WSRC–TR–2000–00328

Savannah River Site

Environmental Report for 2000

Editors

Margaret W. Arnett
Albert R. Mamatey

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

Front Cover — Many plant and animal species make the Savannah River Site their home. This year's environmental report cover features a few of them against a backdrop of the Savannah River as it flows along the site's southwestern border. The double-crested cormorant (*Phalacrocorax auritus*) is a dark, goose-like bird with short legs, webbed toes, a long neck, and a beak sharply hooked at the tip. Attaining a height of up to 3 feet, it resides in coastal regions during the summer, but may move to inland lakes and rivers from autumn through spring. The prickly pear cactus (*Oputia compressa*) is a woody plant that grows in dry, upland habitats. Its body consists of thick, succulent segments, and it has spines and easily detached barbed hairs. The gray rat snake (*Elaphe obsoleta*) is most common in wooded or swampy areas. Adults often grow to 4 feet, but can reach 6 to 7 feet in length. They are excellent climbers and feed on birds and their eggs, as well as on rodents. The gulf fritillary butterfly (*Agraulis vanillae*) generally is found in the southern United States. It is bright orange, with black marks and three white, black-rimmed spots on each wing; its habitat includes woodland edges, brushy fields, and even city gardens. It has come to rest here on a collection of water shields (*Braseria schreberi*), which thrive in areas of quiet water. A jelly-like substance on the plants' stems and on the lower surfaces of their leaves keeps micro-organisms from colonizing on them. The photographs for the 2000 report cover were taken at various site locations by Al Mamatey of the Westinghouse Savannah River Company's Environmental Protection Department. The cover was designed by Eleanor Justice of the company's Management Services Department – Illustrating and Design Group.

For more information about this report, or to obtain additional copies, contact:

Bob Lorenz, Manager
Environmental Sampling and Reporting
Westinghouse Savannah River Company
Building 735–16A
Aiken, SC 29808
Telephone: 803–725–3556
E-mail address: robert.lorenz@srs.gov

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Dave Filler	Paul Johns	Matt Parker	Joseph Trahan
Lynne Geary	Larry Koffman	Bill Payne	Gary Wein
Kent Gilbreath	Jeff Lintern	Linda Perry	George Wingard

Environmental Advisory Committee:

Dr. Edgar Berkey – Vice President and Chief Science Officer, Concurrent Technologies Corporation; Adjunct Professor of Environmental Engineering, University of Pittsburgh

Dr. Keros Cartwright – Principal Hydrogeologist, Illinois Geological Survey; Adjunct Professor of Geology, University of Illinois

Dr. Bernd Kahn – Director, Environmental Research Center; Professor Emeritus, Nuclear Engineering and Health Physics, Georgia Institute of Technology

Dr. Dennis Paustenbach – Group Vice President, Environmental & Health Groups for Exponent, Inc., Menlo Park, California

Dr. Milton Russell – Senior Fellow, Joint Institute for Energy and Environment (a research collaboration of the University of Tennessee, Oak Ridge National Laboratory, and the Tennessee Valley Authority; Professor Emeritus of Economics, University of Tennessee

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Preface

The *Savannah River Site Environmental Report for 2000* (WSRC–TR–2000–00328) is prepared for the U.S. Department of Energy (DOE) according to requirements of DOE Order 231.1, “Environment, Safety and Health Reporting.” The report’s purpose is to

- present summary environmental data that characterize site environmental management performance
- confirm compliance with environmental standards and requirements
- highlight significant programs and efforts
- assess the impact of SRS operations on the public and the environment

SRS has had an extensive environmental monitoring program in place since 1951 (before site startup). In the 1950s, data generated by the onsite environmental monitoring program were reported in site documents. Beginning in 1959, data from offsite environmental surveillance activities were presented in reports issued for public dissemination. SRS reported onsite and offsite environmental monitoring activities separately until 1985, when data from both programs were merged into one public document.

The *Savannah River Site Environmental Report for 2000* is an overview of effluent monitoring and environmental surveillance activities conducted on and in the vicinity of SRS from January 1 through December 31, 2000. It is prepared by the Environmental Monitoring Section (EMS) of Westinghouse Savannah River Company (WSRC). The “SRS Environmental Monitoring Plan” (WSRC–3Q1–2–1000) and the “SRS Environmental Monitoring Program” (WSRC–3Q1–2–1100) provide complete program descriptions and document 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 environmental report’s data 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), sampling or analytical equipment malfunctions, and compromise of the samples in the preparation laboratories or counting room.

Report Documents Available on Web

Readers can now find the *SRS Environmental Report*—as well as the accompanying data book and summary—on the World Wide Web.

The address for access to these documents on the Web is as follows:

http://www.srs.gov/general/srenviro/endrpt/index.html

To inquire about the report documents, or to request hard copies, please contact

Bob Lorenz, Manager
Environmental Sampling and Reporting
Westinghouse Savannah River Company
Building 735–16A
Aiken, SC 29808

Telephone: (803) 725–3556
E-mail address: robert.lorenz@srs.gov

Unless otherwise indicated, the figures and tables in this report are generated using results from the routine monitoring program. No attempt has been made to include all data from environmental research programs. A more complete listing of routine monitoring program data can be found in *Savannah River Site Environmental Data for 2000* (WSRC–TR–2000–00329).

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

- Analytical results and their corresponding uncertainty terms generally are reported with up to three significant figures. This is a function of the computer software used and may imply greater accuracy in the reported results than the analyses would allow.
- Units of measure and their abbreviations are defined in the glossary (beginning on page 243) and in charts at the back of the report.
- The reported uncertainty of a single measurement reflects only the counting error—not other components of random and systematic error in the measurement process—so some results may imply a greater confidence than the determination would suggest.
- An uncertainty quoted with a mean value represents the standard deviation of the mean value. This number is calculated from the results themselves and is not weighted by the uncertainties of the individual results.

- All values represent the weighted average of all acceptable analyses of a sample for a particular analyte. Samples may have undergone multiple analyses for quality assurance purposes or to determine if radionuclides are present. For certain radionuclides, quantifiable concentrations may be below the minimum detectable activity of the analysis, in which case the actual concentration value is presented to satisfy DOE reporting guidelines.
- 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 beta/gamma radiation from sources external to the body.

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Acronyms and Abbreviations

Note: *Sampling location abbreviations can be found on page xxiii.*

A

AEC – U.S. Atomic Energy Commission

ALARA – As low as reasonably achievable

ANSP – Academy of Natural Sciences of Philadelphia

B

BSRI – Bechtel Savannah River, Inc.

