, are considered and quantified separately. This is because they apply to relatively low-probability scenarios, such as consumption of fish caught exclusively from the mouths of SRS streams, or to unique scenarios, such as volunteer deer hunters.

Fish Consumption Pathway

Analyses of fish taken from the mouths of the six SRS streams and the subsequent estimated doses from the maximum consumption (19 kilograms per year) [Hamby, 1991] and average consumption (9 kilograms per year) of these fish were determined for 1993 [SRS Data, 1994]. Fish flesh was composited by species for each location and analyzed for tritium, strontium-90 cesium-137, plutonium-238, and plutonium-239.

The maximum hypothetical dose from this pathway was estimated to be 1.3 mrem (0.013 mSv) from the consumption of bass collected at the mouth of Steel Creek. This hypothetical dose is based on the low-probability scenario that, during 1993, a fisherman consumed 19 kilograms (42 pounds) of bass caught exclusively from the mouth of Steel Creek. Some fraction of this estimated dose is due to cesium-137 present from worldwide fallout; however, that amount is difficult to determine and is not subtracted from the total.

Because a higher committed dose would result from eating fish caught on site in SRS streams and ponds than from eating river fish [SRS Data, 1994], access to SRS streams and ponds is restricted. Therefore, the fish consumption pathway dose does not include fish caught within the SRS boundary.

Deer and Hog Consumption Pathway

For approximately six weeks each year, controlled deer and wild hog hunts are conducted at SRS. These hunts help control the on-site deer and wild hog populations.

Participants in the hunts are volunteers. Before any harvested animal is released to a hunter, SRS personnel perform a field analysis for cesium-137 on the deer and hogs at the hunt site, using portable sodium iodide detectors.

The estimated dose from consumption of the harvested deer or hog meat is determined for each hunter. During 1993, the maximum dose that could have been received by a hunter was estimated to be 57.3 mrem (0.57 mSv), more than 57 percent of DOE's 100-mrem all-pathway dose standard. This dose was determined for a prolific hunter who had harvested seven animals (four deer and three hogs) during the 1993 hunts. The hunter-dose calculation is based upon the conservative assumption that the hunter individually consumed the entire edible portion—approximately 162 kilograms (360 pounds)—of all the animals he harvested from SRS.

An additional deer meat consumption pathway considered during 1993 was for a hypothetical individual whose entire intake of meat during the year was deer meat. It was assumed that this hypothetical individual harvested deer that had resided on SRS, but then moved off site. The estimated dose was based on the maximum meat consumption rate for an adult of 81 kilograms (180 pounds) per year [Hamby, 1991].

Based on these low-probability assumptions and on the average concentration of cesium-137 (4.8 pCi/g) in deer harvested from SRS during 1993, the potential maximum dose from this pathway was estimated to be 4.1 mrem (0.04 mSv). This dose is 4.1 percent of DOE's 100-mrem all-pathway dose standard.

Dose to Native Aquatic Animal Organisms

DOE Order 5400.5 establishes an interim dose standard for protection of native aquatic animal organisms. The absorbed dose limit to these organisms is 1 rad/day (0.01 Gy/day) from exposure to radioactive material in liquid effluents released to natural waterways.

Hypothetical doses to aquatic biota in SRS streams are calculated annually to demonstrate compliance with this 1-rad/day (0.01-Gy/day) dose standard. Upper-limit doses are calculated with measured radioactivity transport and minimum flow rates for each surface stream. Flow rates are chosen to maximize the biota

dose. Source terms (stream transport) are provided by the Environmental Protection Department's Environmental Monitoring Section [SRS Data, 1994].

The CRITR computer code [Soldat et al., 1974], incorporated as part of the LADTAPII code, calculates internal and external dose to aquatic biota and to higher trophic levels that depend on aquatic biota for food. The CRITR Code is one of the three aquatic biota dose codes recommended by DOE [DOE, 1991]. External doses are calculated with the same external dose factors used for man [DOE, 1988]. Internal doses are based on the physical size of the biota (effective radius) and on effective energies provided for each radionuclide for each radius. The maximum dose to biota was estimated to be 0.017 rad/day (0.00017 Gy/day), which occurred in ducks in Four Mile Creek. This is 1.7 percent of the 1-rad/day (0.01-mGy/day) DOE dose limit.

Radiation Assessment Program

The preparation of documents describing the effects of SRS operations on the environment began in 1988. Plans are to prepare separate documents for each of the major radionuclides. The documents describe the operating history of the site with regard to the production, storage, and release of each radionuclide. The transport of the radionuclide in air, surface water, and groundwater is explained, and a calculation of the dose estimate is presented. As of December 31, 1993, several documents had been published^a:

- *Tritium in the Savannah River Site Environment*, WSRC-RP-90-424-1, Rev. 1
- *Cesium in the Savannah River Site Environment*, WSRC-RP-92-250
- *Uranium in the Savannah River Site Environment*, WSRC-RP-92-315
- *Radioiodine in the Savannah River Site Environment*, WSRC-RP-90-424-2
- *Assessment of Radiocarbon in the Savannah River Site Environment*, WSRC-TR-93-215
- *Assessment of Technetium in the Savannah River Site Environment*, WSRC-TR-93-217
- *Plutonium in the Savannah River Site Environment*, WSRC-RP-92-879, Rev. 1

A document has been prepared for strontium, and the tritium document has been updated. Publication of these reports is scheduled for early 1994. Documents for noble gases and mercury are in production and are scheduled for publication early in 1995.

^a Copies of these documents can be obtained from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Chapter 8

Nonradiological Effluent Monitoring

Carl Cook and Larry Eldridge
Environmental Protection Department

Introduction

Nonradioactive air emissions originating at Savannah River Site (SRS) facilities are monitored (by a combination of direct measurement, sample extraction and measurement, or process knowledge) at their points of discharge. Air monitoring verifies that all emissions and ambient concentrations are within regulatory standards.

Monitoring of nonradiological liquid effluents encompasses sampling and analysis and is performed by the Environmental Protection Department's Environmental Monitoring Section (EMS) and the Savannah River Technology Center (SRTC).

A complete description of the EMS sampling and analytical procedures used for nonradiological monitoring can be found in the "SRS Environmental Monitoring Plan" (WSRC-3Q1-2-1000). A summary of data results is presented in this chapter; however, more complete data can be found in *SRS Environmental Data for 1993* (WSRC-TR-94-077).

Air Effluents

The following paragraphs describe the applicable standards for the nonradiological air effluent monitoring program, the monitoring program itself, and the 1993 monitoring results.

Applicable Regulations

The South Carolina Department of Health and Environmental Control (SCDHEC) regulates nonradioactive air emissions—both criteria pollutants and toxic air pollutants—from SRS sources. Each source is permitted by SCDHEC, with specific limitations identified, as outlined in various South Carolina air pollution control regulations and standards. The applicable standards are source dependent and are too numerous to list for SRS sources. The primary standards that govern criteria air pollutants and ambient air quality are identified in SCDHEC Air Pollution Control Regulation 62.5, Standard No. 2. This standard lists eight criteria air pollutants

commonly used as indices of air quality (e.g., sulfur dioxide, nitrogen dioxide, and lead) and provides an allowable site boundary concentration for each pollutant. The standards for toxic air pollutants are identified in Regulation 62.5, Standard No. 8, which identifies 257 toxic air pollutants and their respective allowable site boundary concentrations. Specific permits for operating facilities are listed in appendix B, "SRS Environmental Permits."

SCDHEC airborne emissions standards for each SRS permitted source are different, based on size and type of facility, type and amount of expected emissions, and the year that the facility was placed into operation. For process and diesel engine stacks in existence prior to January 1, 1986, and powerhouse stacks built before February 11, 1971, the opacity standard is 40 percent. For new sources placed into operation after these dates, the opacity standard is 20 percent. Table 8-1 shows typical standards for criteria pollutants from SRS coal-fired boilers.

Compliance with the various standards is determined in several ways. At the SRS powerhouses, stack compliance tests are performed every two years for each boiler by airborne emissions specialists under contract to SRS. The tests include sampling of the boiler exhaust gases to determine particulate emission rates and carbon dioxide and oxygen concentrations and the laboratory analysis of coal for sulfur content, ash content, moisture content, and BTU (British thermal unit) output. SCDHEC also conducts visible emissions observations during the tests to verify compliance with opacity standards. The day-to-day

Table 8-1
Nonradiological Airborne Emissions Standards
for SRS Coal-Fired Boilers

Sulfur dioxide	3.5 lb/10 ⁶ BTU ^a
Total suspended particulates	0.6 lb/10 ⁶ BTU
Opacity	40%

^a British thermal unit

Table 8-2
SRS Power Plant Boiler Capacities

Location	Number of Boilers	Capacity (BTU/hr)
A-Area	2	71.7E + 06
D-Area	4	39.6E + 07
H-Area	3	71.1E + 06

control of particulate matter less than 10 microns is maintained with opacity meters in all SRS powerhouse stacks.

For the package steam generating boilers in K-Area and P-Area, compliance with sulfur dioxide standards is determined by analysis of the fuel oil being purchased from the off-site boiler. Compliance with particulate emission standards was proven by mass balance calculations rather than stack emission tests.

Compliance by SRS diesel engines and other process stacks is determined during annual compliance inspections by the local SCDHEC district air manager. These inspections include a review of operating parameters, an examination of continuous emission monitors (where required for process stacks), and a visible-emissions observation for opacity.

Compliance by all toxic air pollutant and criteria pollutant sources is also determined by using U.S. Environmental Protection Agency (EPA)-approved air dispersion models. Air dispersion modeling determines site boundary concentrations of pollutants and is extremely conservative unless refined models are used.

Description of Monitoring Program

Major nonradiological emissions of concern from stacks at SRS facilities include sulfur dioxide, carbon monoxide, oxides of nitrogen, particulate matter less than 10 microns, volatile organic compounds, and toxic air pollutants. Stacks that have such emissions at SRS include diesel engine powered equipment, package steam generators, powerhouse boilers, and various process facility stacks. Emissions from these sources are determined from calculations using fuel oil consumption rates, total hours of operation, and the multipliers provided in EPA's "Compilation of Air Pollution Emission Factors," AP-42. The calculation for sulfur dioxide also uses the average sulfur content of the coal and assumes 100 percent liberation of sulfur and 100 percent conversion to sulfur dioxide.

At SRS, 102 permitted emission sources, both portable and stationary, are powered by internal combustion diesel engines. These sources include portable air

compressors, diesel generators, emergency cooling water pumps, and fire water pumps ranging in size from 150 kilowatts to 2050 kilowatts for generators and 200 horsepower to 520 horsepower for air compressors and pumps. Total fuel oil consumption for these sources in 1993 was calculated to be 817,217 gallons of No. 2 diesel fuel oil.

Three coal-fired power plants with nine boilers operate at SRS. The location, number of boilers, and capacity of each boiler for these plants are listed in table 8-2. The four D-Area boilers use pulverized coal as their primary fuel; they use propane, No. 2 fuel oil, and used oil as secondary fuels. The other boilers are stoker fed and use coal as their only fuel.

The coal-fired boilers burned 223,709 tons of coal in 1993. The D-Area power plant boilers also burned 46,489 gallons of used oil; 83,529 gallons of No. 2 fuel oil for energy recovery; and 3,530 gallons of propane as boiler startup fuel.

SRS also has four package steam generating boilers fired by No. 2 diesel fuel oil. These steam generating boilers are used primarily to heat buildings during cold weather. If necessary, they are used during process facility operation. They burned 874,446 gallons of fuel oil during 1993. The location, number of boilers, and capacity of each boiler are shown in table 8-3.

Monitoring Results

Table 8-4, which shows the 1993 atmospheric emissions of sulfur dioxide, oxides of nitrogen, carbon monoxide, particulate matter less than 10 microns, and volatile organic compounds from SRS sources, is broken down by types of sources rather than by area. All calculated emissions were within applicable SCDHEC standards during 1993. However, two H-Area boilers exceeded their permit limit for particulate emissions during required biennial stack compliance tests. SRS received a Notice of Violation for these exceedances. The issue had not been resolved as of December 31, 1993, but a settlement agreement is expected to be finalized in 1994.

The sulfur content of coal burned in 1993 averaged .79 percent for pulverized coal and 1.66 percent for

Table 8-3
SRS Package Steam Boiler Capacities

Location	Number of Boilers	Capacity (BTU/hr)
K-Area	1	76.8E + 06
K-Area	1	38.0E + 06
K-Area	1	17.0E + 06
P-Area	1	17.0E + 06

Table 8-4
1992 Nonradiological Air Emissions

Coal-Fired Boilers

Sulfur dioxide	6,686.99 tons
Particulates	546.88 tons
NOx	3,476.00 tons
Carbon monoxide	140.72 tons
VOCs	7.88 tons

Fuel Oil-Fired Boilers

Sulfur dioxide	17.47 tons
Particulates	0.85 tons
NOx	8.47 tons
Carbon monoxide	2.12 tons
VOCs	0.08 tons

Diesel Engine Equipment

Sulfur dioxide	12.75 tons
Particulates	13.69 tons
NOx	191.64 tons
Carbon monoxide	41.68 tons
VOCs	13.13 tons

stoker coal—both less than the 2 percent SCDHEC standard.

Ambient Air Quality

SRS does not conduct on-site monitoring for ambient air quality; however, as a result of regulatory requirements, the site is required to show compliance with various air quality standards. To accomplish this, air dispersion modeling was conducted during 1993.

The Environmental Transport Group, a component of the Environmental Technology Section at SRTC, is responsible for all regulatory nonradiological air quality modeling required by SCDHEC. In 1993, the Environmental Transport Group conducted air dispersion modeling using EPA's Industrial Source Complex short-term and long-term models for criteria and toxic air pollutants. These models simulate the dispersion of emissions over extensive areas for time scales ranging from an hour to a year. For realism, a year of hourly site meteorological data was used in 1993 as one of the inputs to the model. Other inputs to the model included source information and air emissions rate data obtained from the SRS Air Inventory Reporting System database.

The modeling conducted by the Environmental Transport Group involved two major tasks. The first, completed in June 1993, modeled the maximum potential emission rates for all toxic air pollutants emitted by SRS sources. Data for 1990 were used to

establish baseline compliance with the requirements of Regulation 62.5, Standard No. 2. The modeling results showed that SRS was in compliance with the site boundary concentration limits for 139 toxic air pollutants.

The second modeling task showed compliance with ambient air quality standards, found in Standard No. 2, for criteria pollutants. Again, 1990 maximum potential emissions data were utilized as a baseline. After correction of some of the initial input data, the modeling results indicated that two of the standards for sulfur dioxide, the maximum 3-hour and maximum annual averages, were being exceeded at two off-site locations. The standards allow for no more than one exceedance a year. The exceedances, found in the vicinity of the D-Area powerhouse, are suspected to be the result of conservative methodologies used in defining the operational characteristics and in calculating the maximum potential emission rates. With concurrence from SCDHEC, SRS was to further review the boiler operations and remodel for sulfur dioxide by March 31, 1994. The states of South Carolina and Georgia continue to monitor ambient air quality near SRS as part of the network associated with the Clean Air Act.

Liquid Effluents

The following paragraphs describe the applicable standards for the nonradiological liquid effluent monitoring program, the monitoring program itself, and the 1993 monitoring results.

Applicable Regulations

The physical properties and concentrations of chemicals and metals in SRS effluents are regulated by SCDHEC under the National Pollutant Discharge Elimination System (NPDES) program.

Standards applicable to nonradioactive constituents and physical properties in SRS wastewater discharges from all outfalls are contained in the site's NPDES permits. Monitoring requirements and standards, as listed in the permits, vary from one outfall to another based on potential releases from the facility.

In 1993, the site discharged water to site streams and to the Savannah River under the authority of three NPDES permits. Of these permits, two (SC0000175 and SC0044903) are industrial wastewater discharge permits, and one (SCR000000) is a general stormwater permit. Also in 1993, regulation of outfall K-011 was moved from permit SC0000175 to permit SC0044903 because of the tie-in of the K-Reactor cooling tower. The outfall was renamed K-018, and the sampling frequency and number of parameters for the outfall were changed. For a description of a survey of total

residual chlorine in K-018 samples, see chapter 13, "Special Surveys and Projects."

As of December 31, 1993, no permit renewal had been issued to replace permit SC0000175, which became effective in 1984 and expired in 1988. The permit renewal is under review by SCDHEC. SRS is operating under the authority of the 1984 discharge permit until the review process is completed and the renewal issued.

There are 48 locations listed as stormwater outfalls in permit SCR000000. These locations are sorted into 11 groups based on potential discharges, and one outfall from each group is monitored as being representative of that group. Further discussion of the NPDES program can be found in chapter 2, "Environmental Compliance."

Description of Monitoring Program

All NPDES points are sampled per applicable permit requirements. Preservation is conducted in the field per 40 CFR Part 136 (the federal document that lists the specific sample collection, preservation, and analytical methods acceptable for the type of pollutant to be analyzed), and chain-of-custody procedures are

followed after collection and during transport to the analytical laboratory. The samples then are accepted by the laboratory and analyzed per procedures listed in 40 CFR Part 136 for the parameters called for by the permit.

Monitoring Results

Analytical results are reported to SCDHEC in a discharge monitoring report. Included in the report is a list of exceedances or locations at which an analysis revealed the water did not meet the requirements set forth in the permit.

In 1993, 67 of the site's 81 permitted industrial wastewater outfalls discharged (operated), 10 did not discharge, and four were not in service. Eight thousand analyses were performed on samples collected from the 67 outfalls, resulting in 10 exceedances. The 10 exceedances are summarized in table 8-5. The compliance rate of 99.9 percent for the year met and surpassed the DOE-mandated goal of 98 percent. A history of exceedances for the past several years is given in figure 8-1. No applicable limits have been established for the stormwater outfalls.

Table 8-5
1993 NPDES Exceedances

Department	Location	Date (1993)	Analysis	Possible Cause	Corrective Action
Construction	DW-002	Mar. 9	pH (max)	drum cleaning	administrative review
	CS-002	Oct. 26	TSS (max)	rainfall	administrative review
			BOD (max & min)		
Power	H-008A	Oct. 13	O & G (ave)	unknown	administrative review
Reactors	K-010	Jan. 25-Feb.2	TSS (max)	construction	flush diversion box
	K-010	Mar. 29	TSS (max & min)	unknown	flush lines with fire hoses
	C-001	Mar. 3	pH (min)	unknown	administrative review
	C-001	Oct. 26	pH (min)	unknown	administrative review
	L-007	Dec.7	TSS (max)	unknown	administrative review
Separations	H-004	Sept. 8	TSS (max)	unknown	administrative review
SRTC/TNX	X-008	Oct. 6	pH (min)	well overflow	administrative review

Number of Exceedances

leaf Graphic

Figure 8-1 History of NPDES Exceedances from 1986 to 1993

To determine the compliance rating, the number of analyses not exceeding limits for a given year is divided by the total number of analyses. For example, in 1990, a total of 6,810 analyses were performed, with 16 exceedances. To calculate the compliance rating for 1990, divide 6,794 (6,810 minus 16) by 6,810 for a quotient of .9976, or 99.8, percent.

Chapter 9

Nonradiological Environmental Surveillance

Sandra Boynton, Jason Chappell, Larry Eldridge, and Craig Hetrick
Environmental Protection Department

Robert D. Turner
Site Services Engineering

Introduction

Nonradiological environmental surveillance at the Savannah River Site (SRS) involves the sampling and analysis of surface waters (SRS streams and the Savannah River), drinking water, sediment, groundwater, and fish.

Extensive surveillance is performed on the river, which borders the site for approximately 35 miles; on the six on-site streams; and on the region's groundwater and drinking water. (A description of the surveillance program and 1993 results for groundwater can be found in chapter 10, "Groundwater.")

Surveillance activities are performed by the Environmental Protection Department's Environmental Monitoring Section (EMS) and the Savannah River Technology Center (SRTC). The Savannah River also is monitored by other groups, including the South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Department of Natural Resources (GDNR). A complete description of the EMS sample collection and analytical procedures used for nonradiological surveillance can be found in the "SRS Environmental Monitoring Plan" (WSRC-3Q1-2-1000). A summary of data results is presented in this chapter. However, more complete data can be found in *SRS Environmental Data for 1993* (WSRC-TR-94-077). Information on the rationale for the nonradiological environmental surveillance program can be found in chapter 3, "Environmental Program Information."

SRS currently does not conduct on-site surveillance for ambient air quality. However, as a result of permit conditions for several new sources at the site, SRTC soon will be conducting air emissions modeling for criteria pollutants to show compliance with ambient air quality standards. The states of South Carolina and Georgia continue to monitor ambient air quality near

SRS as part of a network associated with the Clean Air Act.

Surface Water

Surface water includes site streams and the Savannah River. Samples are taken from established sampling locations at weekly and monthly frequencies.

Site Streams

The following paragraphs describe the nonradiological surveillance of site streams with respect to applicable regulations, the surveillance program, and the 1993 results.

Applicable Regulations

SRS streams are classified as "Freshwaters" by SCDHEC. Freshwaters are defined as surface water suitable for

- primary and secondary contact recreation and as a source for drinking water after conventional treatment in accordance with the requirements of SCDHEC
- fishing and survival and propagation of a balanced indigenous aquatic community of fauna and flora
- industrial and agricultural uses

Before 1993, site streams were classified as Class B Waters and were guided by different standards. (SCDHEC changed the categories of waters into fresh, salt, and groundwaters in 1993 [SCDHEC, 1990].)

Table 9-1 provides some of the specific guides used in water quality surveillance.

Description of Surveillance Program

EMS samples site streams monthly for chemicals, metals, and physical and biological properties to ensure that water quality criteria are met [EMP, 1993]. Stream nonradiological surveillance serves as a check for any

evident degradation that could be attributed to the water discharges regulated by site National Pollutant Discharge Elimination System (NPDES) permits. It also helps detect materials that may be released inadvertently from sources other than routine release points.

Each SRS stream receives varying amounts of wastewater and rainwater runoff from site facilities. Each grab or instantaneous sample gives a snapshot of the water quality at the time of sampling. Data from all samplings are compiled to obtain an over-time indication of the water quality in the stream system. An overview of sampling locations is shown in figure 9-1.

Surveillance Results

The reclassification of the streams to the Freshwaters category lowers the fecal coliform guide by a factor of 5 when compared to the Class B guide limits. This has

had an impact on exceedances. According to the guide, the fecal coliform count should not exceed a geometric mean of 200/100 mL, based on five consecutive samples during any 30-day period, nor shall more than 10 percent of the total samples during any 30-day period exceed 400/100 mL.

Stream locations are sampled for water quality at weekly and monthly frequencies. The data reduction of colony counts and the geometric means are based on each calendar month. The calendar month serves as the 30-day sampling period regardless of whether the month is four or five weeks long. As stated in the previous paragraph, exceedances generally are based on five consecutive samples in a 30-day period; however, because there usually are four samples (weekly) or one sample (monthly) taken in a calendar month, SRS bases exceedances on the calendar month rather than waiting for five consecutive samples.

Table 9-1
South Carolina Water Quality Standards for Freshwaters

Parameters	Standards
a. Fecal coliform	Not to exceed a geometric mean of 200/100 mL, based on five consecutive samples during any 30-day period; nor shall more than 10 percent of the total samples during any 30-day period exceed 400/100 mg/L.
b. pH	Range between 6.0 and 8.5.
c. Temperature	Generally, shall not be increased more than 5 °F (2.8 °C) above natural temperature conditions or be permitted to exceed a maximum of 90 °F (32.2 °C) as a result of the discharge of heated liquids. For exceptions, see E-6, Regulation 61-68, State of South Carolina Water Classifications and Standards (April 24, 1992).
d. Dissolved oxygen	Daily average not less than 5.0 mg/L, with a low of 4.0 mg/L.
e. Garbage, cinders, ashes, sludge, or other refuse	None allowed.
f. Treated wastes, toxic wastes, deleterious substances, colored or other wastes, except those in (e)	None alone or in combination with other substances or wastes in sufficient amounts to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters assigned to this class.
g. Ammonia, chlorine, and toxic pollutants listed in the federal Clean Water Act (307) and for which EPA has developed national criteria (to protect aquatic life).	See E-7 (list of water quality standards based on organoleptic data) and E-8 (water quality criteria for protection of human health), Regulation 61-68 State of South Carolina Water Classifications and Standards (April 24, 1992).

Therefore, if any sample in a given month exceeds the 400/100 mL standard, an exceedance is reported.

Because of the limited samples and the drastic decrease in the limit guide, it appears that there are more

exceedances (76) in 1993 than in past years. The significance of various coliform organisms in water has been and still is a subject of considerable study. Collectively, the coliforms are referred to as indicator organisms because they indicate the presence of human

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Figure 9-1 SRS Streams and Savannah River Water Quality Sampling Locations

On Site	On Site (SCDHEC)	River
Upper Three Runs 1A	Steel Creek 4	River 2
Upper Three Runs 4	Tims Branch 5	River 3B
Four Mile Creek 6	Four Mile A7	River 10
Lower Three Runs 2	Upper Three Runs 4	
Beaver Dam Creek		
Pen Branch 3		
McQueen Branch		
Crouch Branch		

or animal feces. But all coliforms do not necessarily originate from sewage.

All the stream locations experienced at least one pH measurement below the guide range of 6.0 to 8.5. The measurements are 2 to 5 percent below the established guide. These measurements appear to be due to seasonal conditions and are not attributed to effluent discharge from site facilities. Comparison to historical data shows that these data points are within normal fluctuations for surface waters in this area.

All other analyses of SRS stream samples and measurements in site streams met the South Carolina standard guides for Freshwaters in 1993. Data generated from site stream water samples show no significant deviation from the data generated in 1992 at the same locations. No significant trends were identified in the data [SRS Data, 1994].

Savannah River

The following paragraphs describe the nonradiological surveillance of the Savannah River with respect to applicable regulations, the surveillance program, and the 1993 results. Information also is presented on pesticide and herbicide concentrations and on river and stream temperature surveys.

Applicable Regulations

Because SCDHEC classifies the Savannah River as a Freshwater system, the river is governed by the same regulations as site streams (table 9-1, page 116).

Description of Surveillance Program

The Savannah River is sampled monthly at three locations for organic and inorganic contaminants [EMP, 1993]. Sampling locations on the river are shown in figure 9-1, page 117. These sampling sites are located upriver and downriver of the site to provide a means of comparing the SRS contribution of pollutants with "background" levels of chemicals from natural sources and from contaminants produced by

municipal sewage plants, medical facilities, or other industrial facilities upriver of the site. Nonradiological surveillance of the river also serves as a check for any degradation that could be attributed to the water discharges regulated by site NPDES permits.

Field measurements for conductivity, dissolved oxygen, pH, and temperature also are taken monthly in the Savannah River to monitor the river water quality and ensure that the water quality criteria are met.

Each grab or instantaneous sample gives a snapshot of the water quality at the time of sampling. Data from all samplings are compiled to obtain an over-time indication of the water quality in the river.

Laboratory analyses are conducted for other water quality parameters, such as metals, chemicals, and physical and biological properties.

In addition, the Academy of Natural Sciences of Philadelphia conducts special environmental surveys on the Savannah River through a program begun in 1951. Academy studies for 1993 are discussed in chapter 13, "Special Surveys and Studies."

Surveillance Results

A comparison of Savannah River water quality analyses upriver and downriver of SRS showed no significant differences [SRS Data, 1994].

The change in the standard guides described in the applicable regulations (table 9-1, page 116) was applied to the river as well as to site streams. The increase in instances of fecal coliform counts exceeding the guides is attributed to the change in the standard guides. Comparison to historical data shows that the coliform data is within normal fluctuations for river water in this area. All other 1993 analytical results and measurements for river samples were within the standard guides for Freshwaters. Data generated from site river water samples show no significant deviation from the data generated in 1992 at the same locations. No significant trends were identified in the data [SRS Data, 1994].

Drinking Water

The following paragraphs describe the nonradiological surveillance of drinking water with respect to applicable regulations, the surveillance program, and the 1993 results.

Applicable Regulations

SRS drinking water systems must meet the water quality criteria mandated by South Carolina Primary Drinking Water Regulations (R61-58) and any applicable EPA standards where state regulations may not be

Pesticides and Herbicides

Pesticides and herbicides have been monitored at SRS since 1976 to assess their concentrations in surface waters from site streams and the Savannah River. Water samples from seven stream and two river locations were analyzed for 22 pesticides and herbicides during 1993.

Pesticides and herbicides analyzed for in SRS river and stream waters were less than minimum detectable concentrations during 1993 [SRS Data, 1994].

finalized. SCDHEC implements drinking water standards for South Carolina that are at least as stringent as U.S. Environmental Protection Agency (EPA) standards. Many of these regulations apply only to community drinking water systems. Although SRS is considered to have noncommunity drinking water systems, it uses all SCDHEC maximum contaminant levels and recommended guidelines as site water quality standards to ensure the safety of its drinking water. (Drinking water standards for specific contaminants are listed in appendix D, "Drinking Water Standards.")

Description of Surveillance Program

The 27 separate on-site drinking water systems are monitored by Power Operations and Site Services Engineering. Most of the larger systems draw water from wells installed in the Black Creek-Middendorf formations. The smaller systems utilize shallow wells that draw water from the Congaree or McBean formations.

The drinking water is disinfected with chlorine to ensure that bacteriological concentrations remain below state and federal limits. Sodium hydroxide or soda ash is added to water in larger systems to maintain a pH within acceptable limits. Phosphates also are added to five on-site systems for iron and corrosion control. The concentrations of chemicals added to the water are monitored daily at all 27 on-site systems.

Samples from all drinking water supplies are analyzed routinely for total coliform bacteria. The sampling frequency depends on the population served by the water system. Samples for various chemical and volatile organics analyses are collected annually from the 13 larger systems and biannually for the smaller systems. SCDHEC periodically performs compliance sampling for these analyses as well.

As part of new SCDHEC and EPA regulations, samples have been selected from the 13 larger water systems and analyzed for lead and copper concentrations.

Chlorocarbons in drinking water are monitored by SRS at six domestic water wells and two process water wells in A-Area and M-Area. The sampling frequency ranges from monthly to quarterly. Chlorocarbons also are measured semiannually at all drinking water systems.

Surveillance Results

The 13 larger SRS domestic water systems (those for which reporting is required) were in compliance with SCDHEC standards for total coliform bacteria.

Of 1,470 sample results from the annual chemical analysis program, one exceeded SCDHEC primary

(health-based) limits. This exceedance, a radiological result at the Aiken Barricade for radium-226, is discussed in chapter 6, "Radiological Environmental Surveillance."

All volatile organics samples collected by SCDHEC met state standards.

Process water wells 20A and 53A in the M-Area vicinity continued to show elevated chlorocarbon concentrations as a result of groundwater contamination identified in 1981. In 1993, the maximum concentration in these process wells was 202 µg/L trichloroethylene, measured in well 53A.

Chlorocarbon concentrations were not detected by SRS and subcontracted laboratory personnel in A-Area domestic water wells or in the A-Area domestic water system. Service water sample analyses results exceeded the EPA standard for trichloroethylene (5µg/L); however, this water is being used as process water.

All the larger systems met SCDHEC limits for lead and copper concentrations except for the Savannah River Forest Station system. Soda ash will be added to this system to adjust the pH and lower the levels of lead and copper. A more detailed discussion of drinking water compliance appears in the Safe Drinking Water Act section of chapter 2, "Environmental Compliance."

Sediment

The following paragraphs describe the nonradiological surveillance program for sediment and the program's 1993 results.

Description of Surveillance Program

The nonradiological surveillance program monitors pesticides and herbicides to assess their concentrations and accumulations in the sediments of SRS streams and the Savannah River to ensure no residual carry-over of pesticides or herbicides. Sediment samples from two Savannah River and seven site stream locations were analyzed for 22 pesticides and herbicides during 1993. Sediment sampling locations are shown in figure 9-2.

In 1993, SRS instituted a program of annual sampling of site stream sediments for inorganic contaminants. The program was designed to provide a surveillance method to determine if inorganic contaminants are being deposited in sediments in on-site streams. Seven on-site stream locations, two Savannah River sites, and two background sites were chosen for sampling.

Surveillance Results

No pesticides or herbicides were detected in 1993 in the Savannah River or in stream sediment samples. All sample results were below the detection limits of the

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Figure 9-2 SRS Streams and Savannah River Water and Sediment Sampling Locations

Surface water is sampled to comply with SCDHEC regulations. Sediment is sampled for pesticides, herbicides, and inorganic contaminants.

EPA analytical procedures used [SRS Data, 1994]. (Pesticides and herbicides in stream and river waters are discussed on page 118.)

The inorganics program was designed to document the build-up, if any, of contaminants over time. The sediments were analyzed by a subcontracted laboratory. A toxicity characteristics leaching procedure extraction was performed on the samples, and the resulting extract was analyzed per acceptable EPA analyses. Two parameters, sodium and manganese,

were inadvertently left off but will be included in the 1994 analytical list. Data collected during the first set of samples indicated that approximately 30 ppm of uranium were present in sediment from all sample locations [SRS Data, 1994]. Because naturally occurring radioactivity does not occur at 30 ppm, the samples were treated as suspect, and the data were reviewed. Additionally, all sites were resampled. Review of the initial data found no evidence of problems; however, the spectral data were discarded,

which made it impossible to conclusively validate or invalidate the initial set of data.

The second set of data showed less than detectable amounts of uranium at all locations [SRS Data, 1994]. These results indicate that the data reported from the first set of samples were incorrect.

Because the program has been in existence for only one year and is designed to show trends, no conclusions can be drawn from the data.

Fish

The following paragraphs describe the nonradiological surveillance of fish with respect to applicable regulations, the surveillance program, and the 1993 results.

Applicable Regulations

Other than through occupational exposure, the greatest source of mercury intake by people is the consumption of food, particularly fish. The U.S. Food and Drug Administration (FDA) has established an action limit of 1.0 $\mu\text{g Hg/g}$ [FDA, 1990]. Action limits are established to reflect maximum allowable concentra-

Photo by Al Mamatey (NFN)

An EMS analyst obtains a fish tissue sample for mercury analysis as part of the nonradiological fish surveillance program.

tions for fish destined for interstate commerce. SRS uses the FDA guideline, which has been adopted by SCDHEC, to gauge concentrations of mercury in fish from on-site streams.

Description of Surveillance Program

EMS analyzes the flesh of fish caught from on-site streams and ponds, the Savannah River, and the Edisto River (the control location) to determine concentrations of mercury in the fish [EMP, 1993]. The fish analyzed represent the most common edible species of fish in the Central Savannah River Area (CSRA).

Surveillance Results

In 1993, a total of 211 fish from SRS streams and ponds, the Savannah River, and the Edisto River were collected and analyzed for mercury [SRS Data, 1994].

The mercury concentrations in fish analyzed from on-site waters ranged from a high of 2.87 $\mu\text{g Hg/g}$ in a bass from L Lake to a low of 0.03 $\mu\text{g Hg/g}$ in a catfish from Beaver Dam Creek.

Mercury concentrations in off-site fish ranged from a high of 1.47 $\mu\text{g Hg/g}$ in a catfish from the mouth of Four Mile Creek to a low of <0.01 $\mu\text{g Hg/g}$ in a mullet from the Savannah, Georgia, area.

Concentrations from the Edisto River ranged from a high of 0.3 $\mu\text{g Hg/g}$ to a low of 0.1 $\mu\text{g Hg/g}$, both in crappie from the West Bank Landing area.

Perspective on Mercury

Mercury in the environment can come from natural sources, such as volcanoes and venting of the earth's crust, and from man-made sources and processes, such as fungicides and fossil fuel combustion by-products and the manufacture of chlorine, sodium hydroxide, plastics, and electrical apparatus.

An important source in the SRS region may be in releases upriver of the site. Much of the mercury detected in SRS fish has been attributed to off-site sources, such as Savannah River water [Davis et al., 1989]. Savannah River water is pumped onto the site for use as cooling water and subsequently is pumped into site streams and lakes.

Chapter 10

Groundwater

William M. Fay and Kathleen Gore
Exploration Resources, Inc.

Introduction

Groundwater beneath an estimated 5 to 10 percent of the Savannah River Site (SRS) has been contaminated by industrial solvents, tritium, metals, or other constituents used or generated by operations at SRS. Groundwater in areas indicated on figure 10-1 contains one or more of these constituents at or above the levels of Safe Drinking Water Act primary drinking water standards (DWS) promulgated by the U.S. Environmental Protection Agency (EPA).

This chapter describes the groundwater monitoring results for approximately 100 locations (figure 10-1) within designated areas at SRS, which is located in Aiken, Barnwell, and Allendale counties of South Carolina. Only summaries of results exceeding standards will be found in this report. The following detailed 1993 quarterly groundwater reports are public documents: *The Savannah River Site's Groundwater Monitoring Program, First Quarter 1993* (ESH-EMS-930096); *The Savannah River Site's Groundwater Monitoring Program, Second Quarter 1993* (ESH-EMS-930097); *The Savannah River Site's Groundwater Monitoring Program, Third Quarter 1993* (ESH-EMS-930098); *The Savannah River Site's Groundwater Monitoring Program, Fourth Quarter 1993* (ESH-EMS-930099); and *Environmental Protection Department's Well Inventory* (ESH-EMS-930261).

For details on groundwater monitoring at any of the sites discussed in this report, see the well inventory report to determine which well series monitor(s) a particular site. Full results for each well sampled during a quarter are presented alphabetically by well series in the quarterly report.

Groundwater aquifers are major pathways by which potentially hazardous substances at SRS may enter nearby streams and eventually the Savannah River. Substances in the soil may be dissolved in rainwater, which moves them downward through the unsaturated zone to the water table. The water then flows downgradient toward the discharge point.

To identify the extent of contamination in groundwater and to predict the possible fate of the contaminants, scientists must determine the location and movement of groundwater. To make this determination, an understanding of how groundwater moves, in general, and an understanding of how that movement will be influenced by the specific geologic setting at SRS are required.

Groundwater Hydrology

When rain falls, a portion of the rainwater accumulates as groundwater by soaking into the ground, infiltrating soil and rock. The accumulation of groundwater in pore spaces of sediments creates sources of useable water. Groundwater eventually reappears at the surface in springs, swamps, stream and river beds, or wells. Thus, groundwater is a reservoir whose primary input is rainwater infiltrating the soil and whose output is discharge to springs, swamps, streams, rivers, and wells.

Water from the surface moves into the soil by percolating downward through the pore spaces between sediment grains. The smaller the pore spaces, the slower the flow of water through the sediment. The physical property that describes the ease with which water may move through the pore spaces and cracks in a solid is called permeability, and it is largely determined by the volume and size of pore spaces in the solid and how well the pore spaces are connected.

As water infiltrates the earth, it travels down through the unsaturated zone, where the pore spaces are filled partly with water and partly with air. Water moving through the unsaturated zone eventually reaches the saturated zone, where the pore spaces are completely filled with water. The boundary between the unsaturated and saturated zones is known as the water table. The water table generally follows, in subtle form, the contour of the surface topography. Springs, swamps, and beds of streams and rivers are the outcrops of the water table, where groundwater is discharged to the surface.

Groundwater beneath SRS flows slowly, at rates ranging from inches per year to several hundred feet per year, toward streams and swamps on site and into

Figure 10-1 Facilities Monitored by the SRS Monitoring Well Network, Including Areas with Constituents Exceeding Drinking Water Standards in 1993

Key for Figure 10-1.

Acid/Caustic Basins

1. F-Area Acid/Caustic Basin
2. H-Area Acid/Caustic Basin
3. K-Area Acid/Caustic Basin
4. P-Area Acid/Caustic Basin
5. R-Area Acid/Caustic Basin

Burning/Rubble, Rubble, and Metals Burning Pits

6. A-Area Burning/Rubble Pits and A-Area Ash Pile
7. A-Area Metals Burning Pit
8. Burma Road Rubble Pit
9. C-Area Burning/Rubble Pit
10. D-Area Burning/Rubble Pits
11. F-Area Burning/Rubble Pits
12. K-Area Burning/Rubble Pit
13. L-Area Burning/Rubble Pit
14. N-Area (formerly Central Shops) Burning/Rubble Pits
15. N-Area Burning/Rubble Pit South
16. P-Area Burning/Rubble Pit
17. R-Area Burning/Rubble Pits

Coal Pile Runoff Containment Basins and Ash Basins

18. A-Area Coal Pile Runoff Containment Basin
19. C-Area Coal Pile Runoff Containment Basin
20. D-Area Coal Pile Runoff Containment Basin and Ash Basins
21. F-Area Coal Pile Runoff Containment Basin
22. H-Area Coal Pile Runoff Containment Basin
23. K-Area Ash Basin
24. K-Area Coal Pile Runoff Containment Basin
25. P-Area Coal Pile Runoff Containment Basin
26. R-Area Coal Pile

Disassembly Basins

27. C-Area Disassembly Basin
28. K-Area Disassembly Basin
29. L-Area Disassembly Basin
30. P-Area Disassembly Basin
31. R-Area Disassembly Basin

Seepage and Retention Basins

32. C-Area Reactor Seepage Basins
33. F-Area Seepage Basins and Inactive Process Sewer Line
34. Ford Building Seepage Basin
35. H-Area Retention Basins
36. H-Area Seepage Basins and Inactive Process Sewer Line
37. K-Area Retention Basin
38. K-Area Reactor Seepage Basin
39. L-Area Reactor Seepage Basin
40. M-Area Settling Basin
41. Metallurgical Laboratory Seepage Basin
42. New TNX Seepage Basin
43. Old F-Area Seepage Basin
44. Old TNX Seepage Basin
45. P-Area Reactor Seepage Basins
46. R-Area Reactor Seepage Basins
47. Savannah River Laboratory Seepage Basins

Operating Buildings and Facilities

48. F-Area Canyon Building and A-Line Facility
49. F-Area Effluent Treatment Cooling Water Basin
50. H-Area Auxiliary Pump Pit
51. H-Area Canyon Building
52. H-Area Effluent Treatment Cooling Water Basin
53. K-Area Tritium Sump
54. N-Area Hazardous Waste Storage Facility
55. S-Area Defense Waste Processing Facility
56. S-Area Low-Point Pump Pit
57. S-Area Vitrification Building
58. Z-Area Low-Point Drain Tank
59. Z-Area Saltstone Facility

Plume Monitoring

60. A-Area and M-Area
61. Separations and Waste Management Areas
62. TNX

Radioactive Waste Storage and Disposal

63. Old Burial Ground
64. Mixed Waste Management Facility/Low-Level Radioactive Waste Disposal Facility
65. Burial Ground Expansion
66. Hazardous Waste/Mixed Waste Disposal Facility
67. F-Area Tank Farm
68. H-Area Tank Farm

Sanitary Landfill**Sludge Application Sites**

69. F-Area Sanitary Sludge Land Application Site
70. H-Area Sanitary Sludge Land Application Site
71. K-Area Sludge Land Application Site
72. Kato Road Sewage Sludge Application Site
73. Lower Kato Road Sewage Sludge Application Site
74. Orangeburg Sewage Sludge Application Site
75. Par Pond Sludge Land Application Site
76. Road F Sewage Sludge Application Site
77. Sandy (Lucy) Sewage Sludge Application Site
78. Second Par Pond Borrow Pit Sewage Sludge Application Site
79. 40-Acre Hardwood Sewage Sludge Application Site

Other Sites

80. B-Area Gas Station
81. Chemicals, Metals, and Pesticides (CMP) Pits
82. D-Area Oil Disposal Basin
83. K-Area Diesel Tank Spill
84. L-Area Acid/Caustic Basin and Oil & Chemical Basin
85. Miscellaneous Chemical Basin
86. Motor Shop Oil Basin
87. N-Area Diesel Spill
88. N-Area Fire Department Training Facility
89. N-Area Hydrofluoric Acid Spill
90. Road A (Baxley Road) Chemical Basin
91. Silverton Road Waste Site
92. TNX Burying Ground

the Savannah River. Figures 10-2 (page 155) and 10-3 (page 156) illustrate the horizontal flow directions of two regional aquifers monitored beneath SRS. Horizontal flow directions of groundwater within these aquifers are indicated by bold arrows perpendicular to potentiometric contours. In both aquifers, the direction of flow beneath monitored waste sites generally is toward the Savannah River, the Savannah River swamp, Upper Three Runs Creek, or Lower Three Runs Creek. Surface water in the swamp and creeks eventually flows into the Savannah River.

The flow of groundwater and the position of the water table may be complicated by variations in the permeability of the subsurface. Because the earth's permeability varies greatly, groundwater flowing through subsurface strata does not travel at a constant rate or without impediment. Strata that transmit water easily (such as those composed primarily of sand) are called aquifers, and strata that restrict water movement (such as clay layers) are called aquitards. An aquifer with an aquitard lying above and beneath it is termed a confined aquifer. Groundwater moves through aquifers toward natural exits, or discharge points, to reappear at the surface.

The direction of groundwater flow through an aquifer system is determined only partly by the permeability of the strata containing the aquifer. Hydraulic gradient, the difference in hydraulic head over a specified distance, is the driving force for groundwater movement through the saturated zone. The hydraulic head, or elevation of the water in a well or piezometer at any given point in an aquifer, is a function of the energy associated with elevation and the pressures exerted by surrounding water. Because hydraulic head is not just a function of elevation, downgradient is not necessarily synonymous with downhill. The downgradient direction will have a horizontal and vertical component, just as a household drain moves wastewater both horizontally and vertically toward the lowest point of exit. Aquitards deflect groundwater movement just as drain-pipe walls control the direction of wastewater movement. In an aquifer constrained by aquitards such as horizontal clay layers, the downgradient direction tends to be more horizontal than vertical.

Monitoring wells are used extensively to assess the effect of operations on groundwater quality, generally to determine the effect of a specific site on groundwater quality nearby. Wells positioned to intercept the groundwater flowing away from a site are called downgradient wells, while wells placed to intercept groundwater before it flows under a site are called upgradient wells. Wells sampling groundwater flowing next to a site are called sidegradient wells. Any contamination of the downgradient wells not present in

the upgradient wells at a site may be assumed to be a product of that site.

Wells are drilled to various depths in the saturated zone below the area to be monitored. A portion of the well casing, the screen, is perforated to allow water to enter the well. Thus, the screen zone refers to the zone of subsurface strata whose water is being sampled by the well. The water rises in the well casing to equilibrate with the hydraulic head of the water surrounding the well's screen zone. By comparing the water levels in adjacent wells screened in the same zone, the hydraulic gradient can be determined, and the horizontal direction of groundwater flow can be predicted.

The vertical direction of groundwater movement is controlled by the permeability of the aquitards and the relative difference in hydraulic head of the water on either side of an aquitard. Vertical gradients can be determined by comparing the water levels between adjacent wells screened on either side of an aquitard. If the water levels in deeper wells are higher than those in shallower wells, the vertical component of flow is upward.

Vertical and horizontal groundwater flow directions are in part determined by the permeability and continuity of geologic strata. In order to monitor effectively the movement of groundwater and any hazardous constituents it may contain, researchers at SRS have undertaken many detailed studies of the geology of strata beneath the site.

Geological and Hydrogeological Setting at SRS

SRS is located on the Upper Atlantic Coastal Plain, approximately 20 miles southeast of the Fall Line, which separates the Piedmont and Coastal Plain provinces. The site is on the Aiken Plateau, a relatively flat area that slopes southeastward and is dissected by several tributaries of the Savannah River.

SRS is underlain by a 700- to 1,200-foot-thick, seaward-thickening wedge of Coastal Plain sediment composed of unconsolidated sands, clayey sands, sandy clays, and lesser amounts of calcareous sediment. These layers are underlain by dense crystalline igneous and metamorphic rock or younger consolidated sediments of the Triassic Period. The Triassic formations and older igneous and metamorphic rocks are hydrologically isolated from the overlying Coastal Plain sediments by a regional aquitard. A cross section of the Coastal Plain sediments is presented graphically in figure 10-4 (page 157).

Within the Coastal Plain sediments, the sandy strata are generally porous and permeable and may form

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Workers on an auger rig begin a boring to set the casing for an SRS groundwater monitoring well. Such wells are used extensively to assess the effect of site operations on groundwater quality.

aquifers. Strata rich in clays are made less porous by the presence of tiny pore-filling clay particles. Clayey strata, therefore, are less permeable than sandy strata and tend to be aquitards.

Discussed in this report are three major water-bearing zones in Coastal Plain sediments, divided by regional aquitards. In ascending order, these are the Cretaceous zone, the Congaree-Fourmile zone, and the upper saturated zone, including the water table in most areas. (These terms are informal.) Monitoring wells at SRS primarily are used to sample water from these zones.

The deepest aquifer monitored at SRS occurs in sediments of geologic formations of Cretaceous age. These Cretaceous sediments are largely permeable quartz sands and sandy clays capable of yielding abundant water; they constitute a regionally important aquifer. The Cretaceous zone is separated from the overlying Congaree-Fourmile zone by a regional aquitard composed of sandy-clay and clay sediments.

The Congaree-Fourmile zone is a locally important source of groundwater, occurring in moderately to well-sorted sand and interbedded sandy-clay sediments capable of yielding several hundred gallons of water

per minute. A local aquitard, composed predominantly of clay and identified in SRS literature as "Green Clay," overlies the Congaree-Fourmile zone, separating it from the upper saturated zone. In the Savannah River Valley between SRS and Georgia, this aquitard and the sediments of the underlying Congaree-Fourmile zone have been eroded by river channel migration and incision.

Sediments of the upper saturated zone are predominantly sandy clay and calcareous sediments and generally yield low amounts of water. Numerous discontinuous clay-rich layers (including the "Tan Clay" of SRS literature) create local aquitards in the upper saturated zone, resulting in locally complex patterns of groundwater flow.

At SRS, the horizontal direction of groundwater movement is largely governed by the depths of incisions of the creeks and streams where water is discharged to the surface. The valleys of the smaller perennial streams allow discharge from the upper saturated formations. The valleys of major tributaries of the Savannah River drain formations of intermediate depth, and the valley of the Savannah River drains deep formations. Generally, groundwater in the deep

Cretaceous zone flows toward and discharges into the Savannah River on both the Georgia and South Carolina sides of the river. Groundwater in intermediate-depth lower Eocene-age formations (the Congaree-Fourmile zone) flows toward and discharges into Upper Three Runs Creek or the Savannah River, depending on proximity. Groundwater in younger sediments (the upper saturated zone) generally flows toward and discharges into the nearest perennial stream, swamp, or river.

Few aquitards are continuous across SRS. Generally, in the northwestern part of the site (near A-Area and M-Area; figure 10-5, page 158), aquitards are less continuous, permitting vertical flow of groundwater. Where aquitards are more continuous, as they are in the southeastern portion of SRS, groundwater movement is predominantly horizontal. Along the Pen Branch fault (figure 10-4, page 157), aquitards (and transmissive zones) are offset, making the aquitards effectively discontinuous and increasing the likelihood of vertical interchange of water from one transmissive zone to another.

Beneath much of SRS, hydraulic head decreases with depth, so the vertical component of groundwater flow is downward. This is the case in A-Area and M-Area, where discontinuous aquitards and downward-decreasing hydraulic head allow the downward movement of water from the water table to deeper zones. This type of area is called an aquifer recharge zone (figure 10-5, page 158). However, because of the discharge of groundwater to the valleys of Upper Three Runs Creek and the Savannah River, the hydraulic head in sediments in the Congaree-Fourmile zone is less than the hydraulic head in the Cretaceous zone. Thus, the vertical hydraulic gradient is upward, from the lower to the upper sediments, in some areas (figure 10-5, page 158). This upward flow occurs, for example, in the separations and waste management areas, where both the aquitard and an upward hydraulic gradient restrict downward flow of groundwater—and any associated hazardous substances—from the Congaree-Fourmile zone into the Cretaceous zone.

Uses of Groundwater in the Vicinity of SRS

Groundwater is used as a domestic, municipal, and industrial water supply throughout the Upper Coastal Plain. Most municipal and industrial water supplies in Aiken County are developed from the Cretaceous zone. Domestic water supplies are primarily developed from the Congaree-Fourmile zone and the upper saturated zone. In Barnwell and Allendale counties of South Carolina some municipal users are supplied from the

Congaree-Fourmile zone and overlying units that thicken to the southeast.

At SRS, most groundwater production is from the Cretaceous zone, with a few lower-capacity wells pumping from the Congaree-Fourmile zone. Every major operating area at SRS has groundwater production wells. Total groundwater production at SRS is from 9 to 12 million gallons per day, similar to the volume pumped for industrial and municipal production within 10 miles of SRS.

Description of Monitoring Program

The Groundwater Monitoring Program at SRS gathers information to determine the effect of site operations on groundwater quality. The program is designed to accomplish the following:

- assist SRS in complying with environmental regulations and U.S. Department of Energy (DOE) directives
- provide data to identify and monitor constituents in the groundwater
- permit characterization of new facility locations to ensure that they are suited to house the intended facilities
- support basic research projects

The Groundwater Monitoring Program at SRS is performed by the Groundwater Monitoring Group of the Westinghouse Savannah River Company Environmental Protection Department's Environmental Monitoring Section (EMS). The Groundwater Monitoring Group provides the services for installing monitoring wells, collecting and analyzing samples, and reporting results to assist other departments in meeting their responsibilities.

Sample Scheduling and Collection

EMS schedules groundwater sampling either in response to specific requests from SRS personnel or as part of the ongoing EMS groundwater monitoring program. These groundwater samples provide data for reports required by federal and state regulations and for internal reports and research projects. The ongoing groundwater monitoring program schedules wells to be sampled at intervals ranging from quarterly to biennially. New wells added to the program are analyzed for a comprehensive list of constituents (table 10-1) for four consecutive quarters. Except for a number of old wells not constructed properly for collecting samples for all analyses, these comprehensive analyses are conducted every second year for all active EMS monitoring wells.

Table 10-1 Constituents for Groundwater Analyses**Comprehensive-Analyses Constituents**

Aluminum
 Arsenic
 Barium
 Boron
 Cadmium
 Chloride
 Chromium
 Fluoride
 Herbicides/pesticides suite
 2,4-Dichlorophenoxyacetic acid
 Endrin
 Lindane
 Methoxychlor
 Toxaphene
 2,4,5-TP (Silvex)
 Iron
 Lead
 Lithium
 Major ions suite
 Calcium
 Magnesium
 Potassium
 Silica
 Manganese
 Mercury
 Nitrate as nitrogen
 pH
 Phenols
 Selenium
 Silver
 Sodium
 Specific conductance
 Sulfate
 Total dissolved solids
 Total organic carbon
 Total organic halogens
 Total phosphates (as P)
 Gross alpha
 Nonvolatile beta
 Total alpha-emitting radium
 Tritium

Gas Chromatographic Volatile Organic Analyses Constituents

Carbon tetrachloride
 Chloroform
 Tetrachloroethylene
 1,1,1-Trichloroethane
 Trichloroethylene

Personnel outside EMS may request that samples be collected as frequently as monthly. Comprehensive-analyses constituents may be analyzed by request. Additional radioactive constituents that may be analyzed by request include gamma emitters, stron-

tium-89, strontium-90, radium-228, and uranium isotopes. Additional nonradioactive constituents that may be analyzed by request include suites of herbicides, pesticides, additional metals, volatile organics (most often gas chromatographic volatile organic analyses), and other constituents.

Wells with certain constituent concentrations above certain limits subsequently are sampled either annually or semiannually, depending on the concentrations of the constituents. Comprehensives were scheduled in 1993 for established wells. Field measurements of pH, specific conductance, temperature, turbidity, and water level are taken quarterly at all active EMS monitoring wells. Alkalinity also is measured in the field during most sampling events.

Groundwater samples are collected from monitoring wells, generally with either pumps or bailers dedicated to the well to prevent cross-contamination among wells. Occasionally, portable sampling equipment is used; it is decontaminated between wells.

Sampling and shipping equipment and procedures are consistent with EPA, South Carolina Department of Health and Environmental Control (SCDHEC), and U.S. Department of Transportation guidance. EPA-recommended preservatives and sample-handling techniques are used during sample storage and transportation to both on-site and off-site analytical laboratories. Potentially radioactive samples are screened for total activity prior to shipment to determine appropriate packaging and labeling requirements.

Deviations from scheduled sampling and analysis for 1993 are enumerated in the SRS quarterly groundwater monitoring reports cited on the first page of this chapter.

Analytical Procedures

In 1993, General Engineering Laboratories of Charleston, South Carolina, performed most of the groundwater analyses. Roy F. Weston, Inc., of Lionville, Pennsylvania, also performed groundwater analyses. The contracted laboratories are certified by SCDHEC to perform specified analyses.

The EMS radiological laboratory at SRS screened potentially radioactive samples for total activity prior to shipment; analyzed samples from certain K-Area wells for gross alpha, nonvolatile beta, gamma emitters, and tritium; and analyzed samples from certain wells at the F-Area and H-Area seepage basins for gamma emitters. Clemson Technical Center, Inc., of Anderson, South Carolina, and Environmental Physics of Charleston subcontracted radiological analyses. TMA/Eberline of Oak Ridge, Tennessee, performed radiological analyses for Roy F. Weston, Inc.

Full lists of constituents analyzed, analytical methods used, and the laboratories' detection limits are given in the SRS quarterly groundwater reports cited earlier.

Evaluation of Groundwater Data

EMS receives analytical results and field measurements as reports and as computer files that are loaded onto a mainframe computer at SRS. Logbooks track receipt and transfer of data to the mainframe database, and computer programs present data in a format that can be validated.

Quality control practices include the following:

- verification of well names and sample dates for field and analytical data
- verification that all analyses requested on the chain-of-custody forms are complete for each laboratory
- identification of data entry problems (e.g., duplicate records, incorrect units)
- comparison of analytical data to historical data and review of the data for transcription, instrument, or calculation errors
- comparison of blind replicates and laboratory in-house duplicates for inconsistencies
- identification of laboratory blanks and blind blanks with elevated concentrations

Possible transcription errors and suspect results are documented and submitted to the appropriate laboratory for verification or correction. No changes are made to the database until the laboratory documents the problem and solution. Changes to the database are recorded in a logbook.

The quarterly groundwater monitoring reports identify queried results that have been verified by the laboratory and list groundwater samples associated with blanks having elevated results. These reports also present the results of intra- and interlaboratory QA comparisons. See also chapter 11, "Quality Assurance."

Changes to the Groundwater Monitoring Program During 1993

Well Abandonments and Additions to the Sampling Schedule

Seven wells that had monitored the Savannah River Laboratory seepage basins were abandoned in 1993 because they were too close to the proposed closure cap. Six replacement wells and one new well were installed at appropriate distances.

The following 37 other wells were monitored for the first time in 1993:

- Two replacement wells and one new well monitored the Solid Waste Disposal Facility (SWDF)—formerly the Radioactive Waste Burial Grounds.
- One new well monitored the D-Area burning/rubble pits.
- Six new wells monitored the F-Area burning/rubble pits.
- Six new wells monitored the inactive sewer lines in F-Area.
- One new well monitored the inactive sewer lines in H-Area.
- Eleven new wells monitored the A-Area and M-Area plume.
- Nine new wells monitored the Silverton Road waste site.

Changes in Scheduling Procedures

During 1993, the only constituents scheduled for analyses based on previous concentrations above certain limits were comprehensive analyses and gas chromatographic volatile organic analyses (table 10-1).

Changes in Sampling Procedures

A new sampling procedure was implemented effective fourth quarter 1992. In the past, samples had been collected for dissolved metals analyses by pressure filtration through 0.45-diameter pores. Samples collected for metals analyses no longer are filtered; results now represent concentrations of total rather than dissolved metals. In addition, variable speed pumps were installed in some wells that have had a history of elevated metals results when centrifugal pumps were used. The variable speed pumps are used to collect samples at a slower flow rate (no greater than 1 liter per minute) to minimize turbidity in the samples.

These changes in sampling procedures and equipment affect some analytical results and may cause a shift in data trends. Increases in the concentrations of some metals may be attributed to the lack of filtration. The most notable concentration increases have been for iron and aluminum. Slight increases also have been noted for calcium, chromium, copper, lead, magnesium, tin, and zinc. Conversely, lower turbidity values and a decrease in some metal concentrations (aluminum, barium, cadmium, cobalt, copper, iron, manganese, and zinc) have been observed for wells sampled using the variable speed pumps, even though filtering has ceased.

Applicable Standards

The analytical results of samples taken from SRS monitoring wells that exceed federal primary DWS, both final and proposed, are discussed in this chapter. South Carolina policy is to classify groundwater aquifers as potential drinking water sources and therefore to maintain the quality of these waters as suitable for drinking water [SCDHEC, 1985]. DWS are not, however, invariably the standards applied by regulatory agencies to those SRS waste units under their jurisdiction. For instance, standards under the Resource Conservation and Recovery Act (RCRA) are DWS, background levels, and alternate concentration limits.

Two constituents having DWS, dichloromethane and bis(2-ethylhexyl)phthalate, are not discussed in this chapter. Both are common laboratory contaminants and are reported in groundwater samples with little or no reproducibility. Both constituents are reported, with appropriate flags and qualifiers, in the data tables of the quarterly reports cited earlier.

Four constituents without drinking water standards are discussed in the text when their values exceed certain levels. These constituents are specific conductance at values equal to or greater than 100 $\mu\text{S}/\text{cm}$, alkalinity at values equal to or greater than 100 mg/L, total dissolved solids (TDS) at values equal to or greater than 200 mg/L, and pH at values equal to or below 4.0 or equal to or above 8.5. The selection of these values as standards for comparison is somewhat arbitrary; however, these values exceed levels usually found in background wells at SRS. The occurrence of elevated alkalinity, specific conductance, pH, and TDS within a single well may indicate leaching of the grouting material used in well construction rather than degradation of the groundwater.

Monitoring Results

The following sections describe the groundwater monitoring results for approximately 100 locations (figure 10-1) within designated areas at SRS. The section is arranged in the following order: acid/caustic basins; burning/rubble and metals burning pits; coal pile runoff containment basins, ash piles and basins, and coal piles; disassembly basins; seepage and retention basins; operating buildings and facilities; plume monitoring; radioactive waste storage and disposal facilities; sanitary landfill; sludge application sites; and other sites. Table 10-2 presents an overview of the well network for the monitored locations.

The discussions of recent trends in the data are based on the results presented in the groundwater monitoring

chapters of the annual SRS environmental reports from 1983 through 1992 and on the results for the first three quarters of 1993. Mechanical failure or inaccessibility prevented the sampling of some wells throughout the year. Other wells were dry or needed to be added to the purged-water containment program before further sampling could occur. The quarterly groundwater monitoring reports cited earlier identify wells for which scheduled analyses could not be performed—and specify the reason.

Geographical descriptions in the text are based on true north rather than SRS grid coordinates. All figures are oriented by Universal Transverse Mercator grid coordinates. Figure 10-6 (page 159) provides an overview of the site.

Acid/Caustic Basins

The acid/caustic basins in F-Area, H-Area, K-Area, L-Area, P-Area, and R-Area are unlined earthen pits (approximately 50 by 50 by 7 feet deep) that received dilute sulfuric acid and sodium hydroxide solutions used to regenerate ion-exchange units in power plant water purification processes at the reactor and separations areas in the center of SRS. The basins allowed mixing and neutralization of the dilute solutions before their discharge to nearby streams.

The basins were constructed between 1952 and 1954. They are uncovered, and most are dry except during periods of prolonged precipitation. The R-Area and L-Area basins were abandoned in 1964 and 1968, respectively. The other basins remained in service until 1982, when the water purification systems were either shut down or modernized. However, the H-Area basin continued to receive steam condensate from a hose box and drainage from a chemical pad until it was abandoned in 1985.

The F-Area, H-Area, K-Area, and P-Area basins are on the site evaluation list of the Federal Facility Agreement (FFA) executed during 1993 between SRS, EPA, and SCDHEC. SCDHEC permitted SRS to proceed with the stabilization of the H-Area and P-Area acid/caustic basins according to an Interim Status Closure Plan (Revision 3, 2/5/92) that proposes the closure of the four basins. During July through September 1993, the basins were dewatered, vegetation was removed and disposed of, the basins were filled with compacted soil from the Burma Road clay pit, a grass cover was established, and the fences were reinstalled. Soil along the F-Area, H-Area, K-Area, and P-Area acid/caustic sewer lines was sampled for characterization in November and December 1993.

Work plans for characterization of the L-Area and R-Area acid/caustic basins have been submitted to EPA Region IV and SCDHEC as part of the RCRA/Compre-

hensive Environmental Response, Compensation, and Liability Act (CERCLA) process for determining the extent of contamination at these basins. The L-Area characterization has been combined with characterization of the L-Area oil and chemical basin; see "Other Sites" (page 147) for further information and monitoring results.

F-Area Acid/Caustic Basin

The F-Area acid/caustic basin is east of F-Area (figure 10-7, page 160). During 1993, gross alpha was detected above DWS in six of the seven wells monitoring the groundwater beneath this basin. In past years, gross alpha had been above standard in only one or two wells. The contamination continues to be less than five times the standard.

Alpha-emitting radium exceeded standard in one well during 1993, radium-226 was above DWS in two wells, and nonvolatile beta was above standard in one. Alkalinity, pH, and lead were above standards in one well during 1993, and, as in past years, specific conductance was elevated in several wells.

H-Area Acid/Caustic Basin

The H-Area acid/caustic basin is southwest of H-Area near the tank farm (figure 10-7, page 160). In 1993, as in recent years, tritium activity exceeded the DWS in all wells in this area. Likewise, specific conductance and TDS were elevated in three wells. Chromium was detected above the DWS in a single analysis of one well during 1993, as was lead in another well.

K-Area Acid/Caustic Basin

The K-Area acid/caustic basin is on the east side of K-Area (figure 10-8, page 161). In 1993, lead was detected above the DWS in one analysis in one well. No other chemical or radioactive constituents were detected above the DWS at the basin. As in past years, specific conductance and TDS were elevated in most of the wells. Also, pH was elevated in one well, as in 1992.

P-Area Acid/Caustic Basin

The P-Area acid/caustic basin is east of P-Area and Road F (figure 10-9, page 162). In 1993, no chemical constituents and, as in 1992, no radioactive constituents were detected above the DWS on a regular basis. Lead was detected in one well and radium-228 in two wells in the same quarter, but those results appear anomalous. In a situation similar to that of past years, alkalinity was elevated in one well, TDS in two wells, and specific conductance in four wells. Sulfate, which was elevated in one well in 1992, was not detected above the DWS in any well in 1993.

R-Area Acid/Caustic Basin

The R-Area acid/caustic basin is south of R-Area, just south of Road G (figure 10-10, page 163). In 1993, as in previous years, lead was detected above the DWS in one well in a single analysis. No radioactive constituents and no other chemical constituents were detected above standards in the area, including gross alpha, which had been detected in a single analysis in 1992.

Burning/Rubble, Rubble, and Metals Burning Pits

From 1951 to 1973, burnable wastes such as paper, wood, plastics, rubber, oil, degreasers, and drummed solvents were received and burned monthly in one or more of the burning/rubble pits in the following areas: A, C, D, F, K, L, N, P, and R. In 1973, the burning of waste stopped, and the pits were covered with a layer of soil. Rubble wastes, including paper, wood, cans, concrete, and empty galvanized-steel barrels and drums, then were disposed of in the pits until they reached capacity and were covered with soil. All burning/rubble pits were inactive by 1981, and all are covered except the R-Area pit, which has not been backfilled.

Similarly, lithium-aluminum alloy, aluminum pieces, metal drums, other metal scraps, and plastic pipe were deposited and burned periodically in the A-Area metals burning pit, beginning about 1952. In 1974, the solid materials remaining on the site were covered with soil, and the pit was regraded. The site is inactive.

The Burma Road rubble pit consists of two excavated earthen pits that may contain paint cans, fluorescent light fixtures, metal, concrete, lumber, poles, and glass. Unknown quantities of refuse were deposited here from approximately 1973 through 1983. The pit is inactive and has been covered with soil.

All these pits are RCRA/CERCLA units. Work plans to characterize fully the extent of contamination have been submitted to EPA and SCDHEC.

A-Area Burning/Rubble Pits and A-Area Ash Pile

These burning/rubble pits and the A-Area ash pile (active since 1979) are west of Road D, south of A-Area (figure 10-11, page 164). Revision 2 of the RCRA Facility Investigation/Remedial Investigation (RFI/RI) work plan was submitted to the regulators in October 1993.

As in much of the rest of A-Area and M-Area, tetrachloroethylene and trichloroethylene were the only constituents detected above standards during

1993. In past years, in addition to chlorinated volatile organics, lead and mercury have been detected slightly above standards in one well for one sampling event.

A-Area Metals Burning Pit

The A-Area metals burning pit is south of the burning/rubble pits (figure 10-11, page 164). In 1993, as in 1992 and 1991, lead was elevated in one of the wells, which also has exhibited elevated alkalinity, pH, specific conductance, and TDS, indicating contamination by grout.

As in the past and as in the rest of A-Area and M-Area, chlorinated volatile organics were detected above DWS. In past years, antimony, nickel, nonvolatile beta, and tritium have been detected in one or more of the wells. One well exhibited total alpha-emitting radium just above standard during 1993; this group of radionuclides has been elevated in one or more wells since 1989.

Burma Road Rubble Pit

The Burma Road rubble pit is southwest of F-Area (figure 10-7, page 160). In 1993, as in the past, lead, total alpha radium, tritium, and specific conductance were above standards in wells at the Burma Road rubble pit. This is very similar to results since the wells first were sampled in 1990. During 1993, potassium-40 was slightly above its proposed DWS in one well.

C-Area Burning/Rubble Pit

The C-Area burning/rubble pit is west of C-Area (figure 10-12, page 165). Two wells were not sampled during 1992 or 1993 because past trichloroethylene levels would require containerizing their purged water. During 1993, one of the other two wells contained slightly elevated levels of trichloroethylene, and both contained tritium at or slightly above its DWS. These results are very similar to those of past years.

D-Area Burning/Rubble Pits

Soil and groundwater RFI/RI assessments at these pits, west of D-Area (figure 10-13, page 166), were undertaken during 1993; reports will be submitted to EPA and SCDHEC during 1994. One new well was added as a part of the characterization.

During 1993, nitrate was elevated in one well. Low pH (below standard) was detected in two wells, and specific conductance was elevated in the same two wells, as it has been since 1988.

F-Area Burning/Rubble Pits

Soil and groundwater RFI/RI assessments at these pits, north of Road C and west of F-Area (figure 10-7,

page 160), were undertaken during 1993; a rubble pit where burning did not occur is included. Reports will be submitted to EPA and SCDHEC during 1994. During the course of the investigation, nine new wells were added to the four existing wells at the waste unit.

During 1993, alkalinity was elevated in one of the new wells. Carbon tetrachloride was consistently elevated in one well, and tetrachloroethylene and trichloroethylene consistently were elevated in two. These results are quite similar to those of 1988 through 1991. Volatile organics were not scheduled for analysis in 1992.

Neither gross alpha, above DWS in two wells during 1993, nor strontium-90, elevated in one, had been detected above standards in previous years.

K-Area Burning/Rubble Pit

The K-Area burning/rubble pit is northeast of K-Area (figure 10-8, page 161). During 1993, lead and tetrachloroethylene were detected above DWS in two wells, and trichloroethylene was elevated in one well. These results are similar to those of recent years.

L-Area Burning/Rubble Pit

At this location northwest of L-Area (figure 10-8, page 161), lead was elevated in two wells during 1993, as it has been in at least one well in recent years.

N-Area Burning/Rubble Pits

These pits are north of N-Area, formerly Central Shops (figure 10-12, page 165). During 1993, the only constituent above standard was lead above DWS in one well, as it had been in 1991 and 1992.

N-Area Burning/Rubble Pit South

This pit is southeast of N-Area (figure 10-12, page 165). During 1993, as in 1992, no constituents were detected above standards.

P-Area Burning/Rubble Pit

During 1993, lead, tetrachloroethylene, and trichloroethylene were above DWS in one well at this pit, west of P-Area (figure 10-9, page 162). The other wells had no constituents above standards. In past years, two wells have contained lead and/or chlorinated volatile organics above standards.

R-Area Burning/Rubble Pits

These pits are southeast of R-Area, southeast of Road G (figure 10-10, page 163). During 1993, lead was elevated in one well, as it had been in 1991. Specific conductance was elevated in three wells for the first time.

Coal Pile Runoff Containment Basins and Ash Basins

Electricity and steam at SRS are generated by burning coal. Coal piles originally existed in the following

areas: A, C, D, F, H, K, L, P, and R. The facilities generally contained a 90-day reserve of coal that was not rotated. During long-term exposure to the environment, chemical and biological oxidation of sulfur compounds in coal resulted in the formation of sulfuric acid.

The coal pile in R-Area was removed in 1964, and the L-Area coal pile was removed in 1968. To achieve compliance with the National Pollutant Discharge Elimination System permit issued in 1977, coal pile runoff containment basins in A-Area and D-Area were completed in October 1978, and basins in C-Area, F-Area, H-Area, K-Area, and P-Area were completed in March 1981. The coal piles in C-Area and F-Area were removed in 1985. In 1991, the K-Area coal pile was reduced to a 2-inch base, and 75 percent of the P-Area coal pile was removed.

Rainwater runoff from the remaining coal piles in A-Area, D-Area, H-Area, K-Area, and P-Area flows into the coal pile runoff containment basins via gravity flow ditches and sewers. The basins allow mixing of the runoff and its seepage into the subsurface, thus preventing the entry of large surges of low pH runoff into surface streams. The basins in C-Area and F-Area also still collect runoff, although no coal remains at either location. All these basins are RCRA/CERCLA units.

Ash sluice water from the D-Area and K-Area powerhouses has been discharged to the D-Area ash basins and the K-Area ash basin, respectively, since 1951. These, like other ash basins and ash piles, are site evaluation units under the FFA.

A-Area Coal Pile Runoff Containment Basin

This basin is east of Road D southeast of A-Area (figure 10-11, page 164). During 1993, as in the past, two wells monitoring this basin had elevated specific conductance and levels of gross alpha and alpha-emitting radium that exceeded DWS. This is consistent with results since 1988. As in the past, one well had a single analysis above DWS for nonvolatile beta. During 1993, TDS was elevated in one well. In past years, chlorinated volatile organics were detected above DWS.

C-Area Coal Pile Runoff Containment Basin

This basin is southeast of C-Area (figure 10-12, page 165). During 1993, as in past years, no chemical or radioactive constituents exceeded DWS at this site.

D-Area Coal Pile Runoff Containment Basin and Ash Basins

The containment basin is south of D-Area; the ash basins are southwest of the D-Area perimeter fence (figure 10-13, page 166).

During 1993, arsenic was above DWS for the first time since 1990 in two wells monitoring these basins. Results generally were similar to those of recent years. Analytes above DWS include chlorinated volatile organics, tritium, sulfate, alpha-emitting radium, nonvolatile beta, gross alpha, and metals, including lead in one well and nickel in eight wells. Alkalinity was elevated in two wells, TDS in 12 wells, and specific conductance in several wells, and pH exceeded the acidic standard in six wells.

F-Area Coal Pile Runoff Containment Basin

This basin is southeast of F-Area (figure 10-7, page 160). During 1993, as in the past, lead and alpha-emitting radium exceeded DWS in one well each, and specific conductance was elevated in one well. In 1992, tetrachloroethylene had exceeded DWS in one well, which was dry the only time it was scheduled for volatile organics during 1993.

H-Area Coal Pile Runoff Containment Basin

This basin is east of H-Area (figure 10-7, page 160). Consistent with past results, single analyses of gross alpha and alpha-emitting radium were above DWS in one well; two wells had pH lower than 4; and specific conductance was elevated in three wells and TDS in two. As in past years, tritium exceeded DWS in all wells.

During 1993, antimony, beryllium, nickel, and trichloroethylene exceeded DWS in one well each at this site for the first time in recent years. From 1988 through 1992, lead was found primarily in an upgradient well; however, lead was above DWS in only one downgradient well during 1993.

K-Area Ash Basin

This basin is southwest of K-Area (figure 10-8, page 161). During 1993, alpha-emitting radium was above DWS in three wells monitoring this basin. These results are similar to those of past years. A single analysis of gross alpha was above DWS, and results for lead were above DWS in three wells. As in recent years, alkalinity, TDS, and specific conductance were elevated in one well. Specific conductance also was elevated in a second well.

K-Area Coal Pile Runoff Containment Basin

This basin is west of K-Area (figure 10-8, page 161), between the K-Area ash basin and reactor seepage basin.

One well had elevated alpha-emitting radium, specific conductance, TDS, and low pH. A single analysis of lead was above the DWS in a different well. Tritium, gross alpha, and sulfate were not elevated, although they have been in past years.

P-Area Coal Pile Runoff Containment Basin

This basin is southeast of the coal pile and south of P-Area (figure 10-9, page 162). During 1993, results were similar to those obtained since 1988: lead was above DWS in one well monitoring this basin; two wells exceeded the acidic standard for pH; all wells had elevated specific conductance; and TDS and sulfate were elevated in one well.

R-Area Coal Pile

Two wells were installed inside the boundaries of the former coal storage area, west of the R-Area reactor building (figure 10-10, page 163), for groundwater assessment in relation to the R-Area reactor seepage basins. One was first sampled during second quarter 1992. The other has never been sampled because of hardware problems. During 1993, lead exceeded DWS at this site, and specific conductance was elevated, as in 1992.

Disassembly Basins

The disassembly basins are concrete-lined tanks that contain water and are adjacent to reactors at SRS, inside the reactor buildings. Irradiated assemblies (reactor fuel and target rods) were rinsed and stored in the basins prior to their shipment to the separations areas. Some radioactivity was transferred to the basin water as a liquid or oxide corrosion film on the irradiated components and from leaks in porous components.

Sand filters were used to remove radioactive particulates from the disassembly basin water. The filtered water was circulated through deionizers to remove additional constituents and was periodically purged through regenerated deionizers to the reactor seepage basins. The disassembly basins then were filled with clean water.

The disassembly basins are on the FFA site evaluation list.

C-Area Disassembly Basin

Both wells at the C-Area disassembly basin (figure 10-12, page 165) have contained tritium above the DWS since 1988. Lead generally also has been above standard in both wells. Conductivity was elevated in one well in 1991 and 1993.

K-Area Disassembly Basin

Lead and tritium were detected above DWS in all three wells at the K-Area disassembly basin (figure 10-8, page 161), and total alpha-emitting radium was elevated in one well. Specific conductance, tetrachloroethylene, and trichloroethylene were detected above standards in two wells in 1993. Results have been similar in other years since 1988.

L-Area Disassembly Basin

During 1993, lead was slightly above DWS in both wells at the L-Area disassembly basin (figure 10-8, page 161), and tetrachloroethylene was slightly above DWS in one well. Specific conductance was elevated in both of the wells. These results are similar to those of past years.

P-Area Disassembly Basin

Tritium and lead were above DWS and specific conductance was elevated at the P-Area disassembly basin (figure 10-9, page 162). These results are similar to those of past years.

R-Area Disassembly Basin

Specific conductance has been elevated in all three wells at the R-Area disassembly basin (figure 10-10, page 163) since they were installed early in 1990. Lead was above DWS in two wells in 1993, as it was in 1992. Alkalinity and TDS were elevated in one well.

Seepage and Retention Basins

Seepage, retention, and settling basins have been used at SRS to store or dispose of wastewater from various operations. Since 1957, active reactor seepage basins have received low-level radioactive purge water from the disassembly basins. Although many radionuclides have been discharged to the basins, almost all of the radioactivity is due to tritium and small amounts of strontium-90, cesium-137, and cobalt-60.

Purge water was pumped directly from the disassembly basins to the seepage basins until the 1960s, when the use of mixed-bed deionizers and sand filters to reduce the radioactivity began. From 1970 to 1978, the seepage basins for active reactors were bypassed, and the filtered, deionized purge water was discharged directly into nearby streams. In 1978, the seepage basins for reactors in C-Area, L-Area, and P-Area were reactivated. The K-Area reactor seepage basin was used from 1957 to 1960 only. The R-Area reactor seepage basins have been filled and covered with asphalt. The K-Area and R-Area reactor seepage basins are RCRA/CERCLA units.

The three C-Area reactor seepage basins were active, periodically receiving purge water, until the C-Area

reactor was shut down in 1985. The L-Area reactor seepage basin was used from 1958 until 1969 and from 1985 until the reactor was shut down in 1988. The P-Area reactor was shut down in 1988 for maintenance and safety improvements and has not been restarted. The C, L, and P basins are on the FFA site evaluation list.

The K-Area retention basin was used for disposal of purge water from the K-Area disassembly basin from 1965 until 1988, when the reactor was shut down for maintenance and safety upgrades and never restarted.

C-Area Reactor Seepage Basins

These basins are about 650 feet west of the reactor building (figure 10-12, page 165). One well monitoring the basins was not sampled because high levels of trichloroethylene would require containerization of its purged water. During 1993, as in recent years, tritium was above DWS in the groundwater near the basin by as much as three orders of magnitude. Lead was above DWS in two wells all three quarters. Trichloroethylene was elevated in two wells but less consistently. Specific conductance was above standard in one well all three quarters. These results are similar to those of past years, except that lead contamination has increased from one well to two.

F-Area Seepage Basins and Inactive Process Sewer Line

Beginning in 1955, the F-Area seepage basins received wastewater from F-Area containing low-level radioactivity and chemicals, including chromium, mercury, nitric acid, and sodium hydroxide. The basins operated under RCRA interim status from 1980 until they were taken out of service in the fourth quarter of 1988. SCDHEC accepted the RCRA closure certification for these basins on April 26, 1991. The F-Area seepage basins are a RCRA/CERCLA unit southwest of Road C (figure 10-7, page 160). The sewer line goes from northwest of the F-Area canyon building to northeast of the F-Area seepage basins.

The portion of the sewer lines within the fenced limited-access area is regulated under CERCLA, while the portion from the fence to the seepage basins is governed by RCRA. The RCRA portion of the lines has been characterized extensively, both for soils and groundwater contamination. A draft Screening Baseline Risk Assessment based on closure options was being prepared during 1993. An expedited investigation of the CERCLA portion of the lines was authorized by the regulators to characterize soils, and results were provided to the regulators in August 1992. An RFI/RI work plan was submitted in February 1992 to propose a more complete characterization.

During 1993, as in the past, the contaminant plume in the vicinity of the F-Area seepage basins was characterized by low pH, high nitrate-nitrite concentrations, and elevated specific conductance. TDS also was above its standard in many wells. Only two wells were high in alkalinity. In addition, cadmium, lead, mercury and nickel were detected above DWS in several wells monitoring the upper saturated zone. Thallium was detected just above DWS in two wells. The only organic constituents detected above DWS were carbon tetrachloride and tetrachloroethylene in one well each and trichloroethylene in four wells.

Radionuclide contamination is widespread in the upper saturated zone near the basins. Almost all the wells contain tritium above DWS. Approximately two-thirds of such wells exhibit nonvolatile beta above DWS by as much as two orders of magnitude. Gross alpha was elevated nearly as frequently. Many more isotopes were analyzed for during 1993 than have been in the past. Specific radionuclides elevated above standards include alpha-emitting radium, iodine-129, and technetium-99 in nearly two-thirds of the wells; radium-228, strontium-89, and strontium-90 in approximately half the wells; americium-241, radium-226, uranium-233/234, and uranium-238 in approximately one-third of the wells; and cesium-137, curium-243/244, curium-245/246, plutonium-238, thorium-234, and uranium-235 in smaller numbers of wells.

Tritium was above DWS in all but one of the sewer line wells, including the wells close to the canyon building and associated facilities. Other radionuclide contamination along the sewer line is limited to the wells closer to the tank farm and seepage basins. Gross alpha, nonvolatile beta, and alpha-emitting radium were above DWS in three or four wells each. Potassium-40 was detected barely above standard in one well during one quarter.

Contamination in this area in the Congaree-Fourmile zone is less extensive than in the upper saturated zone. Tritium activity exceeded the DWS in half the seepage basin wells monitoring the Congaree-Fourmile zone; in addition, nitrate-nitrite, thallium, nonvolatile beta, strontium-89, strontium-90, and technetium-99 exceeded the DWS in at least one well each. Elevated specific conductance, found in most of the wells monitoring the Congaree-Fourmile zone, may result from the natural occurrence of soluble calcium carbonate minerals in the Congaree and associated formations. Elevated pH and alkalinity in a few wells indicate that leaching of well grout may be affecting the water quality in these wells.

One well in the Cretaceous zone was analyzed during one quarter of 1993; none of the constituents analyzed was above DWS.

Ford Building Seepage Basin

The Ford Building seepage basin, in the southeast portion of N-Area (figure 10-12, page 165), received low-level radioactive wastewater from Ford Building operations (repairing heat exchangers) from 1964 to January 1984. The basin is a RCRA/CERCLA unit.

In 1993, lead was detected above DWS in one well and tritium was above DWS in two wells monitoring this basin. Specific conductance was elevated in one well. These results are similar to those of 1991 and 1992.

H-Area Retention Basins

A small, unlined earthen retention basin (the old H-Area retention basin) was used from 1955 to 1973 to provide temporary emergency storage for cooling water from the chemical separations process that contained radionuclides and possibly trace quantities of chemicals. That basin is open but inactive and is a CERCLA unit. Preliminary screening of remedial technologies has been performed, and a Phase I RI work plan for preliminary characterization was approved in October 1993. Soil samples were obtained at the old H-Area retention basin in November 1993.

A larger, rubber-lined retention basin replaced the original basin in 1973 and is still in use for receipt of diverted cooling water or tank farm stormwater runoff. Both basins are southeast of the intersection of Road 4 and Road E (figure 10-7, page 160).