BTU – British Thermal Unit

C

CAA – Clean Air Act

CAAA – Clean Air Act Amendments of 1990

CAB – Citizens Advisory Board

CAS – Chemical abstract numbers

CDC – Centers for Disease Control and Prevention

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)

CFC – Chlorofluorocarbon

CFR – Code of Federal Regulations

CIF – Consolidated Incineration Facility

CLED – Contaminated Large-Equipment Disposition

CMP – Chemicals, metals, and pesticides

COU – Catalytic oxidation unit

CSRA – Central Savannah River Area

CSWTF – Central Sanitary Wastewater Treatment Facility

CWA – Clean Water Act

CX – Categorical exclusion

D

D&D – Deactivation and decommissioning

DCG – Derived concentration guide

DOE – U.S. Department of Energy

DOE/EML – U.S. Department of Energy Environmental Measurements Laboratory

DOE–HQ – U.S. Department of Energy-Headquarters

DOE–SR – U.S. Department of Energy-Savannah River Operations Office

DUS – Dynamic Underground Stripping

DWPF – Defense Waste Processing Facility

DWS – Drinking water standards

E

EA – Environmental Assessment

ECA – Environmental Compliance Authority

EE/CA – Engineering Evaluation/Cost Analysis

EGG – Environmental Geochemistry Group

EIS – Environmental Impact Statement

EMCAP – Environmental Monitoring Computer Automation Program

EMS – Environmental Monitoring Section of the Environmental Protection Department (of Westinghouse Savannah River Company)

EPA – U.S. Environmental Protection Agency

EPCRA – Emergency Planning and Community Right-to-Know Act

EPD – Environmental Protection Department (of Westinghouse Savannah River Company)

ERA – Environmental Resource Associates

ERD – Environmental Restoration Division

ESCO – Energy Services Company

ETF – Effluent Treatment Facility

EST – Environmental Sciences and Technology Department

F

FDD – Facilities Disposition Division

FFA – Federal Facility Agreement

FFCA – Federal Facility Compliance Agreement

FFCAct – Federal Facility Compliance Act

FONSI – Finding of No Significant Impact

G

GDNR – Georgia Department of Natural Resources

GIMS – Geographical Information Management System

GIS – Geographic Information System

GOCO – Government-owned, contractor-operated

GSA – General Separations Area

H

HBFC – Hydrobromofluorocarbon

HCFC – Hydrochlorofluorocarbon

HEAST – *Health Effects Assessment Summary Tables* (EPA)

HVAC – heating, ventilation, and air conditioning

HWMF – Hazardous Waste Management Facility

I

ICRP – International Commission on Radiological Protection

ISO – International Organization for Standardization

K

KAMS – K-Area Materials Storage

L

LDR – Land disposal restrictions

LLD – Lower limit of detection

M

MACT – Maximum Achievable Control Technology

MAP – Mitigation Action Plan

MCL – Maximum contaminant level

MDA – Minimum detectable activity

MDC – Minimum detectable concentration

MDL – Minimum detectable limit

MOX – Mixed oxide

MRD – Mean relative difference

MWMF – Mixed Waste Management Facility

N

NCRP – National Council on Radiation Protection and Measurements

NEPA – National Environmental Policy Act

NESHAP – National Emission Standards for Hazardous Air Pollutants

NFN – No file negative

NHPA – National Historic Preservation Act

NIST – National Institute of Standards and Technology

NOV – Notice of Violation

NPDES – National Pollutant Discharge Elimination System

NSPS – New Standards of Performance for Stationary Sources

NWP – Nationwide permit

O

ODS – Ozone-depleting substances

P

PAR Pond – Pond constructed at Savannah River Site in 1958 to provide cooling water for P-Reactor and R-Reactor (P and R; hence, PAR)

PEIS – Programmatic Environmental Impact Statement

pH – Measure of the hydrogen ion concentration in an aqueous solution (acidic solutions, pH from 0–6; basic solutions, pH > 7; and neutral solutions, pH = 7

Q

QA – Quality assurance

QAP – Quality Assurance Program (Department of Energy)

QA/QC – Quality assurance/quality control

QC – Quality control

R

RBOF – Receiving Basin for Offsite Fuel

RCRA – Resource Conservation and Recovery Act

RFI/RI – RCRA Facility Investigation/Remedial Investigation

ROD – Record of Decision

RQ – Reportable quantity

RTF – Replacement Tritium Facility

S

SARA – Superfund Amendments and Reauthorization Act

SCDHEC – South Carolina Department of Health and Environmental Control

SDWA – Safe Drinking Water Act

SEIS – Supplemental Environmental Impact Statement

S&HO – Safety and Health Operations

SIRIM – Site Item Reportability and Issues Management

S&M – surveillance and maintenance

SRARP – Savannah River Archaeological Research Program

SREL – Savannah River Ecology Laboratory

SRIP – Savannah River Implementation Procedure

SRL – Savannah River Laboratory (now Savannah River Technology Center)

SRS – Savannah River Site

SRTC – Savannah River Technology Center (formerly Savannah River Laboratory)

STP – Site Treatment Plan

SUD – Site Utilities Division of Westinghouse Savannah River Company

SVE – Soil vapor extraction

SWD – Solid Waste Division

SWDF – Solid Waste Disposal Facility

SWMF – Solid Waste Management Facility

T

TCLP – Toxicity Characteristic Leaching Procedure

TLD – Thermoluminescent dosimeter

TMDL – Total maximum daily load

TPBARS – Tritium Producing Burnable Absorber Rods

TRU – Transuranic waste

TSCA – Toxic Substances Control Act

U

USFS–SR – U.S. Department of Agriculture Forest Service–Savannah River

USGS – U.S. Geological Survey

V

VIA – Values Impact Assessments

VOC – Volatile organic compound

W

WET – Whole Effluent Toxicity

WIPP – Waste Isolation Pilot Plant

WSRC – Westinghouse Savannah River Company

Sampling Location Information

Note: This section contains sampling location abbreviations that are used in the text and/or on the sampling location maps. It also contains a list of sampling locations that are known by more than one name (see next page).

Location Abbreviation	Location Name/Other Applicable Information
4M	Four Mile
4MC	Four Mile Creek
BDC	Beaver Dam Creek
BG	Burial Ground
EAV	E-Area Vaults
FM	Four Mile
FMC	Four Mile Creek (Fourmile Branch)
GAP	Georgia Power Company
HP	HP (sampling location designation only; not an actual abbreviation)
HWY	Highway
KP	Kennedy Pond
L3R	Lower Three Runs
NRC	Nuclear Regulatory Commission
NSB L&D	New Savannah Bluff Lock & Dam
PAR	“P and R” Pond
PB	Pen Branch
RM	River Mile
SC	Steel Creek
SWDF	Solid Waste Disposal Facility
TB	Tims Branch
TC	Tinker Creek
TNX	Multipurpose Pilot Plant Campus
U3R	Upper Three Runs

Sampling Locations Known by More Than One Name

Augusta Lock and Dam; New Savannah Bluff Lock and Dam

Beaver Dam Creek; 400–D

Four Mile Creek–2B; Four Mile Creek at Road C

Four Mile Creek–6; Four Mile Creek at Road A–13–2

Lower Three Runs–2; Lower Three Runs at Patterson Mill Road

Pen Branch–3; Pen Branch at Road A–13–2

R-Area downstream of R–1; 100–R

River Mile 118.8; U.S. Highway 301 Bridge Area; Highway 301; US 301

River Mile 129.1; Lower Three Runs Mouth

River Mile 141.5; Steel Creek Boat Ramp

River Mile 150.4; Vogtle Discharge

River Mile 152.1; Beaver Dam Creek Mouth

River Mile 157.2; Upper Three Runs Mouth

River Mile 160.0; Dernier Landing

Steel Creek at Road A; Steel Creek–4; Steel Creek–4 at Road A; Steel Creek at Highway 125

Tims Branch at Road C; Tims Branch–5

Tinker Creek at Kennedy Pond; Tinker Creek–1

Upper Three Runs–4; Upper Three Runs–4 at Road A; Upper Three Runs at Road A; Upper Three Runs at Road 125

Upper Three Runs–1A; Upper Three Runs–1A at Road 8

SRS Observes 50th Anniversary

50 Years Ago . . .

It was a time when the world was still recovering from World War II. Relations between the United States and the Soviet Union were crumbling, and the Cold War had begun. Panic followed the president's message that the Soviet Union was believed to have set off an atomic explosion. The Korean War had started, and it was a scary time in the world.