In 1993, lead was found above DWS in one well monitoring these basins. Tritium exceeded DWS in four wells. These results are similar to those of the past. Also in 1993, strontium-90 was above DWS in a single analysis of one well at this site.

H-Area Seepage Basins and Inactive Process Sewer Line

Starting in 1955, the H-Area seepage basins received wastewater from H-Area containing low-level radioactivity and chemicals, including nitric acid, mercury, and sodium hydroxide. Basin 3 has been inactive since 1962. Basins 1, 2, and 4 operated under RCRA interim status from 1980 until they were taken out of service in the fourth quarter of 1988. SCDHEC accepted the RCRA closure certification for these basins November 30, 1991.

The basins are southwest of H-Area, southwest of the intersection of Road E and Road 4 (figure 10-7, page 160), and the sewer line extends from west of the

H-Area fence to northeast of the H-Area seepage basins. See "F-Area Seepage Basins and Inactive Process Sewer Line" (page 136) above for more information on the sewer lines.

During 1993, as in the past, the contaminant plume in the vicinity of the H-Area seepage basins was characterized by high nitrate-nitrite concentrations and elevated specific conductance. TDS was above standard in a few wells, and alkalinity in one well. Copper, lead, and mercury were detected above DWS in a few wells monitoring the upper saturated zone. The pH was above DWS in some wells and below in others. In addition, arsenic and cadmium appeared above DWS in one well each. The only organic constituents detected above DWS were tetrachloroethylene in five wells and trichloroethylene in one.

Radionuclide contamination is widespread in the upper saturated zone near the basins. Around three-quarters of the wells contained tritium above DWS. Approximately one-third of such wells exhibited nonvolatile beta above DWS, by as much as two orders of magnitude, while gross alpha was above its standard in about one-fourth. Many more isotopes were analyzed for during 1993 than have been in the past. Specific radionuclides elevated above standards include technetium-99 in approximately half the wells, strontium-90 and iodine-129 in approximately one-third, and strontium-89 in about one-fourth. Alpha-emitting radium and radium-226 were detected above DWS in a few wells, and radium-228, strontium-89/90, and thorium-234 were above their standards in one well each. Cobalt-60 was detected, just above DWS but very consistently, in six wells, while uranium-233/234 and uranium-238 were above their standards in one well the only time it was sampled.

Tritium was above DWS in all the sewer line wells. Other radionuclide contamination along the sewer line appears to be distributed all along the line. Nonvolatile beta and strontium-90 were above DWS in the same two wells. Iodine-129 and technetium-99 were above standards in one well. Lead in two wells and nitrate-nitrite in one well were the only chemical constituents exceeding DWS at this site. Specific conductance was elevated in three sewer line wells.

Contamination in the Congaree-Fourmile zone is less extensive than in the upper saturated zone. Tritium activity exceeded the DWS in four of the 19 seepage basin wells monitoring the Congaree-Fourmile zone; in addition, nitrate-nitrite, nonvolatile beta, radium-228, strontium-90, and technetium-99 exceeded the DWS in at least one well each. All additional radiological contamination was in three of the four wells found to contain tritium. All four are downgradient of the basins; two are not far south of the old burial ground.

TDS was above standard in a few Congaree-Fourmile wells. Elevated specific conductance, found in all the wells monitoring this zone during all three quarters, may result from the natural occurrence of soluble calcium carbonate minerals in the Congaree and associated formations. Elevated pH and alkalinity in a few wells indicate that leaching of well grout may be affecting the water quality in these wells. One well in the Cretaceous zone was analyzed during 1993; lead was above DWS and pH was below the acidic standard.

K-Area Reactor Seepage Basin

This basin is west of K-Area (figure 10-8, page 161). In 1993, tritium exceeded DWS in all wells monitoring this basin. In one well, tritium was consistently three orders of magnitude above the DWS. Lead and tetrachloroethylene exceeded DWS in one well each, and trichloroethylene exceeded its DWS in two wells.

K-Area Retention Basin

This basin is northwest of K-Area (figure 10-8, page 161). During 1993, lead was detected above DWS in two of four wells monitoring the groundwater beneath this basin, and tritium was consistently detected in all four, as it has been since these wells first were sampled during fourth quarter 1991.

L-Area Reactor Seepage Basin

This basin is southeast of L-Area, adjacent to the L-Area oil and chemical basin (figure 10-8, page 161). During 1993, as in the past, tritium activity exceeded DWS in all but one of the wells monitoring groundwater near this basin. Lead concentrations, which had been elevated in at least one well in past years, were not detected above DWS in 1993.

M-Area Settling Basin

The M-Area hazardous waste management facility, a RCRA-regulated unit south of A-Area and M-Area and west of Road D (figure 10-11, page 164), consists of the M-Area settling basin and Lost Lake. The unlined basin, in operation from 1958 until 1985, received wastewater containing metal-cleaning solvents, depleted uranium, and other chemicals and metals from fuel fabrication processes in M-Area. Surface water flowed from this basin; therefore, it was classified as a settling basin rather than a seepage basin. Water from the settling basin flowed through an overflow ditch to Lost Lake, a shallow upland depression. A seepage area formed adjacent to the ditch and Lost Lake. Closure under RCRA was certified by SCDHEC April 26, 1991.

No constituents were detected above DWS in the background wells during 1993; one well had high TDS

values. As in past years, chlorinated volatile organics were the primary constituents above DWS among the point-of-compliance wells. Trichloroethylene and tetrachloroethylene were detected above DWS in nearly all the wells. In five wells consistently and another well once, 1,1-dichloroethylene was above its standard. There was one apparently anomalous detection of 1,1,1-trichloroethane above standard.

Dense nonaqueous phase liquid contamination first was detected in 1991 at one of the point-of-compliance wells at the M-Area hazardous waste management facility. During 1993, for the first time, PCB contamination in the same well was detected and confirmed in multiple samplings. Detection above DWS of several metals (antimony, barium, cadmium, and thallium in one well each) was sporadic during 1993, but lead was above its standard consistently in four wells.

Alkalinity was above standard in several wells, as were nitrate-nitrite, high pH, and specific conductance. Nonvolatile beta in three wells was the only radioactive parameter above standard.

Since the beginning of the full-scale recovery system for groundwater remediation in April 1985, groundwater flow has changed markedly near this facility, and changes over time in concentrations of analytes are difficult to interpret.

Metallurgical Laboratory Seepage Basin

The Metallurgical Laboratory seepage basin, at the east edge of A-Area (figure 10-11, page 164), received wastewater effluent from the Metallurgical Laboratory Building from 1956 until 1985. Wastewater released to the basin consisted of small quantities (5 to 10 gallons per day) of laboratory wastes, mostly rinse water, from metallographic sample preparation (degreasing, cleaning, etching) and corrosion testing of stainless steel and nickel-based alloys. Noncontact cooling water (approximately 900 gallons per day) also was discharged.

Revision V of the RCRA closure plan for the hazardous waste management facility, comprising the seepage basin, the process sewer line leading to it, and the adjacent Carolina bay, was approved by SCDHEC in late 1991. The basin was dewatered, backfilled, and capped with low-permeable clay. The basin closure construction was completed in May 1992 and certified by SCDHEC in July 1992.

About one-fourth of the wells at this basin had levels of chlorinated volatile organics above their DWS in 1993. Lead and alpha-emitting radium exceeded DWS in two wells. These results were consistent with those of previous years. Two wells showed elevated levels of

alkalinity and TDS, as well as high specific conductance and pH, which may be the effect of ground contamination.

New TNX Seepage Basin

The new TNX seepage basin, in the east section of the TNX facility across River Road from the TNX process area (figure 10-13, page 166), replaced the old TNX seepage basin and operated from 1980 to 1988. This basin is a RCRA-regulated unit. A waste site assessment report and a groundwater quality assessment/corrective action feasibility plan have been submitted to SCDHEC for review. A closure plan was submitted in March 1992. During 1993, as in the past, specific conductance and TDS were elevated in one or two wells. For the second year, no radioactive or chemical constituents were detected above DWS.

Old F-Area Seepage Basin

The old F-Area seepage basin, the first seepage basin constructed in F-Area, was used for disposal of wastewater from the canyon building from November 1954 until mid-May 1955, when it was abandoned. The basin is north of the F-Area perimeter security fence (figure 10-7, page 160). During operation, the seepage basin received a variety of wastewaters, including evaporator overheads, laundry wastewater, and an unknown amount of chemicals. For three months in 1969, spent nitric acid solutions used to etch depleted uranium were discharged to the basin. In 1984, low-level contaminated water was released to the basin.

An RFI/RI work plan was submitted to EPA and SCDHEC in February 1993, and characterization was initiated during 1993.

Groundwater monitoring results in 1993 were consistent with those of previous years at this site. Gross alpha and nonvolatile beta were above DWS in two wells. Strontium-89/90, strontium-90, and radium-228 also exceeded their DWS in two wells. Iodine-129, uranium, uranium-233/234, and uranium-238 were above their DWS in one well. Alpha-emitting radium and tritium exceeded DWS in three wells monitoring this basin. Nitrate-nitrite as nitrogen and trichloroethylene were the only chemical constituents exceeding DWS, in one and two wells, respectively. Specific conductance was elevated in two wells and pH was low in one well.

Old TNX Seepage Basin

The old TNX seepage basin, in the southwest corner of the TNX facility (figure 10-13, page 166), received waste from pilot-scale tests conducted at TNX from

1958 to 1980. In 1981, the basin wall was breached and the impounded water was drained into the adjacent wetlands. The basin then was backfilled with a sand and clay mixture and the top capped with clay. This basin is a RCRA/CERCLA unit.

During 1993, as in the past, trichloroethylene and nitrate or nitrate-nitrite as nitrogen were reported above DWS in several wells. Carbon tetrachloride exceeded its DWS in two wells; lead was above its standard in one. Specific conductance was elevated in several wells, while alkalinity and TDS were elevated in one. For the first time in several years, no radioactive constituents were above standards.

P-Area Reactor Seepage Basins

These basins are southwest of the reactor building (figure 10-9, page 162). In 1993, as in the past, tritium activity exceeded the DWS in all wells monitoring these basins, and lead exceeded standard in several wells.

R-Area Reactor Seepage Basins

On November 8, 1957, an experimental fuel element failed during a calorimeter test in the emergency section of the R-Area disassembly basin. Following this incident, the original seepage basin received approximately 2,700 Ci of nonvolatile beta activity, including strontium-90 and cesium-137, each of which has a half-life of about 30 years. Much of the released radioactivity was contained in that basin, which was backfilled in December 1957. Five more basins were placed in operation in 1957 and 1958 to assist in containing the radioactivity.

In 1960, basins 2 through 5 were closed and backfilled. The ground surface above basins 1 through 5 was treated with herbicide and covered with asphalt. In addition, a kaolinite cap and dike was constructed over and around basin 1 and the northwest end of basin 3 to minimize lateral movement of the radioactive contamination. Basin 6, which received water directly from the disassembly basin from 1960 until 1964, was backfilled in 1977. The basins are just outside the perimeter fence northwest of R-Area (figure 10-10, page 163).

The number of wells at these basins that had elevated constituents was increased in 1993. Alpha-emitting radium was found above its DWS in 34 wells, lead in 33 wells, and cadmium in 30 wells. Nonvolatile beta exceeded DWS in 25 wells and gross alpha exceeded DWS in 22 wells. Mercury was above its DWS in 10 wells; strontium-90, in eight wells; and tritium, in six wells. Nitrate-nitrite as nitrogen exceeded DWS in two wells for the first time in several years. Specific

conductance was elevated in 10 wells, and pH was high in one well.

Savannah River Laboratory Seepage Basins

Located across the road from the Savannah River Technology Center (SRTC), formerly the Savannah River Laboratory (SRL), the SRL basins (figure 10-11, page 164) received low-level radioactive laboratory wastewater through underground drains until they were taken out of service in October 1982. Two basins were placed in operation in 1954. Two more were added in 1958 and 1960, respectively, to provide additional holding capacity.

An exception to the practice of discharging only low-level alpha or beta-gamma wastewater was made in 1971, when 0.68 Ci of curium from a leaking separator pit in the SRL radioactive waste tanks was disposed of in the basins. Approximately 34 million gallons of wastewater were discharged to the basins during their operating life. A closure plan revision was submitted to SCDHEC for review in December 1993. The closure will consist of placement of a RCRA-style cap over the basin. This is a RCRA/CERCLA unit.

In 1993, chlorinated volatile organics and tritium were detected above DWS in several wells at this site. Specific conductance and pH were elevated in some wells. Alpha-emitting radium was very slightly above its standard in two wells during one quarter. These results are similar to those of previous years.

Operating Buildings and Facilities

F-Area Canyon Building and A-Line Uranium Recovery Facility

At the canyon building (figure 10-7, page 160), irradiated products from the reactors are dissolved using nitric acid, and the desired radionuclides are separated from fission products. At the A-Line uranium recovery facility, uranium oxide is produced from uranyl nitrate.

In 1993, the majority of the groundwater monitoring results were similar to those of previous years. Chlorinated volatile organics and nitrate-nitrite as nitrogen were found above DWS in several wells, as were gross alpha, alpha-emitting radium, nonvolatile beta, and tritium. Strontium-89, strontium-89/90, and strontium-90 were above DWS in one well at this site, with activities up to 1,000 times the standards. Specific conductance was elevated in numerous wells, and alkalinity and TDS were elevated in two wells each. Low pH was found in one well.

Results for lead, mercury, and high pH were inconsistent with those of previous years. Lead exceeded DWS in many more wells than in the past. Mercury was found above DWS in one well, and high pH was found in one well—the first time these analytes exceeded standards in at least the past five years.

F-Area Effluent Treatment Cooling Water Basin

The F-Area and H-Area effluent treatment cooling water basins, southwest of their respective areas (figure 10-7, page 160), receive diverted cooling water from the separations processes. The water is sent to the F-Area and H-Area Effluent Treatment Facility (ETF) if contaminated or to a permitted outfall if uncontaminated. The ETF, on the south side of H-Area, was placed in service in 1988 to treat wastewater formerly sent to the F-Area and H-Area seepage basins.

In 1993, no radioactive or chemical constituents were detected above the DWS. Specific conductance was slightly elevated in one well.

H-Area Auxiliary Pump Pit

The H-Area auxiliary pump pit facility will pump high-level radioactive sludge and precipitate from the H-Area tank farm to the S-Area low-point pump pit. When the pumps are shut down, this facility, at the east end of H-Area (figure 10-7, page 160), will collect the solution in a temporary holding tank via gravity flow lines.

As in past years, specific conductance was elevated in one well in this area. There also was a single instance of strontium-90 detected above standard in the same well. No other radioactive or chemical constituents were detected above the DWS in 1993.

H-Area Canyon Building

As in F-Area, materials from the reactors are dissolved at the canyon building, and the desired radionuclides are separated from waste products.

In 1993, tritium exceeded DWS in all wells monitoring this site. Lead exceeded DWS in two wells, and gross alpha and nonvolatile beta were detected above DWS in one well. Three chlorinated volatile organics were detected above DWS in one well at this site. Specific conductance was elevated in three wells. These results are similar to those of previous years.

H-Area Effluent Treatment Cooling Water Basin

See "F-Area Effluent Treatment Cooling Water Basin." As in recent years, all four wells in the H-Area effluent

treatment cooling water basin had levels of tritium activity above the DWS. In one well, there was also a single instance of strontium-90 above the DWS.

K-Area Tritium Sump

A single well, installed in 1992, monitors the water table near the K-Area process water storage tank, just west of the K-Area reactor building (figure 10-8, page 161). The tank stores water collected in sumps within the K-Area reactor building. Tritium activity in this sump water ranges from barely detectable to greater than 5 Ci/mL.

In 1993, tritium activity was above the DWS, as it was in 1992, the first time that the K-Area tritium sump was monitored. Total alpha-emitting radium and specific conductance were above standards in a single analysis.

N-Area Hazardous Waste Storage Facility

Building 645-N of the hazardous waste storage facility has been in service since 1983, 645-2N since 1987, and 645-4N since 1984. Buildings 645-N and 645-4N contain hazardous waste, and building 645-2N contains mixed wastes (a mixture of low-level radioactive waste and hazardous waste). Wastes are stored inside the buildings in drums placed on diked concrete floors designed to contain liquid spills. This facility, an active RCRA-regulated unit, is northwest of N-Area (figure 10-12, page 165). In 1993, as in 1992, no radioactive or chemical constituents were detected above standards in the groundwater below these buildings.

S-Area Defense Waste Processing Facility

The Defense Waste Processing Facility (DWPF), in S-Area (figure 10-7, page 160), will process high-level radioactive waste from the tank farms at F-Area and H-Area into an inert glass form solidified within stainless steel canisters. The glass will be stored temporarily within S-Area; eventual permanent storage will be in an off-site federal geologic repository.

Groundwater monitoring results for 1993 at this site are consistent with those of previous years. Lead was detected above DWS in a single analysis from one well. Tetrachloroethylene and trichloroethylene were above DWS in one well. Tritium exceeded DWS in two wells.

S-Area Low-Point Pump Pit

The S-Area low-point pump pit, at the south end of S-Area (figure 10-7, page 160), will receive high-level

radioactive sludge and precipitate from the H-Area tank farm and pump it to the DWPF vitrification building; it also will receive waste being recycled from the vitrification building back to the tank farm. As at the H-Area auxiliary pump pit, when the pumps are shut down, the sludge and precipitate remaining in the line will drain back into a temporary holding tank via gravity flow lines.

No radiological or chemical constituents have been detected above DWS at this site since 1989.

S-Area Vitrification Building

The S-Area vitrification building, also known as the S-Area canyon building, will contain the process and auxiliary equipment to incorporate high-level radioactive waste into leach-resistant glass.

Lead and tritium were the only chemical and radiological constituents exceeding DWS in groundwater at this site. Specific conductance was elevated in four wells, alkalinity was elevated in two wells, and pH and TDS were elevated in one well each. These results are similar to those of previous years, except that lead has not been above DWS at this site in the past five years.

Z-Area Low-Point Drain Tank

The Z-Area low-point drain tank facility (in southeastern S-Area, figure 10-7, page 160) receives low-level radioactive salt solution from the H-Area tank farm and pumps it to the Z-Area salt solution holding tank. When the H-Area pump is shut down, the low-point drain tank can collect the solution remaining in the lines via gravity flow.

Tritium was the only chemical or radiological constituent detected above DWS in wells monitoring this facility in 1993. Specific conductance, an indicator parameter, was elevated in one well at this site. These results are similar to those of recent years.

Z-Area Saltstone Facility

The Saltstone Facility (figure 10-7, page 160), in Z-Area, processes and permanently disposes of low-level radioactive salt solution supernatant from the underground storage tanks at F-Area and H-Area and from ETF concentrate. Z-Area began radioactive operations in June 1990.

In 1993, nitrate-nitrite as nitrogen was detected above DWS in a single analysis of groundwater from this site. No other chemical or radiological constituent exceeded DWS in wells monitoring this facility.

Plume Monitoring

A-Area and M-Area

In addition to the groundwater monitoring conducted at specific locations in A-Area and M-Area (figure 10-11, page 164), numerous plume definition wells also monitor a 5-square-mile area to assess the extent of volatile organic contamination. The first plume definition wells were installed soon after discovery of the contamination in June 1981.

A groundwater remediation program has been under way for more than 10 years. Following successful demonstration of a prototype stripper in 1983 and 1984, a full-scale recovery system consisting of 11 recovery wells and a 400-gallon-per-minute air stripper began decontaminating the plume in April 1985. That stripper has operated at approximately 450 to 500 gallons per minute since April 1990. The prototype stripper, with one recovery well, has been used since 1992 to remove solvents from groundwater near SRTC; it operates at approximately 55 gallons per minute. Through September 1993, approximately 300,000 pounds of volatile organics had been removed from nearly 1.75 billion gallons of groundwater.

The plume definition well network extends from the region north of SRTC, between Road 1 and the SRS boundary, south to wells near the miscellaneous chemical basin and the metals burning pit, and from Tims Branch in the east toward the Silverton Road waste site in the west. The plume encompasses approximately 3 square miles.

In 1991, SCDHEC requested that all purged water containing more than 500 parts per billion of total volatile organic compounds be treated prior to its release to the environment. To comply with this request, the purged water from wells in the A-Area and M-Area is pumped into a water truck and transported to the air stripper for processing. A 10,000-gallon, double-walled storage tank, scheduled to become operational by January 1, 1994, has been constructed to provide a permanent solution to the handling, transporting, and disposal of purged water from A-Area and M-Area.

The groundwater plume beneath A-Area and M-Area was characterized during 1993, as in the past, by chlorinated solvent concentrations at or above DWS—primarily trichloroethylene and, to a lesser extent, tetrachloroethylene and other chlorinated solvents.

The highest concentrations of chlorinated solvents were detected in many upper saturated zone and Congaree-Fourmile zone wells in the vicinity of known

point sources in A-Area and M-Area. From 1990 through 1993, trichloroethylene was reported above DWS in wells approximately 2,000 feet from the nearest SRS boundary. Solvent concentrations above DWS in the Lower Congaree-Fourmile and Ellenton Sand zones are nearly as widespread as in the upper saturated and Congaree-Fourmile zones. During 1993, trichloroethylene also was detected above DWS in two wells in the Black Creek Unit.

In addition to chlorinated solvents, several metals, nitrate-nitrite, and radionuclides—including alpha-emitting radium, gross alpha, nonvolatile beta, uranium, uranium-233/234, and uranium-238—exceeded DWS in plume definition wells. Two wells had low pH values; two others had exceptionally high levels of sulfate in one sampling. Elevated levels of alkalinity, pH, TDS, and specific conductance were detected in some of the wells, indicating the possible influence of well grout.

The distribution of trichloroethylene in the groundwater generally is linked to proximity to point sources and to hydraulic gradients. Low horizontal gradients in the upper saturated zone and downward vertical gradients from the water table to the Cretaceous zone have resulted in the downward transport of trichloroethylene into lower zones. Horizontal flow in the Congaree-Fourmile zone to the south and southwest has resulted in the transport of trichloroethylene into regions in this zone downgradient of surface point sources.

Separations and Waste Management Areas

A number of wells were installed in the separations areas (figure 10-7, page 160) in 1951 and 1952. These wells, which range from approximately 15 to 90 feet deep, measure water-table elevations and monitor for radioactive constituents (gross alpha, nonvolatile beta, and tritium) in the groundwater in and around F-Area and H-Area.

These wells were monitored for chemical constituents for the first time in 1993. Lead and cadmium exceeded DWS in almost all the wells monitoring this plume. Mercury and tritium were found above DWS in four and five wells, respectively, throughout the separations area. Gross alpha and alpha-emitting radium exceeded DWS in one well during 1993. Specific conductance was elevated in seven wells, and alkalinity was elevated in one. These wells have steel casings that could affect the metal concentrations in the water.

TNX

Because operations in this area have caused a contaminant plume, primarily of volatile organics, TNX groundwater (figure 10-13, page 166) is a

RCRA/CERCLA unit. An Interim Action Proposed Plan for the TNX groundwater operable unit was being prepared during 1993 for submittal to EPA. The plan proposes the evaluation through treatability and feasibility studies of the most effective and efficient method to remediate the groundwater contamination.

During 1993, as in the past, a background well for this area had no constituents above DWS. One centrally located well had levels exceeding the DWS of gross alpha, carbon tetrachloride, nitrate-nitrite as nitrogen, TDS, tetrachloroethylene, and total alpha-emitting radium. Concentrations of trichloroethylene that exceeded the DWS were found in that well, in three wells in or near the swamp downgradient of the TNX burying ground, and, during only one quarter, in two of three samples from a well northeast of all facilities in the TNX. Elevated levels of specific conductance were found in several wells.

Many of the constituents found above DWS only in the centrally located well in 1993 had been found in downgradient wells from 1990 through 1992. Radium-228, which had been detected above standard in several wells in or near the swamp during 1992, was not analyzed during 1993; however, nonvolatile beta was below standards in all wells during 1993.

Radioactive Waste Storage and Disposal Facilities

The burial grounds located in E-Area between F-Area and H-Area in the center of SRS (figure 10-7, page 160) have been used for storage and disposal of radioactive solid waste produced at SRS or shipped from other facilities since 1952. The original area, known as the old burial ground, contains low-level alpha beta-gamma trenches, intermediate level beta-gamma trenches, and alpha waste trenches. As the trenches were filled, they were covered with soil. When the old burial ground was filled in 1974, operations shifted to the adjacent Radioactive Waste Burial Grounds—now the SWDF.

Until 1965, transuranic wastes were placed in plastic bags and cardboard boxes and buried in earthen trenches. Between 1965 and 1974, lower level transuranic wastes were buried unencapsulated in trenches, and higher level transuranic wastes were buried in retrievable concrete containers or encapsulated in concrete. Since 1974, transuranic wastes contaminated with greater than 1.0×10^{-2} $\mu\text{Ci/g}$ have been stored in containers on concrete pads with monitoring sumps. Transuranic waste storage pads 1-17 are on the FFA list of RCRA-regulated units.

Since mid-1984, newly generated low-level beta-gamma waste has been placed in metal boxes or metal drums. Currently, it is disposed of in engineered trenches and covered with at least 4 feet of soil. Some wastes that do not have forms conducive to containerization are disposed of in shallow land-burial slit trenches.

Mixed wastes disposed of at, or stored within, the old burial ground and portions of the newer grounds include lead, cadmium, mercury, and tritiated pump oil. Some of the waste is contained in welded stainless steel containers or metal drums and stored within concrete cylinders. Degraded radioactive organic solvents and tritiated pump oil have been stored in 22 underground storage tanks in the old burial ground. In addition, two areas of the old burial ground were used for incineration of solvents.

The burial grounds complex, comprising the old burial ground, solvent storage tanks S01-S22, and the portions of the SWDF not otherwise regulated, is a RCRA/CERCLA unit. An RFI/RI work plan was submitted in March 1992, and seismic, soil gas, and ground-penetrating radar surveys were conducted in 1993. Groundwater monitoring results for this unit are presented geographically; see "Old Burial Ground" and "Mixed Waste Management Facility/Low-Level Radioactive Waste Disposal Facility."

Solvent storage tanks S23-S30 are RCRA-regulated units. The tritiated pump oil from mixed waste storage tank S32 has been removed and incinerated in the beta-gamma incinerator; closure of that tank under RCRA by grouting was certified by SCDHEC in September 1988.

The newer burial ground within the SWDF contains two regulated sections. Closure under RCRA of the Mixed Waste Management Facility (MWMF), where disposal of mixed wastes was halted in 1986, was certified by SCDHEC in April 1991.

The remainder of the SWDF is known as the Low-Level Radioactive Waste Disposal Facility (LLRWDF). Generally, since March 1986, only radioactive wastes certified as free of hazardous materials have been accepted for disposal in the burial ground. However, mixed wastes in the form of rags and wipes used for radioactive decontamination and containing RCRA-listed solvents were disposed of until January 1990 in portions of the LLRWDF. A closure and post-closure plan for the so-called solvent rags portion, 10 discrete areas comprising a total of about 21 noncontiguous acres, was submitted to SCDHEC in August 1993. Other sections of the LLRWDF being operated contain trenches for only radioactive waste.

Mixed waste storage building 643-29E, within the boundaries of the LLRWDF, has been in use since March 1987; mixed waste storage building 643-43E is tentatively scheduled to begin receiving waste during 1994. Both these buildings also are RCRA-regulated units.

The Consolidated Incineration Facility (CIF) has been proposed to incinerate much of the SRS inventory of combustible hazardous, mixed, and low-level radioactive waste. An Environmental Impact Statement will determine what is to be burned.

Liquid radioactive wastes are handled at the tank farms, which are comprised of subsurface tanks containing aqueous radioactive wastes in the form of sludges, supernatant liquid of varying salt concentrations, and salt cake. The solutions volume is reduced in the tank farm evaporators and eventually will be processed at the DWPF into cement (low-level waste) or a glass form (high-level waste).

The F-Area tank farm, in the southwest portion of F-Area (figure 10-7, page 160), is comprised of 22 subsurface tanks. In 1961, tank 8 was overfilled, causing soil and possible groundwater contamination.

The H-Area tank farm, at the south end of H-Area (figure 10-7, page 160), is comprised of 29 subsurface tanks. In 1960, tank 16 leaked an undetermined number of gallons of waste into the soil. The tank's remaining waste was removed by 1972. Revision 2 of a RCRA/CERCLA work plan for tank 16 was submitted to EPA and SCDHEC in November 1992. Characterization activities began in August 1993 and will continue in 1994. A spill also occurred at tank 13 in 1983.

Wells at the tank farms are bailed without purging because of purged-water disposal limitations.

Old Burial Ground

As in previous years, most wells monitoring the upper saturated zone at the old burial ground had tritium activities at or above the DWS. The highest tritium activity, up to four orders of magnitude above the DWS, was recorded in samples from wells within the facility's boundaries. Gross alpha, alpha-emitting radium, nonvolatile beta, and metals also were above DWS in groundwater below the old burial ground.

Elevated concentrations of chlorinated organic solvents (chiefly trichloroethylene) were reported for several wells in the upper saturated zone, generally in the southwest corner of the old burial ground. One well was not sampled during 1993 because previous

trichloroethylene values were high enough that purged water would require special disposal procedures.

Several wells within both the upper saturated zone and the Congaree-Fourmile zone showed elevated levels of alkalinity, pH, specific conductance, and TDS. Three wells were not sampled during 1993 because previous pH values were high enough that purged water would require special disposal procedures. One well within the upper saturated zone had low pH values.

Mixed Waste Management Facility/ Low-Level Radioactive Waste Disposal Facility

Because the MWMF is geographically within the LLRWDF, a single network of wells monitors both facilities, and results are not separated.

Tritium activities exceeded DWS by as much as three orders of magnitude in most upper saturated zone wells. Alpha-emitting radium and gross alpha activities above DWS also were found in at least one upper saturated zone well.

Concentrations of chlorinated organic solvents (chiefly trichloroethylene) were detected above DWS in several wells. Lead concentrations above DWS also were found in a few wells within the upper saturated zone. Two very high results for sulfate were reported for one well during one sampling event. Elevated pH and specific conductance were detected in several wells, while elevated alkalinity was detected in two and low pH in one.

Several upper saturated zone wells classified as site characterization wells, located north and east of these burial grounds, showed tritium activities and lead concentrations above DWS. These older, steel-cased wells also exhibited high specific conductance. One had low pH.

Alpha-emitting radium and nonvolatile beta activities were detected above DWS in one well, and trichloroethylene in another, within the Congaree-Fourmile zone. Specific conductance was elevated in all of the Congaree-Fourmile zone wells, and alkalinity, pH, and TDS were above standards in several.

Solid Waste Disposal Facility Expansion (E-Area Vaults)

Concrete vaults for disposal of solid radioactive waste are being constructed east and north of the SWDF.

During 1993, one well at this site could not be sampled because purged water from the well requires special disposal procedures because of previously high levels

of pH. Tritium was above DWS in about half the other wells monitoring this area, including both upgradient and downgradient wells. Lead, pH below the acidic standard, radium-228, and trichloroethylene were detected in one or two wells each.

During 1993, as in 1992, tritium was detected in one of the wells monitoring the Congaree-Fourmile zone. Lead was detected at its standard during one quarter in one of the Congaree wells. These results are similar to those obtained since the wells were installed in 1991, except that alpha-emitting radium, gross alpha, and nonvolatile beta had been detected above DWS during 1991 and 1992.

Elevated alkalinity and specific conductance in two wells in the upper saturated zone, along with high pH and TDS in one of them, suggest the influence of well grout, as does elevated alkalinity and specific conductance in both Congaree wells, and high pH and TDS in one.

E-Area Hazardous Waste/Mixed Waste Disposal Facility

Wells were installed in 1991 to provide background data for a proposed hazardous waste/mixed waste disposal facility north of the SWDF (figure 10-7, page 160) and to assess quality of groundwater flowing from the MWMF toward Upper Three Runs Creek.

In 1993, lead exceeded DWS in one well monitoring this site. Tritium was detected above DWS in a single analysis. Specific conductance was also elevated in one well. These analytes were found above standards at this site in 1992.

F-Area Tank Farm

During 1993, cadmium was detected above DWS, and alpha-emitting radium and specific conductance were elevated in most of the wells at the F-Area tank farm. Gross alpha was above standard in several wells, as was lead. Nonvolatile beta was elevated in only four of 26 wells tested, two of them very close to tank 8. Mercury, nitrate-nitrite, chromium, and tritium were found above DWS in one or two wells. A few wells exhibited high pH and TDS.

The number of wells containing nonvolatile beta above its screening level has decreased in recent years, from 13 in 1988 to nine in 1991 and six in 1992. The numbers of wells having other radioactive constituents above standards in 1993 are similar to those of recent years, but gross alpha and nonvolatile beta maximum results are an order of magnitude lower than in 1989.

The heavy metals have not been analyzed for in recent years in these wells. Four of the wells have steel casings; the others have PVC (polyvinyl chloride) casings. High specific conductance and pH values indicate probable grout contamination of some of these wells.

H-Area Tank Farm

Cadmium, lead, tritium, and alpha-emitting radium were elevated in approximately half the H-Area tank farm wells during 1993. Lead was present at up to 100 times its standard, while tritium was detected at no more than 10 times its DWS. Gross alpha was above its DWS in seven of the 32 wells during the year. Other constituents appeared above DWS in one to three wells each: carbon tetrachloride (in only one well in one of three sampling events), 1,1-dichloroethylene, nickel, thallium, trichloroethylene, cesium-137, nonvolatile beta, strontium-90, and uranium-233/234. Specific conductance was elevated above its standard in several wells.

These results are similar to those of past years, except that mercury and nitrate generally have been above DWS in several wells. Some of the wells have steel casings, which may be contributing to the metal concentrations detected in the groundwater; the other wells have PVC casings.

Sanitary Landfill

The sanitary landfill, southwest of Road C (figure 10-14, page 167), began receiving waste from office, cafeteria, and industrial activities during 1974. Materials such as paper, plastics, rubber, wood, cardboard, rags, metal debris, pesticide bags, empty cans, animal carcasses, asbestos in bags, and sludge from the site's wastewater treatment plant are placed in unlined trenches and covered daily with soil or a fabric substitute. The original section of the landfill and its southern expansion have been filled. The active portion is known as the northern expansion, or the interim sanitary landfill. The landfill contains about 54 acres of waste.

The landfill operates under a revision of a domestic waste permit issued in 1992 and scheduled to expire in July 1994. As required by a settlement agreement between DOE and SCDHEC, SRS has applied for closure under RCRA of the original landfill and its southern expansion. These areas of the landfill received solvent-laden rags and wipes used for cleaning and decontamination in addition to the previously identified wastes. The RCRA Closure Permit Application was submitted to SCDHEC in March 1993.

During 1993, one well monitoring this site could not be sampled because purged water from it requires special

disposal procedures because of previously high levels of chloroethene (vinyl chloride). As in the past, tritium activities and concentrations of chlorinated volatile organics and benzene exceeded the DWS in numerous wells in and around the landfill. Elevated alkalinity, specific conductance, TDS, and low pH also were found in many of these wells. Total alpha-emitting radium was above standard in two wells, and a single analysis of gross alpha was detected in one well.

Chloroethene was detected above the DWS in eight wells. Two wells contained elevated levels of mercury. One well contained levels of lindane above standard. Antimony, which had been elevated in numerous wells in 1992, was not tested for in 1993. Lead and cadmium, which had been above DWS in a few wells in the past, were not elevated in 1993. All elevated constituents were detected in the main section of the landfill and the south expansion. No elevated constituents were discovered in the north expansion.

Sludge Application Sites

These sites originally were the subject of a research program using domestic sewage sludge to reclaim borrow pits and to enhance forest productivity at SRS. In 1980, as permitted by SCDHEC, sludge was applied to the following application sites: the K-Area site, Kato Road site, Lower Kato Road site, Orangeburg site, Par Pond site, Road F site, Sandy (Lucy) site, Second Par Pond borrow pit site, and the 40-acre hardwood site. After sludge was applied to the sites, hardwoods and pines were planted to quantify the wood biomass that could be produced using the sludge as a fertilizer and soil conditioner.

As permitted by SCDHEC IWP-175, sludge from Aiken, South Carolina, and Augusta, Georgia, municipal wastewater treatment plants was applied to the F-Area site, H-Area site, Kato Road site, Lower Kato Road site, Orangeburg site, Road F site, Sandy (Lucy) site, Second Par Pond Borrow Pit site, and 40-acre hardwood site, all of which are on the FFA site evaluation list. All sludge application permits have expired; revegetating of the sites is continuing.

In November 1993, SCDHEC approved the discontinuation of groundwater monitoring at all of these sites except the F-Area, H-Area, K-Area, and Par Pond sites because the sites have not received applications of sewage sludge since 1981 and because historical monitoring results show no impact from sludge applications.

F-Area Sanitary Sludge Land Application Site

The F-Area sanitary sludge land application site covers 8 acres southeast of F-Area (figure 10-7, page 160). Sludge from SRS sanitary wastewater treatment plants was disposed of at this location from 1987 until third quarter 1990. A closure plan was approved in November 1993 for this site. Groundwater monitoring will continue because of the proximity of the wells to the old burial ground.

In 1993, as in previous years, lead and tritium were above DWS in two wells at this site. Specific conductance also was elevated in two wells. These results are similar to those of previous years.

H-Area Sanitary Sludge Land Application Site

Sewage sludge from SRS sanitary wastewater treatment plants was disposed of at this 13-acre site southeast of H-Area (figure 10-7, page 160) from November 1990 to May 1992. A closure plan was approved in November 1993 for this site.

In 1993, lead was the only analyte exceeding DWS at this site. It was elevated in only one well, as it had been since 1989.

K-Area Sludge Land Application Site (Formerly the K-Area Borrow Pit)

In 1988, the N-Area sanitary sewage sludge lagoon was closed, and the lagoon sludge was applied to the K-Area and Par Pond borrow pits. In 1989, this location, covering 17 acres southeast of K-Area (figure 10-8, page 161), was declared a RCRA/CERCLA unit because of the presence of chlordane in the lagoon sludge applied to the site. Previously, sludge from Aiken and Augusta municipal wastewater treatment plants had been applied to this site under SCDHEC permit IWP-175.

In 1993, as in 1992 and 1991, lead in one well was the only analyte detected above DWS at this site.

Kato Road Sewage Sludge Application Site

This site is in the western portion of SRS (figure 10-14, page 167). Barium and chromium were detected above DWS in one well each in 1993. These metals had not been detected above DWS at this site in at least the past five years. Gross alpha and nonvolatile beta were above DWS in two wells, and radium-226 was above DWS in one well.

Lower Kato Road Sewage Sludge Application Site

This site is adjacent to the Kato Road sewage sludge application site (figure 10-14, page 167).

Barium and chromium were detected above DWS for the first time at this site during 1993, as at the Kato Road sewage sludge application site. Lead was detected above DWS in two wells at this site. Gross alpha and nonvolatile beta were detected above DWS in all three wells at this site. The number of wells exhibiting contamination has been increasing in recent years.

Orangeburg Sewage Sludge Application Site

This site is in the western portion of SRS, west of the Sanitary Landfill (figure 10-14, page 167).

Chromium, lead, and mercury exceeded DWS in two wells monitoring this site in 1993. The third well could not be sampled for constituents having DWS because it was dry or nearly dry. Gross alpha and nonvolatile beta also were above DWS in the other two wells. None of these constituents had been above DWS in recent years.

Par Pond Sludge Land Application Site (Formerly the Par Pond Borrow Pit Site)

In 1988, the N-Area sanitary sewage sludge lagoon was closed, and the lagoon sludge was applied to the K-Area and Par Pond borrow pits. Previously, sludge from Aiken and Augusta municipal wastewater treatment plants had been applied to this site under SCDHEC permit IWP-175. In 1989, this site, covering 22 acres south of Par Pond (figure 10-9, page 162), became a RCRA/CERCLA unit because of the presence of chlordane in the lagoon sludge applied to the site. Chlordane never has been detected in the groundwater below this site.

In 1993, chromium exceeded DWS in one well and lead exceeded DWS in two wells at this site. Gross alpha and nonvolatile beta were above DWS in one well. These results are somewhat different from those of previous years.

Road F Sewage Sludge Application Site

This site is in the northern portion of SRS (figure 10-6, page 159). Chromium was the only chemical constituent to exceed DWS at this site in 1993. It was above DWS in one well. Gross alpha and nonvolatile beta

exceeded DWS in all three wells monitoring this site. Until 1993, no chemical or radiological constituents had exceeded DWS at this site since 1988, except for alpha-emitting radium in a single well in 1990.

Sandy (Lucy) Sewage Sludge Application Site

This site is in the northwestern portion of SRS (figure 10-11, page 164). Several metals were detected above DWS at this site for the first time in 1993: barium, cadmium, lead, and mercury. Gross alpha exceeded DWS in three wells, as did nonvolatile beta in two. TDS were detected above standard in a single analysis of one well, while pH was below standard and specific conductance above standard in two other wells monitoring this site.

Second Par Pond Borrow Pit Sewage Sludge Application Site

This site is in the eastern portion of SRS, on the eastern edge of Par Pond (figure 10-6, page 159). In 1993, lead was detected above DWS in two wells monitoring this site, the first time a chemical constituent has exceeded DWS at this site in the past five years. Gross alpha was detected above DWS in all three wells. In most recent years, one of the wells contained gross alpha and alpha-emitting radium above standards.

40-Acre Hardwood Sewage Sludge Application Site

This site is in the southwestern portion of SRS, south of the Road A chemical basin (figure 10-13, page 166). Gross alpha and nonvolatile beta were detected above DWS in wells at this site in 1993, as they were in 1992. Lead and TDS were elevated in one well in a single analysis for the first time in the past five years.

Other Sites

B-Area Gas Station

Elevated benzene, which could be the result of old underground gas or diesel storage tanks, has been detected near B-Area. EMS has inspected the area and believes there may be two underground storage tanks southeast of B-Area (figure 10-14, page 167). The first suspected tank appears to be at an abandoned gas station between Kato Road and Road C-2. The second appears to be an old diesel tank in front of a storage and laboratory facility.

Groundwater at this site was not analyzed for benzene in 1993. No chemical or radiological constituents exceeded DWS at this site.

Chemicals, Metals, and Pesticides Pits

The chemicals, metals, and pesticides pits were used from 1971 through 1979 to dispose of drummed oil, organic solvents, and small amounts of pesticides and metals. In 1984, the pits, which are west of Road C (figures 8 and 12), were excavated to form two trenches, backfilled, and capped. During excavation, most of the contaminated material (liquid in original drums, free liquid drummed during excavation, and contaminated soil) was removed to the hazardous waste storage facility. This facility is a RCRA/CERCLA unit.

Lead, trichloroethylene, and tetrachloroethylene were detected above DWS in several wells monitoring this site in 1993. Specific conductance and pH also were elevated in numerous wells, probably because of the presence of naturally occurring carbonate rock. These results are similar to those of previous years.

D-Area Oil Disposal Basin

The D-Area oil disposal basin was constructed in 1952 and received waste oil products from D-Area that were unacceptable for incineration in the powerhouse boilers. These waste oils may have contained hydrogen sulfide, chlorinated organics, or other chemicals. In 1975, the oil basin was removed from service and backfilled with soil. The basin is a RCRA/CERCLA unit also known as the D-Area oil seepage basin. Located north of D-Area (figure 10-13, page 166), it is monitored in accordance with the RFI/RI work plan. An Interim Action Proposed Plan was submitted to EPA and SCDHEC in November 1993 to remove drums within the basin. Pending regulatory approval, the interim action will be completed in 1994.

In 1993, two chlorinated volatile organics were detected above DWS in one well monitoring this site. Specific conductance also was elevated in one well. These results are similar to those obtained since 1988.

K-Area Diesel Tank Spill

Following the discovery of a leaking buried diesel supply line, most of the diesel-contaminated soil was removed from this area, in the center of K-Area and north of the K-Area disassembly basin (figure 10-8, page 161), except where continued excavation would have jeopardized the structural integrity of an underground storage tank. Because some of the diesel-contaminated soil was left in place, SCDHEC required the installation of a monitoring well.

As in the past, tritium was the only constituent above DWS in 1993.

L-Area Acid/Caustic Basin and L-Area Oil and Chemical Basin

From 1961 to 1979, the L-Area oil and chemical basin received small quantities of radioactive oil and chemical waste that could not be discharged to effluent streams, regular seepage basins, or the separations areas' waste management systems. The waste came from throughout SRS, primarily from the reactor areas and the contaminated-equipment workshop through a pipeline known to have leaked. The basin, a radiologically controlled area south to southeast of the L-Area fence (figure 10-8, page 161), has been inactive since 1979.

Groundwater below the acid/caustic basin has been affected by its proximity to the oil and chemical basin. The two areas were combined as one operable RCRA/CERCLA unit in the RFI/RI Phase II Work Plan for the L-Area oil and chemical basin.

In 1993, as in the past, lead, tetrachloroethylene, and tritium were above the DWS in several wells in this area. Alkalinity, specific conductance, pH, and/or TDS were above standards in some of the wells, as in previous years, suggesting the influence of well grout.

Miscellaneous Chemical Basin

The miscellaneous chemical basin, in operation by 1956, was closed and graded in 1974. There are no records of the materials disposed of at this location, west of Road D near the A-Area metals burning pit (figure 10-11, page 164). However, soil gas investigations revealed volatile organics in the near-surface soils at the basin. It is assumed that the site was used to dispose of waste solvents and possibly waste oil. The basin is inactive and, with the A-Area metals burning pit, is a RCRA/CERCLA unit.

Three chlorinated volatile organics were detected in several wells monitoring this site in 1993. Alkalinity, pH, specific conductance, and TDS were elevated in two wells at the site, probably because of grout contamination of the wells. These results are similar to those obtained since 1988. However, certain constituents that were below standards in 1993 had been elevated in prior years: nonvolatile beta, alpha-emitting radium, and lead.

Motor Shop Oil Basin

This unlined basin was placed in service in 1977 to receive liquid effluent from the Motor Shop, including trace quantities of engine oil, grease, kerosene, ethylene glycol, and soap. All waste passed through an oil skimmer prior to discharge into the basin. In August 1983, all discharges to the basin were terminated. This basin is inactive but collects rainwater during periods of heavy precipitation.

The basin is at the south edge of A-Area (figure 10-11, page 164), near National Pollutant Discharge Elimination System Outfall A-014, a source of volatile organics. It is a RCRA/CERCLA unit.

Two chlorinated volatile organics were detected above DWS in groundwater at this site in 1993. These results are similar to those of previous years.

N-Area Diesel Spill

Leaking tanks are buried at the diesel fuel storage facility southeast of the hazardous waste storage facility and northwest of the fire department training facility in N-Area (figure 10-12, page 165). A program is under way for characterization and remediation of diesel contamination.

During 1993, as in recent years, results for benzene were above DWS in one well of this series, and chlorinated volatile organics were above DWS in several wells. As in 1992, lead also was above DWS in one well. Specific conductance was elevated in two wells, and pH exceeded the alkaline standard in one; this is similar to results obtained since the wells first were sampled in 1990.

N-Area Fire Department Training Facility

The fire department training facility, also known as the N-Area burnable oil basin, is a shallow pit surrounded by an 18-inch-high asphalt dike used from 1979 to 1982 by the SRS Fire Department to train personnel in the use of firefighting equipment. After this time, the area was excavated and backfilled. The facility, at the southeast end of N-Area near the Ford Building seepage basin (figure 10-12, page 165), is on the FFA site evaluation list.

Alpha-emitting radium was the only chemical or radiological constituent exceeding DWS at this site. No constituents have exceeded DWS in wells monitoring this facility since 1989, except for tritium in a single well in 1990.

N-Area Hydrofluoric Acid Spill

It is uncertain whether a spill occurred at the N-Area hydrofluoric acid spill area or if contaminated soil or containers were buried there. The spill or burial occurred prior to 1970, and an identification sign is the only evidence that material was released. This location, at the south end of N-Area near Road 3 (figure 10-12, page 165), is a RCRA/CERCLA unit.

During 1993, 2,3,7,8-tetrachlorodibenzodioxin was reported above DWS in one of three replicate analyses

from one of the wells at this site. No other radiological or chemical constituents had results above DWS.

Road A (Baxley Road) Chemical Basin

The Road A chemical basin is reported to have received miscellaneous radioactive and chemical aqueous waste, but no records of the materials disposed of at the basin are available. The basin was closed and backfilled in 1973. Located east of D-Area (figure 10-13, page 166), it is a RCRA/CERCLA unit.

In 1993, lead was the only constituent detected above DWS in wells at this basin; it consistently exceeded DWS in two wells.

Silverton Road Waste Site

The Silverton Road waste site, near the intersection of Cook and Silverton roads (figure 10-11, page 164), was used for disposal of metal shavings, construction debris, tires, drums, tanks, and miscellaneous other items. The startup date is unknown, and no records of waste disposal activities were kept. Operations at this location ceased in 1974, and the waste material is covered with soil and vegetation. It is a RCRA/CERCLA unit.

Soil and groundwater RFI/RI assessments at this waste site were begun in 1993 and will continue into 1994. Reports will be submitted to EPA and SCDHEC during 1995. Nine new wells added in the course of the investigation are included in table 10-2. However, analytical results from these wells were not available for this report.

Five chlorinated volatile organics and lead were detected above DWS in several wells monitoring this site in 1993. Also, copper and thallium were detected above DWS in one well each. No radiological constituents exceeded DWS, and specific conductance in one well was the only indicator parameter exceeding standard in 1993. These results are similar to those of previous years.

TNX Burying Ground

The TNX burying ground was created to dispose of debris from an experimental evaporator that exploded at TNX in 1953. The buried material included contaminated conduit, tin, drums, structural steel, and depleted uranium. Although most of this material was excavated and sent to the Radioactive Waste Burial Grounds (now the SWDF) between 1980 and 1984, an estimated 27 kg of uranyl nitrate remains buried at the TNX location. The TNX burying ground, located within the TNX operating fence (figure 10-13, page 166), is a RCRA/CERCLA unit.

In 1993, three wells at this site could not be monitored. Purged water from these three wells requires special disposal procedures because of previously high levels of trichloroethylene. Three chlorinated volatile organics, nitrate as nitrogen, and nitrate-nitrite as nitrogen exceeded DWS in the other wells at this site. Gross alpha and alpha-emitting radium slightly exceeded

their standards in one or two wells; analyses for specific radionuclides were not scheduled in 1993. Specific conductance and TDS also were detected above standards in groundwater from wells at this burial ground. These results are similar to those of previous years.

Table 10-2 Aquifer and Gradient Assignments of Wells

Page 1 of 4

Location	Upper Saturated Zone Wells				Lower Zone Wells	Fig. No.
	Up	Down	Side	Una ^a		
Acid/Caustic Basins						
F-Area (FAC)	2	1	3			10-7
H-Area (HAC)	1	2	1			10-7
K-Area (KAC)	2	3	4			10-8
L-Area (see L-Area Oil and Chemical Basin)	-	-	-	-	-	10-8
P-Area (PAC)	2	4				10-9
R-Area (RAC)	1	2	1			10-10
Burning/Rubble and Metals Burning Pits						
A-Area Burning/Rubble Pits and Ash Pile (ARP)	1	1	2			10-11
A-Area Metals Burning Pit (ABP)	2	6	2		2	10-11
Burma Road Rubble Pit (BRR)	1	4				10-7
C-Area Burning/Rubble Pit (CRP)	2	1	1			10-12
D-Area Burning/Rubble Pits (DBP)	2	1	1			10-13
F-Area Burning/Rubble Pits (FBP)	2	2		6		10-7
K-Area Burning/Rubble Pit (KRP)	1	1	2			10-8
L-Area Burning/Rubble Pit (LRP)	1	2	1			10-8
N-Area Burning/Rubble Pits (CSR)	2	1	1			10-12
N-Area South of Ford Building Seepage Basin Burning/Rubble Pit (CBR)				3		10-12
P-Area Burning/Rubble Pit (PRP)	1	2	1			10-9
R-Area Burning/Rubble Pits (RRP)	1	2	1			10-10
A-Area Coal Pile Runoff Containment Basin (ACB)	1	1	2			10-11
C-Area Coal Pile Runoff Containment Basin (CCB)	1	2	1			10-12
D-Area Coal Pile Runoff Containment Basin and D-Area Ash Basins (DCB)	8	7				10-13
F-Area Coal Pile Runoff Containment Basin (FCB)	1	3	2			10-7
H-Area Coal Pile Runoff Containment Basin (HCB)	1	2	1			10-7
K-Area Ash Basin (KAB)	2	1	1			10-8
K-Area Coal Pile Runoff Containment Basin (KCB)	1	1	1			10-8
P-Area Coal Pile Runoff Containment Basin (PCB)		2	2			10-8
R-Area Coal Pile (RCP)		1			1	10-10
Disassembly Basins						
C-Area Disassembly Basin (CDB)		2				10-12
K-Area Disassembly Basin (KDB)		1	2			10-8

^a Unassigned

Table 10-2 Aquifer and Gradient Assignments of Wells

Page 2 of 4

Location	Upper Saturated Zone Wells				Lower Zone Wells	Fig. No.
	Up	Down	Side	Una ^a		
L-Area Disassembly Basin (LDB)		2				10-8
P-Area Disassembly Basin (PDB)	1		1			10-9
R-Area Disassembly Basin (RDB)	1	2				10-10
Seepage and Retention Basins						
C-Area Reactor Seepage Basins (CSB)	1	3	2			10-12
F-Area Seepage Basins and Inactive Process Sewer Line (F, FSB, FSL)	6	24	11	10	50	10-7
Ford Building Seepage Basin (HXB)	3	2				10-12
H-Area Retention Basins (HR3, HR8)	1	2	3			10-7
H-Area Seepage Basins and Inactive Process Sewer Line (HSB, HSL)	13	34	11	9	72	10-7
K-Area Reactor Seepage Basin (KSB, K301P)	2	1	2			10-8
K-Area Retention Basin (KRB)	1	3				10-8
L-Area Reactor Seepage Basin (LSB)	1	1	2			10-8
M-Area Settling Basin (MSB POC wells)	5	11	2		30	10-11
Metallurgical Laboratory Seepage Basin (AMB)	2	6	1		9	10-11
New TNX Seepage Basin (YSB)	1	1	2			10-13
Old F-Area Seepage Basin (FNB)	1	1	2			10-7
Old TNX Seepage Basin (XSB)	1	1	2		3	10-13
P-Area Reactor Seepage Basins (PSB)		5	2			10-9
R-Area Reactor Seepage Basins (RSA, RSB, RSC, RSD, RSE, RSF, P20)	34	17	2		4	10-10
Savannah River Laboratory Seepage Basins (ASB)	3	3	2		20	10-11
Operating Buildings and Facilities						
F-Area Canyon Building and A-Line Uranium Recovery Facility (FAL, FCA, NBG)	3	17	3			10-7
F-Area Effluent Treatment Cooling Water Basin (FET)	1	3				10-7
H-Area Auxiliary Pump Pit (HAP)	1	1				10-7
H-Area Canyon Building (HCA)	2	2				10-7
H-Area Effluent Treatment Cooling Water Basin (HET)	1	2	1			10-7
K-Area Tritium Sump (KSM)				1		10-8
N-Area Hazardous Waste Storage Facility (HWS)	1		1			10-12
S-Area Defense Waste Processing Facility (SBG)	4	2				10-7

^a Unassigned

Table 10-2 Aquifer and Gradient Assignments of Wells

Page 3 of 4

Location	Upper Saturated Zone Wells				Lower Zone Wells	Fig. No.
	Up	Down	Side	Una ^a		
S-Area Low-Point Pump Pit (SLP)		1	1			10-7
S-Area Vittrification Building (SCA)	5	2	1	2		10-7
Z-Area Low-Point Drain Tank (ZDT)		1	1			10-7
Z-Area Saltstone Facility (ZBG) and Y-Area (YSC)	2	1		3	3	10-7
Plume Monitoring						
A-Area and M-Area Plume Definition Wells (ABW, AC, MSB)						10-11
Separations (E, F, and H) and Waste Management Areas Plume Monitoring (Z 9, ZW)				10		10-7
TNX (TNX, P26)	5	8	1		1	10-13
Radioactive Waste Storage and Disposal Facilities						
Old Burial Ground (BG, BGO, MGA, MGC, MGE, MGG)		40	1		19	10-7
Mixed Waste Management Facility/Low-Level Radioactive Waste Disposal Facility (BG, BGO, HSB 85)	6	22	16		33	10-7
Burial Ground Expansion (BGX)	5	6	5		2	10-7
E-Area Hazardous Waste/Mixed Waste Disposal Facility (HMD)		4				10-7
F-Area Tank Farm (FTF)	5	19	3			10-7
H-Area Tank Farm (HTF, 241-H, P27 [Tank 16], HC [Tank 16])		32				10-7
Sanitary Landfill (LFW)	4	41	8		4	10-14
Sludge Application Sites						
F-Area Sanitary Sludge Land Application Site (FSS)	1	2	1			10-7
H-Area Sanitary Sludge Land Application Site (HSS)		2	1			10-7
K-Area Sludge Land Application Site (KSS)	1	2				10-8
Kato Road Sewage Sludge Application Site (SSS 19-21)		2	1			10-14
Lower Kato Road Sludge Application Site (SSS 4-6)	1	2				10-14
Orangeburg Sewage Sludge Application Site (SSS 7-9)		2	1			10-14
Par Pond Sludge Land Application Site (PSS, SSS 17)	1	2	1			10-9
Road F Sewage Sludge Application Site (SSS 22-24)	1	2				10-6

^a Unassigned

Table 10-2 Aquifer and Gradient Assignments of Wells

Page 4 of 4

Location	Upper Saturated Zone Wells				Lower Zone Wells	Fig. No.
	Up	Down	Side	Una ^a		
Sandy (Lucy) Sewage Sludge Application Site (SSS 10-12)	1	2				10-11
Second Par Pond Borrow Pit Sewage Sludge Application Site (SSS 25-27)	2	1				10-6
40-Acre Hardwood Sewage Sludge Application Site (SSS 1-3)	1	2				10-13
Other Sites						
B-Area Gas Station (P29)				4	2	10-6
Chemicals, Metals, and Pesticides Pits (CMP)	4	3	1		12	10-8
N-Area Diesel Spill (CSD)				9		10-12
N-Area Fire Department Training Facility (CSO)		2				10-12
N-Area Hydrofluoric Acid Spill (CSA)	1	1	2			10-12
Coal Pile Runoff Containment Basins, Ash Piles and Basins, and Coal Piles						
D-Area Oil Disposal Basin (DOB)				4		10-13
K-Area Diesel Tank Spill (KDT)		1				10-8
L-Area Oil and Chemical Basin (LAC, LAW, LCO)	4	7				10-8
Miscellaneous Chemical Basin (MCB)	3	1	2		3	10-11
Motor Shop Oil Basin (AOB)	1	1	1			10-11
Road A (Baxley Road) Chemical Basin (BRD)	2	3				10-13
Silverton Road Waste Site (SRW)	4	10	3		22	10-11
TNX Burying Ground (TBG)	1	6			1	10-13

^a Unassigned

Figure 10-2 Potentiometric Surface and Horizontal Groundwater Flow Direction of the Congaree-Fourmile Zone at SRS During the First Quarter of 1993

Figure 10-3 Potentiometric Surface and Horizontal Groundwater Flow Directions of the Cretaceous Zone at SRS During the First Quarter of 1993

Figure 10-5 Vertical Gradient Relationship Between the Congaree-Fourmile and Cretaceous Zones at SRS During the First Quarter of 1993

Figure 10-6 Areas and Locations Monitored for Groundwater Quality at SRS

Figure 10-7 Separations and Waste Management Areas

Figure 10-8 K-Area and L-Area and the Chemicals, Metals, and Pesticides Pits

Figure 10-6 P-Area and Par Pond

Figure 10-10 R-Area

Figure 10-11 A-Area and M-Area

Figure 10-12 C-Area and N-Area

Figure 10-13 D-Area and TNX

Figure 10-14 Sanitary Landfill and Sludge Sites

Wells that were monitored during 1983 and are discussed in this report are represented on the figures by this symbol: o

Chapter 11

Quality Assurance

Craig Hetrick, Larry Eldridge, Lynne Geary, Bob Henderson, and M.M. Khalil
Environmental Protection Department

Kathleen Gore
Exploration Resources, Inc.

Introduction

The Environmental Monitoring Section (EMS) of the Environmental Protection Department (EPD) at the Savannah River Site (SRS) maintains a quality assurance/quality control (QA/QC) program to verify the integrity of data generated within the environmental monitoring program and its subcontracted laboratories. Each aspect of the monitoring plan, from sample collection to data reporting, must address quality assurance, quality control, and quality assessment standards defined in the QA/QC program [EMP, 1993]. This chapter defines the guidelines and applicable standards for the environmental monitoring QA/QC program.

Applicable Regulations

U.S. Department of Energy (DOE) Order 5700.6C, "Quality Assurance," sets requirements and guidelines for departmental QA practices. Westinghouse Savannah River Company (WSRC) is developing an implementation plan, scheduled for release in 1994, to address the order. To ensure compliance with regulations and to provide overall quality requirements for site programs, WSRC has developed the *Westinghouse Savannah River Company Quality Assurance Management Plan* (WSRC-RP-92-225). The requirements of WSRC-RP-92-225 are implemented by the *Westinghouse Savannah River Company Quality Assurance Manual* (WSRC 1Q).

The *Environmental Monitoring Section Quality Assurance Plan*, Volume III (WSRC-3Q1-2), part of the EMS WSRC-3Q1 procedure series, was written to apply the QA requirements of WSRC 1Q to the environmental monitoring and surveillance program. The EMS WSRC-3Q1 procedure series includes procedures on sampling, radiochemistry, and water quality that emphasize the quality control requirements for EMS.

The National Emissions Standards for Hazardous Air Pollutants (NESHAP) define specific QA requirements

for monitoring radiological air emissions [EPA, 1989]. The EMS QA program's plan to comply with these requirements is found in WSRC-3Q1-2, Volume I, Attachment 3-1, "NESHAP QA Plan" (WSRC-1M-91-60). The Environmental Monitoring Computer Automation Project (EMCAP), a computer-based sample tracking and data repository system, serves as a NESHAP-required sample tracking system for the EMS laboratory.

To ensure valid and defensible monitoring data, the records and data generated by the monitoring program are maintained according to the requirements of DOE Order 1324.2A, "Records Disposition," and of WSRC 1Q. QA records include sampling and analytical procedure manuals, logbooks, chain-of-custody forms, calibration and training records, analytical notebooks, control charts, validated laboratory data, and environmental reports. These records are maintained and stored per the requirements of WSRC-1M-93-0060, *WSRC Sitewide Records Inventory and Disposition Schedule*.

QA/QC for EMS Laboratories

Data produced by EMS are evaluated to ensure that they are reliable and correct. This includes 1) training for EMS personnel and 2) the continuous assessment of data obtained in the field and laboratory.

Training for Personnel

All EMS personnel are responsible for understanding and complying with all requirements applicable to the activities with which they are involved. Emphasis is placed on regulations that govern the environmental monitoring program. Courses include training on applicable QA procedures, Occupational Safety and Health Administration-mandated training, and General Employee Training.

Training for EMS technicians begins with an eight-week course conducted by Analytical Laboratories, followed by specific training determined by job assignment. EMS work is based on procedures in the 3Q series, as follows:

- Environmental Sampling Procedures, WSRC-3Q1-3
- Environmental Radiochemistry Procedures, WSRC-3Q1-4
- Environmental Water Quality Procedures, WSRC-3Q1-5
- Environmental Counting Room Procedures, WSRC-3Q1-6

Internal QA Program

Each EMS group conducts specific QA checks and conforms to accepted practices as part of its routine work functions.

Collections

As part of the nonradiological monitoring program, EMS routinely conducts a blind-sample program for field measurements of pH and conductivity to assess the quality and reliability of field data measurements.

During 1993, blind pH field measurements were taken for 42 samples, and blind conductivity field measurements were taken for 36 samples. All conductivity measurements differed from the true value by less than 15 percent. Ninety-five percent of the field pH

measurements were within 0.4 pH units of the true value [SRS Data, 1994].

Field measurements for chlorine, dissolved oxygen, and temperature also are performed by EMS personnel. However, because of their changing physical nature, these parameters do not lend themselves to a blind-sample program. Quality control of these analyses relies on instrumentation calibration, per the EMS WSRC-3Q1 procedure series.

Counting and Chemistry Laboratories

Laboratory performance is evaluated through instrument checks, control charts, and data analysis. In the chemistry group, graphical and numerical trending is conducted on technician and method performance, with reports generated for sample results exceeding warning limits. The Counting Laboratory runs source checks and instrument backgrounds and performs calibrations regularly to monitor and characterize instrumentation.

Routine samples prepared and counted in EMS laboratories are subject to a variety of quality control checks to assess and ensure their validity. These checks make up 30 percent of the analytical workload. The Chemistry Laboratory prepares spikes, blanks, duplicates, and blind samples to check the performance of a

routine analysis. Spikes and blanks are used to calculate a recovery efficiency of an analytical method, to adjust for background radiation, and/or to evaluate counting equipment performance.

Blind samples, of which the radionuclide composition is unknown to the technicians preparing or counting the samples, provide a constant check on laboratory proficiency. Whenever possible, blind and spiked samples are prepared from National Institute of Standards and Technology-traceable material or standardized against National Institute of Standards and Technology material. Upon completion of analyses, ratios between the measured and true values are calculated (measured/true), and the results are added to control charts to identify trends. In order to address the high relative error of radioactive measurements at low levels, the difference between measured and true values is evaluated against standard deviation units of the true value. During 1993, blind samples were analyzed for tritium, gross alpha and beta, and gamma-emitting radionuclides. All 1993 blind samples were less than two standard deviations from their true value, thus validating analytical work in the chemistry and counting laboratories.

Data Validation

Results received from the Counting Laboratory are evaluated by EMCAP. Sample parameters, such as air flows, counting aliquots, and decay times, are flagged if values exceed preset limits or vary significantly from previous entries. Also, maximum and minimum radioactive acceptance levels, based on historical results, are calculated daily for all routine environmental samples. Sample results falling outside the acceptance range are submitted for individual review,

which frequently results in analytical reruns, in recounts, or in resampling for verification.

Gamma Radiation Measurements

Hand-held survey meters and thermoluminescent dosimeters (TLDs) are used for measuring environmental gamma radiation. Survey meter performance is verified by response checks prior to each use. Meters are calibrated every six months or after repair.

The quality assurance program for TLDs is described in Chapter 3 of WSRC 5Q2.1, "Radiological Control and Health Physics External Dosimetry Procedures." Specifics of the program include TLD reader calibration every six months, element-specific correction factors, the processing of QA badges of known exposure with field badges, and the establishment of control limits on individual badge performance.

External QA Program

In addition to the internal blind-sample program, the EMS laboratory routinely participates in two interlaboratory comparison programs to track performance accuracy. Under both programs, samples are sent to participating laboratories at intervals throughout the year, and results from the laboratories are compared. These comparisons not only test the accuracy of procedures, but compare SRS with other laboratories nationwide.

DOE's Quality Assurance Program (QAP) tests the quality of environmental data reported to DOE by its contractors. Reference samples for this program—including samples of soil, water, vegetation, and air filters—are prepared by the DOE Environmental Measurements Laboratory and sent to the participating laboratories. Analytical results are reported to the

Statistical Terms Used in this Chapter

coefficient of variation measure of precision calculated as the standard deviation divided by the average of a set of values; usually multiplied by 100 to be expressed as a percentage

mean measurement of central tendency, commonly called the average

mean relative difference (MRD) measure of reproducibility of identical chemical analyses

median middle value of a set of data when the data are ranked in increasing or decreasing order

percent difference measure of accuracy used to compare "known" values with laboratory measurements; represents the absolute difference between the known and measured value divided by the true value; usually multiplied by 100 to be expressed as a percentage

standard deviation indication of the dispersion of a set of results around the average of samples collected

t-test statistical test of significance frequently employed by laboratories to assess the comparability of two sets of data

Environmental Measurements Laboratory within 90 days and compared with the test results of other laboratories. The Environmental Measurements Laboratory evaluates the results and distributes them to the participating laboratories.

The second program is administered by the Quality Assurance Division (QAD) of the U.S. Environmental Protection Agency (EPA) Environmental Monitoring System Laboratory-Las Vegas. This division is responsible for quality control of environmental radiological measurements. EPA provides participating laboratories with water, air, and milk samples that contain a variety of radionuclides that have activity concentrations near environmental background levels. The QAD program enables EMS to document the accuracy of radiological analysis data, to identify instrument and procedural problems, and to compare analysis performance with other participating laboratories.

Control charts are maintained for the QAD and QAP results. Warning limits are set at 2 sigma (two times the expected deviation of the known value) and acceptance limits at 3 sigma. Historical trends alert EMS to a method bias that may be occurring in its laboratories.

The results reported by EMS in the QAD and QAP programs generally fell within 20 percent of the EPA or DOE values [SRS Data, 1994]. All the QAD results were reported within a 2-sigma warning limit except for those from one sample analyzed for strontium-90 in milk, one analyzed for gross beta on air filters, and one analyzed for uranium in water. These three results were

within a 3-sigma acceptance level. EMS results in the QAP program were in consistent agreement with the true values, showing the greatest bias in samples with low activity levels and in difficult matrices for chemical separation. In those analyses with which EMS had difficulties during previous years, such as the determination of strontium in vegetation, performance improved markedly in 1993 with the implementation of changes in procedures and techniques. Both the QAD and QAP programs indicate that EMS results are accurate—according to the standards of intercomparison agencies—and that they compare favorably with those of other environmental laboratories.

QA/QC for Subcontracted Laboratories

Subcontracted laboratories providing analytical services must have a documented QA/QC program and must meet the quality requirements defined in WSRC 1Q. Subcontracted laboratories primarily perform nonradiological analyses. The subcontracted laboratories used during 1993 are listed in table 11-1.

Groundwater

Groundwater analyses at SRS are performed by subcontracted laboratories. During 1993, General Engineering Laboratories and Roy F. Weston, Inc., were the primary subcontractors for nonradiological analyses. Environmental Physics and Clemson Technical Center were the primary subcontractors for radiological analyses. Samples for radiological analyses were sent to Weston, which in turn subcontracted them to TMA/Eberline. Teledyne Isotopes performed

QA Terminology in the Laboratory

quality assurance (QA) planned and systematic actions taken to provide adequate confidence in monitoring and measurement data

quality control (QC) overall system of activities that control and verify the quality of monitoring and measurement data

accuracy degree of agreement between a measurement and an accepted reference or true value

bias systematic (constant) underestimation or overestimation of the true value

precision measure of mutual agreement among individual measurements of the same property

spiked sample sample to which a known amount of some substance has been added

replicate sample repeated but independent determinations on the same sample

split sample portions taken from the same sample and analyzed by different technicians or laboratories

blanks clean samples analyzed to establish a baseline or background value used to adjust or correct results

standard reference materials materials with certain properties certified by the National Institute of Standards and Technology

control chart graphical chart of some measured parameter for a series of samples

Table 11-1
Subcontracted Laboratories for 1993

General Engineering Laboratories	
groundwater	
metals analyses for SRS streams and the Savannah River	
Roy F. Weston, Inc.	
groundwater	
metals analyses for SRS streams and the Savannah River	
Environmental Physics	
groundwater radiological analyses	
Clemson Technical Center	
groundwater radiological analyses	
Teledyne Isotopes	
subcontracted groundwater radiological analyses for Environmental Physics	
TMA/Eberline, Inc.	
subcontracted groundwater radiological analyses for Roy F. Weston, Inc.	
NPDES analyses	
metals analyses for SRS streams and the Savannah River	

certain analyses on samples sent to Environmental Physics.

EMS personnel perform a quarterly evaluation of each subcontracted laboratory to ensure that the laboratories maintain technical competence and follow required QA programs. Each evaluation includes an examination of laboratory performance with regard to sample receipt, instrument calibration, analytical procedures, data verification, data reports, records management, nonconformance and subsequent corrective actions, and preventive maintenance. EMS provides reports of the findings and recommendations to each laboratory and conducts follow-up evaluations as necessary.

During 1993, approximately 5 percent of groundwater samples collected were submitted for analysis to the primary laboratory and to a different laboratory as a QA check. Blind and duplicate samples are analyzed as an intralaboratory QA check; split samples are analyzed as an interlaboratory QA check. A statistical measure, the Mean Relative Difference (MRD), is used

to assess result reproducibility and laboratory performance. Laboratory comparisons were conducted for General Engineering, Weston, Environmental Physics, and Clemson Technical Center.

Trip blanks, representing 5 percent of the samples sent to each laboratory, were submitted to General Engineering and Weston. Equipment blanks were sent to the laboratories with samples to be analyzed for dissolved parameters. Both trip and equipment blanks were used as blind blanks, and the results were used for interlaboratory comparisons.

Certified environmental quality control samples purchased from Environmental Resource Associates were sent to General Engineering and Weston. Each laboratory analyzed for a variety of constituents. The results were evaluated based on the percentage within the acceptable concentration range of the certified values. For the first three quarters of 1993, General Engineering analyzed 296 constituents; 274 (92.6 percent) fell within the acceptance limit. For Weston, 269 of 292 (92.1 percent) constituents analyzed fell within the acceptance limit. Figure 11-1 shows the performance within different analyte groups for both laboratories.

During the first three quarters of 1993, Clemson Technical Center participated in an EPA-conducted water intercomparison study to certify laboratories for specific analyses. EPA sent Clemson Technical Center samples spiked with known concentrations of radionuclides. Results for 28 of 34 (82.4 percent) radionuclides analyzed were within control limits set by EPA.

Full results—including MRD calculations, where appropriate—for all these QA/QC evaluations may be found in the following groundwater reports: *The Savannah River Site's Groundwater Monitoring Program, First Quarter 1993* (ESH-EMS-930096), *The Savannah River Site's Groundwater Monitoring Program, Second Quarter 1993* (ESH-EMS-930097), *The Savannah River Site's Groundwater Monitoring Program, Third Quarter 1993* (ESH-EMS-930098), *The Savannah River Site's Groundwater Monitoring Program, Fourth Quarter 1993* (ESH-EMS-930099).

Nonradiological Liquid Effluents

Nonradiological liquid effluent samples are collected at each permitted SRS outfall according to requirements in the National Pollutant Discharge Elimination System (NPDES) permit issued by the South Carolina Department of Health and Environmental Control (SCDHEC). Effluent samples are analyzed by the D-Area laboratory for fecal coliform; by EMS for temperature, pH, dissolved oxygen, and chlorine; and by a subcontracted laboratory for other constituents,

Figure 11-1 Subcontracted Laboratories' QC Sample Analyses

Subcontracted laboratories for groundwater monitoring analyzed certified QC samples for a variety of constituents in 1993. Both laboratories were well within acceptance limits for total analyses.

such as metals, organics, and oil and grease. In 1993, the primary subcontractor for the NPDES program was TMA/Eberline, Inc.

Interlaboratory Comparison Program

Interlaboratory comparison studies are used to compare the quality of results between laboratories performing the same analyses. During 1993, TMA/Eberline and EMS were involved in interlaboratory comparison studies conducted by EPA.

All subcontracted laboratories analyzing NPDES samples must participate in the EPA Discharge Monitoring Report Quality Assurance assessment program. Under this program, EPA sends performance samples with constituents normally found in industrial

and municipal wastewaters to participating laboratories.

These water samples have known chemical parameters, such as chemical oxygen demand, and contain known concentrations of constituents, such as total suspended solids, oil and grease, and certain trace metals. EPA provides a final comprehensive report to the program participants. The report contains a statistical analysis of all data, as well as documentation of the "true" sample value, with stated "acceptance limits" and "warning limits." Accepted variations from the "true" sample value depend on a variety of factors, including the precision of the analysis and the extent to which the results can be reproduced.

In 1993, TMA/Eberline ran analyses for 24 parameters under the EPA program and received acceptable ratings

on all but one test, a cadmium result that differed by 6 µg/l. EMS analyzed for two parameters, chlorine and pH, under this program. While the chlorine result was acceptable, the pH measurement was less than the lower acceptable limit by 0.02 standard pH units.

Intralaboratory Comparison Program

The intralaboratory program is used to compare performance within a laboratory by analyzing duplicate samples and blind samples throughout the year. TMA/Eberline analyzed 126 duplicate samples for various parameters during 1993. Ninety-one percent of these analyses showed a difference of less than the 20 percent acceptance range. Seven of the exceedances involved either total suspended solids or oil and grease, the analyses of which typically produce highly variable results [SRS Data, 1994].

TMA/Eberline also analyzed 13 blind samples submitted by EMS. None of the analyses differed by more than the acceptance range of 20 percent [SRS Data, 1994].

Stream and River Water Quality

Metals analyses for SRS streams and the Savannah River also are performed by a subcontracted laboratory. The water quality program requires quality

checks of 10 percent of the samples to verify the analytical results. In the first quarter of 1993, split samples were sent for metals analyses to TMA/Eberline, the subcontractor laboratory, and to Weston, the verifying laboratory. Although results for Weston generally were lower than those for TMA/Eberline, a paired analysis of the data concluded that the median of differences was not statistically different from zero at the 95-percent confidence level. In the second quarter, a similar comparison between Weston and General Engineering Laboratories showed near-perfect agreement.

Also checked during the first two quarters of 1993 were laboratory methodology and analysis repeatability between the subcontracted and verifying laboratories. Water from all EMS water quality field locations was composited into one sample, then split into three replicates for the subcontracted laboratory and three for the verifying laboratory. Paired *t*-tests showed that methodology was consistent between TMA/Eberline and Weston in the first quarter and General Engineering and Weston in the second quarter. For both quarters, the average percent coefficient of variation for the analyses of all three laboratories was below 10 percent, an indication that result repeatability was satisfactory.

Chapter 12

Nonroutine Occurrences

Pete Fledderman
Environmental Protection Department

Introduction

The Savannah River Site's (SRS) environmental monitoring program extends beyond monitoring routine radioactive releases to the environment. Also monitored are nonroutine occurrences, which are unplanned releases of radiological or nonradiological material. This chapter covers only releases for which operations requested EMS assistance/confirmatory assessment actions.

If a nonroutine radioactive release is suspected, a special sampling and analysis program is initiated to determine whether a release actually occurred and to evaluate its environmental impact and dose consequences, when applicable.

Samples are collected from the suspected source of the release and from locations along the release's environmental pathway. The samples—which may include air, water (process, stream, or river),

vegetation, and/or soil—then are analyzed as priority samples (figure 12-1).

All radiological results (atmospheric and liquid) from nonroutine releases are incorporated into final dose determinations (see chapter 5, "Radiological Effluent Monitoring," and chapter 7, "Dose"). Therefore, doses are not calculated for every nonroutine release.

Only one nonroutine radioactive release occurred at SRS during 1993.

F-Area Atmospheric Plutonium Release—December 1993

On December 27, 1993, alpha monitors on the 291-F stack indicated elevated levels of activity. An initial investigation by field personnel determined that the resulting alarm was not caused by elevated natural activity, but rather that it likely was the result of a release. Subsequent investigations determined that a

Figure 12-1 Regime for Nonroutine Releases
If a nonroutine release is suspected, SRS follows a specific sampling and analysis regime to determine the kind and amount of material released, then calculates annual dose consequences and environmental impacts.

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transfer of liquid between two underground tanks had, in fact, caused a release.

A one-day filter paper sample, collected December 27 from the plus 195 sampling system monitoring the F-Area 195-foot stack, was sent to the Environmental Monitoring Section (EMS) December 28 for expedited analysis. Plus 195 samples from the F-Area 195-foot stack are collected routinely by operations personnel and sent weekly to EMS. On December 30, a filter paper sample from the isokinetic sampling system monitoring the F-Area 195-foot stack was collected and sent to EMS for expedited analysis. Isokinetic samples from the F-Area 195-foot stack also are collected routinely by operations personnel and sent weekly to EMS. The collection period for the December 30 sample was December 26–30, which included the high alpha activity alarm period.

From the air sample data, EMS determined that there had been an increase in released alpha activity for the December 27–28 period and that the majority of the activity was plutonium-238. Because the isokinetic sampling system is the sample of record for reporting purposes, the release estimate was put at 188 μCi of

plutonium-238 and 24 μCi of plutonium-239 during the December 26–30 time period. These values are well above the 1993 average weekly release values of 2 μCi of plutonium-238 and 14 μCi of plutonium-239 [Hetrick, 1994; SRS Data, 1994]. WSRC emergency response models estimated a hypothetical maximum exposure of $1.9\text{E}-3$ mrem at the site boundary.

EMS also collected special samples from the following routine environmental surveillance locations downwind of the stack (figure 12–2):

- the two air monitoring stations (Darkhorse and Highway 39) located on the site perimeter at the Williston barricade
- the Aiken Airport, Aiken State Park, Springfield, and Lees air monitoring stations—located approximately 25 miles from the site boundary

These perimeter and off-site locations showed levels consistent with weekly average concentrations observed during 1993 [Hetrick, 1994; SRS Data, 1994]. Based on these results, the activity released appears to have been confined to within the SRS boundary. No elevated activity was observed at the site perimeter or off site.

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Figure 12–2 Plume Direction

As shown in the figure, the plume moved northeasterly toward the site perimeter; however, no elevated activity was detected at or beyond the site boundary.

Chapter 13

Special Surveys and Projects

Pete Fledderman and Larry Eldridge
Environmental Protection Department

Robin Davis
Academy of Natural Sciences of Philadelphia

Introduction

In addition to routine sampling and special sampling during nonroutine environmental releases, special radiological and nonradiological surveys are conducted on site and off site by the Savannah River Site (SRS) Environmental Protection Department's Environmental Monitoring Section (EMS) and other groups, including the Savannah River Technology Center (SRTC) and the Academy of Natural Sciences of Philadelphia). Both short- and long-term radiological and nonradiological surveys are used to monitor the effects of SRS effluents on the environment at SRS and in its immediate vicinity.

All results discussed in this chapter are based on available sample analysis results. Because of sampling and/or analytical difficulties, some sample analyses may be missing. Details about the number of samples analyzed and the results of those analyses appear in "SRS Environmental Data for 1993" (WSRC-TR-94-077).

Savannah River Swamp Survey

In the 1960s, a portion of the Savannah River Swamp between Steel Creek Landing and Little Hell Landing was contaminated with approximately 25 Ci of cesium-137 and 1 Ci of cobalt-60 (figure 13-1). The contamination resulted from failed fuel elements that leaked radioactivity into the disassembly basin; occasionally, this water was discharged to Steel Creek. During periods of high river flow, Steel Creek flowed along the lowlands comprising the swamp and entered the Savannah River at Little Hell Landing. Consequently, some radioactivity settled into part of the swamp. The contaminated swamp area extends beyond the SRS boundary to private property known as Creek Plantation. The off-site swamp area is uninhabited and not easily accessible.

Ten sampling trails were established in the swamp in 1974 so that specific locations could be routinely monitored to determine the amount and migration of

radioactivity within the Savannah River Swamp. Fifty-four monitoring locations starting at the river bank and extending to the high ground were established along these trails. These monitoring locations are identified by the distance (in feet) from the river beginning at the river bank (i.e., 0 feet is on the bank; 1,000 feet is inland 1,000 feet from the bank; etc.). This convention will be followed throughout this section.

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Figure 13-1 Swamp Contamination
Radioactivity released from SRS operations contaminated the Savannah River Swamp between Steel Creek and Little Hell Landing during the 1960s.

Comprehensive surveys were conducted annually along the trails between 1974 and 1977 to characterize the contaminated area. The frequency of the comprehensive surveys was reduced to 5-year intervals after 1977 because no significant changes in radiological conditions were measured. The most recent comprehensive survey was conducted in 1989.

Cursory surveys, which consist of gamma radiation measurements and sampling at selected locations, have been conducted annually to provide interim monitoring of the swamp.

The 1993 survey was a cursory survey and followed the program changes implemented in 1990. Exposure rates were measured using micro-R meters at 100-foot intervals along each sampling trail. Thermoluminescent dosimeters (TLDs) were placed at each of the 54 sampling locations to provide an integrated exposure measurement, and samples of soil and vegetation were collected from one location on each trail [SRS Data, 1994]. These 10 sampling locations (which is one of the 54 established historical locations) were

designated in 1990 as the points to be used for comparative purposes during cursory surveys. Each location corresponds to the area on its trail that historically has exhibited the highest activity levels.

Gamma Exposure Rates

A survey using micro-R meters was conducted along each of the sampling trails. Exposure rates at both ground level and 1 meter were measured at 100-foot intervals. The micro-R measurements run from background levels (a nominal 5 to 10 $\mu\text{R/hr}$) to a maximum 50 $\mu\text{R/hr}$, found on trail 5 at 2,000 feet. These micro-R readings were used primarily as a screening tool to provide a gross indication of gamma exposure rates and distribution of areas showing elevated activity, rather than a quantitative measurement of exposure rates; TLDs are used for this purpose.

TLDs were placed at each of the 54 previously established sampling and monitoring locations. The TLDs were retrieved and analyzed after an exposure period of approximately one month.

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Figure 13-2 Savannah River Swamp Sampling Trails

In 1974, ten sampling trails were established in the Savannah River Swamp to conduct surveys of the movement of contamination from SRS operations.

As discussed in detail in chapter 6, "Radiological Environmental Surveillance," the extensive changes made in the TLD program in late 1992 have had a noticeable impact on field monitoring results, primarily in that they have improved the accuracy of ambient gamma exposure measurements. Because of the improvements, the 1993 readings appeared elevated when compared to results from previous years. Not surprisingly, this phenomenon also was observed in the TLD results from the swamp survey.