Responding to a directive from President Harry S. Truman to the U.S. Atomic Energy Commission, E.I. du Pont de Nemours and Company and the commission negotiated a contract whereby Du Pont would design, construct, and operate what was to become the Savannah River Plant.

An announcement was made November 28, 1950, that the federal government had chosen a site to construct a plant to produce plutonium and tritium for defense purposes. Plutonium sets off the nuclear chain reaction in bombs, and tritium is a hydrogen isotope that boosts the explosive power of weapons, making them deadlier than the bombs that destroyed Hiroshima and Nagasaki.

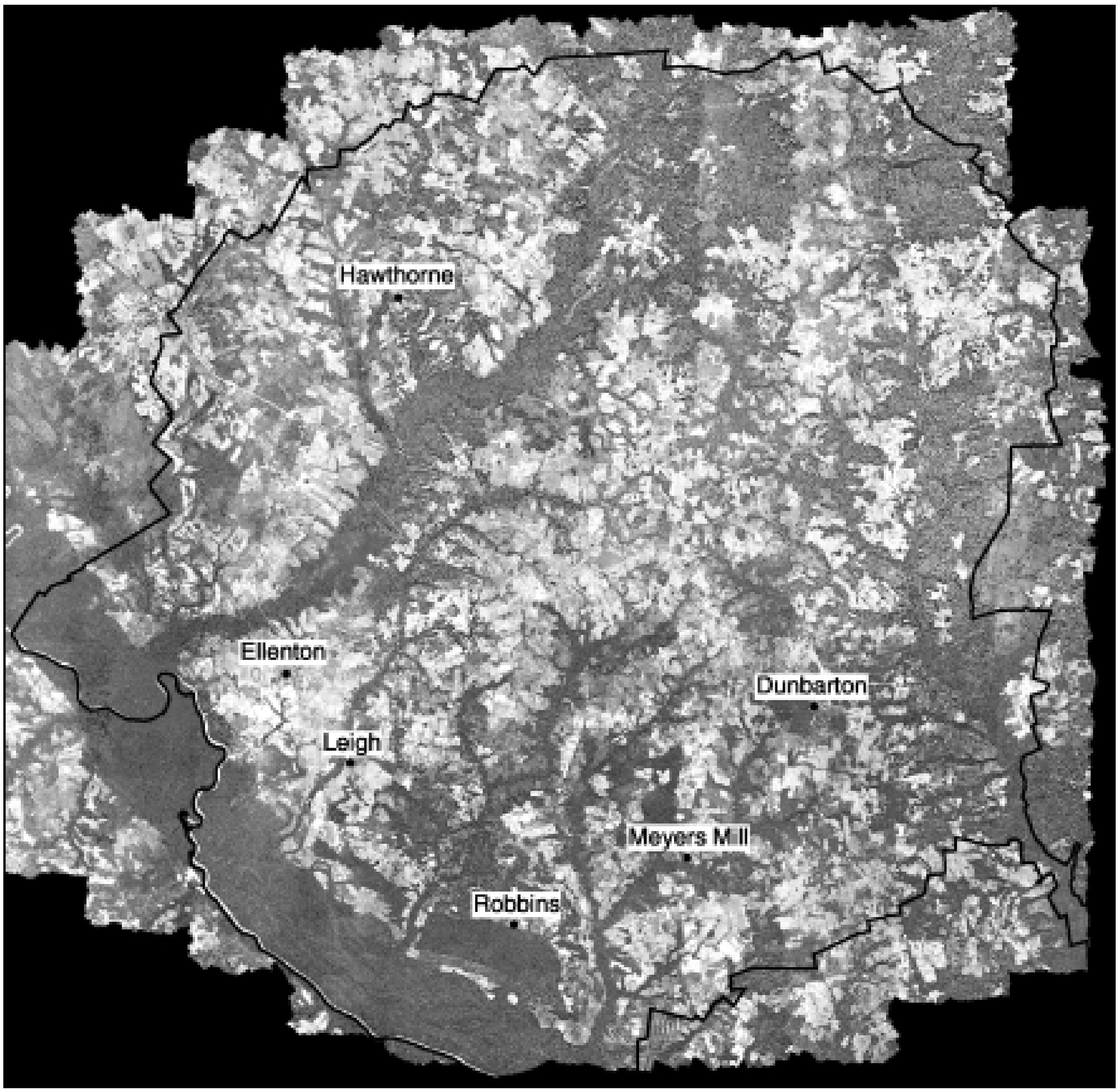
The Savannah River Plant was to be built in parts of Aiken, Barnwell, and Allendale counties in South Carolina. The 250,000-acre area had been selected by applying the following criteria:

- 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
- access to adequate transportation
- land not subject to floods and major storms
- the availability of millions of gallons of water, low in mineral content, for cooling and process use
- suitable terrain and topography

SRS Archives Photos

The moving of houses was a familiar site after the 1950 announcement that the federal government would build the Savannah River Plant on 250,000 acres in Aiken, Barnwell, and Allendale counties in South Carolina. Most of the 1,500 displaced families were relocated to towns around the plant border by the government.

Du Pont, the Atomic Energy Commission, and the U.S. Army Corps of Engineers had considered 114 sites in 18 states before recommending the South Carolina site, which met all the established criteria. About 1,500 families in seven communities (Ellenton, Dunbarton, Meyers Mill, Hawthorne, Robbins, Leigh, and Sleepy Hollow) were told they would have to relocate within 18 months. Government contractors moved residents' homes to locations around the plant's border and compensated landowners for their losses. Reactions ranged from dismay, fear, and bitter resentment to hopes for an economic boon and a feeling of profound patriotism for helping the country in a time of great need. Most of Ellenton's residents made new homes in a town they named New Ellenton. Other displaced residents started over again in surrounding towns, and still others moved far away.



U.S. Forest Service Photo Modified by EPD/GIS

An aerial photograph taken before the Savannah River Plant was constructed depicts the Savannah river, streams, and farmland as well as several of the towns and communities whose habitants had to relocate outside the site boundary. The site boundary and names of towns are superimposed over the photograph.