A result of the improvements is that direct comparisons of 1993 monitoring results with those of previous years are not possible. Because excessive rainfall forced cancellation of the swamp survey in 1992, results from 1991 are the latest available for comparison. Despite these circumstances, results from the 1993 survey were consistent with those from 1991. Locations showing elevated exposure rates during 1991 also showed elevated rates in 1993. Furthermore, the same areas on each trail showed increased exposure rates, indicating little change in the swamp's ambient gamma exposure field.

Because the 1993 survey was a cursory survey, only a limited number of locations—one on each of the 10

sampling trails—were sampled for gamma-emitting radionuclide analysis. A comparison, at all 10 soil sampling locations, of the cesium-137 concentration with the gamma exposure rate indicated no quantifiable relationship between the two.

Gamma-Emitting Radionuclides

Soil plugs (0-to-3-inch) and vegetation were collected from each of the 10 established monitoring locations. These samples were analyzed for gamma-emitting nuclides. The primary isotope detected was cesium-137, with a smaller number of samples having detectable cobalt-60. These results were expected and are consistent with the source term and previous survey results.

Cesium-137 was detected in all ten of the soil samples and nine of the 10 vegetation samples. Cobalt-60 was detected in three of the ten soil samples and none of the vegetation. The maximum cesium-137 level in soil was 105 pCi/g measured at 2,150 feet on trail 1, and the maximum cesium-137 level in vegetation was 38.7 pCi/g measured at 2,530 feet on trail 6. Cobalt-60 was detected at 2,150 feet on trail 1, 1,900 feet on trail 4, and 2,900 feet on trail 8, with a maximum concentration of 0.34 pCi/g on trail 1. Although the

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EMS analysts (from left) place TLDs, collect vegetation samples, and obtain exposure rate measurements during the 1993 cursory survey at the Savannah River Swamp. Surveys are conducted regularly along ten sampling trails established in 1974 in a contaminated area of the swamp between Steel Creek Landing and Little Hell Landing.

maximum cesium-137 and cobalt-60 concentrations were observed at the same location, no correlation was observed between levels of these two nuclides in soil.

The distribution of cesium-137 in the swamp soil from the 1990, 1991, and 1993 surveys indicates some movement of the activity within the swamp. The cesium-137 levels have shown a noticeable change on seven of the trails, while the remaining trails show relatively consistent results. However, the unchanging results from trail 10 indicate that the activity has not left the swamp on its lower end and spread the contaminated area. The cesium-137 concentration has shown a sudden large increase on trails 1 and 2, with a slower but consistent increase on trail 6. The increased concentrations found in trails 1 and 2 indicate the possible movement of additional cesium-137 into the swamp from Steel Creek. Steady decreases are observed in trails 4, 5, 8, and 9. When considered as a whole, these analytical results do not indicate a general migration of activity along the entire swamp, but rather localized movement.

Cesium-137 activity was detected in nine of the ten vegetation samples. Although these concentrations were consistently lower than the soil from the same location and generally followed activity levels in the soil, a constant ratio between the two was not observed. Only two trends of note were observed: a consistent and steady increase in cesium-137 on trail 6, and a similar drop of activity on trail 9. Changes in the cesium-137 levels in vegetation with time are more variable because of the many biological and physical factors influencing the results.

Strontium

The soil and vegetation samples were also analyzed for strontium. Due to the relatively short half life of strontium-89, all activity is assumed to be strontium-90. All soil samples showed strontium activities below the lower limit of detection (LLD), while only four of the ten vegetation samples showed concentrations above the LLD. The maximum strontium in vegetation level was 0.99 pCi/g, which was measured on trail 6. Because of the relatively small data set, few conclusions can be reached from these results.

The four locations having strontium concentrations above the LLD have historically shown these higher results. Little change in strontium concentration has been observed at these locations since 1990. Although the maximum cesium-137 and strontium levels were measured in the same vegetation sample, the distribution of strontium in vegetation shows little correlation to the cesium levels observed in vegetation.

Pen Branch Survey

A survey of the Pen Branch system was conducted in late 1992. Pen Branch is a stream which originates in the center of the site and flows generally S/SW to the Savannah River. Along the way, it receives process effluent from K-Reactor. This survey was conducted as part of the routine environmental surveillance program and was designed to characterize the Pen Branch system prior to the restart of K-Reactor.

For the survey, six sampling trails were established (figure 13-3):

Trail	Location
T-1	Pen Branch at Road 6-4.2
T-2	Sampling location Indian Grave 21 (IGB-21)
T-3	K-Canal above IGB-21
T-4	K-Canal at Road B
T-5	Pen Branch at Road A
T-6	Sampling location Pen Branch-3 (Pen Branch at Road A-13.2)

Similar to previous special surveys of site stream systems, both sides of the stream were characterized from the stream bank to high ground. Beginning at the stream bank, gamma exposure rate measurements (ground level and 1 meter) were obtained using portable survey instruments (micro-R meters) at 30-meter intervals. Media sampling consisted of soil cores, soil plugs, and vegetation samples obtained from the stream bank, floodplain, and high ground on each side of the stream. In addition, TLDs were placed at each sampling location to determine integrated gamma exposure over about 1-month.

Samples were returned to the EMS labs for analysis. Soil plugs were analyzed for gamma-emitting nuclides, total strontium, and plutonium-238/239; cores were divided into 3-inch segments and analyzed for gamma-emitting nuclides; and vegetation was analyzed for gamma-emitting nuclides, gross alpha/beta, and tritium [SRS Data, 1994].

The results indicate that, because of previous operations at K-Reactor, radioactive material is present in the Pen Branch system. This activity is primarily cesium-137, with smaller amounts of cobalt-60, strontium, plutonium-238 and plutonium-239. With the exception of the control trail (T-1), activity is found along the entire length of the stream.

Gamma Exposure Rates

Gamma exposure rates along each trail were monitored by two methods: TLDs and portable survey instru-

ments (micro-R meters). The survey meter readings were taken at 30-meter intervals from the stream bank to high ground. These measurements indicate that large areas of the floodplain show slightly elevated gamma exposure rates. The micro-R readings were used as a screening tool to provide a gross indication of gamma exposure rates and distribution of areas showing elevated activity. Measurements ranged from background (a nominal 5 to 10 $\mu\text{R/hr}$ or less) to a high of 24 $\mu\text{R/hr}$, found on the N/W bank of T-5.

Major improvements were made to the EMS TLD program in late 1992, shortly before the beginning of the Pen Branch survey. Among the changes was the acquisition of portable bar code readers to record TLD badge placement and retrieval information. During the Pen Branch survey, problems were encountered with the field operation of the bar code equipment, as well as with the associated computer programs that process the bar code data. Because of these complications, TLD exposure information for the survey is not available.

Such problems, not unexpected during the startup of a new program, have been solved.

Gamma-Emitting Nuclides

The analytical results indicate the presence of gamma-emitting isotopes in the soil and vegetation of the Pen Branch system. Although a small number of exceptions exist, gamma levels in both are generally above site perimeter and off-site levels.

The primary isotope observed was cesium-137, which was quantified at 32 of the 36 soil plugs, 69 of 108 core segments, and 22 of 33 vegetation samples. Unless otherwise indicated, references to gamma activity should be interpreted as cesium-137 activity. The only other detectable man-made gamma-emitting isotope was cobalt-60, which was observed at several locations in the soil/sediment.

The distribution of elevated (detectable) cobalt-60 generally followed the cesium-137 levels in soil, but no consistent cobalt-60 to cesium-137 ratio was observed. Of particular interest are the cobalt-60 levels in

Figure 13-3 Pen Branch Survey Sampling Locations

soil/sediment, which were substantially higher than those observed in previous surveys of other site stream systems. Cobalt-60 is an activation product normally produced during reactor operation. Therefore, its presence in the Pen Branch system is not surprising in areas downstream of K-Reactor and may be attributed to K-Area operations. However, it is not known if the activity is the result of 1) a long-term buildup of cobalt-60 released by normal effluent discharges, 2) nonroutine releases from K-Area, or 3) a combination of these two processes.

The gamma activity in soil appears to peak at T-4 before decreasing, while gamma activity in vegetation appears to peak at T-5. The maximum cesium-137 levels observed in soil/sediment was 22.1 pCi/g at the 3-6-inch core segment collected at the T-6 N/W bank, while the highest cesium-137 level observed in vegetation was 2.31 pCi/g at the T-5 N/W high ground. However, slightly elevated levels in both vegetation and soil/sediment are still found at T-6, indicating deposition of activity along the entire length of Pen Branch downstream of K-Reactor. In general, activity levels in soil/sediment were higher on the S/E side of the stream. The cesium-137 levels in vegetation appear to be more uniformly distributed between S/E and N/W sides of the stream. No correlation was observed between cesium-137 levels in soil and vegetation from the same location.

Comparison of cesium-137 levels between bank, floodplain, and high ground from a given trail do not show the expected pronounced decrease in activity at the high ground observed during surveys of other streams. In general, higher activities are seen on the floodplain than in the stream bank; this is likely attributed to resuspension and erosion of sediments which occurred during K-Reactor restart testing.

The activity distribution in core segments shows a majority of the gamma activity located in the top segment (0-3 inches), with activity generally decreasing with increasing depth. Of the 35 0-3-inch core segments analyzed, cesium-137 activity was detected in 30 of the segments. Fewer segments from lower depths showed detectable activity: 23 of 35 segments from 3-6 inches; 12 of 26 segments from 6-9 inches; and 1 of 12 segments from 9-12 inches. In general, segments from these depths showed lower cesium-137 levels than the 0-3-inch level, with cesium-137 concentration decreasing with increasing depth.

Gross Beta and Strontium

Gross beta analyses were performed on vegetation samples and total strontium was performed on soil/sediment samples; this was required since no gross

beta screening procedure is available for soil/sediments. Because of the relatively short half life of strontium-89 (approximately 50.5 days), all strontium observed is assumed to be the longer lived strontium-90.

Of the samples analyzed, none of the 35 soil plugs showed activity over the respective minimum detectable activities, while all 33 of the vegetation samples analyzed showed activity over the LLD. Because of this, no comparison can be made between strontium levels in soil/sediment and gross beta levels in vegetation.

The strontium-in-soil results are consistent with results of the routine EMS soil surveillance program. In 1993, only one on-site soil surveillance location—near F-Area—showed strontium activity above the LLD. All other on-site sampling locations, as well as site perimeter and off-site locations, showed strontium activity below the LLD.

The gross beta activity levels observed were generally consistent with levels observed in vegetation samples from the site perimeter. The maximum gross beta level observed was 19.6 pCi/g, which was found at the high ground on the S/E side of T-6. Examination of the gross beta and cesium results in vegetation showed no apparent correlation between the two analytes. In fact, many of the higher gross beta results are often observed at locations showing relatively low cesium-137 levels.

The distribution of gross beta activity is not concentrated in one area, as the cesium levels were. The higher levels (over 9 pCi/g) were observed on trails 1, 2, 3, and 6, and were approximately distributed between the S/E and N/W sides of the stream. However, the high ground samples showed not only the highest beta levels, but also composed the area with the largest fraction of higher results. In addition, the presence of activity levels on the control trail (T-1) upstream of K-Area higher than many downstream locations supports the observation that gross beta levels in vegetation appear to be at or near background levels.

Gross Alpha and Plutonium-238/239

Gross alpha analyses were performed on vegetation samples and plutonium-238/239 analyses were performed on soil/sediment samples; this was required since no gross alpha screening procedure is available for soil/sediments. Of the 35 soil plug samples analyzed, 20 soil plugs showed plutonium-238 activity over the LLD, and 34 of the soil plugs showed plutonium-239 activity over the LLD, while all 33 of the vegetation samples analyzed showed activity over the LLD.

The maximum plutonium-239 concentration in soil was 0.178 pCi/g found on the S/E floodplain of T-4.

The maximum plutonium-238 concentration was 0.064 pCi/g and was also observed at this location. These concentrations of plutonium-238 and plutonium-239 are consistent with levels found at routine on-site surveillance locations near F-Area and H-Area and are slightly higher than site perimeter monitoring locations.

As with the other nuclides analyzed, no apparent pattern of the spatial distribution of plutonium-239 was observed. The distribution of locations showing detectable plutonium-239 was uniformly distributed with respect to trail number, side of the stream, and location (bank, floodplain, or high ground). However, T-4 showed the highest plutonium-239 levels as well as the two locations of highest activity. Plutonium-239 levels at T-6 were approximately equal to those observed at the control trail (T-1).

In general, the plutonium-238 levels in soil followed the distribution of plutonium-239; all locations having plutonium-238 concentrations greater than the LLD also showed detectable plutonium-239. However, a quantifiable ratio between plutonium-238 and plutonium-239 concentrations in soil was not observed. As predicted by this observation, the distribution of locations showing detectable plutonium-238 was uniformly distributed with respect to trail number, side of the stream, and location (bank, floodplain, or high ground), similar to that observed for plutonium-239. With the exception of T-2 and T-4, plutonium-238 levels in all trails were approximately equal to those observed at the control trail (T-1). The T-4 results also showed the highest plutonium-238 levels, as well as the single location of highest activity. The T-2 results also indicated increased plutonium-238 levels, although not as elevated as those on T-4.

The maximum gross alpha result was 6.73 pCi/g, which was measured at the high ground on S/E side of T-1. Although some exceptions exist, the gross alpha levels observed in Pen Branch vegetation are higher than those observed at site perimeter and off-site locations.

The gross alpha results in vegetation did not follow the same pattern observed for plutonium isotopes. The locations showing detectable results appear to be evenly distributed with respect to trail number, side of the stream, and location (bank, floodplain, or high ground), similar to the pattern observed for plutonium isotopes. However, locations showing the highest gross alpha activity do not correspond to areas showing the highest plutonium levels. The control trail (T-1) showed the point of highest activity. This concentration was almost twice that observed at the location with the next highest concentration—and may be an anomaly.

With this exception, T-2 showed the highest consistent activity levels, with the remaining four trails showing approximately equal gross alpha levels. In general, no relationship was observed between plutonium levels in soil and gross alpha levels in vegetation. Results from T-2 offer the only example of a possible relationship between plutonium levels in soil and gross alpha levels in vegetation. Locations on this trail showed increased levels in both media, but a consistent and quantifiable ratio between soil and vegetation was not observed.

Tritium

Tritium analysis was performed on 33 vegetation samples. (All the results in this section are expressed as pCi/mL of free water.) Of the 33 samples analyzed, 26 showed tritium concentrations above the LLD. The maximum concentration measured was 7.26 pCi/mL and occurred in vegetation from the floodplain on the S/E side of T-2. The tritium levels measured were higher than those observed at the site perimeter and off-site locations, but were consistent with levels observed at on-site locations around F-Area, H-Area, S-Area, and Z-Area.

Detectable tritium levels were observed at locations on all trails; the distribution was uniform with respect to side of stream and position in the stream valley (bank, floodplain, and high ground). However, both the distribution of detectable tritium levels and the tritium concentration varied with trail. Relative to the control trail values, tritium concentrations were elevated on T-2, T-3, and T-4, with a maximum observed on T-3. Tritium levels across a given trail were consistent, with little or no variation with distance away from the stream.

Conclusion

The results of this survey indicate levels of radionuclides present in the Pen Branch system which are elevated over site "background" locations (site perimeter and off site), but which are generally consistent with levels found near operating areas. Major nuclides identified include cesium-137, cobalt-60, tritium, and plutonium isotopes. The distribution of activity is variable, depending on the nuclide of interest, but generally shows elevated levels on locations at Indian Grave Branch, K-Canal, and the confluence of these two. Activity drops off further downstream to levels near those found at the control trail (T-1).

K-018 Outfall Total Residual Chlorine Study

In 1993, seven total residual chlorine exceedances occurred at the K-018 National Pollutants Discharge

Elimination System (NPDES) outfall. Five of these exceedance occurred in September and October. As a result, SRS conducted a study designed to determine possible causes of the exceedances.

A study was conducted from October 11–24, 1993. It involved collecting samples from NPDES outfall K-018 and seven other locations that contribute water to K-018. When total residual chlorine was equal to or greater than 0.1 mg/L (the limit set by NPDES), additional samples were taken at that location and analyzed for substances that could interfere with the test method.

The results indicate that on ten occasions the total residual chlorine level was greater than 0.1 mg/L at separate locations; however, on seven of the occasions, the increased values were found in the 186 basin or in the influent to the 186 basin. Both of these sources consist of river water that does not have chemical additives from the site. A subsequent study performed by an outside contractor indicates that when a sample from the 186 basin that exceeds the 0.1 mg/L total residual chlorine level is treated for interferences, the level of total residual chlorine decreases substantially. Therefore, procedures for removing possible interference from samples exceeding the 0.1 mg/L are being developed. For a complete description of nonradiological outfall sampling, see chapter 8, "Nonradiological Effluent Monitoring."

River Quality Surveys

The Division of Environmental Research of the Academy of Natural Sciences of Philadelphia has been conducting biological and water quality surveys of the Savannah River since 1951. These surveys are designed to assess potential effects of SRS contaminants and warm-water discharges on the general health of the river and its tributaries. They therefore look for spatial patterns of biological disturbance that are geographically associated with the site and for temporal patterns of change which indicate improving or deteriorating conditions.

Components of these surveys include algae, rooted aquatic plants, protozoa, insects and other macroinvertebrates, fish, and basic water chemistry. Detailed studies of all components have been conducted about every four years, with annual studies of certain groups of organisms, notably diatoms. Multiple levels of the aquatic food web are studied because no single group is reliably the best indicator of ecosystem health, and also because there is a broad consensus that maintaining the integrity of the entire system is important.

The study design employed in the comprehensive Savannah River surveys includes four sampling

stations: three exposed to SRS influence (stations 3, 5, and 6) and an unexposed reference station (station 1) upriver (figure 13–4). Multiple exposed stations are required because of the complex pattern of SRS inputs along the river. Potential impacts are assessed by determining whether differences exist between the exposed and reference stations that are either greater or of a different character than would be expected if they were due merely to natural differences among sampling sites.

For example, the character of differences among stations is judged in part by comparing the individual species collected. Evidence of impact exists if a station shows elevated abundances of species known to tolerate pollution and depressed abundances of species known to be sensitive to pollution. If this pattern is detected at the exposed stations, but not at the reference station, SRS is implicated. If, however, the pattern is seen at the reference station, the impact must be due to sources upriver from the study area.

Other types of evidence that show impact include decreased numbers of species, decreased cumulative numbers of individuals, numerical dominance by a small proportion of the species present, decreased individual growth rates, and decreased body weights of individuals relative to their lengths. These patterns arise because pollution tends to reduce individual and population growth rates in a majority of species, while a few tolerate or even prefer such conditions.

Determining whether exposed and reference stations differ is complicated by the fact that considerable variation exists even among samples collected at the same time from the same location. Apparent differences may therefore be spurious if each station is characterized by only a single sample. For this reason, the Academy's surveys typically collect multiple samples from each station, making it possible to quantify both of the important components of variation: within and among stations. Compelling evidence for station differences exists if variation among samples from different stations is significantly greater than (average) variation among samples from the same station, as judged by appropriate statistical techniques. Otherwise, apparent station differences can be explained simply by natural variability.

Another type of variation which the Academy's surveys address is variation over time. Important components of temporal variation include seasonal trends, multiyear trends, and natural (trendless) variability. All of these components can be assessed using the unique dataset generated by the Academy's long-term monitoring program in the Savannah River (figure 13–5). Regular sampling with standardized collection techniques has continued largely unmodi-

fied since the early 1950s, making this one of the most comprehensive ecological datasets available for any of the world's rivers.

Such long-term records of biological change are valuable for several reasons. Since they allow the normal degree of year-to-year variability at a site to be quantified, changes observed from one survey to the next can be assessed to determine whether they fall within the normal range, much as one would use a control chart (figure 13-6). Only changes outside this range provide evidence of altered conditions at the study site.

These datasets are also useful in distinguishing between potential impacts of SRS and variation caused by certain other factors. In particular, part of the biological variation observed over time is caused by documented changes, such as variations in river flow, wastewater treatment methods, and dredging activities. Correlations between the known history of such changes on the one hand, and components of variation in long-term datasets on the other, provide evidence that these components were not caused by SRS.

Finally, long-term datasets can provide compelling evidence for multiyear trends of improvement or deterioration in ecosystem health. For example, preliminary analyses of some of the Academy's long-term data suggest there has been a relatively steady increase in the diversity (number of species) of aquatic insects living in the river during the last 35 years (figure 13-5, C). Since aquatic insect diversity is believed to be a sensitive measure of environmental quality, this pattern may indicate a long-term trend of improving water quality in the Savannah River.

The Academy's 1993 studies on the Savannah River included biweekly diatometer monitoring throughout the year, comprehensive surveys near SRS in May, June, September and December 1993 (algae, protozoa, noninsect macroinvertebrates, insects and fish), sampling near the Georgia Power and Light Company's Vogtle Electric Generating Plant in September (algae, protozoa, noninsect macroinvertebrates, insects and fish), and sediment-core studies in the vicinity of SRS in June. A discussion of results as of December 31, 1993 follows.

Figure 13-4 Academy Sampling Sites

The Academy of Natural Sciences of Philadelphia has established specific sampling locations for surveys of the Savannah River. Stations 1, 3, 5, and 6 are used in most of the surveys.

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Diatoms

Artificial substrates (Catherwood Diatometers®) were deployed near SRS for 26 two-week exposure periods between December 22, 1992, and December 21, 1993. One sample from each of the three sampling stations (stations 1, 5, and 6) was analyzed for each exposure period, using the semi-detailed method. These analyses provided data on the number and relative abundances of diatom species. The detailed reading method was

used to analyze slides for two exposure periods (slides removed April 13 and October 12, 1992). Water quality was assessed by comparing stations and sampling periods based on the relative abundances and diversity of species and their ecological requirements and tolerances.

Additional diatometer slides were exposed during three quarterly periods (the early spring quarter was not sampled). These samples were read by the semi-de-

A. Number of diatom species in diatometers at station 6, 1954–1992

B. Number of algal taxa at station 6, 1951–1989

C. Number of insect taxa at station 6, 1959–1992

D. Number of fish at stations 1, 3, 5, and 6, 1952–1992

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Figure 13–5 Examples from the Academy's Long-Term Dataset for the Savannah River
Components from this dataset can be used to assess components temporal variation.

Catherwood Diatometers®**What are they?**

Devices used to collect diatoms (groups of algae).

How do they work?

Vertically oriented glass slides on the device serve as artificial substrates for colonization by diatoms. The diatometers, which are secured by anchors, float so that the slides remain just below the water's surface.

Why are they useful?

This diatometer samples the diatom flora continuously in a nonselective manner to obtain a representative collection of diatom growth.

What happens after the diatoms are collected?

Following the exposure period, the used diatometers are replaced by clean ones and immediately placed in the river to ensure that the river is continuously sampled.

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Figure 13-6 Number of Diatom Species in Diatometers at Station 5

The graph shows the 1992 values superimposed on the mean plus or minus 1 standard deviation for 1978-1992. Exposure periods represent 26 two-week intervals during which diatometers were deployed in the Savannah River.

tailed method and were also analyzed for chlorophyll *a*. The purpose of these additional samples is to facilitate comparison with the insect data (page 191).

As in the previous five years of study, the number of diatom species (species richness) was consistently lower at station 6 (below Lower Three Runs) than at the reference station (station 1), while richness at station 5 (below Steel Creek) did not appear to differ from the reference station. Of the 25 exposure periods analyzed to date, species richness was lower at station 6 than at the reference station (station 1) for 18 exposure periods. Richness at station 5 was lower than at the reference station for roughly half of the exposure periods (12 of the 25 exposure periods analyzed to date).

Values for the species evenness parameter (percent dominance) were not as conclusive as in previous years. Evenness was lower (i.e., percent dominance was higher) at station 6 than at the reference station (station 1), but the pattern was not as consistent as in the previous five study years. Evenness at station 5, on the other hand, was consistently higher than at the reference station.

The lower values for species richness and evenness at station 6, compared to the reference station, reflect a less balanced biota. As in past years (1988–1993), diatom communities at station 6 indicate deteriorated water quality, probably due to conditions on Lower Three Runs. Differences between the reference station and station 5 do not indicate differences in water quality.

Algae and Aquatic Macrophytes

Field studies were carried out at three to six stations on the Savannah River at various locations, roughly between Demiere's Landing (river mile 160) and Johnson's Landing (river mile 125) during May, June, September, and December 1993.

A total of 459 algal collections was made and examined either at the field laboratory, at the Academy or at both. All the material is now at the Academy where identification of species continues.

The diatom samples have been cleaned and microscope slides prepared for analysis and permanent storage in the Academy diatom herbarium. The specimens of filamentous algae and the aquatic macrophytes have been dried on herbarium papers and will be added to the algae and macrophyte herbaria.

The identifications of the algal material from the two stations near Hancock's Landing are almost complete, and preliminary indications are that there has been no

change in the condition of the water at that location compared to the conditions found during the 1991 study.

When the rest of the identifications have been completed, the data will be compared to data gathered from these four stations regularly since 1951, and conclusions will be drawn concerning the condition of the river in the study area. The data available to date and the field observations made during the surveys do not suggest any significant change in the condition of the water at these four stations.

Protozoa

Samples of protozoa were taken at stations 1, 3, 5, and 6 during June and September 1993, and at Plant Vogtle stations (stations V-1 and V-2) during September 1993. All of these collections contained healthy, well-balanced protozoan assemblages. The various protozoan species were present in low numbers, but the species composition was comparable to that of previous surveys. This consistency indicates a well-established protozoan assemblage adapted to the hydrological rigors of the Savannah River.

Noninsect Macroinvertebrate Fauna

In 1993, studies of the noninsect macroinvertebrate fauna were conducted in the vicinity of SRS and near Plant Vogtle. Comprehensive collections were made at the four SRS stations (stations 1, 3, 5, and 6) in June and September. Preliminary examination revealed a total of 41 species in the September samples but fewer in the June samples, which were collected during high water. A total of 17 species was collected from stations V-1 and V-2.

The results suggest a relationship between the number of species collected and the presence or absence of dense beds of submerged aquatic vegetation (figure 13-7). These beds are among the most important habitats in the Coastal Plain portion of the Savannah River. They have been absent since 1990, due to hydrological factors such as widely fluctuating water levels and increased current speeds. The number of species was lower in 1993 in both SRS and Vogtle collections, compared to previous surveys when dense beds of aquatic plants were present (1989 at SRS and 1985, 1986, and 1988 at Plant Vogtle).

The 1993 SRS studies were augmented by a survey of the mussel fauna in October. The number of mussel species in the comprehensive surveys declined consistently from 15 in the early 1970s to only 5 in 1989. To determine whether these species had actually disappeared, the mussel survey was expanded to include collection by several investigators rather than one and searches of deeper troughs (by divers) rather

than only shallow areas. Most of the mussels recorded from past surveys were collected, indicating they are still present.

Insect Studies

Quantitative and qualitative collections of aquatic insects were made in the Savannah River during four periods for 1993. Samples were collected at stations 1, 5, and 6 in May and December, and at stations 1, 3, 5, and 6 in June and September. The collection of these samples has followed a consistent protocol since the Academy's quantitative study of insects on the Savannah River began in 1958.

Over 100 different insect taxa were collected from the Savannah River during the four surveys in 1993. Among the more common insects were the clinging mayflies *Stenonema mexicanum integrum* and *Tricorythodes* spp., the predatory stoneflies *Paragnetina kansensis* and *Perlesta* spp. complex, and the filter feeding caddisflies *Chimarra mosleyi* and *Hydropsyche rossi*. Although data analyses for 1993 were not complete as of December 31, 1993, results from the 1992 data do reveal general patterns regarding the health of the aquatic insect assemblages in the Savannah River.

During the 1992 study, the overall diversity of insects (as measured by the Shannon-Wiener Diversity index) was lowest at the reference station (station 1) and highest at station 6, which is the station farthest downriver from SRS. In addition, the pollution tolerance of the insect assemblage (as measured by a modified Hilsenhoff Biotic Index) was highest at the reference station (station 1) and lowest at station 6. These results indicate that the aquatic insect

assemblages are healthiest at the exposed stations. The reference station appears to be affected negatively by pollution sources farther upriver, with recovery occurring as the river flows past SRS.

The pattern of apparently healthier insect assemblages below SRS than at the upriver reference station is consistent with previous Academy studies of the aquatic insects. Analyses for the 1993 studies will include an assessment to determine whether this pattern persists.

In addition to the studies conducted near SRS, qualitative and quantitative samples of aquatic insects were also collected upriver and downriver from Plant Vogtle during September 1993. Over 50 different taxa were collected in the qualitative samples. Among the more abundant insects collected were the swimming mayfly *Baetis intercalaris*, the clinging mayfly *Stenonema modestum*, the filter-feeding caddisflies *Chimarra mosleyi* and *Hydropsyche rossi*, and the riffle beetle *Macronychus glabratus*. Detailed results from the quantitative collections were not available as of December 31, 1993.

Fish Studies

The Academy conducted two types of fish surveys on the Savannah River in 1993. A comprehensive survey was conducted in June and September at stations 1, 3, 5, and 6. The river above the reference station (station 1) was reconnoitered to locate suitable sites for rotenone sampling, since siltation has led to progressive deterioration of appropriate habitat within this station. Several sites were located and sampled. The sites at the reference station (station 1) were also sampled to provide comparisons with the new sites.

Figure 13-7 Number of Noninsect Macroinvertebrate Species at Stations V-1 and V-2

Dense beds of aquatic vegetation were present into September 1989 but were lacking by September 1990.

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The second type of survey involved sampling near Plant Vogtle and was conducted concurrently with the September comprehensive survey. Samples were taken at stations V-1 and V-2, using protocols similar to those of past surveys. As part of the surveys, midwater trawling was tested (primarily in June) as a means of collecting larger, open water fish. Few specimens were collected, and the technique will probably not be substituted for other sampling elements in the future.

Following completion of the field portion of the comprehensive survey, the following laboratory work has been done: (1) curation of specimens, including preparation of appropriate chain-of-custody, sample log-in files and other quality assurance and control procedures; (2) filleting of fish specimens for analysis of metal concentrations; and (3) identification and measurement (length of most specimens and weight of several common species) of fish from the June survey.

Following completion of the field portion of the Plant Vogtle survey, the following laboratory work was done: (1) curation of specimens, including preparation of appropriate chain-of-custody, sample log-in files and other quality assurance and control procedures; (2) filleting of fish specimens for analysis of metal concentrations; and (3) initiation of identification and measurement of fish.

Remaining tasks include (1) completion of identifications (September comprehensive and Plant Vogtle); (2) completion of measurement of length and weight (both surveys); (3) analysis of age-growth relationships (dissection, preparation, and analysis of otoliths of 1 to 2 species); (4) data tabulation and analysis; and (5) report preparation.

Sediment

Studies of Savannah River sediments were conducted for the first time in 1993. The purpose of these studies is to determine whether it is feasible to employ sediment-core techniques in the river and, if so, to conduct a preliminary assessment of the historical record of contaminant inputs revealed by the cores.

Field sampling was conducted in June 1993. Sediment cores were collected from cutoff meanders at four locations upriver from SRS, one near the site, and six downriver. The cores were sectioned into slices 1 centimeter thick to evaluate the layer-by-layer deposition of contaminant trace metals and trace organic compounds to sediments in the river. Differences in the concentrations of these substances signify variations in inputs to the site either by discharge or by atmospheric inputs. The measurement of fluxes requires dating by lead-210 and, if possible, cesium-137. These analyses are not yet complete.

To date, two cores have been analyzed for various sediment features including loss-on-ignition, porosity, and contaminant trace metals cadmium and lead. Loss-on-ignition serves as a surrogate measure of organic matter or organic carbon in the sample. It is analyzed by igniting an aliquot of the sample at 550 °C for 15 minutes. The loss of mass at this temperature is assumed to be organic matter. Identification of the fraction of organic carbon in sediment samples is important because hydrophobic organic contaminants and some metals (particularly lead) have an affinity for organic matter. This effect must be taken into account in interpreting differences in contaminant concentrations among layers.

Porosity is a dimensionless measure of pore space within a sediment volume. It is measured by comparison of wet and dry weights of fresh sediment, assuming a sediment density of 2.45 g/cm³ and water density of 1 g/cm³. In the present context, porosity is important for two reasons. First, it provides an indirect estimate of sediment particle size since smaller particles tend to have larger pore volumes in a unit volume of sediment. Second, it allows sediment accumulation models to be correct for compaction, by which lower layers in a core become compressed and so represent more years of deposition per centimeter than do upper layers. Samples with low porosity are typically sandy (moderately large inorganic particles) and are likely to be characterized by low content of contaminants.

Particle size is important in analyzing sediment cores because finer particles, typical of clay, have a greater affinity for trace metals. This is true in part because finer particles have a comparatively greater total surface area per volume of sediment, providing more surface for adsorption of metals. In addition, clay particles typically are negatively charged and therefore attract positively charged metals such as cadmium and lead.

Cadmium and lead were selected for preliminary evaluation because they are typical anthropogenic contaminants resulting from a variety of industrial applications. They also are widely distributed by atmospheric processes. All samples analyzed for cadmium and lead were digested in HNO₃, using a microwave oven for heating. Analytes were analyzed using graphite furnace atomic absorption spectrophotometry.

The two cores chosen for the first analysis were collected from two cutoff meanders along the river. The farthest upriver site was at Eagle Point, which also happens to be the mid-reach sediment sampling site near river mile 153. All other sites were either far upriver or downriver from Eagle Point. The other site

chosen was Cox Point, located downriver from Eagle Point at about river mile 168.

Eagle Point core showed a fairly consistent loss-on-ignition, with two notable low values at 4 centimeters and again between 11 and 14 centimeters (figure 13-8). While these lower values do not have a significant effect on porosity of the sediment, which was quite consistent throughout the sediment core, they appear to have some effect on trace metal content. The low concentrations of cadmium and lead at about 4 centimeters are likely related to the loss-on-ignition being about half as great at that depth as in the layer above. The lead content in sediments below 4 centimeters showed an increase along with loss-on-ignition, but cadmium did not follow the pattern, apparently because of smaller inputs. Both cadmium and lead showed concentration increases below 7 centimeters, not related to change in loss-on-ignition, but apparently caused by greater inputs at the times the layers were deposited. The striking increase in cadmium and lead below 13 centimeters is a result of both increased inputs and an increase in loss-on-ignition at that depth. The increase of cadmium input is quite obvious because of its extreme value at 13 to 14 centimeters and the comparatively lower values below. The lead profile below 13 centimeters parallels the loss-on-ignition profile, suggesting that the lead variation is a function of different amounts of organic matter.

From review of maps and aerial photographs, the Eagle Point site is in a comparatively new cutoff, so the variation in metals and loss-on-ignition at 14 centimeters may be related to cutoff history. Dating results may further identify relationships between metal content and cutoff history.

The loss-on-ignition of the Cox Point core varied only slightly throughout the analyzed depth (figure 13-8). All Cox Point loss-on-ignition values were higher than those for Eagle Point core. The Cox Point porosity varied little over depth, suggesting that the sediment material was quite consistent in grain size. Because of the consistency of loss-on-ignition and porosity at this site, little variation in the trace metal content might be expected, assuming that inputs have been consistent. Evaluation of the cadmium profile of Cox Point suggests, however, that the input of cadmium over the history of this segment of the sediment core was not constant.

The lead profile at Cox Point showed little variation with depth and suggests that inputs might have declined in recent times. A full evaluation of dating profiles will be necessary, however, before reaching a final conclusion about inputs. The lead values here are

unusually low for a river apparently affected by anthropogenic factors. Surface sediments from open Lake Michigan, for example, show values of over 100 $\mu\text{g/g}$, while lakes in remote regions of the Canadian Arctic affected only by anthropogenic inputs from atmospheric deposition show values similar to observations at Cox Point. Cadmium values were in the range observed in some arctic sediments, while again considerably less than observed in open Lake Michigan.

The low concentrations of trace metals in these sediments in comparison with other areas suggests a lack of consistent, undisturbed inputs, perhaps because of the age of the cut-offs that were sampled. Background concentrations of either cadmium or lead in either Eagle Point or Cox Point core probably have not been reached. Dating information and analysis of metals in deeper core sections will help identify whether or not background values have been identified.

Pen Branch Reforestation

The significant reduction in the production mission of SRS reactors has resulted in the reevaluation of the mitigation strategies identified in the 1991 Mitigation Action Plan (MAP) and its 1992 annual update. The annual MAP update provided a status and target date for activities within each of the five program elements. The Mitigation Action Plan-Program Implementation Plan described the actions to be taken, the responsible organizations, and the status of actions required to meet the commitments. The text of the MAP identified mitigation commitments and other mitigation-related issues requiring resolution, and referenced pertinent sections of the K-Reactor, L-Reactor, and P-Reactor environmental impact statement [DOE, 1990b]. The MAP was composed of five elements that acted as discrete units or plans. These elements were

- mitigation for Fish Kills Resulting from Reactor Operation
- studies to Determine if Entrainment Mitigation is Needed
- mitigation for Impacts on Individual Workers from Termination of Reactor Operations
- evaluation of Options for Disassembly Basin Purge Water Discharges
- mitigation for Wetlands Adversely Impacted by Continued Operation of K-Reactor

As a result of the March 30, 1993, mission change, mitigation activities were reduced to three program elements: those associated with Pen Branch reforestation; the socioeconomic impact of the workforce reduction; and seepage basin usage. The elements associated with fish kills and entrainment mitigation

Figure 13-8 Sediment Core Data for Cores from Eagle Point and Cox Point
The cores were taken at 1-centimeter intervals.

needs are no longer required due to mission changes at SRS. Elements associated with individual workers have been completed in the 1993 MAP update. Elements of the disassembly basin purge water discharges have been deferred until the K-Reactor mission is further defined. The only purges that may

occur would be in emergency conditions. The mitigation for wetlands adversely impacted by Operations is the only section of the MAP which remains as an active program element. At the direction of DOE, it has been agreed by all parties involved with the reporting process that the SRS annual environmen-

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Figure 13-9 Wetlands Rehabilitation Flow Path

tal report will be used to report progress on the reforestation portion of the commitment.

A precise history of the regulatory commitment for the reforestation can be found in the MAP 1992 Update [DOE, 1992a]. Since that time, the change in mission relating to K-Reactor and the increased technical information on the extent of damage and natural recovery in the Pen Branch corridor and delta have altered the details of the reforestation effort.

The following paragraphs describe the implementation of mitigation measures related to the reforestation mitigation actions that have been committed to by DOE (i.e., Mitigation for Wetlands Adversely Impacted by Continued Operation of K-Reactor element).

The DOE policy is to preserve and protect wetland resources at SRS in accordance with the national goal of "no net loss of wetlands" [Watkins, 1989]. Consistent with that policy, DOE committed to restore all wetlands impacted by the operation of K-Reactor. Integral to this mitigation is the understanding of actual

effects incurred by wetlands from K-Reactor operation. Phase I of the Pen Branch mitigation began in 1993 with the reforestation of the corridor area. If necessary, any mitigation involving enhancements to riverine wetlands, streams, or areas other than Pen Branch will begin 2000. The general flow path for the restoration effort is outlined in figure 13-9.

A number of tasks were required prior to the implementation of the operational reforestation. These included a literature review of other studies that included similar restoration efforts and a baseline characterization of the plant communities present in the Pen Branch corridor and delta [WSRC, 1991]. Studies of the effects of cold flow testing on biological communities in Pen Branch and its associated wetlands were conducted, and a report on the effects of the power ascension testing is in draft form [Wilde, 1991; Gladden et al., 1991; Paller et al., 1991]. A program is in place to monitor the post-thermal recovery and will be continued with control plots in all the areas of reforestation. A number of research studies have been

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Researchers monitor vegetation growth in the Pen Branch area.

conducted testing species selection and seedling characteristics to identify appropriate methodologies for the reforestation effort.

DOE has proposed three methodologies to mitigate wetland losses incurred as a result of past K-Reactor operation.

- Reforestation of the Pen Branch corridor and delta by natural succession
- Reforestation of the Pen Branch corridor and delta by planting
- Compensatory mitigation

Reforestation of the Pen Branch Corridor and Delta by Natural Succession

Natural revegetation has been occurring in the Pen Branch delta since K-Reactor last operated for an extended period of time (1988). This is supported by the occurrence of natural revegetation in Steel Creek during the past 25 years. At that time, cooling of the L-Reactor was accomplished by using L Lake instead of Steel Creek.

In 1991 SRTC initiated a project to reevaluate the acreage of wetland forest affected by previous reactor

operation and document areas that had shown recovery since K-Reactor shutdown in 1988. In 1992, using aerial photography and aircraft acquired multispectral data, researchers determined that an area of 583 acres was included in the swamp and marsh area that either had been or could be clearly affected resulting in tree canopy loss or vegetation damage [Blohm, 1992]. This is a substantial reduction from the 670 acres estimated in the K-Reactor, L-Reactor, and P-Reactor environmental impact statement [DOE, 1990b].

Of the 583 acres evaluated, 165 acres were determined to be bottomland hardwood in 1987, the last full year of K-Reactor operation. From 1987 to 1991, the coverage of bottomland hardwood progressively increased to 224 acres. Concurrently, increased coverage by willow and scrub-shrub vegetation was also noted, indicating a normal successional sequence for this type of habitat. Generally, these increases in woody vegetation cover occurred through a reduction in the *Lugwigia* spp., mud-flat and open-water-cover categories. Thus, with the general reassessment of the originally affected wetland acreage and the documented coverage by native hardwood species, the acreage to be considered for reforestation is approximately 359 acres rather than 670 acres. Reassessment of this area using data from 1992 and 1993, including documentation of areas known to have experienced natural reseeding by

cypress, may further reduce the acreage targeted for reforestation actions.

Reforestation of the Pen Branch Corridor and Delta by Planting

The Pen Branch corridor and delta will be reforested using indigenous wetlands species. The reforested areas will be managed until successful reforestation has been achieved. This is the preferred method of mitigation for Pen Branch. Recent observations indicate that cypress, tupelo, and other species are becoming reestablished naturally in portions of the Pen Branch delta. This natural reforestation will be quantified and monitored. Intervention into this natural process will only be considered to maximize survival of the desired species. Areas of the Pen Branch corridor and delta judged not to be revegetating satisfactorily are being replanted with indigenous bottomland forest species appropriate for the soil types and hydrologic regime. A number of tasks were identified in the MAP relating to the Pen Branch reforestation element.