By February 1, 1951, construction had begun. By the evacuation deadline, construction workers had arrived by the thousands. In June 1951, 8000 construction workers were on site. By September 1952, the number of plant workers had swelled to almost 38,600.The first facility to begin operating, the heavy water plant, started up August 17, 1952, and the first of five production reactors achieved operating status December 28, 1953. All five reactors had achieved operating status by March 1955. In addition, between 1951 and 1955, two chemical separations plants, a fuel and target manufacturing area, laboratories, 230 miles of new roads, the state’s first cloverleaf intersection, and power plants were constructed. The initial investment of $250,000 eventually would grow to $1.4 billion.

Initial Construction Facts . . .

Peak construction force	38,582 workers
Earth moved	39,150,000 cubic yards = a wall 10 feet high and 6 feet wide from Atlanta, Georgia, to Portland, Oregon
Concrete	1,435,000 cubic yards = a highway 6 inches thick and 20 feet wide from Atlanta, Georgia to Philadelphia, Pennsylvania
Reinforcing steel	118,999 tons = 3,300 cars or a train 30 miles long
Structural steel	27,000 tons = a train 8 miles long
Lumber	85,000,000 board feet = enough lumber for a city of 15,000 homes with an average population of 45,000 people
Blueprints	2,000,000 blueprints = a strip of paper 24 inches wide reaching from Atlanta, Georgia, to Seattle, Washington

Through the Years . . .

Although the reactors were designed primarily to manufacture materials for defense purposes, they eventually achieved much more. By 1988, more than 100 different radioisotopes had been produced in the reactors, including californium-252, used in medicine, and cobalt-60, used in industry.

A research program was begun in 1951 to determine the amount of natural radioactivity already present at the plant. This calculated figure was used as a baseline to measure increases of radioactivity resulting from the nuclear reactors. Later, the Savannah River Laboratory (which became known as the Savannah River Technology Center) was started to develop technologies for use within the plant.

Also begun in 1951 was an ecological laboratory to measure changes in the environment. Its first task was to inventory the flora and fauna of the site before any reactors were built. This laboratory became the permanent Savannah River Ecology Laboratory.

An archaeological program began at SRS in 1978 (although excavations had begun in 1973). Since then, nearly 2 million artifacts have been collected, analyzed, and stored at SRS. Currently, there are about 1,590 known archaeological sites, with the potential for more than 12,000 additional sites to be studied. Researchers of the Savannah River Archaeological Research Program believe the history of the site reaches back to 1000 A.D.

The U.S. Forest Service began planting trees on the site in 1952. Prior to that, there were pockets of trees where wetlands existed, but most of the site was farmland. More than 75 million pine seedlings were planted during the first several years on land characterized by weeds, dust, and erosion. Today, the majority of the site is dense forest.

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 Department of Energy, which has overseen all site activities since that time.

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

Beginning October 1, 1996, the site was operated under a new contract by an integrated team led by WSRC. Under this contract, WSRC is responsible for SRS's nuclear facility operations; Savannah River Technology Center; environment, safety, health, and quality assurance; and all the site's administrative functions. Bechtel Savannah River, Inc., is responsible for environmental restoration, project management, engineering, and construction activities. Babcock & Wilcox Savannah River Company is responsible for facility decontamination and decommissioning, and British Nuclear Fuels Savannah River Corporation is responsible for the site's solid waste program.

Through the years, the parent companies of WSRC shifted from Westinghouse Electric Corporation to Columbia Broadcasting System (CBS) to Morrison Knudsen to Washington Group International Inc.

Today and Tomorrow . . .

Nuclear materials are no longer made at the SRS, and one of the site's main missions is dealing with the pollution created by the reactors and support facilities. In addition, the site has been chosen to process plutonium for disposal and to recycle tritium for replenishing that which is decaying in the nation's nuclear arsenal. The site also will fabricate fuel for commercial power reactors.

SRS and surrounding communities observed the site's 50th anniversary with a year-long calendar of activities that culminated in a daylong celebration November 28 featuring speeches by dignitaries at various programs, a reunion of former residents of the towns and communities who had to move, the dedication to former residents of Ellenton of an SRS 50th anniversary commemorative marker near the original Ellenton historical marker, a press conference, and fireworks.

Site Facts . . .

- Construction at the Savannah River Plant began in 1951.
- The site, which covers 310 square miles in South Carolina, is bordered on the west by the Savannah River.
- In 1972, the Savannah River Plant was designated as the first National Environmental Research Park, a unique environment for preserving and studying vegetation and wildlife.
- The Savannah River Plant produced plutonium and tritium for national defense until 1988.
- The site was operated by E.I. du Pont de Nemours and Company until 1989, when Westinghouse Savannah River Company became the prime operating contractor and the Savannah River Plant was renamed the Savannah River Site.
- The Savannah River Site began a transition in 1991, after the end of the Cold War, toward its new mission.
- In 1994, the Savannah River Site was South Carolina's largest private employer, with a work force of about 21,000.
- The average population density in counties surrounding the site is 85 people per square mile, with the largest concentration in Augusta, Georgia.
- By the time the Soviet Union broke up in 1991, more than 25,000 people were employed at the site. After the Cold War ended, employment was scaled back to about 14,000 people.
- The Savannah River Site is owned today by the Department of Energy.

Note: This section was prepared by Margaret Arnett. Sources were *History of Du Pont at the Savannah River Plant*, by William P. Bebbington; *Memories of Home: Dunbarton and Meyers Mill Remembered*, by Tonya Algerine Browder, Richard David Brooks, and David Colin Crass, Savannah River Archaeological Research Heritage Series 1; *Memories of Home: Reminiscences of Ellenton*, by Tonya Algerine Browder and Richard David Brooks, Savannah River Archaeological Research Heritage Series 2; "Past and Present," a 30-day history newspaper series published by The Augusta Chronicle, Augusta, Ga., November 1–30, 2000; and "1950–2000, Savannah River Site," a special tabloid section published by The Aiken Standard, Aiken, S.C., November 27, 2000.

Executive Summary

THE mission at the Savannah River Site (SRS) is focused primarily on support of the national defense, nonproliferation, and environmental cleanup. SRS—through its prime operating contractor, Westinghouse Savannah River Company (WSRC)—continues to maintain a comprehensive environmental monitoring program.

In 2000, effluent monitoring and environmental surveillance were conducted extensively within a 2000-square-mile network reaching 25 miles from SRS—with some monitoring performed as far as 100 miles from the site (near Savannah). The area includes neighboring cities, towns, and counties in Georgia and South Carolina. Thousands of samples of air, rainwater, surface water, drinking water, groundwater, food products, wildlife, soil, sediment, and vegetation were collected and analyzed for radioactive and/or nonradioactive contaminants.

Potential Radiation Doses

Table 1 shows the 2000 potential radiation doses from SRS releases compared with the applicable federal dose standards and with estimated doses from naturally occurring background radiation. All potential radiation doses attributed to SRS in 2000 were below applicable regulatory standards.

Liquid Pathway

For 2000, the potential dose to the maximally exposed individual from liquid releases of radioactivity to the Savannah River was estimated at 0.14 mrem (0.0014 mSv). This dose is 0.14 percent of the U.S. Department of Energy (DOE) 100-mrem all-pathway dose standard for annual exposure.

The dose was about 36 percent less than the 1999 dose of 0.22 mrem (0.0022 mSv)—primarily because of a decrease in the amount of cesium-137 measured in Savannah River fish.

The 2000 collective dose from liquid releases was estimated to be 3.9 person-rem (0.039 person-Sv).

Drinking Water Pathway

Offsite doses were calculated for persons consuming drinking water from two water treatment plants located downriver of SRS near Beaufort, South Carolina, and Port Wentworth, Georgia. The maximum dose from each facility was about 0.06 mrem (0.0006 mSv). These doses are 1.5 percent of the drinking water standard of 4 mrem per year (0.04 mSv per year).

Airborne Pathway

For 2000, the potential dose to the maximally exposed individual from airborne releases of radioactive materials was 0.04 mrem (0.0004 mSv). This is about 33 percent less than the 1999 dose of 0.06 mrem (0.0006 mSv)—primarily because of decreases in the amount of unspecified alpha emitters released from SRS during 2000. The dose is 0.4 percent of the 10-mrem per year (0.1-mSv per year) limit for exposure to airborne releases from a DOE facility.

The collective dose from airborne releases was estimated to be 2.3 person-rem (0.023 person-Sv), which is less than 0.01 percent of the collective dose received from naturally occurring sources of radiation (about 186,000 person-rem).

All Pathway

To demonstrate compliance with the DOE Order 5400.5 all-pathway dose standard of 100 mrem per year (1.0 mSv per year), SRS conservatively combines the maximally exposed individual airborne pathway and liquid pathway dose estimates, even though the two doses are calculated for hypothetical individuals residing at different geographic locations.

For 2000, the potential maximally exposed individual all-pathway dose was 0.18 mrem (0.0018 mSv) (0.04 mrem from airborne pathway plus 0.14 mrem from liquid pathway). This dose is about 36 percent less than the 1999 all-pathway dose of 0.28 mrem (0.0028 mSv). A 10-year history of SRS maximum potential all-pathway doses to the maximally exposed individual is shown in figure 1.

Sportsman

In 2000, the maximum potential dose to an actual onsite hunter was about 63 mrem (0.63 mSv), which is 63 percent of DOE's 100-mrem all-pathway dose standard. During the onsite deer hunts, this individual harvested two animals—the edible portion totaled about 41 kilograms (91 pounds)—and was assumed to have eaten all the meat.

If a hypothetical offsite hunter living near the site boundary consumed 81 kg (179 pounds) of meat—the annual maximum adult consumption rate for meat—taken from deer living on site prior to being

Table 1 2000 Potential Radiation Doses from SRS Releases Compared with Applicable Dose Standards and Estimated Doses from Naturally Occurring Radiation

Maximally Exposed Individual Doses

Exposure Pathway	Maximum Potential Dose from 2000 Releases[a]	Applicable Dose Standard[b]	Percent of Standard	Percent of Natural[c]
Airborne Releases				
Total Airborne	0.04 mrem	10 mrem[d]	0.4	0.01
Liquid Releases				
Total Liquid	0.14 mrem	NA[e]	NA[e]	0.05
All Pathways[f]	**0.18 mrem**	100 mrem	0.18	0.06
Treated Drinking Water				
Beaufort-Jasper	0.06 mrem	4 mrem[g]	1.5	0.02
Port Wentworth	0.06 mrem	4 mrem[g]	1.5	0.02
Special-Case Exposure Scenarios				
Sportsman Dose				
Deer and hog consumption				
Onsite hunter	62.6 mrem	100 mrem	62.6	20.9
Offsite hunter	5.7 mrem	100 mrem	5.7	1.9
Fish consumption				
Steel Creek bass	0.64 mrem	100 mrem	0.64	0.2
Savannah River Swamp soil exposure[h]				
Hunter	4.4 mrem	100 mrem	4.4	1.5
Fisherman	.54 mrem	100 mrem	0.54	0.18
Goat Milk Consumption Dose				
Max. individual	0.05 mrem	10 mrem	0.5	0.02
Irrigation Pathway Dose				
Max. individual	0.11 mrem	100 mrem	0.11	0.04

Population (Collective) Doses

Exposure Pathway	Maximum Potential Dose from 2000 Releases[a]	Applicable Dose Standard[b]	Percent of Standard	Percent of Natural[c]
Airborne Releases				
Total Airborne	2.3 person-rem	NA[e]	NA[e]	0.01
Liquid Releases				
Total Liquid	3.9 person-rem	NA[e]	NA[e]	0.01

a Committed effective dose equivalent.

b Dose standards are from DOE Order 5400.5, “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]. The population (collective) dose due to naturally occurring radiation is estimated to be about 186,000 person-rem.

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 Not applicable; there is no separate standard for population dose or 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.

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

h A combination of external exposure to—and incidental ingestion and inhalation of—Savannah River Swamp soil

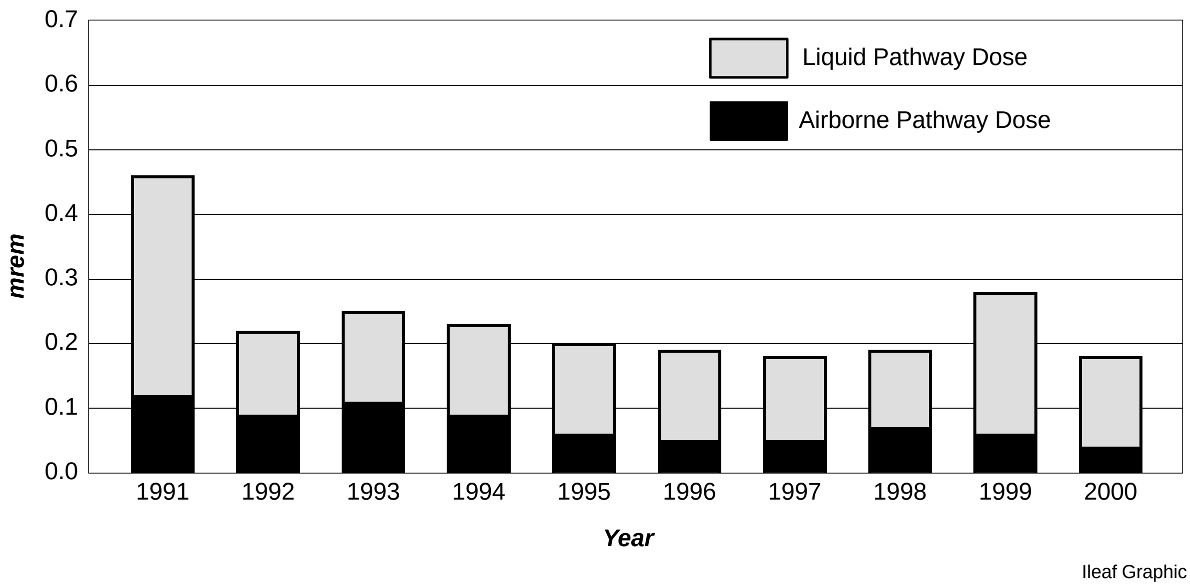


Figure 1 Ten-Year History of SRS Potential All-Pathway Doses to the Maximally Exposed Individual (Airborne plus Liquid Pathways)

harvested, the individual's maximum dose could have been 5.7 mrem (0.57 mSv). This dose was based on the average concentration of cesium-137 measured in animals harvested at SRS during 2000.