All of these have been met, changed due to mission, or are scheduled for later target dates. The initial seedling planting of the corridor area has been completed. This consisted of planting approximately 31 acres of the lower corridor with a mixture of flood tolerant hardwood species and cypress seedlings, and an additional 47 acres of the upper corridor with a mixture of bottomland hardwood species seedlings. Monitoring plots are being installed to assess the survival of the seedlings. Preliminary indications are that survival and growth in the lower corridor area are quite good. Within the areas that have been planted are areas that will serve as untreated controls to assess the effectiveness of the reforestation effort. This acreage is part of that committed to in the MAP and it will be assessed at a later date to see if it will reforest naturally due to its proximity to the mitigated acreage. If not, it may have to receive planting at a later date. Planning for the restoration of about 200 acres of the delta area is underway. Site preparation of the area will begin during the summer of 1994.

Compensatory Mitigation

This option will provide equivalent mitigation at sites other than Pen Branch, either by enhancing degraded wetlands or by creating new wetlands. This option will be evaluated in detail in 2000, following the evaluation

of the success of reforesting Pen Branch corridor and delta. However, it is the least desired option. Mitigation of this type can consist of one or more of the following.

Restoration of In-kind Bottomland Hardwood Habitat on Four Mile Creek or Steel Creek

Four Mile Creek and Steel Creek are previously disturbed streams similar to Pen Branch and are located within the site boundary. The restoration of wetland forests along this watercourse would provide functionally equivalent, in-kind mitigation and achieve a restoration of wetland functions and habitat closest to those present in the Pen Branch area.

Restoration of Carolina Bays and Other Degraded Wetlands on SRS

The original site area was farmed extensively before it was established in 1951, and many of its wetlands were adversely impacted during this time. Bays were ditched and drained and bottomland forest communities were impacted by farm ponds and highway crossings. Wetlands that were altered or degraded are in the process of being identified. Those deemed most valuable can be restored through alteration of the hydrologic regimen. As an example, ditches can be plugged and causeways removed to restore wetland acreage.

Restoration and Purchase of Off-site Wetlands

If additional mitigation is required, the DOE could locate, purchase, and donate through a state, federal, or private conservation organization, lands of suitable value. This could involve the purchase of Carolina bays that are threatened with development and are not currently protected, or the purchase of wetlands that have been converted to croplands. In the case of the latter, mitigation would involve restoration of the fields to forested wetlands. These lands could be purchased only from willing sellers and could be contained within the Savannah River drainage basin.

A number of tasks associated with compensatory mitigation actions were listed in the MAP. The only one that has been completed is the identification of ecologically significant SRS wetlands that have been degraded or altered [DOE, 1992b]. The necessity to perform the other listed tasks will be determined based on the results of the Pen Branch mitigation.

Appendix A

SRS Critical Pathways Analysis

The following discussion summarizes the results of a critical pathways analysis of Savannah River Site (SRS) operations. The analysis covers radionuclide releases to the atmosphere and to surface water, the principal media that carry radioactivity off site, and implications for the environmental monitoring program.

Although many different radionuclides are released from SRS facilities each year, fewer than 10 are significant contributors to off-site doses. Information from the 1986–1993 SRS annual environmental reports was examined to determine which radionuclides and exposure pathways are most important in terms of the quantity of radionuclides released, the dose to the maximally exposed individual, and the collective dose to the population. This type of analysis, called a critical pathways analysis, provides an indication of the important radionuclides and pathways for a particular site.

Releases to Air

Table A-1 shows the amounts of radionuclides in airborne effluents during the eight-year period. Overall, the largest releases during the period were of tritium and the noble gas krypton-85. The table also shows that releases of radionuclides in particulate form were lower than those in gaseous form.

Particulate fission products include the nuclides strontium-89,90, cesium-137, ruthenium-106, and cerium-144. Particulate activation products include

Table A-1
Radionuclides Released to Air from 1986 through 1993

Radionuclide Category	Activity Released to the Atmosphere (Ci)							
	1986	1987	1988	1989	1990	1991	1992	1993
Hydrogen, Carbon, Iodine								
Tritium as water vapor	2.9E+5	2.7E+5	2.9E+5	2.2E+5	1.8E+5	1.4E+5	1.0E+5	1.3E+5
Tritium as hydrogen gas	1.4E+5	3.2E+5	1.7E+5	9.2E+4	7.8E+4	6.3E+4	5.6E+4	5.8E+4
Total tritium	4.3E+5	5.9E+5	4.6E+5	3.1E+5	2.5E+5	2.0E+5	1.6E+5	1.9E+5
Carbon-14	5.6E+1	4.1E+1	2.4E+1	1.8E+1	6.7E-1	6.2E-1	1.9E-1	1.7E-2
Iodine-129	8.7E-2	7.2E-2	6.3E-2	5.2E-2	1.3E-2	1.0E-1	3.5E-3	5.0E-3
Iodine-131,133,135	2.6E-2	1.3E-2	5.0E-4	3.6E-4	1.2E-4	1.0E-4	1.4E-1	3.4E-2
Noble Gases								
Argon-41	8.3E+4	8.8E+4	3.0E+4	a	a	a	2.5E+2	a
Krypton-85	7.1E+5	4.0E+5	2.4E+5	4.2E+4	3.0E+3	1.1E+4	5.0E+1	0.0E+0
Short-lived krypton and xenon isotopes	1.9E+4	1.4E+4	1.4E+4	a	a	a	2.4E-3	a
Particulates								
Fission and activation products	9.3E-2	1.2E+0	4.3E-2	6.4E-3	1.2E-2	4.8E-3	2.3E-3	2.8E-3
Uranium	1.6E-3	8.5E-3	1.5E-3	5.1E-3	5.2E-3	2.7E-3	1.6E-3	1.9E-3
Transuranic elements	2.5E-3	2.9E-3	1.5E-3	2.4E-3	3.5E-3	9.2E-4	1.3E-3	2.5E-3

a There were no releases of argon-41 or short-lived isotopes of krypton and xenon during 1989, 1990, 1991, and 1993, when reactors were not operating.

cobalt-60 and manganese-54. There are three naturally occurring uranium nuclides: uranium-234, uranium-235, and uranium-238. A primary transuranic element is plutonium, with isotopes plutonium-238 and the pair plutonium-239,240. Also in that group are isotopes of americium and curium. The total particulate release exceeded 0.1 Ci ($3.7\text{E}+09$ Bq) in only one of the eight years (1987). That year, the release was composed primarily of cesium-137.

Figure A-1 illustrates the contributions of the various radionuclides to the committed effective dose equivalent (EDE) to the maximally exposed adult. This hypothetical person is presumed to be located at a point on the SRS boundary where the maximum concentrations of radionuclides are present. The habits and food supply of the individual are presumed to be those that maximize exposure to radiation. (See chapter 7, "Dose," for a complete discussion of maximally exposed individual.)

The data in figure A-1 are divided into three time periods: 1986-87, 1989-90, and 1991 and 1993. Reactors operated for only part of the year during 1988 and 1992; therefore, these years are not included in the comparison. Tritium is the radionuclide that contributes the most to the committed EDE for the hypothetical individual. During the years of reactor operations, argon-41 made the next largest contribution. Throughout all periods, iodine-129 was estimated to contribute 3 to 17 percent, and carbon-14 was estimated to contribute 0.2 to 6 percent of the total committed EDE. In 1987, the particulate fission product cesium-137 was an important contributor (12 percent of the committed EDE) because of a nonroutine release of about 1 Ci ($3.7\text{E}+10$ Bq) of cesium-137 from an H-Area evaporator in the waste management facilities [Mikol et al., 1988].

During reactor operations, the relatively large releases of noble gas isotopes of krypton and xenon contributed less than 3 percent of the committed EDE to the maximally exposed person. Without reactor operations, these nuclides are even less important. The increased relative importance of transuranic elements in 1989-90, 1991, and 1993 is due to two factors:

- lower releases of noble gases and tritium (about a 75 percent decrease)
- an increase in the dose conversion factor for ingestion of plutonium [DOE, 1988]

During 1991 and 1993, when there were no reactor or reduced separations operations, tritium contributed more than 90 percent of the committed EDE for the hypothetical individual. The majority of atmospheric tritium releases from SRS are caused by continuing operations in the tritium facilities.

Similar conclusions about radionuclide importance can be drawn when the collective dose to the population is examined. In fact, the contribution of tritium to the collective committed EDE is even larger than its contribution to that of the maximally exposed individual. Despite the large releases of krypton and xenon isotopes, particularly during reactor operations, those nuclides were not major contributors to collective dose. Noble gases, as a class, contributed about 15 percent to the collective committed EDE when reactors were operating, but less during other years. The long-lived carbon and iodine isotopes were responsible for 2 to 17 percent of the committed EDE to the population during those years. With the exception of 1987, when the release of cesium-137 accounted for almost 20 percent of the collective committed EDE, particulate radionuclides accounted for less than 5 percent of the total.

Releases to Surface Water

Table A-2 shows the quantities of radionuclides from SRS entering the Savannah River from 1986 to 1993. Releases of tritium, most of which are due to groundwater migration from seepage basins, are by far the largest of any radionuclide. Releases of fission and activation products, primarily strontium-90 and cesium-137, ranged from about 0.5 to 1 Ci ($1.9\text{E}+10$ to $3.7\text{E}+10$ Bq). The estimated release of iodine-129 was even lower, about 0.02 Ci ($7.4\text{E}+08$ Bq). Releases of uranium and the transuranic nuclides (plutonium-239,240) were lower than that of iodine-129.

Figure A-2 illustrates the contributions of these releases to the dose of a hypothetical adult who resides just downriver from SRS and to the collective dose to the population. The hypothetical individual's habits are assumed to include a large consumption of fish caught from the river. The radionuclide that contributes most of that person's committed EDE is cesium-137, primarily because of the assumed consumption of fish. The importance of cesium-137 in fish is somewhat overestimated because background cesium-137, which is widespread in the environment from weapons testing, is not subtracted. Tritium is the second most important contributor to the individual committed EDE.

The collective dose from liquid releases includes doses to people who are within 50 miles (80 kilometers) of the center of SRS. Near Beaufort, South Carolina, and at Port Wentworth, Georgia, water is taken from the Savannah River for public drinking water supplies. Consumption of tritium in the water typically accounts for more than 60 percent of the collective dose attributable to SRS releases.

leaf Graph

Figure A-1 Radionuclides Important to Dose from Atmospheric Releases^a

The graphs show the approximate average percent each radionuclide contributed to the dose from atmospheric releases to the maximally exposed adult on the SRS boundary.

^a Several reactors operated only during parts of 1988, so that year is not included in the graph. K-Reactor operated for only part of 1992, so that year is not included in the graph.

Table A-2
Radionuclides Entering the Savannah River from 1986 through 1993

Radionuclide Category	Activity in Releases to the Savannah River (Ci)							
	1986	1987	1988	1989	1990	1991	1992	1993
Hydrogen, Carbon, Iodine								
Total tritium	2.8E+4	2.3E+4	1.9E+4	1.7E+4	1.6E+4	2.7E+4	1.4E+4	1.2E+4
Iodine-129	2.2E-2	2.2E-2	2.2E-2	2.2E-2	2.2E-2	2.2E-2	2.2E-2	2.2E-2
Particulates								
Fission and activation products	4.7E-1	7.8E-1	9.6E-1	5.0E-1	5.5E-1	7.0E-1	8.9E-1	7.4E-1
Uranium	4.4E-2	5.5E-3	5.5E-3	4.3E-4	1.4E-3	3.2E-3	1.9E-3	1.1E-5
Transuranic elements	8.5E-3	1.8E-2	5.5E-3	1.4E-2	2.3E-2	2.0E-2	1.6E-2	9.6E-3

Leaf Graph

Figure A-2 Radionuclides Important to Dose from Liquid Releases

The graphs show the average percent each radionuclide contributed to the dose from liquid releases to the maximally exposed adult and the population from 1986 through 1993.

Summary of Releases

The list of radionuclides of particular interest with regard to doses from SRS operational releases is shown in table A-3. Also shown are some of the properties of these radionuclides related to their potential to produce

doses to individuals and the population. With the exception of argon-41, the radionuclides shown have relatively long half-lives. The types of radiation emitted are variable from one nuclide to the next. The predominance of beta and alpha emitters shows the importance of internal exposures that are due to ingestion or inhalation of radionuclides.

Table A-3
Properties of Dose-Important Radionuclides Released from SRS from 1986 through 1993

Radionuclide	Half-Life	Primary Radiation Emissions ^a	Importance of Food Pathways
Tritium	12.4 y	β	High
Carbon-14	5730 y	β	High
Argon-41	1.83 h	γ	Low
Strontium-90	29.1 y	β	High
Iodine-129	16 million y	β	High
Cesium-137	30.2 y	β, γ	High
Uranium-235	700 million y	α	Low
Uranium-238	4.5 billion y	α	Low
Plutonium-238	87.7 y	α	Low
Plutonium-239	24,100 y	α	Low
Plutonium-240	6,570 y	α	Low
Americium-241	432.7 y	α	Low
Americium-243	7370 y	α	Low
Curium-242	163 d	α	Low
Curium-244	18.1 y	α	Low

^a α stands for alpha; β stands for beta; γ stands for gamma

Pathways for SRS Releases

Figure A-3 illustrates some of the pathways radiation can use to move through the environment. Based on the critical pathways analysis, the most important pathways from SRS atmospheric releases to an individual at the site perimeter were through inhalation, external exposure from radionuclides in the plume, and consumption of vegetables and milk (figure A-4). Because the largest airborne contributor to dose is tritium, which permeates all environmental media, the predominance of inhalation and food pathways is not surprising. Exposure to radionuclides deposited on the ground is a relatively unimportant pathway at SRS.

Four of the radionuclides are relatively mobile in food chains (table A-3). Hydrogen and carbon are important plant nutrients, and iodine is an important trace element. Cesium-137 and potassium, which is important to human metabolism, behave similarly. In contrast, argon-41 and the plutonium isotopes have low mobility in food chains. The former is important only

as a source of external exposure from the plume of noble gases released during reactor operations. Alpha-emitting plutonium nuclides enter the body primarily by direct inhalation of air or ingestion of water. Their concentration in human food chains is not an important exposure pathway. However, for the other four nuclides, food pathways are important contributors to human exposure.

The importance of food chain pathways for biologically active radionuclides is illustrated by the two following comparisons. First, iodine-129 released to the atmosphere can deposit on leafy vegetation, such as lettuce, or on pasture grass consumed by cattle. This process and the subsequent transfer of the radioiodine to meat and milk can lead to much higher exposures than would be received if inhalation were the only route of exposure.

Second, an iodine-129 air concentration of 1 pCi/m³ can lead to concentrations of 1,200, 1,600, and 2,900 pCi/kg of that isotope in milk, meat, and leafy vegetables produced at the same location. Typical doses for consumption of foods containing iodine-129

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Figure A-3 Exposure Pathways

People can be exposed to radioactivity released from SRS in many ways. Radioactivity can leave the facility in airborne or liquid effluents and end up in the food people eat or in the air they breathe.

Leaf Graph

Figure A-4 Pathways from Airborne Releases^a

The graphs show the percent each radionuclide contributed to exposure pathways for the maximum individual dose from airborne releases from SRS from 1986 to 1990.

^a Several reactors operated only during parts of 1988, so that year is not included in the graph. K-Reactor operated for a part of 1992, so that year is not included in the graph.

can be 80 to 280 times greater than the doses that would have been received from inhalation alone. The ratio varies with age; food chain pathways for iodine-129 are more important for children than for adults [NCRP, 1983].

Food chain pathways also can be especially important for some radionuclides released in liquid effluents. The bioaccumulation factor is used to compare the radionuclide content in aquatic organisms with that in the water. For example, the site-specific estimate of the bioaccumulation factor for cesium-137 in freshwater fish is 3,000 L/kg. This means that if the cesium-137 concentration in water is 1 pCi/L, then the concentration of cesium-137 in fish living in the water will be approximately 3,000 pCi/kg. Consumption of 19 kilograms (about 42 pounds) of this fish per year will lead to a cesium-137 intake of about 57,000 pCi. That amount is considerably larger than the total intake from drinking 2 liters of the water each day for an entire year (about 730 pCi). Fish consumption, therefore, can be a more important source of cesium-137 than drinking the water in which the fish live.

These examples simply show the potential importance of food chain pathways for radionuclides with high biological activity. Actual values of bioaccumulation factors for cesium-137 and other nuclides depend on the species of fish, the concentrations of other elements in the water, and other site-specific factors. The uptake of airborne nuclides into food products similarly depends on local conditions.

Impact of Pathway Analysis on Environmental Monitoring

The atmospheric pathways analysis indicates the need to direct environmental monitoring efforts toward contaminants in air, vegetation, and milk. These media can be monitored with air sampling stations, thermoluminescent dosimeters, and analyses of food product samples. Based on the same modeling analysis, the principal radionuclides to monitor are identified.

In terms of the liquid pathways, tritium in drinking water and cesium-137 in fish are the most important radionuclides and media to monitor. Also, sediments may absorb certain radionuclides and some nonradioactive contaminants from surface water. Thus, sediments may represent long-term indicators of environmental quality for some contaminants and, therefore, are monitored regularly. As examples,

cerium, cesium, and plutonium typically accumulate in sediments, whereas tritium and carbon-14 typically remain in the water.

The environmental monitoring program incorporates information obtained from the liquid pathways models to determine what analyses are performed on sediment and surface water samples. As part of the monitoring program, surface water samples are analyzed for concentrations of tritium, gross alpha, nonvolatile beta, and gamma-emitting radionuclides. Sediment samples, on the other hand, are analyzed specifically for cesium-137, strontium-90, plutonium-238, and plutonium-239,240.

In direct response to pathway analysis, a specific change to the SRS environmental monitoring program will be made beginning in 1994: Seepage basin migration samples will be analyzed for iodine-129, which is somewhat mobile in the environment and has a very long half-life (15.7 million years). Because of the difficulty in analyzing for iodine-129 in the recent past (since the mid 1970's), yearly releases of it via seepage basin migration were estimated and not directly measured (see chapter 5, "Radiological Effluent Monitoring").

Groundwater modeling is useful in identifying the best location for monitoring wells and for predicting which contaminants are mobile and how fast they migrate. However, because groundwater flow is not as well defined as stream flow and cannot be observed as easily, groundwater models are considered less precise than models of stream water behavior.

A groundwater monitoring program should focus on contaminants that are the best indicators of leakage or contaminant movement. Tritium is the most mobile radionuclide. Other mobile radionuclides are carbon-14, technetium-99, and iodine-129. Many volatile organic compounds and inorganic compounds also are very mobile in groundwater.

At SRS, tritium oxide (tritium in the form of water) is the most abundant groundwater source term radionuclide. Sources of tritium in groundwater include liquid discharges to streams and basins, as well as rainfall removal of atmospheric tritium releases. Monitoring well samples are analyzed routinely for tritium oxide, the primary indicator of groundwater movement. Samples also are analyzed for other contaminants that may originate from the specific area being monitored.

Appendix B

SRS Environmental Permits

Listed below are the construction and operating permits held by SRS. The permits are divided by type of permit; for each type, the permit number, permit title, and permitted source are provided.

Air Permits

Permit Number	Permit Title
0080-0041-A-CA	VADOSE ZONE SOIL VAPOR EXTRACTION UNIT, A-014 OUTFALL
0080-0041-A-CB	250-GPM AIR STRIPPER, CATALYTIC OXIDATION UNIT
0080-0041-CS-CA	ABRASIVE-BLAST FACILITY, UNIT A, CENTRAL SHOPS
0080-0041-CS-CA	ABRASIVE-BLAST FACILITY, UNIT B, CENTRAL SHOPS
0080-0041-CS-CB	SPRAY PAINT BOOTH, CENTRAL SHOPS
0080-0041-H-CG	CONSOLIDATED INCINERATION FACILITY (CIF) FOR NONRADIOACTIVE HAZARDOUS WASTE, 261-H
0080-0041-H-CG	350-KW EMERGENCY-POWER DIESEL GENERATOR, 254-11H (CIF)
0080-0041-H-CG	350-KW EMERGENCY-POWER DIESEL GENERATOR, 254-12H (CIF)
0080-0041-M-CA	VADOSE ZONE SOIL VAPOR EXTRACTION UNIT, M-AREA SEWER
0080-0041-M-CB	VADOSE ZONE SOIL VAPOR EXTRACTION UNIT, M-AREA BASIN
0080-0041-M-CC	VADOSE ZONE SOIL VAPOR EXTRACTION UNIT, M-AREA SOLVENT STORAGE
0080-0041-PORT-CB	15,000-LB/HR PORTABLE PACKAGE STEAM GENERATOR #1, GENERAL SITE
0080-0041-PORT-CG	300-KW PORTABLE DIESEL GENERATOR, SRO #5430
0080-0041-PORT-CG	300-KW PORTABLE DIESEL GENERATOR, SRO #6455
0080-0041-PORT-CG	600-KW PORTABLE DIESEL GENERATOR, SRO #5422
0080-0042-CG	2500-GPM (370 BHP) DIESEL FIRE PUMP, CENTRAL SHOPS (MATERIAL MANAGEMENT, RECEIVING, & STORAGE)
0080-0042-CJ	SOLVENTS DISTILLATION & CONDENSATION PORTABLE UNIT #3, ALL AREAS
0080-0042-CJ	SOLVENTS DISTILLATION & CONDENSATION PORTABLE UNIT #4, ALL AREAS
0080-0042-CJ	SOLVENTS DISTILLATION & CONDENSATION PORTABLE UNIT #5, ALL AREAS
0080-0042-CN	OFF-GAS COMPONENTS TEST FACILITY, 678-T
0080-0043-CA	365-KW EMERGENCY-POWER DIESEL GENERATOR, 183-2C
0080-0045-CJ	455-KW EMERGENCY-POWER DIESEL GENERATOR, 720-F
0080-0045-CK	NEW SPECIAL-RECOVERY FACILITY, 221-F

Air Permits, continued

Permit Number	Permit Title
0080-0046-CE	150-KW EMERGENCY-POWER DIESEL GENERATOR, 241-96H
0080-0048-CB	800-KW EMERGENCY-POWER DIESEL GENERATOR-A, 107-3P
0080-0048-CC	800-KW EMERGENCY-POWER DIESEL GENERATOR-B, 107-2P
0080-0049-CB	800-KW EMERGENCY-POWER DIESEL GENERATOR-A, 107-L
0080-0049-CC	800-KW EMERGENCY-POWER DIESEL GENERATOR-B, 107-L
0080-0041-A-01	71.7-MMBTU/HR COAL BOILER #1, CYCLONES, 784-A
0080-0041-A-02	71.7-MMBTU/HR COAL BOILER #2, CYCLONES, 784-A
0080-0041-A-03	600-KW EMERGENCY-POWER DIESEL GENERATOR, 794-A
0080-0041-A-04	400-KW EMERGENCY-POWER DIESEL GENERATOR, 773-A
0080-0041-A-05	150-KW EMERGENCY-POWER DIESEL GENERATOR, 751-A
0080-0041-A-06	400-KW EMERGENCY-POWER DIESEL GENERATOR, 503-2A
0080-0041-A-07	200-KW EMERGENCY-POWER DIESEL GENERATOR, 703-A
0080-0041-A-08	250-KW EMERGENCY-POWER DIESEL GENERATOR, 754-4A
0080-0041-A-09	455-KW EMERGENCY-POWER DIESEL GENERATOR, 720-2A
0080-0041-A-10	1250-KW EMERGENCY-POWER DIESEL GENERATOR #1, 754-5A
0080-0041-A-11	1250-KW EMERGENCY-POWER DIESEL GENERATOR #2, 754-5A
0080-0041-A-12	70-GPM AIR STRIPPING COLUMN, A-001A OUTFALL
0080-0041-A-13	SOIL VAPOR EXTRACTION UNIT, OUTFALL A-014
0080-0041-A-14	155-KW EMERGENCY-POWER DIESEL GENERATOR, 737-2A
0080-0041-D-01	396-MMBTU/HR COAL BOILER #1, CYCLONES, ESP, 484-D
0080-0041-D-02	396-MMBTU/HR COAL BOILER #2, CYCLONES, ESP, 484-D
0080-0041-D-03	396-MMBTU/HR COAL BOILER #3, CYCLONES, ESP, 484-D
0080-0041-D-04	396-MMBTU/HR COAL BOILER #4, CYCLONES, ESP, 484-D
0080-0041-D-05	150-KW EMERGENCY-POWER DIESEL GENERATOR, 501-D
0080-0041-D-06	1.1-TON/HR REJECT SYSTEM, BAGHOUSE, 484-D
0080-0041-D-07	300-TON/HR COAL CRUSHER, 484-D
0080-0041-H-01	71.7-MMBTU/HR COAL BOILER #1, 2 CYCLONES, 784-H
0080-0041-H-02	71.7-MMBTU/HR COAL BOILER #2, 2 CYCLONES, 784-H
0080-0041-H-03	71.7-MMBTU/HR COAL BOILER #3, 2 CYCLONES, 784-H

Air Permits, continued

Permit Number	Permit Title
0080-0041-H-04	400-LB/HR TYPE "O" WASTE INCINERATOR, BAGHOUSE, & HEPA FILTERS, 230-H
0080-0041-H-05	SEPARATION PROCESS, 221-H
0080-0041-H-06	200-KW EMERGENCY-POWER DIESEL GENERATOR, 234-4H
0080-0041-H-07	200-KW EMERGENCY-POWER DIESEL GENERATOR, 299-1H
0080-0041-H-08	200-KW EMERGENCY-POWER DIESEL GENERATOR, 241-74H
0080-0041-H-09	250-KW EMERGENCY-POWER DIESEL GENERATOR, 254-1H
0080-0041-H-10	275-KW EMERGENCY-POWER DIESEL GENERATOR, 254-3H
0080-0041-H-11	300-KW EMERGENCY-POWER DIESEL GENERATOR, 221-HB
0080-0041-H-12	300-KW NORMAL/EMERGENCY-POWER DIESEL GENERATOR, 254-5H, #1
0080-0041-H-13	300-KW NORMAL/EMERGENCY-POWER DIESEL GENERATOR, 254-5H, #2
0080-0041-H-14	300-KW EMERGENCY-POWER DIESEL GENERATOR, 232-H
0080-0041-H-15	300-KW EMERGENCY-POWER DIESEL GENERATOR, 234-H
0080-0041-H-16	500-KW EMERGENCY-POWER DIESEL GENERATOR, 232-H, #2
0080-0041-H-17	500-KW EMERGENCY-POWER DIESEL GENERATOR, 254-H
0080-0041-H-18	600-KW EMERGENCY-POWER DIESEL GENERATOR, 292-H
0080-0041-H-19	1000-KW EMERGENCY-POWER DIESEL GENERATOR, 221-H
0080-0041-H-20	500-KW EMERGENCY-POWER DIESEL GENERATOR, 254-8H
0080-0041-H-21	400-KW EMERGENCY-POWER DIESEL GENERATOR, 254-9H
0080-0041-H-22	765-KW EMERGENCY-POWER DIESEL GENERATOR, 254-10H (RTF)
0080-0041-H-23	2500-GPM (330 BHP) DIESEL FIRE PUMP #1, 241-125H (ITP)
0080-0041-H-24	2500-GPM (330 BHP) DIESEL FIRE PUMP #2, 241-125H (ITP)
0080-0041-H-25	455-KW EMERGENCY-POWER DIESEL GENERATOR, 720-H
0080-0041-H-26	TANK 48H TO USE FOR IN-TANK PRECIPITATION (ITP) PROCESS
0080-0041-H-27	TANK 49H TO USE FOR IN-TANK PRECIPITATION (ITP) PROCESS
0080-0041-H-28	STRIPPER BUILDING STACK FOR IN-TANK PRECIPITATION (ITP) PROCESS
0080-0041-H-29	SODIUM TETRAPHENYLBORATE (STPB) TANK TO USE FOR IN-TANK PRECIPITATION (ITP) PROCESS
0080-0041-H-30	TANK 50H TO USE FOR IN-TANK PRECIPITATION (ITP) PROCESS
0080-0041-H-31	TANK 22H TO USE FOR IN-TANK PRECIPITATION (ITP) PROCESS

Air Permits, continued

Permit Number	Permit Title
008G-0041-K-01	194.5-MMBTU/HR COAL BOILER, CYCLONES, UNIT #1
0080-0041-K-03	1250-KW EMERGENCY-POWER DIESEL GENERATOR, 108-1K
0080-0041-K-04	1250-KW EMERGENCY-POWER DIESEL GENERATOR, 108-2K
0080-0041-K-05	150-KW EMERGENCY-POWER DIESEL GENERATOR #1, 108-4K
0080-0041-K-06	150-KW EMERGENCY-POWER DIESEL GENERATOR #2, 108-4K
0080-0041-K-07	200-KW EMERGENCY-POWER DIESEL GENERATOR, 152-7K
0080-0041-K-08	365-KW EMERGENCY-POWER DIESEL GENERATOR, 183-3K
0080-0041-K-09	520-BHP EMERGENCY DIESEL BOOSTER PUMP, 191-K
0080-0041-K-10	800-KW EMERGENCY-POWER DIESEL GENERATOR-A, 107-K
0080-0041-K-11	800-KW EMERGENCY-POWER DIESEL GENERATOR-B, 107-K
0080-0041-K-12	76.8-MMBTU/HR NO. 2 FUEL OIL-FIRED BOILER (NSPS SOURCE), K-AREA
0080-0041-K-13	38-MMBTU/HR NO. 2 FUEL OIL-FIRED PACKAGE STEAM GENERATOR RATED AT 30,000-LB/HR STEAM PRODUCTION (NSPS SOURCE), K-AREA
0080-0041-PORT-01	SOLVENTS DISTILLATION & CONDENSATION UNIT #1, ALL AREAS
0080-0041-PORT-02	SOLVENTS DISTILLATION & CONDENSATION UNIT #2, ALL AREAS
0080-0041-PORT-03	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-112, ALL AREAS
0080-0041-PORT-04	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-113, ALL AREAS
0080-0041-PORT-05	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-114, ALL AREAS
0080-0041-PORT-06	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-115, ALL AREAS
0080-0041-PORT-07	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-116, ALL AREAS
0080-0041-PORT-08	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-128, ALL AREAS
0080-0041-PORT-09	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-129, ALL AREAS
0080-0041-PORT-10	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-130, ALL AREAS
0080-0041-PORT-11	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-131, ALL AREAS
0080-0041-PORT-12	PORTABLE DIESEL-POWERED AIR COMPRESSOR, SME 52-132, ALL AREAS
0080-0041-PORT-13	200-KW MOBILE EMERGENCY GENERATOR, SME 60-171, ALL AREAS
0080-0041-PORT-14	15,000-LB/HR PORTABLE PACKAGE-STEAM-GENERATING BOILER #2 (NSPS), ALL AREAS
0080-0041-PORT-15	PORTABLE NORKOT MAXIGRIND 9100 DIESEL-POWERED CHIPPER UNIT, ALL AREAS

Air Permits, continued

Permit Number	Permit Title
0080-0041-PORT-16	190-KW MOBILE EMERGENCY GENERATOR, SRO #0391, ALL AREAS
0080-0041-PORT-17	250-KW MOBILE EMERGENCY GENERATOR, SRO #7835, ALL AREAS
0080-0041-S-05	2050-KW EMERGENCY-POWER DIESEL GENERATOR #1, 292-S
0080-0041-S-06	2050-KW EMERGENCY-POWER DIESEL GENERATOR #2, 292-S
0080-0041-S-07	261-BHP EMERGENCY FIRE WATER PUMP, 980-S
0080-0041-S-08	DWPF VITRIFICATION BUILDING (PROVIDES VENTILATION FOR PERSONNEL CORRIDOR, LABORATORIES, WELD TEST, & CHEMICAL STORAGE TANKS -- ZONE 2, 221-S), HEPA FILTER
0080-0041-S-09	DWPF PROCESS STACK (PROVIDES VENTILATION FOR PROCESS CELLS, PROCESS VESSEL VENT, & MELTER OFF-GAS -- ZONE 1, 291-S), SAND FILTER
0080-0041-S-10	DWPF COLD-FEEDS FACILITY (CHEMICAL STORAGE TANKS FOR FORMIC ACID, HYDROXYLAMINE NITRATE, OXALIC ACID, NITRIC ACID, SODIUM HYDROXIDE, & A GLASS-FRIT HANDLING SYSTEM WITH BAGHOUSE, 422-S)
0080-0041-S-11	DWPF 150,000-GAL ORGANIC-WASTE STORAGE TANK VENT (BENZENE STORAGE, 430-S), INTERNAL FLOATING ROOF WITH PRIMARY & SECONDARY SEALS, NITROGEN BLANKET, & HEPA FILTER
0080-0041-S-12	DWPF LOW-POINT PUMP PIT (TRANSFER OF RADIOACTIVE SLURRIES & SOLUTIONS, 511-S), HEPA FILTERS
0080-0041-S-13	DWPF AUXILIARY PUMP PIT (TRANSFER OF RADIOACTIVE SLURRIES & SOLUTIONS, 512-S), HEPA FILTERS
0080-0041-T-02	300-KW EMERGENCY-POWER DIESEL GENERATOR, 673-T
0080-0041-T-03	300-KW EMERGENCY-POWER DIESEL GENERATOR, 672-T
0080-0041-T-04	20-LB/HR SHIRCO INCINERATOR, HEPA FILTERS, 677-T
0080-0041-T-05	PRECIPITATE HYDROLYSIS EXPERIMENTAL FACILITY, 682-T
0080-0041-T-06	1000-KW EMERGENCY-POWER DIESEL GENERATOR, 654-1T
0080-0041-T-07	300-KW EMERGENCY-POWER DIESEL GENERATOR, 654-T
0080-0045-05	URANIUM DISSOLUTION, 221-F
0080-0045-06	200-KW CONTINUOUS RUNNING DIESEL GENERATOR, 254-5F #1
0080-0045-07	200-KW CONTINUOUS RUNNING DIESEL GENERATOR, 254-5F #2
0080-0045-08	175-KW EMERGENCY-POWER DIESEL GENERATOR, 772-F #1
0080-0045-09	175-KW EMERGENCY-POWER DIESEL GENERATOR, 772-F #2
0080-0045-10	350-KW EMERGENCY-POWER DIESEL GENERATOR, 241-19F
0080-0045-11	350-KW EMERGENCY-POWER DIESEL GENERATOR, 235-F

Air Permits, continued

Permit Number	Permit Title
0080-0045-12	350-KW EMERGENCY-POWER DIESEL GENERATOR, 254-4F
0080-0045-13	250-KW EMERGENCY-POWER DIESEL GENERATOR, 254-1F
0080-0045-14	200-KW EMERGENCY-POWER DIESEL GENERATOR, 241-74F
0080-0045-15	600-KW EMERGENCY-POWER DIESEL GENERATOR, 292-F
0080-0045-16	600-KW EMERGENCY-POWER DIESEL GENERATOR, 247-1F NAVAL FUEL (FMF)
0080-0045-17	315-KW EMERGENCY-POWER DIESEL GENERATOR, 221-FB
0080-0045-18	415-KW EMERGENCY-POWER DIESEL GENERATOR, 772-1F
0080-0045-19	300-KW EMERGENCY-POWER DIESEL GENERATOR, 292-2F
0080-0045-20	300-KW EMERGENCY-POWER DIESEL GENERATOR, 254-9F
0080-0045-21	1000-KW EMERGENCY-POWER DIESEL GENERATOR, 221-F
0080-0045-22	600-KW EMERGENCY-POWER DIESEL GENERATOR, 254-10F
0080-0045-23	350-KW EMERGENCY-POWER DIESEL GENERATOR, 254-8F
0080-0045-24	NAVAL FUEL MATERIALS FACILITY (FMF) MAIN STACK - (SCRUBBERS & HEPA FILTERS), 247-F
0080-0045-25	NAVAL FUEL (FMF) WASTEWATER TREATMENT FACILITY - (DEMISTER), 247-F
0080-0045-26	NINE FINISHING PROCESSES FOR NAVAL FUEL (FMF), 247-F
0080-0048-02	194.5-MMBTU/HR COAL BOILER, CYCLONES, 184-P #2
0080-0048-03	1250-KW EMERGENCY-POWER DIESEL GENERATOR, 108-1P
0080-0048-04	1250-KW EMERGENCY-POWER DIESEL GENERATOR, 108-2P
0080-0048-05	150-KW EMERGENCY-POWER DIESEL GENERATOR, 108-4P, #1
0080-0048-06	150-KW EMERGENCY-POWER DIESEL GENERATOR, 108-4P, #2
0080-0048-07	200-KW EMERGENCY-POWER DIESEL GENERATOR, 152-7P
0080-0048-08	365-KW EMERGENCY-POWER DIESEL GENERATOR, 183-2P
0080-0048-09	520-BHP EMERGENCY DIESEL BOOSTER PUMP, 191-P
0080-0049-01	1250-KW EMERGENCY-POWER DIESEL GENERATOR, 108-1L
0080-0049-02	1250-KW EMERGENCY-POWER DIESEL GENERATOR, 108-2L
0080-0049-03	520-BHP EMERGENCY DIESEL BOOSTER PUMP, 191-L
0080-0049-04	150-KW EMERGENCY-POWER DIESEL GENERATOR, 108-4L, #1
0080-0049-05	150-KW EMERGENCY-POWER DIESEL GENERATOR, 108-4L, #2

Air Permits, continued

Permit Number	Permit Title
0080-0049-06	200-KW EMERGENCY-POWER DIESEL GENERATOR, 152-7L
0080-0049-07	365-KW EMERGENCY-POWER DIESEL GENERATOR, 183-2L
0080-0055-02	ALUMINUM-TUBE CLEANING WITH NITRIC ACID, 321-M
0080-0055-03	200-KW EMERGENCY-POWER DIESEL GENERATOR, 320-M
0080-0055-04	610-GPM AIR STRIPPER, M-AREA
0080-0041-Z-01	425-KW EMERGENCY-POWER DIESEL GENERATOR, Z-AREA
0080-0041-Z-02	SILO TO STORE CEMENT OR SLAG, WITH BAGHOUSE, Z-AREA
0080-0041-Z-03	THREE FLY-ASH/CEMENT SILOS WITH BAGHOUSE, Z-AREA
0080-0041-Z-04	WEIGH HOPPER WITH BAGHOUSE, Z-AREA
0080-0041-Z-05	TWO PREMIX AIR BLENDERS WITH BAGHOUSE, Z-AREA
0080-0041-Z-06	PREMIX FEED BIN WITH BAGHOUSE, Z-AREA
0080-0041-Z-07	GROUT MIXER WITH BAGHOUSE, SCRUBBER, & 2 HEPA FILTERS (ONE IN SERVICE, ONE STANDBY), Z-AREA
0080-0041-Z-08	LOW-POINT DRAIN TANK VENT WITH HEPA FILTER, Z-AREA

C.O.E. 404 (Dredge & Fill) Permit

Permit Number	Permit Title
84-2Z-209	RAW-WATER INTAKE CANALS (681-1G, 681-3G, & 681-5G) ON SAVANNAH RIVER

Domestic Water Permits

SCDHEC has granted WSRC-EPD the authority—under the Modified Permitting Program (MPP)—to review domestic water construction permit application packages and to issue domestic water construction and operating permits on behalf of SCDHEC. (Several South Carolina municipalities have similar agreements with SCDHEC.) All domestic water permits listed in this report that begin with "M" fall under the MPP.