The potential maximum dose for a recreational fisherman was based on the consumption of 19 kg (42 pounds)—the maximum adult consumption rate for fish—of Savannah River fish having the highest measured concentrations of radionuclides. In 2000, bass caught at the mouth of Steel Creek had the highest concentrations. Consumption of 19 kg of these bass could have resulted in a dose of 0.64 mrem (0.0064 mSv).

For 2000, in addition to deer and fish consumption, the following exposure pathways were considered for an offsite hunter and an offsite fisherman—both on a privately owned portion of the Savannah River Swamp (Creek Plantation):

- External exposure to contaminated soil
- Incidental ingestion of contaminated soil
- Incidental inhalation of resuspended contaminated soil

The potential dose to the Savannah River Swamp hunter from the combination of these soil exposure pathways was estimated to be 4.4 mrem (0.044 mSv); the dose to the fisherman was estimated to be 0.54 mrem (0.0054 mSv).

Compliance Activities

A major goal at SRS continues to be positive environmental stewardship and full regulatory compliance, with zero violations. The site's employees maintained progress toward achievement of this goal in 2000, as a vast majority of their efforts were successful. For example, no notices of violation (NOVs) were received by SRS under the Clean Air Act (CAA), which had a compliance rate for the year of 100 percent; the Safe Drinking Water Act (SDWA); or the Resource Conservation and Recovery Act (RCRA).

The site also received no NOVs in 2000—and had a National Pollutant Discharge Elimination System (NPDES) compliance rate of 99.7 percent—under the the Clean Water Act (CWA). The compliance rate was calculated by dividing the number of analyses not exceeding permit limits for the year (5,478) by the total number of analyses performed (5,496) to demonstrate compliance with the site's NPDES permits.

Compliance with environmental regulations and with DOE orders related to environmental protection is an integral part of the operations at SRS. Management of the environmental programs at SRS is a significant activity, and assurance that onsite processes do not impact the environment adversely is a top priority. All site activities are overseen by one or more regulatory agencies, including the U.S. Environmental Protection Agency (EPA) and the

South Carolina Department of Health and Environmental Control (SCDHEC).

A systematic effort is in place to identify and address all evolving regulatory responsibilities that concern SRS. As part of the process, communications are maintained with all appropriate regulatory agencies to emphasize the site's commitment to environmental compliance.

SRS operations in 2000 continued to involve a wide variety of processes and chemicals subject to compliance with an increasing number of environmental statutes, regulations, policies, and permits. (For example, the site had 655 construction and operating permits in 2000 that specified operating levels for each permitted source.) Compliance with all requirements helps to ensure that the site, the public, and the surrounding environment are protected from adverse effects that could result from SRS operations. This section offers an overview of some of the environmental compliance issues with which the site was involved during 2000.

High-Level Radioactive Waste Tank Closure

The mission of SRS high-level waste tank closures at the F-Area and H-Area tank systems is to close out tanks in a way that ensures protection of human health and the environment, and in a technically and economically prudent manner. This must be done according to SCDHEC Regulation 61–82, "Proper Closeout of Wastewater Treatment Facilities," and in compliance with Resource Conservation and Recovery Act and Comprehensive Environmental Response, Compensation, and Liability Act requirements.

Tank 20F—a 1.3-million-gallon, single-shelled, carbon steel vessel—and tank 17F (with the same capacity) were closed in 1997. DOE determined in October 1998 that SRS should complete a tank closure environmental impact statement before conducting additional closure activities. A Record of Decision (ROD) on this action, originally scheduled for December 1999 and subsequently rescheduled for 2000, now is expected during 2001.

The assessment of soils and groundwater around the waste tanks will be deferred until complete closure of a geographical grouping of tank systems and their associated support services. Currently, the tank 17F and tank 20F systems cannot be isolated practically from other operational systems (tanks 18F and 19F and the 1F evaporator) for the purpose of assessing potential remedial actions.

The SRS Federal Facility Agreement requires closure of tank 19F in 2003 and tank 18F in 2004. The removal of waste from tank 19F was expected to be completed by October 2000. No new date has been set, but the removal will continue during 2001. A tank 19F closure module subsequently will be prepared and submitted to SCDHEC prior to the initiation of closure activities. The general plan for high-level waste tank system closure was revised and submitted in March 2000 to DOE–HQ, EPA, and SCDHEC for approval, as required by DOE Order 435.1 ("Radioactive Waste Management"). EPA and SCDHEC approved the plan in September 2000; DOE–HQ still was reviewing it at the end of the year.

National Pollutant Discharge Elimination System

The CWA created the NPDES program, which is administered 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 degrade water quality.

SRS had four NPDES permits in 2000, as follows:

- *One permit for industrial wastewater discharge (SC0000175)* – SRS received a modification of this permit from SCDHEC January 1, 1998. The site removed outfalls L–08 and M–04 from this permit in 2000.
- *One general permit for utility water discharge (SCG250162)* – SRS no longer is covered under this permit, having removed the one outfall (001) covered under it in October 2000.
- *Two general permits for stormwater discharge (SCR000000 for industrial and SCR100000 for construction)*

All results of monitoring for compliance with the industrial wastewater discharge permit and the general permit for utility water discharge were reported to SCDHEC in the monthly Discharge Monitoring Reports, as required by the permits.

Air Pollution Control Program

The CAA provides the basis for protecting and maintaining air quality. Some types of SRS air emissions, such as ozone-depleting substances (ODS), are regulated by EPA, but most are regulated by SCDHEC, which must ensure that its air pollution regulations are at least as stringent as the CAA's. This is accomplished through SCDHEC Regulation 61–62, "Air Pollution Control Regulations and Standards."

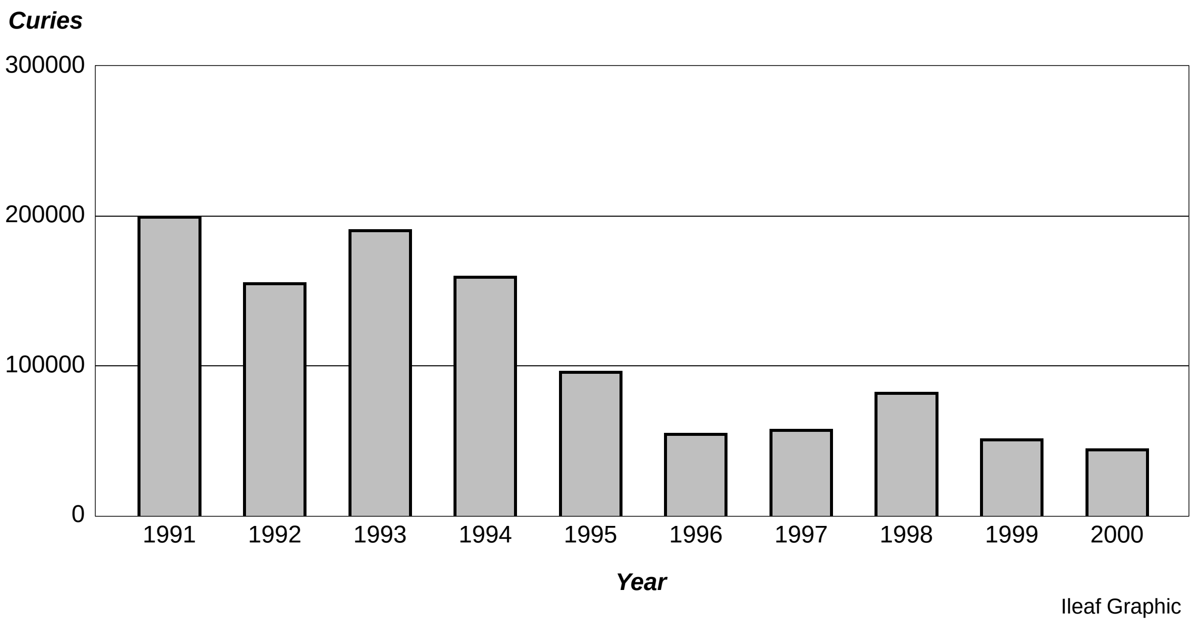


Figure 2 Ten-Year History of SRS Annual Atmospheric Tritium Releases

Under the CAA, and as defined in federal regulations, SRS is classified as a "major source" and, as such, is assigned one permit number (0080–0041) by SCDHEC. SRS holds operating and construction permits from SCDHEC's Bureau of Air Quality, which regulates nonradioactive toxic and criteria pollutant emissions from approximately 199 point sources, several of which have specific emission limits. Of these point sources, 137 operated in some capacity during 2000. The remaining 62 either were under construction or were being maintained in a "cold standby" status.

NESHAP Asbestos Abatement Program

SRS began an asbestos abatement program in 1988 and continues to manage asbestos-containing material by "best management practices." Site compliance in this area also falls under South Carolina and federal regulations, including SCDHEC Regulation 61–86.1 ("Standards of Performance for Asbestos Projects") and 40 CFR 61, Subpart M ("National Emission Standards for Asbestos").

During 2000, SRS personnel removed and disposed of approximately 1,915 square feet and 1,570 linear feet of regulated asbestos-containing material. In addition, contractors removed and disposed of an estimated 25,300 square feet and 10,040 linear feet of regulated asbestos-containing material.

Radiological Effluent Monitoring

SRS collected and analyzed about 4,000 effluent samples in 2000 to quantify radiological releases to the environment from site operations. Tritium again was the major contributor to air and liquid releases, accounting for most of the total radioactivity released.

Airborne Emissions

Krypton and tritium accounted for nearly all of the airborne radioactivity released from the site during 2000. An estimated 52,800 Ci of krypton-85 were released from the separations area in 2000—an increase of 41 percent over the 37,400 Ci released in 1999—probably due to increased operations in F-Canyon. However, because krypton is a noble gas that is not easily absorbed by the human body, it causes very little radiological dose.

Approximately 44,800 Ci of tritium (elemental plus tritium oxide) were released from the site in 2000. This was 13 percent less than the 51,600 Ci released in 1999—a decrease due primarily to completion of the deactivation of D-Area heavy water facilities in 1999. Figure 2 shows a 10-year history (1991–2000) of SRS tritium releases. Since 1995, because of changes in the site's missions and the existence of the Replacement Tritium Facility, the total amount of tritium released has been less than 100,000 Ci per year.

Liquid Discharges

Tritium accounts for most of the radioactivity released to the Savannah River from direct process discharges and from seepage basin and Solid Waste Disposal Facility (SWDF) migration discharges. The amount of tritium released directly from SRS process areas (i.e., reactor, separations, heavy water rework) to site streams during 2000 was 1,660 Ci**,** which was 48 percent more than the 1999 total of 1,120 Ci—a change attributed to increased operations at the Effluent Treatment Facility.

During 2000, the total amount of tritium released to the Savannah River from the site was about 5 percent less than the amount released during 1999—5,960 in 2000 versus 6,290 Ci in 1999.

Radiological Environmental Surveillance

The radiological environmental surveillance program at SRS surveys and quantifies any effects routine and nonroutine operations may have had on the site, the surrounding area, and those populations living in or near the site. Sampled media include air, rainwater, site streams, the Savannah River, drinking water, seepage basins, food products, fish, deer, hogs, turkeys, beavers, soil, sediment, and vegetation.

Overall, 2000 activity levels generally were consistent with 1999 levels. Concentrations of some radionuclides—such as tritium, cesium, and strontium—were at or slightly above their representative minimum detectable concentrations and were consistent with observed historical levels in sampled media. In air and surface water, some onsite activity levels were, as expected, slightly higher than observed in offsite media. Because of production slowdown, most tritium transport in site streams, which has been decreasing in recent years, was attributed to the outcropping at stream banks of contaminated groundwater from retired seepage basins and SWDF.

Nonradiological Effluent Monitoring

Nonradioactive airborne emissions released from SRS stacks—including sulfur dioxide, oxides of nitrogen, carbon monoxide, total particulate matter less than 10 microns, and various toxic air pollutants—were within applicable (SCDHEC) standards in 2000. The site continued to maintain 100-percent compliance with all permitted emission rates and special conditions.

SRS maintained its NPDES compliance rating for liquid releases above 99 percent for the 14th straight year. Results from only 18 of the 5,496 analyses performed in 2000 exceeded permit limits. This resulted in a compliance rating of 99.7 percent—again higher than the DOE-mandated rate of 98 percent.

Nonradiological Environmental Surveillance

The nonradiological environmental surveillance program at SRS involves sampling and analyzing surface waters (site streams and the Savannah River), drinking water, sediment, groundwater, and fish. In 2000, more than 6,300 analyses for specific chemicals and metals were performed on more than 1,200 samples, not including groundwater.

The 2000 water quality data showed normal fluctuations expected for surface water. A comparison of the 2000 data with published historical data for site surface water monitoring did not indicate any abnormal deviations from past monitoring data. All results from analyses for pesticides and herbicides were below the detection limit.

All SRS drinking water systems complied with SCDHEC chemical, bacteriological, lead and copper, synthetic organic, and volatile organic water quality standards in 2000.

In Savannah River and site stream sediment samples, no pesticides or herbicides were found to be above the practical quantitation limits in 2000.

The mercury concentrations in fish analyzed from onsite waters in 2000 ranged from a high of approximately 1.82 µg/g in a bass from PAR Pond to a low of approximately 0.09 µg/g in a bream from L Lake. Mercury concentrations in offsite fish ranged from a high of approximately 1.63 µg/g in a bass from the Highway 301 bridge area to a low of approximately 0.02 µg/g in a mullet from the Highway 17 bridge area near Savannah.