Permit Number	Permit Title
111626	UPGRADE GASEOUS CHLORINATION FACILITY, 683-D
202822	D-AREA DOMESTIC WATER SYSTEM (TEST WELL #2, "DIVISION B")
203427	SODIUM HYPOCHLORITE SYSTEM, 280-F
203467	SODIUM HYPOCHLORITE SYSTEM, 280-H
206501	B-AREA DOMESTIC WATER DEEP WELL, 905-125B (TEST WELL)
206501A1	B-AREA DOMESTIC WATER DEEP WELL, 905-125B (PUMP/PIPING/TREATMENT)

Domestic Water Permits, continued

Permit Number	Permit Title
304134	TNX-AREA WATER TREATMENT PLANT MODIFICATIONS
401354	250,000-GAL DOMESTIC WATER STORAGE TANK, A-AREA
401654	B-AREA WATER TREATMENT PLANT MODIFICATIONS
411337	SODIUM HYPOCHLORITE SYSTEM, 780-1A
LS89028	DOMESTIC WATER TO SERVE GENERAL PHYSICS OFFICE, 777-18A
LS89029	MATERIAL MANAGEMENT, RECEIVING, & STORAGE FACILITIES FIRE TANK MAKE-UP
200092	DEEP WELLS, 905-104L, 904-105L
200279	INSTALL DOMESTIC WATER DEEP WELL, 905-120P, P-AREA
201715	DOMESTIC WATER DEEP WELL, RAILROAD CLASSIFICATION YARD, 905-107G
202822A1	D-AREA DOMESTIC WATER SYSTEM (TEST WELL #1, "DIVISION A")
202822A1	D-AREA DOMESTIC WATER SYSTEM (PUMP, PIPING, TREATMENT, STORAGE TANK)
202915	WATER SUPPLY & WELL SYSTEM, DWPF CONSTRUCTION SUPPORT AREA, S-AREA
203590	100-AREA FIRE STATION WELL, 709-1G (INTERSECTION OF ROAD C & ROAD 7)
203628	REPLACE PISTOL RANGE WELL
203638	REPLACE ALLENDALE BARRICADE WELL
203786	DRINKING WATER WELL, 905-114G, TO SERVE 681-3G
204138	INSTALL DOMESTIC WATER DEEP WELL, 905-106K (REPLACE WELL 905-94K)
204198	REPLACE DOMESTIC WATER DEEP WELL, 905-66H
205142	POLYPHOSPHATE SYSTEMS, 200-F AREA
205217	UPGRADE INSTRUMENTATION, 280-1H (F-Area also covered under this permit)
205217	UPGRADE INSTRUMENTATION, 280-1F (H-Area also covered under this permit)
205702	POLYPHOSPHATE SYSTEMS, 200-H AREA
205877	AUGUSTA BARRICADE WATER WELL, 905-116G
206575	DOMESTIC WATER DEEP WELLS & DISTRIBUTION LINE, A-AREA
207005	ACTIVATED CARBON TREATMENT SYSTEM, 3/700 AREA
207853A1	D-AREA DOMESTIC WATER SYSTEM (BACKUP TEST WELL)
207853A1	D-AREA DOMESTIC WATER SYSTEM (BACKUP PUMP, PIPING, TREATMENT, STORAGE TANK)

Domestic Water Permits, continued

Permit Number	Permit Title
208425 & 208425A1	ATTA DOMESTIC WATER SYSTEM
208434	DOMESTIC WATER SYSTEM, BARRICADES 701-8G, 701-12G, 701-13G
208866	DOMESTIC WATER WELL FOR AIKEN BARRICADE GATE HOUSE (701-5G)
209191A1	PAR POND DOMESTIC WATER TEST WELL
209191A1	PAR POND DOMESTIC WATER TEST WELL (PUMP, PIPING, TREATMENT, STORAGE TANK)
209454	TNX DOMESTIC WATER SYSTEM & WELL
210657	INSTALL DOMESTIC WATER DEEP WELL, 905-103F (REPLACE WELL 905-39F), & DISTRIBUTION SYSTEM
212745	DWPF DOMESTIC WATER WELLS 1 & 2, S-AREA
400203	TNX-AREA HYDROPNEUMATIC DOMESTIC WATER STORAGE TANK
400347	DOMESTIC WATER HEADERS, TNX-AREA
400737	WATER LINE, DWPF, Z-AREA
401118	DOMESTIC WATER FOR NEW WASTE TRANSFER FACILITY (NWTF)
401446	PRODUCTION CONTROL FACILITY FOR 200-AREA PROCESS, 772-1F
402186	DWPF DOMESTIC WATER DISTRIBUTION SYSTEM, S-AREA
402343	H-AREA BACKUP BOOSTER PUMP ("AS BUILT")
402874	SEGREGATED DOMESTIC WATER SUPPLY, 300/700 AREA, PHASE I
402925-R1	DWPF BACKUP DOMESTIC WATER SYSTEM, S-AREA
403434	SEGREGATED DOMESTIC WATER SUPPLY, 300/700 AREA, PHASE II
404608	717-K DOMESTIC WATER
404618	705-C DOMESTIC WATER
405092M	K-AREA THERMAL MITIGATION SYSTEM
407123M	B-AREA ENGINEERING & OPERATIONS SUPPORT FACILITY
405184	WATER LINE, 773-41A, 773-42A
405556	DOMESTIC WATER SYSTEM, 200-H
405566	UPGRADE DOMESTIC WATER SYSTEM, 200-F
406137	DOMESTIC WATER TO SERVE INTERIM STORAGE & REDRUMMING FACILITY, 645-1N & 645-2N (FORMERLY 709-1G & 709-2G)
406871E1	DOMESTIC WATER TO SERVE B-AREA ENGINEERING CENTER, 730-B

Domestic Water Permits, continued

Permit Number	Permit Title
407830	MATERIAL MANAGEMENT RECEIVING & STORAGE FACILITY, CENTRAL SHOPS
408221	K-AREA DOMESTIC WATER TREATMENT & DISTRIBUTION SYSTEM UPGRADE
408285	DOMESTIC WATER TO SERVE TNX-AREA SANITARY WASTEWATER TREATMENT FACILITY
408552	K-AREA FILTER BACKWASH SYSTEM
408595	DOMESTIC WATER LINE, CONSTRUCTION OFFICE BUILDING, 300-M
409484	WATER LINE, REACTOR SIMULATOR FACILITY, 707-C
409955	DOMESTIC WATER & FIRE PROTECTION FOR HELICOPTER FACILITY, 703-5G & 703-6G
410406	DOMESTIC WATER TO SERVE VEHICLE PROTECTION SHELTER SAFETY SHOWER & EYE-WASH STATION, 777-A
411357	ETF-H LIFT STATION DOMESTIC WATER
411995	WATER DISTRIBUTION SYSTEM, 340-M, 341-M
412255	DOMESTIC WATER FROM DOMESTIC WATER DEEP WELLS (905-112G & 905-113G) TO SERVE A-AREA
412917	DRINKING WATER SYSTEM, ETF, 241-84H, 241-81H
48061	TEMPORARY WATER SYSTEM, 905-104L, 904-105L
LS-1-W	WATER LINE, TRITIUM FACILITIES SUPPORT BUILDING, 235-H
LS-106-W	DWPF AUXILIARY-PUMP-PIT WATER LINES, S-511
LS-11-W	WATER LINE, NAVAL FUEL MATERIAL FACILITY (FMF), 247-F
LS-115-W	WATER LINE, CRAFTS & ENGINEERS, CAB/CENTRAL SHOPS
LS-118-W	DOMESTIC WATER TO SERVE 719-4A
LS-119-W	WATER LINE, 730-M
LS-139-W	REPLACEMENT TRITIUM FACILITY (RTF) DOMESTIC WATER, 233-H & 249-H
LS-168-W	DOMESTIC WATER TO SERVE SUPPORT SERVICES BUILDING, 716-2A
LS-178-W	DOMESTIC WATER TO SERVE COMPUTER REPAIR BUILDING, 722-5A
LS-185-W	DOMESTIC WATER TO SERVE 703-41A
LS-187-W	ETF-F LIFT STATION, DOMESTIC WATER
LS-232-W	TEMPORARY DOMESTIC WATER FOR FPF & RTF FACILITIES
LS-233-W	TEMPORARY DOMESTIC WATER TO SERVE F/H ETF CONSTRUCTION OFFICE
LS-238-W	ECF/CAS SECURITY UPGRADE FACILITIES, H-AREA (720-H & 701-3H)

Domestic Water Permits, continued

Permit Number	Permit Title
LS-25-W	CHEMICAL FEED FACILITY WATER SYSTEM, 100-C
LS-264-W	CENTRAL SHOPS CONSTRUCTION DIVISION QUALITY OFFICE BUILDING
LS-265-W	DOMESTIC WATER SUPPLY FOR EQUIPMENT STORAGE & HEALTH PROTECTION (HP) FACILITY, 221-25F
LS-4-W	WATER LINE, OFFICE BUILDING, 703-41A
LS-43-W	"AS BUILT" DOMESTIC WATER TO SERVE 773-A, 773-41A, & 773-42A
LS-55-W	DOMESTIC WATER SUPPLY FOR CHEMICAL FEED FACILITIES IN G & H AREAS (G-AREA)
LS-56-W	DOMESTIC WATER SUPPLY FOR CHEMICAL FEED FACILITIES IN G & H AREAS (H-AREA)
LS-57-W	DOMESTIC WATER TO SERVE RADIOLOGICAL & ENVIRONMENTAL SUPPORT FACILITY, 735-11A
LS-60-W	DOMESTIC WATER LINE FOR 704-S ADMINISTRATION BUILDING, S-AREA
LS-61-W	DOMESTIC WATER LINE TO FEED DWPF SANITARY TREATMENT PLANT, S-AREA
LS-7-W	WATER LINE, NAVAL FUEL MATERIAL FACILITY (FMF), 221-17F, 221-18F
LS-8-W	WATER LINE, 703-4A, 703-6A, 703-34A
LS-81-W	DOMESTIC WATER FOR CONSTRUCTION OFFICE BUILDING, C-AREA
LS-82-W	DOMESTIC WATER FOR SANITARY TREATMENT FACILITY, B-AREA
LS-91009	DOMESTIC WATER TO SERVE TEMPORARY MODULAR OFFICE TRAILERS 245-F THROUGH 245-12F
LS89002	TEMPORARY MODULAR OFFICES, 100-C
LS89008	EXPANSION OF DOMESTIC WATER & FIRE PROTECTION TO SERVE MODULAR OFFICES, B-AREA
LS89016	RELOCATION OF DOMESTIC WATER LINE AT L-AREA SANITARY-FLOW EQUALIZATION BASIN
LS89017	TEMPORARY MODULAR OFFICE TRAILERS 707-7K THROUGH 707-19K
LS89020	INSTALL BLOCK VALVE ON 200-F-AREA WELL WATER HEADER
LS91001	TEMPORARY MODULAR OFFICE TRAILERS 773-62A THROUGH 773-70A
LS91005	DOMESTIC WATER LINE TO FILL IN-TANK PRECIPITATION (ITP) FIRE TANK, 241-20H
LS91006	DOMESTIC WATER LINE TO FILL IN-TANK PRECIPITATION (ITP) FIRE TANK, 241-21H
LS91007	REROUTE DOMESTIC WATER LINE-REPLACEMENT HIGH-LEVEL EVAPORATOR, H-AREA

Domestic Water Permits, continued

Permit Number	Permit Title
LS91010	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, B-AREA
LS91011	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, 3/700-AREA
LS91012	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, C-AREA
LS91013	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, N-AREA
LS91014	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, D-AREA
LS91015	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, FORESTRY AREA
LS91016	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, L-AREA
LS91017	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, P-AREA
LS91018	UPGRADE DOMESTIC WATER SYSTEMS INSTRUMENTS, RAILROAD YARD
M0012E2	B-AREA FIRE PROTECTION SUPPLY SYSTEM
M0013	221-S NITRIC-TANK SAFETY SHOWER/EYE-WASH STATION
M0014	225-H, TRAINING CENTER
M0022	183-2P, PORTABLE BOILER INSTALLATION
M0023	261-H, CONSOLIDATED-INCINERATION FACILITY
M0024	315-M, ESSENTIAL-MATERIALS WAREHOUSE REROUTE
M0032	183-2K, PORTABLE BOILER INSTALLATION
M0033	F-AREA & E-ROAD FIRE PROTECTION SUPPLY
M0042E1	773-72A, LUNCHROOM TRAILER
M0043	704-2H, OPERATION SUPPORT BUILDING
M0052	740-16A, LUNCHROOM TRAILER
M0053	221-S LAB TRAILERS SAFETY SHOWER/EYE-WASH STATION
M0063R1	708-1B, ADMINISTRATIVE SUPPORT BUILDING
M0072E1	731-5G, FLAMMABLE STORAGE FACILITY
M0073	228-H, SAFEGUARDS & HEALTH PROTECTION SHOP
M0082	717-11A, CSWE WORKS ENGINEERING FACILITY
M0083	704-11K, RESTROOM TRAILER
M0092	707-7F, ENGINEERING SUPPORT BUILDING
M0093	D-AREA BACKUP WELL CONNECTOR
M0102	233-20H, 233-21H, TEMPORARY MODULAR OFFICES

Domestic Water Permits, continued

Permit Number	Permit Title
M0103	740-4A, DRINKING WATER FOUNTAIN
M0112	742-G, 742-1G THROUGH 742-14G, TEMPORARY MODULAR OFFICES
M0113	704-11K, 704-12K, & 705-K SUPPLY LINE
M0122	773-71A, SRTC MODULAR RESTROOM UNIT
M0123	673-T, 678-T, & 679-8T SAFETY SHOWERS
M0133	707-18B OFFICE TRAILER

Industrial Wastewater Permits

Permit Number	Permit Title
12888	METALLURGICAL LABORATORY NEUTRALIZATION FACILITY, 723-A
13456	L-TANK "AS BUILT," SRTC
14214	MODIFICATIONS TO NAVAL FUEL (FMF) WASTEWATER TREATMENT FACILITY, BATCH MIXER SYSTEM
16119	F/H ETF PERMANENT pH ADJUSTMENT SYSTEM
17022	UPGRADE D-AREA NEUTRALIZATION FACILITY, 483-1D
17587-IW	TNX-AREA CROSS-FLOW FILTER TEST FACILITY
17588-IW	MOBILE TRICKLE FLOW BIOREACTOR SYSTEM TO BE USED IN A, M, AND TNX AREAS
17596-IW	DWPF PRECIPITATE FEED LATE-WASH FACILITY
10253	M-AREA 610-GPM AIR STRIPPER
10287	LIQUID EFFLUENT TREATMENT FACILITIES (LETF), 300-M
10349	672-T TNX PROCESS SEWER TO OUTFALL X-008
10358	S-AREA OIL/WATER SEPARATOR
10389	M-AREA DRAIN LINE
10469	735-11A LAB BUILDING PROCESS SEWER SYSTEM NEUTRALIZATION FACILITY, 607-17A
10475	NONCONTACT COOLING WATER DIVERSION, 300-M-AREA
10696	INTERIM SLUDGE STORAGE TANK, M-AREA
10765	WASTEWATER NEUTRALIZATION FACILITY, 704-B
10920	SREL WASTEWATER DISINFECTION FACILITY
10949	TRADE WASTE FLOW EQUALIZATION TANK, 607-18A, FOR 703-43A SILVER RECOVERY

Industrial Wastewater Permits, continued

Permit Number	Permit Title
10955	DWPF CONCRETE BATCH PLANT WASTEWATER TREATMENT POND, S-AREA
11406	FIRE BRIGADE TRAINING FACILITIES OIL/WATER SEPARATOR, 411-D
11411	DWPF TREATED EFFLUENT LINE, S-AREA
11413	DWPF CHEMICAL TREATMENT FACILITY, S-AREA
11497	PRODUCTION CONTROL FACILITY SANITARY/PROCESS SEWER, 772-1F
11498	FLOW MONITORING STATION FOR NPDES OUTFALL, L-007
11588	POWERHOUSE EFFLUENT DIVERSION TO ASH BASINS, 200-D (H-AREA also covered under this permit)
11588	POWERHOUSE EFFLUENT DIVERSION TO ASH BASINS, 200-H (D-AREA also covered under this permit)
11589	POWERHOUSE EFFLUENT DIVERSION TO ASH BASIN, 184-P (184-K also covered under this permit)
12622	ORGANICS REMOVAL FACILITY (ORF), TNX
12633	TNX-AREA EFFLUENT TREATMENT PLANT (ETP)
12683	INDUSTRIAL WASTEWATER TREATMENT FACILITY TO SERVE Z-AREA SALT STONE MANUFACTURING FACILITY
12782	REPLACEMENT TRITIUM FACILITY (RTF) PROCESS SEWER
12870	F/H EFFLUENT TREATMENT FACILITY (ETF)
12894	FILTRATE HOLD-TANK COVERS, M-AREA
12922	MODIFICATIONS TO NAVAL FUEL (FMF) WASTEWATER TREATMENT FACILITY, PIPING MODIFICATIONS
12973	P-AREA NEUTRALIZATION FACILITY, 183-2P
13105	ETF PROCESS SEWER LINES, F/H-AREA
13154	FLOW MEASUREMENT DEVICE, L-AREA
13354	D-AREA NEUTRALIZATION FACILITY, 483-1D
13355	F-AREA NEUTRALIZATION FACILITY, 280-1F
13356	H-AREA NEUTRALIZATION FACILITY, 280-H
13357	K-AREA NEUTRALIZATION FACILITY, 183-2K
13431	FLUME AT M-004 OUTFALL
13735	INDUSTRIAL WASTEWATER pH CONTROL SYSTEM, 211-F
13978	TNX ION EXCHANGE FACILITY

Industrial Wastewater Permits, continued

Permit Number	Permit Title
14020	MERCURY & ORGANIC REMOVAL FACILITY FOR F/H ETF
14100	REPAIR ASH BASIN DIKE, 488-1D
14218	NPDES OUTFALL STRUCTURES, F-012 & F-013 (FLOW MONITORING WEIR BOX STRUCTURES)
14219	NPDES OUTFALL STRUCTURES, H-017 & H-018 (FLOW MONITORING WEIR BOX STRUCTURES)
14338	"AS-BUILT" H-Z INTERAREA SALT SOLUTION TRANSFER LINE
14379	UPPER THREE RUNS CREEK DIFFUSER FOR F/H ETF OUTFALL, H-016
14520	"AS BUILT" F/H ETF TANK 50
14624	EXISTING F/H ETF-AREA PROCESS SEWER LINES
14832	MODIFICATION TO M-AREA LIQUID EFFLUENT TREATMENT FACILITIES (LETF), SUPERNATANT TRANSFER & POLYMER ADDITION SYSTEMS
15256	EVAPORATOR RECYCLE LINE FOR F/H ETF
15467	UPGRADE PROCESS SEWERS, 211-F/H ETF (211-F/H)
15892	F/H ETF INTERIM pH ADJUSTMENT SYSTEM (CAUSTIC & ACID SUPPLY)
16449	K-REACTOR EMERGENCY RETENTION BASIN PERCOLATION DRAINFIELD
16478	FOUNDATIONS & SUPPORTING STRUCTURE SURROUNDING CWST, K-AREA RETENTION BASIN
16614	K-REACTOR EMERGENCY RETENTION BASIN LINER & COVER
16783	"AS BUILT" DWPF INDUSTRIAL WASTEWATER TREATMENT FACILITY, S-AREA
16785	K-AREA NATURAL-DRAFT COOLING TOWER THERMAL MITIGATION
16797	(70-GPM AIR STRIPPER) PROTOTYPE AIR STRIPPER COLUMN RELOCATION & RECOVERY WELL INSTALLATION
16938	K-REACTOR RETENTION BASIN, UMBRELLA-TOP STRUCTURE
17424-IW	"AS BUILT" F-AREA HIGH-LEVEL RADIOACTIVE WASTE TANK FARMS (H-Area also covered under this permit)
17424-IW	"AS BUILT" H-AREA HIGH-LEVEL RADIOACTIVE WASTE TANK FARMS (F-Area also covered under this permit)
17434-IW	TNX-AREA TRICKLE-FLOW BIOREACTOR UNIT
7289	"AS BUILT" WASTEWATER TREATMENT FACILITIES, A-AREA (M-AREA also covered under this permit)
7289	"AS BUILT" WASTEWATER TREATMENT FACILITIES, M-AREA (A-AREA also covered under this permit)
7290	"AS BUILT" WASTEWATER TREATMENT FACILITIES, F-AREA

Industrial Wastewater Permits, continued

Permit Number	Permit Title
7291	"AS BUILT" WASTEWATER TREATMENT FACILITIES, H-AREA
7292	"AS BUILT" WASTEWATER TREATMENT FACILITIES, P-AREA
7293	"AS BUILT" WASTEWATER TREATMENT FACILITIES, K-AREA
7294	"AS BUILT" WASTEWATER TREATMENT FACILITIES, C-AREA
7295	"AS BUILT" WASTEWATER TREATMENT FACILITIES, D-AREA
7296	"AS BUILT" WASTEWATER TREATMENT FACILITIES, N-AREA
9974	DWPF CONCRETE BATCH PLANT WASTEWATER TREATMENT POND DECANT STRUCTURE, S-AREA
LS-112-S	FIRE TRAINING FACILITY PROCESS SEWER, 904-D
LS-42-S	INERT L-FACILITY LOADING DOCK SEWER RELOCATION, 234-H

NPDES – Discharge Permits

Permit Number	Permit Title
SC0000175	76 OUTFALLS AT SAVANNAH RIVER SITE
SC0044903	SIX OUTFALLS AT SAVANNAH RIVER SITE

NPDES – No-Discharge Permit

Permit Number	Permit Title
ND0072125	SRS SANITARY SLUDGE LAND APPLICATION SITE, FORESTS (SLUDGE FROM ALL SANITARY WASTEWATER TREATMENT PLANTS)

NPDES – Stormwater Permits

Permit Number	Permit Title
SCR000000	48 INDUSTRIAL STORMWATER OUTFALLS AT SAVANNAH RIVER SITE
SCR100000	TWO NPDES-PERMITTED CONSTRUCTION STORMWATER SITES AT SAVANNAH RIVER SITE

RCRA Permit

Permit Number	Permit Title
SCI890008989	FIVE PERMITTED RCRA FACILITIES AT SAVANNAH RIVER SITE

Sanitary Wastewater Permits

Permit Number	Permit Title
16784	TNX-AREA SANITARY WASTEWATER TREATMENT PLANT (607-40T) EFFLUENT REROUTE FROM OUTFALL X-013 TO X-008A
17273-IW	SANITARY SEWER TO SERVE 704-49S OFFICE BUILDING
17528-IW	SANITARY SEWER TO SERVE ENGINEERING SUPPORT FACILITY, 730-1B, & OPERATIONS SUPPORT FACILITIES, 730-2B & 730-4B
LS-354-S	SANITARY SEWER TO SERVE GENERAL PHYSICS OFFICE, 777-18A
02-91040041	SEPTIC TANK & TILE FIELD TO SERVE OFFICE BUILDING, 704-56H (A.K.A. 5002-H)
02-92080098	SEPTIC TANK & TILE FIELD TO SERVE SREL PAR POND LABORATORY, 737-G
10131-P	SEPTIC TANK & TILE FIELD TO SERVE TOILET TRAILER, 704-47H, & OFFICES, 704-27H, 704-32H, 704-37H, & 704-42H
10132-P	SEPTIC TANK & TILE FIELD TO SERVE 704-44S, 704-45S, & 704-46S (FORMERLY FPF CONSTRUCTION ENGINEERS' OFFICE, 225-1H, 225-2H, & 225-3H)
10236	SANITARY SEWER SYSTEM (LIFT STATION & SEWER LINE) TO SERVE CHANGE STATION FACILITY, 241-58H
10314	DWPF CONSTRUCTION SITE SANITARY SEWER SYSTEM, S-AREA
10499	SANITARY SEWER TO SERVE DWPF, 200-S
10521	CHEMICAL FEED FACILITY (607-16A) FOR A-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7-1A, 607-7-2A, & 607-23A
10522	CHEMICAL FEED FACILITY (607-19F) FOR F-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7F & 607-21F
10523	CHEMICAL FEED FACILITY (607-20H) FOR H-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7H & 607-21H
10524	CHEMICAL FEED FACILITY (607-22P) FOR P-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7P & 607-23P
10525	CHEMICAL FEED FACILITY (607-38N) FOR N-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-18N & 607-42N
10526	CHEMICAL FEED FACILITY (607-14D) FOR D-AREA SANITARY WASTEWATER TREATMENT PLANT, 607-15D
10530	TNX-AREA 20,000-GAL SANITARY WASTEWATER TREATMENT PLANT, 607-40T
10533	SEPTIC TANK & TILE FIELD (607-54G) TO SERVE DEER HUNT BUILDING, 760-12G

Sanitary Wastewater Permits, continued

Permit Number	Permit Title
10825	SANITARY SEWER LIFT STATION (607-19A) TO SERVE 730-A
11407	SANITARY SEWER LIFT STATION TO SERVE 321-M CHANGE ROOM
11442	SANITARY SEWER SYSTEM (LIFT STATION & SEWER LINE) TO SERVE ECR/ICR CONTROL HOUSE, 241-82H
11687	SEPTIC TANK & TILE FIELD TO SERVE WACKENHUT HELICOPTER FACILITY, 703-5B
11755	SEPTIC TANK & TILE FIELD TO SERVE 100-AREA FIRE STATION, 709-1G (INTERSECTION OF ROADS C & 7)
11847	EFFLUENT WEIR FOR TNX-AREA SANITARY WASTEWATER TREATMENT PLANT, 607-40T
12076	SANITARY-SLUDGE LAND APPLICATION, F/H AREA BORROW PITS
12386	SANITARY SEWER TO SERVE 730-M
12695	SANITARY SEWER TO SERVE REPLACEMENT TRITIUM FACILITY (RTF), 233-H
12725	45,000-GAL SANITARY FLOW EQUALIZATION BASIN (607-18F) FOR SANITARY WASTEWATER TREATMENT PLANTS, 607-7F & 607-21F (PHASE III)
12910	H-AREA 30,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-21H
13155	NAVAL FUEL (FMF) FLOW MEASUREMENT DEVICE, OUTFALL F-003(A)
13156	SANITARY SEWER TO SERVE 716-2A
13157	SANITARY SEWER TO SERVE COMPUTER REPAIR BUILDING, 722-5A
13175	97,500-GAL SANITARY FLOW EQUALIZATION BASIN (607-22A) FOR SANITARY WASTEWATER TREATMENT PLANTS, 607-7-1A, 607-7-2A, & 607-23A
13291	SEPTIC TANK & TILE FIELD TO SERVE AUXILIARY PUMP PIT
13430	F-AREA 30,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-21F
13538	SEPTIC TANK & TILE FIELD TO SERVE K-REACTOR COOLING TOWER CONSTRUCTION TRAILER
13539	SEPTIC TANK & TILE FIELD TO SERVE K-REACTOR COOLING TOWER ECR/ICR BUILDING, 153-1K
13717	SEPTIC TANK (831-1Z) & TILE FIELD (831-2Z) TO SERVE Z-AREA
14311	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR C-AREA SANITARY WASTEWATER TREATMENT PLANT, 607-7C
14312	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR K-AREA SANITARY WASTEWATER TREATMENT PLANT, 607-17K
14313	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR L-AREA SANITARY WASTEWATER TREATMENT PLANT, 607-16L

Sanitary Wastewater Permits, continued

Permit Number	Permit Title
14314	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR P-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7P & 607-23P
14315	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR F-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7F & 607-21F
14316	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR H-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7H & 607-21H
14317	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR S-AREA SANITARY WASTEWATER TREATMENT PLANTS, 831-1S & 831-2S
14318	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR D-AREA SANITARY WASTEWATER TREATMENT PLANT, 607-15D
14320	INTERIM SODIUM HYPOCHLORITE DISINFECTION SYSTEM (607-8A) FOR A-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7-1A, 607-7-2A, & 607-23A
14321	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR SREL WASTEWATER DISINFECTION FACILITY, 737-21A
14322	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR N-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-18N & 607-42N
14323	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR NAVAL FUEL (FMF) SANITARY WASTEWATER TREATMENT PLANT, 607-17F
14324	INTERIM SODIUM HYPOCHLORITE DISINFECTION FOR TNX-AREA SANITARY WASTEWATER TREATMENT PLANT, 607-40T
14407	D-AREA 20,000-GPD SANITARY WASTEWATER TREATMENT PLANT EXPANSION, 607-15D
14443	SEPTIC TANK & TILE FIELD TO SERVE 241-102H
15005	A-AREA 65,000-GPD SANITARY WASTEWATER TREATMENT PLANT EXPANSION, 607-23A
15049	35,000-GAL SANITARY FLOW EQUALIZATION BASIN (607-19G) FOR N-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-18G & 607-42G
15416	12,000-GAL SANITARY FLOW EQUALIZATION BASIN (607-16K) FOR SANITARY WASTEWATER TREATMENT PLANT, 607-17K
15417	11,000-GAL SANITARY FLOW EQUALIZATION BASIN (607-24P) FOR P-AREA SANITARY WASTEWATER TREATMENT PLANTS, 607-7P & 607-23P
15418	17,500-GAL SANITARY FLOW EQUALIZATION BASIN (607-15L) FOR SANITARY WASTEWATER TREATMENT PLANT, 607-16L
15419	SANITARY SEWER LIFT STATION TO SERVE REPLACEMENT TRITIUM FACILITY (RTF)
15444	SANITARY SEWER LIFT STATION TO SERVE 341-M
15506	15,000-GAL SANITARY FLOW EQUALIZATION BASIN (607-22F) FOR NAVAL FUEL (FMF) SANITARY WASTEWATER TREATMENT PLANT, 607-17F

Sanitary Wastewater Permits, continued

Permit Number	Permit Title
15530	27,500-GAL SANITARY FLOW EQUALIZATION BASIN (607-4C) FOR SANITARY WASTEWATER TREATMENT PLANT, 607-7C
15740	SANITARY SEWER SYSTEM EXPANSION (TWO LIFT STATIONS & SEWER LINE) TO SERVE C-AREA
16477	SANITARY SEWER TO SERVE N-AREA MATERIAL MANAGEMENT RECEIVING & STORAGE FACILITIES (MMRSF)
16961	SANITARY SEWER LINE FROM MATERIAL MANAGEMENT RECEIVING & STORAGE FACILITIES (MMRSF) TO N-AREA SANITARY WASTEWATER TREATMENT PLANT
17057	B-AREA 80,000-GPD SANITARY WASTEWATER TREATMENT PLANT UPGRADE, 607-4B
17059	SANITARY SEWER TO SERVE B-AREA ENGINEERING CENTER, 730-B
17156	FLOW CONTROL BOXES FOR TNX-AREA SANITARY WASTEWATER TREATMENT PLANT, 607-40T
17157	FLOW CONTROL BOXES FOR H-AREA SANITARY WASTEWATER TREATMENT FACILITIES, 607-7H & 607-21H
17232	SANITARY SEWER TO SERVE 705-3C
17278-IW	SANITARY SEWER TO SERVE 730-1M OFFICE BUILDING
17279-IW	SANITARY SEWER TO SERVE 705-K OFFICE BUILDING
17351-IW	S-AREA 16,000-GPD SANITARY WASTEWATER TREATMENT PLANT UPGRADE
17383-IW	SANITARY SEWER TO SERVE REPLACEMENT TRITIUM FACILITY (RTF) TRAILERS, 233-20H & 233-21H
17419-IW	SANITARY SEWER TO SERVE H-AREA TRAILERS 742-10G THROUGH 742-12G
17499-IW	SANITARY SEWER & LIFT STATION TO SERVE 704-2H
17604-IW	SANITARY SEWER TO SERVE SITE TRAINING BUILDING, 225-H
7947	L-AREA 35,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-16L
8611-P	SEPTIC TANK & TILE FIELD TO SERVE INTERIM STORAGE & REDRUMMING FACILITY, 645-1N (FORMERLY 709-1G), N-AREA
8670	K-AREA 24,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-17K
8928	NAVAL FUEL (FMF) 30,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-17F
9256P	SEPTIC TANK & TILE FIELD TO SERVE LANDFILL MONITORING BUILDING, 642-E
9326	H-AREA 60,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-7H (F, N, & P areas also included under this permit)
9326	P-AREA 10,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-23P (F, H, & N areas also included under this permit)

Sanitary Wastewater Permits, continued

Permit Number	Permit Title
9326	N-AREA 30,000-GPD (607-18G) & 40,000-GPD (607-42G) SANITARY WASTEWATER TREATMENT PLANTS (F, H, & P areas also included under this permit)
9326	F-AREA 60,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-7F (H, N, & P areas also included under this permit)
9694	SANITARY SEWER SYSTEM (LIFT STATION & SEWER LINE) TO SERVE 773-41A & 773-42A
9888	TWO 12,000-GPD SANITARY WASTEWATER TREATMENT PLANTS, 831-1S & 831-2S, S-AREA
9940	SANITARY SEWER TO SERVE REACTOR SIMULATOR FACILITY, 707-C
9983	C-AREA 55,000-GPD SANITARY WASTEWATER TREATMENT PLANT, 607-7C
9998	SEPTIC TANK & TILE FIELD TO SERVE F&H ETF CONTROL BUILDING, 241-84H
LS-10-S	SANITARY SEWER TO SERVE NAVAL FUEL MATERIAL FACILITY (FMF), 247-F & 248-F
LS-129-S	SANITARY SEWER TO SERVE 719-4A
LS-134-S	DWPF SANITARY SEWER LINE MODIFICATION, S-AREA
LS-149-S	SANITARY SEWER TO SERVE TNX EFFLUENT TREATMENT PLANT, 904-T
LS-158-S	SANITARY SEWER TO SERVE 3/700 CONSTRUCTION FACILITY
LS-2-S	SANITARY SEWER TO SERVE TRITIUM FACILITY SUPPORT BUILDING, 235-H
LS-206-S	SEWER PIPE & MANHOLE, 704-1T
LS-227-S	SANITARY SEWER TO SERVE 705-C
LS-228-S	SANITARY SEWER TO SERVE 717-K
LS-239-S	SANITARY SEWER TO SERVE SECURITY FACILITIES ECF (701-4F) & CAS (720-F)
LS-240-S	SANITARY SEWER TO SERVE 720-2A (3/700 AREA SECURITY UPGRADE, PACAS FACILITY)
LS-244-S	SANITARY SEWER TO SERVE SECURITY FACILITIES ECF (701-3H) & CAS (720-H)
LS-256-S	MACERATOR (GRINDER PUMP) FOR F-AREA SANITARY FLOW EQUALIZATION BASIN, 607-18F
LS-275-S	SANITARY SEWER TO SERVE EQUIPMENT STORAGE & HEALTH PROTECTION FACILITY, 221-25F
LS-3-S	SANITARY SEWER TO SERVE 703-41A
LS-32-S	SANITARY SEWER TO SERVE WACKENHUT BUILDINGS 703-B & 703-1B
LS-335-S	SANITARY SEWER TO SERVE TEMPORARY MODULAR OFFICE TRAILERS 704-7K THROUGH 704-19K
LS-336-S	"AS BUILT" OIL/WATER SEPARATOR, 716-A

Sanitary Wastewater Permits, continued

Permit Number	Permit Title
LS-337-S	"AS BUILT" OIL/WATER SEPARATOR, 722-4A
LS-35-S	SANITARY SEWER RELOCATION TO SERVE 735-11A
LS-351-S	SANITARY SEWER TO SERVE TEMPORARY MODULAR OFFICE TRAILERS 245-F THROUGH 245-12F
LS-352-S	SANITARY SEWER TO SERVE N-AREA NEW-EMPLOYEE PROCESSING CENTER
LS-52-S	SANITARY SEWER TO SERVE 707-H
LS-53-S	SANITARY SEWER TO SERVE CONSTRUCTION OFFICE BUILDING, M-AREA
LS-62-S	SANITARY SEWER RELOCATION TO SERVE 717-F
LS-78-S	SANITARY SEWER TO SERVE C-AREA CONSTRUCTION ADMINISTRATION BUILDING
LS-79-S	SANITARY SEWER TO SERVE N-AREA ELECTRICAL OFFICE BUILDING
LS-80-S	SANITARY SEWER TO SERVE N-AREA RECEIVING & STORES WAREHOUSE

SCWRC (Stream Crossing) Permit

Permit Number	Permit Title
SC 88-D-005	F/H ETF DIFFUSER

Solid Waste Permits

Permit Number	Permit Title
CWP-030	BURMA ROAD INERT LANDFILL
DWP-087A	SANITARY LANDFILL
IWP-210	D-F STEAM LINE EROSION CONTROL SITE
IWP-211	200-H EROSION CONTROL SITE
IWP-217	Z-AREA SALTSTONE DISPOSAL FACILITY
IWP-219	200-F EROSION CONTROL SITE

Underground Storage Tank Permits

Permit Number	Permit Title
C-02-GF-09467	FORESTRY AREA 2000-GAL GASOLINE STORAGE TANK, 620-G (A)
C-02-GF-09467	FORESTRY AREA 2000-GAL DIESEL FUEL STORAGE TANK, 620-G (B)
P-02-GF-10838	H-AREA 10,000-GAL GASOLINE STORAGE TANK, 715-2G (A, C, K, L, N, & P AREAS ALSO INCLUDED)
P-02-GF-10838	L-AREA 5000-GAL GASOLINE STORAGE TANK, 715-2G (A, C, H, K, N, & P AREAS ALSO INCLUDED)
P-02-GF-10838	C-AREA 5000-GAL GASOLINE STORAGE TANK, 715-C (A, H, K, L, N, & P AREAS ALSO INCLUDED)
P-02-GF-10838	K-AREA 5000-GAL GASOLINE STORAGE TANK, 715-K (A, C, H, L, N, & P AREAS ALSO INCLUDED)
P-02-GF-10838	P-AREA 5000-GAL GASOLINE STORAGE TANK, 715-P (A, C, H, K, L, & N AREAS ALSO INCLUDED)
P-02-GF-10838	A-AREA 5000-GAL GASOLINE STORAGE TANK, 715-AA (C, H, K, L, N, & P AREAS ALSO INCLUDED)
P-02-GF-10838	A-AREA 5000-GAL DIESEL FUEL STORAGE TANK, 715-AB (C, H, K, L, N, & P AREAS ALSO INCLUDED)
P-02-GF-10838	A-AREA 5000-GAL GASOLINE STORAGE TANK, 715-AC (C, H, K, L, N, & P AREAS ALSO INCLUDED)
P-02-GF-10838	N-AREA 10,000-GAL GASOLINE STORAGE TANK, 715-N #1 (A, C, H, K, L, & P AREAS ALSO INCLUDED)
P-02-GF-10838	N-AREA 10,000-GAL DIESEL FUEL STORAGE TANK, 715-N #2 (A, C, H, K, L, & P AREAS ALSO INCLUDED)
P-02-GF-12476	A-AREA 5000-GAL DIESEL FUEL STORAGE TANK, 754-6A

Appendix C

Radionuclide and Chemical Nomenclature

Nomenclature and Half-life for Radionuclides

Radionuclide	Symbol	Half-life ^{a,b}	Radionuclide	Symbol	Half-life ^{a,b}
Americium-241	Am-241	432.7 y	Niobium-95	Nb-95	35 d
Americium-243	Am-243	7.37E3 y	Osmium-185	Os-185	94 d
Antimony-125	Sb-125	2.7 y	Phosphorus-32	P-32	14.3 d
Argon-41	Ar-41	1.83 h	Polonium-210	Po-210	138.4 d
Beryllium-7	Be-7	53 d	Plutonium-238	Pu-238	87.4 y
Californium-252	Cf-252	2.638 y	Plutonium-239	Pu-239	2.4E4 y
Carbon-14	C-14	5,730 y	Potassium-40	K-40	1.26E9 y
Cerium-141	Ce-141	33 d	Promethium-147	Pm-147	2.62 y
Cerium-144	Ce-144	284 d	Ruthenium-103	Ru-103	39.6 d
Cesium-134	Cs-134	2.05 y	Ruthenium-106	Ru-106	367 d
Cesium-137	Cs-137	30 y	Strontium-89	Sr-89	52 d
Cobalt-58	Co-58	71.3 d	Strontium-90	Sr-90	28.1 y
Cobalt-60	Co-60	5.26 y	Tritium	H-3	12.3 y
Curium-242	Cm-242	163 d	Uranium-235	U-235	7.1E8 y
Curium-244	Cm-244	17.6 y	Uranium-238	U-238	4.5E9 y
Iodine-129	I-129	1.7E7 y	Xenon-133	Xe-133	5.27 d
Iodine-131	I-131	8.05 d	Xenon-135	Xe-135	9.16 h
Krypton-85	Kr-85	10.76 y	Yttrium-90	Y-90	64 h
Krypton-88	Kr-88	2.8 h	Zirconium-95	Zr-95	65 d
Manganese-54	Mn-54	312 d			

Nomenclature for Elements and Chemical Constituents

Constituent	Symbol	Constituent	Symbol
Aluminum	Al	Mercury	Hg
Ammonia	NH ₃	Nickel	Ni
Antimony	Sb	Nitrogen	N
Arsenic	As	Nitrate	NO ₃
Barium	Ba	Nitrite	NO ₂
Beryllium	Be	Oxygen	O
Cadmium	Cd	Ozone	O ₃
Calcium	Ca	Phosphorus	P
Calcium Carbonate	CaCO ₃	Phosphate	PO ₄
Carbon	C	Potassium	K
Chlorine	Cl	Radium	Ra
Chromium	Cr	Rhenium	Re
Cobalt	Co	Selenium	Se
Copper	Cu	Silver	Ag
Fluorine	F	Sodium	Na
Iron	Fe	Sulfate	SO ₄
Lead	Pb	Sulfur Dioxide	SO ₂
Lithium	Li	Thallium	Tl
Magnesium	Mg	Uranium	U
Manganese	Mn	Vanadium	V
		Zinc	Zn

^a h = hour; d = day; y = year

^b Reference: U.S. Department of Health, Education, and Welfare, 1970, *Radiological Health Handbook*, Food and Drug Administration, Bureau of Radiological Health, Rockville, Md.

Nomenclature for Common Chemical Analyses

Analysis	Symbol	Analysis	Symbol
Biological Oxygen Demand	BOD	Total Organic Carbon	TOC
Chemical Oxygen Demand	COD	Total Organic Halogens	TOH
Dissolved Oxygen	DO	Total Phosphates	TPO ₄
Particulate Matter <10 microns	PM ₁₀	Total Solids	TS
Polychlorinated Biphenyl	PCB	Total Suspended Solids	TSS
Total Dissolved Solids	TDS	Volatile Organic Compound	VOC

Appendix D

Drinking Water Standards

Analyte	Level ^a	Units	Status	Reference ^b
Americium-241	6.34E+00	pCi/L	proposed	EPA, 1991
Americium-243	6.39E+00	pCi/L	proposed	EPA, 1991
Antimony	0.006 ^c	mg/L	proposed	EPA, 1990
Antimony-125	1.94E+03	pCi/L	proposed	EPA, 1991
	3.E+02	pCi/L	final	EPA, 1977
Arsenic	0.05	mg/L	final	CFR, 1991
Barium	2.0	mg/L	final	CFR, 1991
Barium-140	5.82E+02	pCi/L	proposed	EPA, 1991
	9.E+01	pCi/L	final	EPA, 1977
Benzene	0.005	mg/L	final	CFR, 1991
Beryllium	0.004	mg/L	proposed	EPA, 1990
Beryllium-7	4.35E+04	pCi/L	proposed	EPA, 1991
	6.E+03	pCi/L	final	EPA, 1977
2-sec-Butyl-4, 6-dinitrophenol (Dinoseb)	0.007	mg/L	proposed	EPA, 1990
Cadmium	0.005	mg/L	final	CFR, 1991
Carbon-14	3.20E+03	pCi/L	proposed	EPA, 1991
	2.E+03	pCi/L	final	EPA, 1977
Carbon tetrachloride	0.005	mg/L	final	CFR, 1991
Cerium-141	1.89E+03	pCi/L	proposed	EPA, 1991
	3.E+02	pCi/L	final	EPA, 1977
Cerium-144	2.61E+02	pCi/L	proposed	EPA, 1991
Cesium-134	8.13E+01	pCi/L	proposed	EPA, 1991
Cesium-137	1.19E+02	pCi/L	proposed	EPA, 1991
	2.E+02	pCi/L	final	EPA, 1977
Chlordane	0.002	mg/L	final	CFR, 1991
Chloroethene (Vinyl chloride)	0.002	mg/L	final	CFR, 1991
Chloroform ^d	0.1	mg/L	final	CFR, 1992
Chromium	0.1	mg/L	final	CFR, 1991
Chromium-51	3.80E+04	pCi/L	proposed	EPA, 1991
	6.E+03	pCi/L	final	EPA, 1977

a Standards for beta- and gamma-emitting radionuclides are based on the 4 mrem/yr whole-body dose [EPA91].

b References found on page 237.

c This is the lower of two proposed levels.

d The level for total trihalomethanes is set at 0.1 mg/L. Because bromated methanes are rarely detected in SRS groundwater, EPD presumes that most of the trihalomethanes present in site groundwater are chloroform.

Analyte	Level ^a	Units	Status	Reference ^b
Cobalt-58	1.59E+03	pCi/L	proposed	EPA, 1991
	9.E+03	pCi/L	final	EPA, 1977
Cobalt-60	2.18E+02	pCi/L	proposed	EPA, 1991
	1.E+02	pCi/L	final	EPA, 1977
Copper	1.3	mg/L	final	CFR, 1991
Curium-242	1.33E+02	pCi/L	proposed	EPA, 1991
Curium-243	8.3E+00	pCi/L	proposed	EPA, 1991
Curium-244	9.84E+00	pCi/L	proposed	EPA, 1991
Curium-246	6.27E+00	pCi/L	proposed	EPA, 1991
Cyanide	0.2	mg/L	proposed	EPA, 1990
Dibromochloropropane	0.0002	mg/L	final	CFR, 1991
1,2-Dichlorobenzene	0.6	mg/L	final	CFR, 1991
1,4-Dichlorobenzene (p-Dichlorobenzene)	0.075	mg/L	final	CFR, 1989
1,2-Dichloroethane	0.005	mg/L	final	CFR, 1991
cis-1,2-Dichloroethylene	0.07	mg/L	final	CFR, 1991
trans-1,2-Dichloroethylene	0.1	mg/L	final	CFR, 1991
1,1-Dichloroethylene	0.007	mg/L	final	CFR, 1991
Dichloromethane (Methylene chloride)	0.005	mg/L	proposed	EPA, 1990
2,4-Dichlorophenoxyacetic acid	0.7	mg/L	final	CFR, 1991
1,2-Dichloropropane	0.005	mg/L	final	CFR, 1992
Endrin	0.0002	mg/L	final	CFR, 1991
Ethylbenzene	0.7	mg/L	final	CFR, 1991
Europium-154	5.73E+02	pCi/L	proposed	EPA, 1991
	2.E+02	pCi/L	final	EPA, 1977
Europium-155	3.59E+03	pCi/L	proposed	EPA, 1991
	6.E+02	pCi/L	final	EPA, 1977
Fluoride	4	mg/L	final	CFR, 1991
Gross alpha	15	pCi/L	final	CFR, 1991
Heptachlor	0.0004	mg/L	final	CFR, 1991
Heptachlor epoxide	0.0002	mg/L	final	CFR, 1991
Hexachlorobenzene	0.001	mg/L	proposed	EPA, 1990
Hexachlorocyclopentadiene	0.05	mg/L	proposed	EPA, 1990
Iodine-129	2.10E+01	pCi/L	proposed	EPA, 1991
	1.E+00	pCi/L	final	EPA, 1977
Iodine-131	1.08E+02	pCi/L	proposed	EPA, 1991
	3.E+00	pCi/L	final	EPA, 1977

^a Standards for beta- and gamma-emitting radionuclides are based on the 4 mrem/yr whole-body dose [EPA91].

^b References found on page 237.

Analyte	Level ^a	Units	Status	Reference ^b
Iron-55	9.25E+03	pCi/L	proposed	EPA, 1991
	___2.E+03	pCi/L	final	EPA, 1977
Iron-59	8.44E+02	pCi/L	proposed	EPA, 1991
	___2.E+02	pCi/L	final	EPA, 1977
Lanthanum-140	6.52E+02	pCi/L	proposed	EPA, 1991
	___6.E+01	pCi/L	final	EPA, 1977
Lead	0.015	mg/L	final	CFR, 1991
Lindane	0.0002	mg/L	final	CFR, 1991
Manganese-54	2.01E+03	pCi/L	proposed	EPA, 1991
	___3.E+02	pCi/L	final	EPA, 1977
Mercury	0.002	mg/L	final	CFR, 1991
Methoxychlor	0.04	mg/L	final	CFR, 1991
Neptunium-237	7.06E+00	pCi/L	proposed	EPA, 1991
Nickel	0.1	mg/L	proposed	EPA, 1990
Nickel-59	2.70E+04	pCi/L	proposed	EPA, 1991
	___3.E+02	pCi/L	final	EPA, 1977
Nickel-63	9.91E+03	pCi/L	proposed	EPA, 1991
	___5.E+01	pCi/L	final	EPA, 1977
Niobium-95	2.15E+03	pCi/L	proposed	EPA, 1991
	___3.E+02	pCi/L	final	EPA, 1977
Nitrate (as N)	10	mg/L	final	CFR, 1991
Nitrite (as N)	1	mg/L	final	CFR, 1991
Nonvolatile beta	4 mrem/yr	pCi/L	final	CFR, 1991
PAHs				
Benz[a]anthracene	0.0001	mg/L	proposed	EPA, 1990
Benzo[b]fluoranthene	0.0002	mg/L	proposed	EPA, 1990
Benzo[k]fluoranthene	0.0002	mg/L	proposed	EPA, 1990
Benzo[a]pyrene	0.0002	mg/L	proposed	EPA, 1990
Chrysene	0.0002	mg/L	proposed	EPA, 1990
Dibenz[a,h]anthracene	0.0003	mg/L	proposed	EPA, 1990
Indenopyrene	0.0004	mg/L	proposed	EPA, 1990
PCBs	0.0005	mg/L	final	CFR, 1991
Pentachlorophenol	0.001	mg/L	final	CFR, 1991
Plutonium-238	7.02E+00	pCi/L	proposed	EPA, 1991
Plutonium-239	6.21E+01	pCi/L	proposed	EPA, 1991
Plutonium-239/240	6.21E+01 ^c	pCi/L	proposed	EPA, 1991
Plutonium-240	6.22E+01	pCi/L	proposed	EPA, 1991
Plutonium-241	6.26E+01	pCi/L	proposed	EPA, 1991

^a Standards for beta- and gamma-emitting radionuclides are based on the 4 mrem/yr whole-body dose [EPA91].

^b References found on page 237.

^c For double radionuclide analyses where each separate radionuclide has its own standard, the more stringent standard is used.

Analyte	Level ^a	Units	Status	Reference ^b
Plutonium-242	6.54E+01	pCi/L	proposed	EPA, 1991
Potassium-40	300	pCi/L	proposed	EPA, 1986
Radium-226	1.57E+1	pCi/L	proposed	EPA, 1991
Radium-228	7.85E+0	pCi/L	proposed	EPA, 1991
Radon-222	300	pCi/L	proposed	EPA, 1991
Ruthenium-103	1.81E+03	pCi/L	proposed	EPA, 1991
	2.E+02	pCi/L	final	EPA, 1977
Ruthenium-106	2.03E+02	pCi/L	proposed	EPA, 1991
	3.E+01	pCi/L	final	EPA, 1977
Selenium	0.05	mg/L	final	CFR, 1991
Sodium-22	4.66E+02	pCi/L	proposed	EPA, 1991
Strontium-89	5.99E+02	pCi/L	proposed	EPA, 1991
	2.E+01	pCi/L	final	EPA, 1977
Strontium-89/90	4.20E+01 ^c	pCi/L	final	CFR, 1991
Strontium-90	4.20E+01	pCi/L	proposed	EPA, 1991
	8.E+00	pCi/L	final	CFR, 1991
Styrene	0.1	mg/L	final	CFR, 1991
Sulfate	400 ^d	mg/L	proposed	EPA, 1990
Technetium-99	3.79E+03	pCi/L	proposed	EPA, 1991
	9.E+02	pCi/L	final	EPA, 1977
Tetrachloroethylene	0.005	mg/L	final	CFR, 1991
Thallium	0.002 ^d	mg/L	proposed	EPA, 1990
Thorium-228	1.25E+02	pCi/L	proposed	EPA, 1991
Thorium-230	7.92E+01	pCi/L	proposed	EPA, 1991
Thorium-232	8.8E+01	pCi/L	proposed	EPA, 1991
Thorium-234	4.01E+02	pCi/L	proposed	EPA, 1991
Tin-113	1.74E+03	pCi/L	proposed	EPA, 1991
	3.E+02	pCi/L	final	EPA, 1977
Toluene	1.0	mg/L	final	CFR, 1991
Total radium	5	pCi/L	final	CFR, 1991
Toxaphene	0.003	mg/L	final	CFR, 1991
2,4,5-TP (Silvex)	0.05	mg/L	final	CFR, 1991
1,2,4-Trichlorobenzene	0.07	mg/L	proposed	EPA, 1990
1,1,1-Trichloroethane	0.2	mg/L	final	CFR, 1991
1,1,2-Trichloroethane	0.005	mg/L	proposed	EPA, 1990
Trichloroethylene	0.005	mg/L	final	CFR, 1991

^a Standards for beta- and gamma-emitting radionuclides are based on the 4 mrem/yr whole-body dose [EPA91].

^b References found on page 237.

^c For double radionuclide analyses where each separate radionuclide has its own standard, the more stringent standard is used.

^d This is the lower of two proposed levels.

Analyte	Level ^a	Units	Status	Reference ^b
Total trihalomethanes ^c (includes bromodichloro- methane, bromoform, chloro- form, and dibromochloro- methane)	0.1	mg/L	final	CFR, 1991
Tritium	6.09E+04	pCi/L	proposed	EPA, 1991
	2.E+01	pCi/mL	final	CFR, 1991
Uranium	0.02	mg/L	proposed	EPA, 1991
Uranium alpha activity	30	pCi/L	proposed	EPA, 1991
Uranium-234	1.39E+01	pCi/L	proposed	EPA, 1991
Uranium-235	1.45E+01	pCi/L	proposed	EPA, 1991
Uranium-238	1.46E+01	pCi/L	proposed	EPA, 1991
Xylenes	10	mg/L	final	CFR, 1991
Zinc-65	3.96E+02	pCi/L	proposed	EPA, 1991
	3.E+02	pCi/L	final	EPA, 1977
Zirconium-95	1.46E+03	pCi/L	proposed	EPA, 1991
	2.E+02	pCi/L	final	EPA, 1977
Zirconium/Niobium-95 ^d	1.46E+03	pCi/L	proposed	EPA, 1991
	2.E+02	pCi/L	final	EPA, 1977

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EPA (U.S. Environmental Protection Agency), 1991. "National Primary Drinking Water Regulations; Radionuclides; Proposed Rule," *Federal Register*, July 18, 1991, pp. 33052-33127, Washington, D.C.

^a Standards for beta- and gamma-emitting radionuclides are based on the 4 mrem/yr whole-body dose [EPA91].

^b References found this page.

^c EPD/EMS does not test for total trihalomethanes, but each of these analytes are tested separately.

^d For double radionuclide analyses where each separate radionuclide has its own standard, the more stringent standard is used.

Appendix E

Environmental Monitoring Reports

Reports of the routine environmental monitoring program at Savannah River Site (SRS) have been prepared periodically since before construction of the site in 1951. The monitoring report numbering system and titles have been changed several times to reflect the evolving progress in the concepts of environmental monitoring. The amount of detailed information contained in the reports also varies from time to time and probably reflects the relative importance and emphasis given to topics by different authors.

Except for July–December 1953, reports were issued semiannually from 1951 to 1962 and annually beginning in 1963. Attempts to find a report for July–December 1953 have been unsuccessful. The on-site report was discontinued in 1985, when the on-site and off-site reports were merged into a single publication.

Some of the monitoring reports originally contained secret information, primarily radioactive release values that could be related to production rates. The secret information in these reports was deleted in the mid-1970s, and a deleted version (DEL) of the report was issued.

On-site Reports

Natural Radioactivity Content of the Savannah River Plant

DP27 Jun 1951–Jan 1953

Works Technical Department Data Record, Health Physics Site Survey Data

DPSPU 54–11–12 Jan–Jul 1953 No report Jul–Dec 1953

Radioactivity in the Environment of the Savannah River Plant

DP92 Jan–Jul 1954

Semiannual Progress Report–Regional

DPSP 55–25–34 Jul–Dec 1954 DPSP 56–25–13 Jan–Jun 1955

Health Physics Regional Monitoring

DPSP 56–25–54 (DEL)	Jul–Dec 1955	DPSPU 60–11–9	Jul–Dec 1959
DPSP 56–25–4 (DEL)	Jan–Jun 1956	DPSP 60–25–26 (DEL)	Jan–Jun 1960
DPSP 57–25–15 (DEL)	Jul–Dec 1956	DPSP 61–25–4 (DEL)	Jul–Dec 1960
DPSP 57–25–43 (DEL)	Jan–Jun 1957	DPSP 62–25–2 (DEL)	Jan–Jun 1961
DPSP 58–25–17 (DEL)	Jul–Dec 1957	DPSP 62–25–9 (DEL)	Jul–Dec 1961
DPSP 58–25–38 (DEL)	Jan–Jun 1958	DPSP 63–25–3 (DEL)	Jan–Jun 1962
DPSPU 59–11–23	Jul–Dec 1958	DPSP 63–25–10 (DEL)	Jul–Dec 1962
DPSPU 59–11–30	Jan–Jun 1959		

Environmental Monitoring at the Savannah River Plant

DPSPU 64–11–12	Jan–Dec 1963	DPSPU 75–302	Jan–Dec 1974
DPST 65–302	Jan–Dec 1964	DPSPU 76–302	Jan–Dec 1975
DPST 66–302	Jan–Dec 1965	DPSPU 77–302	Jan–Dec 1976
DPST 67–302	Jan–Dec 1966	DPSPU 78–302	Jan–Dec 1977
DPST 68–302	Jan–Dec 1967	DPSPU 79–302	Jan–Dec 1978
DPST 69–302	Jan–Dec 1968	DPSPU 80–302	Jan–Dec 1979
DPST 70–302	Jan–Dec 1969	DPSPU 81–302	Jan–Dec 1980
DPST 71–302	Jan–Dec 1970	DPSPU 82–302	Jan–Dec 1981
DPSPU 72–302	Jan–Dec 1971	DPSPU 83–302	Jan–Dec 1982
DPSPU 73–302	Jan–Dec 1972	DPSPU 84–302	Jan–Dec 1983
DPSPU 74–302	Jan–Dec 1973	DPSPU 85–302	Jan–Dec 1984

Off-site Reports

Results of the environmental monitoring program that affected the off-site environment have been reported to the public since 1959. These reports contained data from the site boundary and beyond. The off-site report was discontinued in 1985, when the on-site and off-site reports were merged into a single publication. A listing of the off-site reports follows.

The Effect of the Savannah River Plant on Environmental Radioactivity

No document number	Jan-Mar 1960	DPST 65-30-2	Jan-Jun 1965
No document number	Apr-Jun 1960	DPST 66-30-1	Jul-Dec 1965
No document number	Jul-Sep 1960	DPST 66-30-2	Jan-Jun 1966
No document number	Oct-Dec 1960	DPST 67-30-1	Jul-Dec 1966
No document number	Jan-Mar 1961	DPST 67-30-2	Jan-Jun 1967
No document number	Apr-Jun 1961	DPST 68-30-1	Jul-Dec 1967
No document number	Jul-Sep 1961	DPST 68-30-2	Jan-Jun 1968
DPSPU 62-30-11	Oct-Dec 1961	DPST 69-30-1	Jul-Dec 1968
DPSPU 62-30-24	Jan-Jun 1962	DPST 69-30-2	Jan-Jun 1969
DPSPU 63-30-12	Jul-Dec 1962	DPST 70-30-1	Jul-Dec 1969
DPSPU 63-30-1	Jan-Jun 1963	DPST 70-30-2	Jan-Jun 1970
DPSPU 64-30-1	Jul-Dec 1963	DPST 71-30-1	Jul-Dec 1970
DPSPU 64-30-2	Jan-Jun 1964	DPST 71-30-16	Jan-Jun 1971
DPSPU 65-30-1	Jul-Dec 1964		

Environmental Monitoring in the Vicinity of the Savannah River Plant

DPSPU 72-30-1	Jan-Dec 1971	DPSPU 79-30-1	Jan-Dec 1978
DPSPU 73-30-1	Jan-Dec 1972	DPSPU 80-30-1	Jan-Dec 1979
DPSPU 74-30-1	Jan-Dec 1973	DPSPU 81-30-1	Jan-Dec 1980
DPSPU 75-30-1	Jan-Dec 1974	DPSPU 82-30-1	Jan-Dec 1981
DPSPU 76-30-1	Jan-Dec 1975	DPSPU 83-30-1	Jan-Dec 1982
DPSPU 77-30-1	Jan-Dec 1976	DPSPU 84-30-1	Jan-Dec 1983
DPSPU 78-30-1	Jan-Dec 1977		

Savannah River Plant Environmental Report

DPSPU 85-30-1	Jan-Dec 1984
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Environmental Reports (Combined On-site and Off-site)

In 1985, the on-site and off-site environmental monitoring reports were merged into a single publication. A listing of these reports follows.

Savannah River Site Environmental Report

DPSPU 86-30-1	Jan-Dec 1985	WSRC-IM-90-60	Jan-Dec 1989
DPSPU 87-30-1	Jan-Dec 1986	WSRC-IM-91-28	Jan-Dec 1990
DPSPU 88-30-1	Jan-Dec 1987	WSRC-TR-92-186	Jan-Dec 1991
WSRC-RP-89-59-1a	Jan-Dec 1988	WSRC-TR-93-075	Jan-Dec 1992

Appendix F

Errata from 1992 Report

The following information was reported incorrectly in the *Savannah River Site Environmental Report for 1992*, WSRC-TR-93-075:

Page xviii, left column, fourth paragraph: The estimated dose is 0.90 percent of the 10 mrem/yr limit—not 0.09 percent.

Page xx, left column, third paragraph: During 1992, the maximum individual EDE to an on-site hunter was 49 mrem—not 49 rem. Also, the reference to the annual maximum adult consumption rate for meat should be 81 kg (179 lb)—not 81 kg (178 lb).

Page xx, right column, third full paragraph: Measurements of gamma radiation levels were made at 454 locations on and off site—not 392 locations.

Page 21, table 2-3 (Releases of Toxic Chemicals by SRS in 1990, 1991 Reporting Years): The units of measure—pounds—inadvertently were omitted from the table.

Page 35, table 3-3 (Properties of Most Important Radionuclides, in Terms of Off-site Dose to People, Released from SRS from 1986 to 1990): Strontium-90 inadvertently was omitted from the table.

Page 57, table 4-1 (1992 Atmospheric Releases by Source): The figure 4.99E+01 in the "Kr-85" row of the "Reactors" column should have appeared one column to the right, under "Separations."

Page 87, left column, second full paragraph: The maximum concentration of cesium-137 measured in a wild turkey trapped at SRS during 1992 was 2 pCi/g—not 1 pCi/g—and the minimum concentration was 1 pCi/g—not 2 pCi/g.

Page 103: The pie chart caption should read, "Tritium accounts for 82.5 percent of the treated-drinking-water dose from two water treatment facilities downriver from SRS."

Page 103, right column, third paragraph: The reference to the maximum meat consumption rate for an adult should be 81 kg/year (179 lb/year)—not 81 kg/year (180 lb/year).

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Glossary

A

absorption – The process by which the number and energy of particles or photons entering a body of matter is reduced by interaction with the matter.

accuracy – The closeness of the result of a measurement to the true value of the quantity.

activity – See radioactivity.

adsorption – The surface retention of solid, liquid, or gas molecules, atoms, or ions by a solid or liquid, as opposed to absorption, the penetration of substances into the bulk of the solid or liquid.

ALARA – As low as reasonably achievable.

aliquot – The quantity of sample being used for analysis.

alkalinity – Alkalinity is a measure of the buffering capacity of water, and since pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water, the buffering capacity is important to water quality.

alpha particle – A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air – The surrounding atmosphere as it exists around people, plants, and structures.

analyte – A constituent or parameter that is being analyzed.

anomaly – A deviation beyond normal variations.

anion – A negatively charged ion.

Appendix IX – List of constituents specified by Appendix IX of the Code of Federal Regulations, Title 40, Part 264. Analyses for Appendix IX constituents are required by the Resource Conservation and Recovery Act under specified conditions.

aquifer – A saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

aquitard – A geologic unit that inhibits the flow of water.

atom – Smallest particle of an element capable of entering into a chemical reaction.

atomic absorption spectrometry (AA) – Chemical analysis performed by vaporizing a sample and measuring the absorbance of light by the vapor.

Atomic Energy Commission (AEC) – A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian application. It was abolished by the Energy Reorganization Act of 1974 and succeeded by the Energy Research and Development Administration (now part of the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission).

B

beta particle – A negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

blank – A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. In such cases, the measured value or signal for the substance being analyzed is believed to be due to artifacts. Under certain circumstances, that value may be subtracted from the measured value to give a net result reflecting the amount of the substance in the sample. EPA does not permit the subtraction of blank results in EPA-regulated analyses.

blind blank – A sample container of deionized water sent to a laboratory under an alias name as a quality control check.

blind replicate – In the EMS Groundwater Monitoring Program, a second sample taken from the same well at the same time as the primary sample, assigned an alias well name, and sent to a laboratory for analysis (as an unknown to the analyst).

blind sample – A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

Brailsford pump – A surface water sampling device which is stationed on a stand above a stream. The device, which continuously samples stream water, consists of an all-plastic valveless piston driven by a Brailsford small electric motor. The variable pump speed is set normally at 0.75 gallons/day.

BSRI – Bechtel Savannah River Inc.

C

CAA – Clean Air Act (federal).

CAAA – Clean Air Act Amendments of 1990 (federal).

calibration – Determination of variance from a standard of accuracy of a measuring instrument to ascertain necessary correction factors.

Carolina bay – A type of shallow depression commonly found on the coastal Carolina plains. Carolina bays are typically circular or oval. Some are wet or marshy, while others are dry.

cation – Positively charged ion.

Central Savannah River Area (CSRA) – A 12-county area in Georgia and South Carolina surrounding Augusta, Georgia. SRS is included in the CSRA.

CEPEP – Comprehensive Environmental Protection Evaluation Program (federal).

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) (federal).

CERCLA-reportable release – A release to the environment that exceeds reportable quantities as defined by CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act).

CFC – Chlorofluorocarbon.

CFR – Code of Federal Regulations.

chain-of-custody – A form that documents sample collection, transport, analysis, and disposal.

chemical oxygen demand (COD) – Indicates the quantity of oxidizable materials present in a water and varies with water composition, concentrations of reagent, temperature, period of contact, and other factors.

chlorocarbons – Compounds of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, tetrachloroethylene, etc. They are among the most significant and widespread environmental contaminants. Classified as hazardous wastes, chlorocarbons may have a tendency to cause detrimental effects, such as birth defects.

Cl – See curie.

CIF – Consolidated Incineration Facility.

closure – Control of a hazardous waste management facility under RCRA requirements.

CLP – Contract Laboratory Program (EPA).

COD – See chemical oxygen demand.

compliance – Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

comprehensive analyses – A group of analyses that forms the core of the EMS Groundwater Monitoring Program each quarter.

concentration – The amount of a substance contained in a unit volume or mass of a sample.

conductivity – A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in a water and the temperature at which the measurement is made.

contamination – Deposition of unwanted material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation – Ionizing radiation with very high energies, originating outside the earth's atmosphere. Cosmic radiation is one source contributing to natural background radiation.

count – The signal that announces an ionization event within a counter; a measure of the radiation from an object or device.

counter – A general designation applied to radiation detection instruments or survey meters that detect and measure radiation.

counting geometry – A well-defined sample size and shape for which a counting system has been calibrated.

CSRA – Central Savannah River Area.

curie (Ci) – A unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

kilocurie (kCi) – 10^3 Ci, one thousand curies; 3.7×10^{13} disintegrations per second.

millicurie (mCi) – 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.

microcurie (μ Ci) – 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.

picocurie (pCi) – 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

CWA – Clean Water Act (federal).

CX – Categorical exclusion.

D

D&D – Decontamination and decommissioning.

DCG – See derived concentration guide.

decay, radioactive – The spontaneous transformation of one radionuclide into a different radioactive or non-radioactive nuclide, or into a different energy state of the same radionuclide.

decontamination and decommissioning – See Environmental Restoration.

derived concentration guide (DCG) – The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and lens of the eye. The guides for radionuclides in air and water are given in DOE Order 5400.5.

desorption – The process of removing a sorbed substance by the reverse of adsorption or absorption.

detector – Material or device (instrument) that is sensitive to radiation and can produce a signal suitable for measurement or analysis.

diatoms – Unicellular or colonial algae of the class Bacillariophyceae, having siliceous cell walls with two overlapping, symmetrical parts. Diatoms represent the predominant periphyton (attached algae) in most water bodies and have been shown to be reliable indicators of water quality.

diatometer – Diatom collection equipment consisting of a series of microscope slides in a holder that is used to determine the amount of algae in a water system.

disintegration, nuclear – A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dissolved oxygen – A desirable indicator of satisfactory water quality in terms of low residuals of biologically available organic materials. Dissolved oxygen prevents the chemical reduction and subsequent leaching of iron and manganese from sediments.

DNC – Department NEPA Coordinator.

DOE – U.S. Department of Energy.

DOE-HQ – U.S. Department of Energy–Headquarters.

DOE-SR – U.S. Department of Energy–Savannah River Operations Office.

dose – The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

absorbed dose – The quantity of radiation energy absorbed by an organ, divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad=0.01Gy).

dose equivalent – The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem=0.01 sievert).

committed dose equivalent – The calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).

committed effective dose equivalent – The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

effective dose equivalent – It is the sum of the dose equivalents received by all organs or tissues of the

body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.

collective dose equivalent/collective effective dose equivalent – The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius, and expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

dosimeter – A portable detection device for measuring the total accumulated exposure to ionizing radiation.

dosimetry – The theory and application of principles and techniques involved in the measurement and recording of radiation doses. Its practical aspect is concerned with using various types of radiation instruments to make measurements.

downgradient – In the direction of decreasing hydrostatic head.

downgradient well – A well that is installed hydraulically downgradient of a site and may be capable of detecting migration of contaminants from a site.

drinking water standards (DWS) – Federal primary drinking water standards, both proposed and final, as set forth by EPA.

duplicate result – A result derived by taking a portion of a primary sample and performing the identical analysis on that portion as is performed on the primary sample.

DWPF – Defense Waste Processing Facility.

DWS – See drinking water standards.

E

EA – Environmental Assessment.

EDE – Effective dose equivalent.

effluent – A liquid or gaseous waste discharge to the environment.

effluent monitoring – The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures of members of the public, and demonstrating compliance with applicable standards.

EIS – Environmental Impact Statement.

EMCAP – Environmental Monitoring Computer Automation Project.

EMS – Environmental Monitoring Section (WSRC).

Environmental Restoration – A DOE program that directs the assessment and cleanup of its sites (remediation) and facilities (decontamination and decommissioning) contaminated with waste as a result of nuclear-related activities.

EPA – U.S. Environmental Protection Agency.

EPCRA – Emergency Planning and Community Right-to-Know Act.

EPD – Environmental Protection Department (WSRC).

ERDA – Energy Research and Development Administration (DOE predecessor).

ES&H – Environment, Safety, and Health (DOE-HQ).

ETF – Effluent Treatment Facility.

exposure (radiation) – The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that exposure to ionizing radiation which takes place during a person's working hours. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation – Exposure to ionizing radiation when the radiation source is located outside the body.

F

fauna – The population of animals in a given area, environment, formation, or time span.

fecal coliform – The coliform group comprises all of the aerobic, nonspore-forming, rod-shaped bacteria. The test determines the presence or absence of coliform organisms.

FFA – Federal Facility Agreement.

FFCA – Federal Facility Compliance Agreement.

FFCAct – Federal Facility Compliance Act.

field blank – A sample container of deionized water generated by filling the sample container at the sample location and treated as a groundwater sample.

flagging criteria – Criteria established to aid in determining the relative concentration and testing frequency for analytes.

flora – The population of plants at a given area, environment, formation, or time span.

FONSI – Finding of No Significant Impact.

formation – A mappable unit of consolidated or unconsolidated geologic material of a characteristic lithology or assemblage of lithologies.

G

gamma ray – High-energy, short wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to X-rays except for the source of the emission.

gamma-emitting radionuclide – Radionuclide that emits gamma rays.

gamma spectrometry – A system consisting of a detector, associated electronics, and a multichannel analyzer that is used to analyze samples for gamma-emitting radionuclides.

gas-flow proportional counter – A device or instrument that measures various alpha- and beta-emitting radionuclides.

Gaussian puff/plume model – A computer simulated atmospheric dispersion of a release using a Gaussian (normal) statistical distribution to determine concentrations in air.

GDNR – Georgia Department of Natural Resources.

Geiger-Mueller (GM) counter – A highly sensitive, gas-filled radiation detector, which operates at voltages sufficiently high to produce ionization. The counter is used primarily in the detection of gamma radiation and beta emission. It is named for Hans Geiger and W. Mueller, who invented it in 1928.

genotoxicology – the study of the effects of chemicals or radioactive contaminants on the genetics of individual animals or plants.

Geographic Information System – Computer-based system for storing, manipulating, and analyzing geographical information.

GIS – See Geographic Information System.

GOCO – Government-owned, contractor-operated.

grab sample – A sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

groundwater, unconfined – Groundwater exposed to the unsaturated zone.

H

half-life, biological – The time required for a biological system, such as that of a human, to eliminate by natural processes half the amount of a substance (such as a radioactive material) that has entered it.

half-life, radiological – The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

HCFC – Hydrochlorofluorocarbon.

head reversal – The hydrologic phenomenon in which a deeper formation has a higher water pressure than a more shallow formation in the same location. This condition results in a tendency for groundwater to flow upward from the deeper media to the more shallow formation.

heavy water – Water in which the molecules contain oxygen and deuterium, an isotope of hydrogen that is heavier than ordinary hydrogen.

herbaceous – Having little or no woody tissue.

herbicides/pesticides – Suite of analyses consisting of 2,4-dichlorophenoxyacetic acid, endrin, lindane, methoxychlor, toxaphene, and 2,4,5-TP (silvex).

high-purity germanium (HPGe) detector – A device that detects photon radiation by employing diffused junctions generated by the application of a high voltage across a semiconductor material.

hydrogeology – Hydrolic aspects of site geology.

ICRP – International Commission on Radiological Protection.

Inorganic – Involving matter other than plant or animal.

In situ – In its original place. Field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

Internal blank – deionized water sample generated by the laboratory; an internal blank is analyzed with each batch of samples as an in-house check of analytical procedures and equipment.

Internal dose factor – A factor used to convert intakes of radionuclides to dose equivalents.

Internal radiation – Internal radiation occurs when natural radionuclides enter the body by ingestion of foods, milk, and water, and by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion – An atom or compound that carries an electrical charge.

ion exchange – Process in which a solution containing soluble ions is passed over a solid ion exchange column that removes the soluble ions by exchanging them with labile ions from the surface of the column. The process is reversible so that the trapped ions are removed (eluted) from the column and the column is regenerated.

Irradiation – Exposure to radiation.

Isco sampler – A portable, microprocessor-controlled water sampler that utilizes a peristaltic pump for sample collection. The sampler may be used with a flowmeter to obtain a flow-proportional sample or without a flowmeter to obtain a time-proportional sample.

Isotopes – Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

long-lived isotope – A radionuclide that decays at such a slow rate that a quantity of it will exist for an

extended period (half-life is greater than three years).

short-lived isotope – A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

L **laboratory blank** – See internal blank.

LDR – Land disposal restrictions.

LETf – Liquid Effluent Treatment Facility.

liquid scintillation cocktail – A solution combined with a radioactive sample which converts the energy of the particle emitted during radioactive decay into light, which is detected by a liquid scintillation counter.

liquid scintillation counter – The combination of phosphor, photomultiplier tube, and associated circuits for counting light emissions produced in the phosphors.

littoral zone – The shallow water along the shore line of a body of water.

LLD – See lower limit of detection.

lower limit of detection (LLD) – The smallest concentration/amount of analyte that can be reliably detected in a sample at a 95 percent confidence level.

M **maximally exposed individual** – A hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

mercury – A silver-white, liquid metal solidifying at -38.9°C to form a tin-white, ductile, malleable mass. It is widely distributed in the environment and biologically is a nonessential or nonbeneficial element. Human poisoning due to this highly toxic element has been clinically recognized.

microbes – Microscopic organisms.

migration – The transfer or movement of a material through the air, soil, or groundwater.

milliroentgen (mR) – A measure of X-ray or gamma radiation. The unit is one-thousandth of a roentgen.

minimum detectable concentration – The smallest amount or concentration of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

monitoring – Process whereby the quantity and quality of factors that can affect the environment and/or human health are measured periodically in order to regulate and control potential impacts.

MRD – See mean relative difference.

mrem – The dose equivalent that is one-thousandth of a rem.

N

natural radiation – Radiation arising from cosmic and other naturally occurring radionuclide (such as radon) sources present in the environment.

NCRP – National Council on Radiation Protection and Measurements.

NEPA – National Environmental Policy Act.

NESHAP – National Emission Standards for Hazardous Air Pollutants.

nonroutine radioactive release – Unplanned or non-scheduled release of radioactivity to the environment.

nonstochastic effects – Biological effects in which the severity in affected individuals varies with the magnitude of the dose above a threshold.

NOV – Notice of Violation.

NPDES – National Pollutant Discharge Elimination System.

NRC – U.S. Nuclear Regulatory Commission.

nuclide – An atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

O

ODS – Ozone-depleting substances.

organic – Of, relating to, or derived from living organisms (plant or animal).

OSHA – Occupational Safety and Health Administration.

outcrop – A place where groundwater is discharged to the surface. Springs, swamps, and beds of streams and rivers are the outcrops of the water table.

outfall – The point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

P

paddlewheel sampler – A water sampling device, constructed of a Lexan® wheel, suspended on two pontoons and anchored in streams and rivers.

parts per billion (ppb) – A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or ng/mL.

parts per million (ppm) – A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L.

PCB – Polychlorinated biphenyl.

PEIS – Programmatic Environmental Impact Statement.

person-rem – Collective dose to a population group. For example, a dose of one rem to 10 individuals results in a collective dose of 10 person-rem.

pH – A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0–6, basic solutions have a pH > 7, and neutral solutions have a pH = 7.

PIP – Public Involvement Plan.

population dose commitment – See collective dose equivalent under dose.

ppb – See parts per billion.

ppm – See parts per million.

priority pollutants – A group of approximately 130 chemicals (about 110 are organics) that appear on an EPA list because they are toxic and relatively common in industrial discharges.

process water – Water used within a system process.

process sewer – Pipe or drain, generally located underground, used to carry off process water and/or waste matter.

purge – To remove water prior to sampling, generally by pumping or bailing.

purge water – Water that has been released to seepage basins to allow a significant part of tritium to decay before the water outcrops to surface streams and flows to the Savannah River.

PVC – polyvinyl chloride.

Q

QA – See quality assurance.

QAD – Quality Assurance Division (EPA).

QAP – Quality Assurance Program (DOE).

QC – See quality control.

quality assurance (QA) – Any action in environmental monitoring to assure the reliability of monitoring and measurement data.

quality control (QC) – The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes.

quality factor – The factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

quench – (a) The reduction of the signal from a liquid scintillation cocktail due to chemical or color interferences; (b) a process by which a gas (usually a halogen) is added to a detector to inhibit avalanche ionizations.

R

rad – The unit of absorbed dose deposited in a volume of material.

radiation detection instruments – Devices that detect and record the characteristics of ionizing radiation.

radioactivity – The spontaneous emission of radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

radioisotopes – Radioactive isotopes.

radionuclide – An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

raw water holding pond – pond that holds water that has not been purified.

RBOF – Receiving Basin for Offsite Fuel.

RCRA – See Resource Conservation and Recovery Act.

RCRA site – Solid waste management unit under RCRA regulation. See Resource Conservation and Recovery Act.

reagent – Any substance used in a chemical reaction to detect or measure another substance or to convert one substance into another by means of the reaction that it causes.

reagent blank – A control sample which is used to determine the background of each reagent or solvent used in a given method of analysis. They are composed of all constituents that will contact the sample except the sample itself.

real-time instrumentation – An operation in which programmed responses to an event are essentially simultaneous with the event itself.

reclamation – Recovery of wasteland, desert, etc., by ditching, filling, draining, or planting.

reforestation – The process of planting new trees on land once forested.

release – Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem – The unit of dose equivalent (absorbed dose in rads $\times$ the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem) which is one-thousandth of a rem.

remediation – The correction of a problem. See Environmental Restoration.

replicate – In the EMS Groundwater Monitoring Program, a second sample from the same well taken at the same time as the primary sample and sent to the same laboratory for analysis.

replicate result – The analytical result of a blind replicate sample. See blind replicate.

Resource Conservation and Recovery Act (RCRA) – Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

RFI Program – RCRA Facility Investigation Program; EPA-regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

RFI/RI – RCRA Facility Investigation/Remedial Investigation. See RFI/RI Program.

RFI/RI Program – RCRA Facility Investigation/Remedial Investigation Program. At SRS, the expansion of the RFI Program to include CERCLA and hazardous substance regulations.

roentgen – A unit of exposure from X- or gamma rays. One roentgen equals 2.58×10^{-4} coulombs per kilogram of air.

routine radioactive release – A planned or scheduled release of radioactivity to the environment.

RQ – Reportable quantity.

RTF – Replacement Tritium Facility.

S

SARA – Superfund Amendments and Reauthorization Act.

SCDHEC – South Carolina Department of Health and Environmental Control.

screen zone – In well construction, the section of a formation that contains the screen, or perforated pipe that allows water to enter the well.

SDWA – Safe Drinking Water Act (federal).

SEA – Special Environmental Analysis.

seepage basin – An excavation that receives wastewater. Insoluble materials settle out on the floor of the basin and soluble materials seep with the water through the soil column where they are removed partially by ion exchange with the soil. Construction may include dikes to prevent overflow or surface runoff.

SEIS – Supplemental Environmental Impact Statement.

self-absorption – Absorption of radiation by the sample itself, preventing detection by the counting instrument.

sensitivity – The capability of methodology or instruments to discriminate between samples with differing concentrations or containing varying amounts of analyte.

settleable solids – Material settling out of suspension within a defined period.

settling basin – A temporary holding basin (excavation) that receives wastewater which is subsequently discharged.

sidegradient well – A well that intercepts groundwater flowing next to a site; a sidegradient well is located neither upgradient nor downgradient to the monitored site.

sievert (Sv) – The SI (International System of Units) unit of dose equivalent, 1 Sv=100 rem.

Solid Waste Disposal Facility (SWDF) – A place for burying unwanted radioactive material to prevent escape of radioactivity. The surrounding water acts as a shield. Such material is placed in watertight, noncorrodible containers so that it cannot leach out and invade underground water.

source – A point or object from which radiation or contamination emanates.

source check – A radioactive source with a known amount of radioactivity used to check the performance of the radiation detector instrument.

source term – Quantity of radioactivity released in a set period of time that is traceable to the starting point of an effluent stream or migration pathway.

spike – The addition of a known amount of reference material containing the analyte of interest to a blank sample.

split sample – Two samples from the same well, taken at the same time, and sent to two different laboratories for analysis.

SRARP – Savannah River Archaeological Research Program.

SREL – Savannah River Ecology Laboratory (University of Georgia).

SRFS – Savannah River Forest Station (U.S. Forest Station).

SRS – Savannah River Site.

SRS stream – Any natural stream on the SRS site. Surface drainage of the site is via these streams to the Savannah River.

SRTC – Savannah River Technology Center.

stable – Not radioactive or not easily decomposed or otherwise modified chemically.

stack – A vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

standard deviation – An indication of the dispersion of a set of results around their average.

stochastic effects – Biological effects, whose probability, rather than the severity, is a function of the magnitude of the radiation dose without threshold (i.e., stochastic effects are random in nature).

stormwater runoff – Surface streams that appear after precipitation.

strata – Beds, layers, or zones of rocks.

substrate – The substance, base, surface, or medium in which an organism lives and grows.

sulfate – Sulfate is widely distributed in nature and may be present in natural waters in concentrations ranging from a few to several thousand mg/L.

surface water – All water on the surface of the earth, as distinguished from groundwater.

Sv – See sievert.

SWDF – See Solid Waste Disposal Facility.

T

temperature – The thermal state of a body considered with its ability to communicate heat to other bodies.

tank farm – An installation of interconnected underground tanks for storage of high-level radioactive liquid wastes.

terrestrial radiation – Ionizing radiation emitted from radioactive materials, primarily potassium-40, thorium, and uranium, in the earth's soils. Terrestrial radiation contributes to natural background radiation.

thermoluminescent dosimeter (TLD) – A device used to measure external gamma radiation.

TLD – See thermoluminescent dosimeter.

total activity – The total quantity of radioactive decay particles that are emitted from a sample.

total dissolved solids – Dissolved solids and total dissolved solids are terms generally associated with freshwater systems and consist of inorganic salts, small amounts of organic matter and dissolved materials.

total phosphorus – When concentrations exceed 25 mg/L at the time of the spring turnover on a volume-weighted basis in lakes or reservoirs, it may occasionally stimulate excessive or nuisance growths of algae and other aquatic plants.

total organic halogens – A measure of the total concentration of organic compounds that have one or more halogen atoms.

total solids – The sum of total dissolved solids and suspended solids.

total suspended particulates – Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transmissive zone – A zone of sediments sufficiently porous and permeable to allow the flow of groundwater through the zone.

transuranic waste – Solid radioactive waste containing primarily alpha-emitting elements heavier than uranium.

TRI – Toxic Release Inventory.

trip blank – A sample container of deionized water that is transported to the well sample location, treated as a well sample, and sent to the laboratory for analysis; trip blanks are used to check for contamination resulting from transport, shipping, and site conditions.

TSCA – Toxic Substances Control Act.

turbidity – A measure of the concentration of sediment or suspended particles in solution.

U

uncontrolled area – Any area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials. The area beyond the boundary of SRS is an uncontrolled area.

upgradient – In the direction of increasing hydrostatic head.

USFS – U.S. Forest Service.

USGS – U.S. Geological Survey.

V

vadose zone – Soil zone located above the water table.

variation – The divergence in the structural or functional characteristics of an organism from those considered typical of the group to which it belongs.

volatile organic compounds – 1,1,1-TCE, Perclene, Triclene are common names for trichloroethane, tetrachloroethylene, and trichloroethylene, respectively. Used in many processes, the levels of these carcinogenic compounds must be kept to a minimum. They are measured by volatile organic analyses content.

W

waste unit – An inactive area that is known to have received contamination or had a release to the environment.

watershed – The region draining into a river, river system, or body of water.

weighting factor – A value used to calculate dose equivalents. It is tissue specific and represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue. The weighting factors used in this report are recommended by the ICRP (Publication 26).

wetlands – A lowland area, such as a marsh or swamp, inundated or saturated by surface or groundwater sufficiently to support hydrophytic vegetation typically adapted for life in saturated soils.

WIND – Weather INFORMATION and Display.

wind rose – A diagram in which statistical information concerning direction and speed of the wind at a location is summarized.

worldwide fallout – Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

WSRC – Westinghouse Savannah River Company.

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Units of Radiation Measure		
Current System	<i>Système International</i>	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Fractions and Multiples of Units				
Multiple	Decimal Equivalent	Prefix	Symbol	Report Format
10^6	1,000,000	mega-	M	E+06
10^3	1,000	kilo-	k	E+03
10^2	100	hecto-	h	E+02
10	10	deka-	da	E+01
10^{-1}	0.1	deci-	d	E-01
10^{-2}	0.01	centi-	c	E-02
10^{-3}	0.001	milli-	m	E-03
10^{-6}	0.000001	micro-	μ	E-06
10^{-9}	0.000000001	nano-	n	E-09
10^{-12}	0.000000000001	pico-	p	E-12
10^{-15}	0.000000000000001	femto-	f	E-15
10^{-18}	0.000000000000000001	atto-	a	E-18

Conversion Table					
Multiply	By	To Obtain	Multiply	By	To Obtain
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liq qt-U.S.	0.946	L	L	1.057	liq qt-U.S.
ft ²	0.093	m ²	m ²	10.764	ft ²
mi ²	2.59	km ²	km ²	0.386	mi ²
ft ³	0.028	m ³	m ³	35.31	ft ³
d/m	0.450	pCi	pCi	2.22	d/m
pCi	10^{-6}	μ Ci	μ Ci	10^6	pCi
pCi/L (water)	10^{-9}	μ Ci/mL (water)	μ Ci/mL (water)	10^9	pCi/L (water)
pCi/m ³ (air)	10^{-12}	μ Ci/mL (air)	μ Ci/mL (air)	10^{12}	pCi/m ³ (air)

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END