Academy of Natural Sciences of Philadelphia River Quality Surveys

The Patrick Center for Environmental Research of the Academy of Natural Sciences of Philadelphia (ANSP) 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.

The 1999 and 2000 surveys examined algae, rooted aquatic plants (1999), insects and other macroinvertebrates, and fish yearly or twice yearly. Diatoms, a type of algae, were examined monthly.

Final results of the 1999 study are presented in this report, along with an interpretation of their place in assessing temporal trends in water quality. Progress to date for each component of the 2000 study also is reported.

Assessments of the various biological groups in the 1999 river quality survey (diatoms, other attached algae, rooted aquatic plants, insects, noninsect macroinvertebrates, and fish) were consistent with one another and demonstrated similar communities at exposed and reference stations.

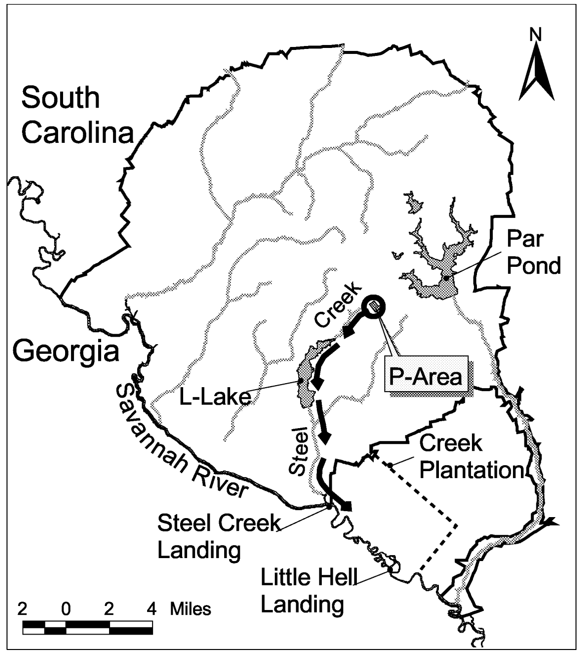
Results of the 2000 river quality survey were not complete in time for publication in this report. However, field notes and preliminary sample analyses did not reveal any obvious differences between communities at exposed and reference stations.

Groundwater

SRS monitors groundwater for radioactive and nonradioactive constituents to identify contamination that may have occurred because of site operations, to assess contaminant migration, and to meet regulatory requirements imposed under the site RCRA permit and Federal Facility Agreement. All these efforts contribute to the site's policy of protecting human health and the environment.

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. This report describes groundwater monitoring results for approximately 1,180 wells in 77 locations within designated areas at the site. In 2000, a total of 24,806 radiological analyses and 125,924 nonradiological analyses were performed on groundwater samples. The numbers of analyses have decreased considerably since 1997, primarily because of increased efficiency and reduced duplication.

Preremediation characterization and subsequent remediation are ongoing to detect and clean up contaminants in groundwater at SRS. Also, volatile organic compounds are undergoing bioremediation, air-stripping, and *in situ* recirculation. Metals and radionuclides are being removed from groundwater via pump-and-treat activities. Tritium is being managed by recirculation to provide additional time for its decay. The site will continue to monitor its groundwater to ensure that contamination is detected and addressed in a safe and efficient manner.



SRTC Map

Figure 3 Swamp Contamination

Radioactivity released from SRS operations contaminated the Savannah River Swamp between Steel Creek and Little Hell Landing during the 1960s. Approximately 25 Ci of cesium-137 and 1 Ci of cobalt-60 were released from the P-Area storage basin to Steel Creek and migrated downstream to a part of the Savannah River Swamp that extends beyond the SRS boundary.

Special Surveys

In addition to routine sampling and special sampling during nonroutine environmental releases, special sampling for radiological and nonradiological surveys is conducted on and off site. Both short- and long-term radiological and nonradiological surveys are used to monitor the effects of SRS effluents on the site's environment and in its immediate vicinity.

Savannah River Swamp Surveys

The Creek Plantation, a privately owned land area located along the Savannah River, borders the southeast portion of SRS. The land is primarily undeveloped and agricultural; it is used in equestrian-related operations. A portion of Creek Plantation along the Savannah River is a low-lying swamp known as the Savannah River Swamp, which is uninhabited and not easily accessible.

In the 1960s, an area of the Savannah River Swamp on Creek Plantation—specifically, the area between Steel Creek Landing and Little Hell Landing—was contaminated by SRS operations (figure 3). In 1974, a series of 10 sampling trails was established through the swamp, and 52 monitoring locations were designated on the trails to allow for continued monitoring at a consistent set of locations. Comprehensive and cursory surveys of the swamp have been conducted periodically since 1974. These surveys measure radioactivity levels to determine changes in the amount and/or distribution of radioactivity in the swamp. A comprehensive survey was conducted in 2000.

Results of the 2000 survey generally were consistent with those observed in previous surveys. Over time, some changes in the spatial distribution of activity throughout the swamp have been observed, which means that some localized movement of activity may be occurring. However, there has been little change in the results from the downstream location (trail 10), which indicates that activity is not migrating out of the identified contaminated area.

Mitigation Action Plan for Pen Branch Reforestation

The final Environmental Impact Statement for the continued operation of K-Reactor, L-Reactor, and P-Reactor at SRS predicted several unavoidable impacts to the site's wetlands. This resulted in the development of a Mitigation Action Plan (MAP) that documented the DOE approach to mitigating these impacts [DOE, 1990].

Natural revegetation has been occurring in the Pen Branch delta since K-Reactor last operated for an extended period of time (1988). The Pen Branch corridor and delta are being reforested by planting with indigenous wetlands species. The seeds were planted and grown at a State of Georgia nursery during 1993–1995 for use in the Pen Branch seedling planting program. These seedlings—of species appropriate to the area being reforested—subsequently were transplanted to the Pen Branch wetland areas.

A peer-reviewed, special volume of *Ecological Engineering* (an environmental professional journal) was published in 2000 to document in scientific literature the successful restoration of the Pen Branch wetland system [Nelson et al., 2000]. The volume contains 15 of the papers that were presented at a 1999 workshop at Clemson University—or that were part of the research effort—as well as a summary paper of the major points (from discussions at the workshop) that relate to success criteria for wetland restoration. The workshop's purpose was to present at a single forum the results of all efforts at restoration. The special volume documents—at the year 2000 assessment that was part of the original MAP timetable—the successful restoration of the impacted area by planting.

Chapter 1
Introduction

Margaret Arnett
Environmental Protection Department

To Read About . . . See Page . . .

2000 Highlights

- In January, DOE announced that a pit disassembly and conversion facility, a mixed oxide fuel fabrication facility, and an immobilization facility would be built at SRS. These facilities will be used to process plutonium in support of future site missions.
- The K-Reactor building was modified for use as an interim storage location for nuclear materials from other DOE facilities. The KAMS project modified a portion of the building to store drums of plutonium. The entire building was renamed the K Nuclear Materials Management Facility to better reflect its current mission in providing storage and management of key nuclear assets—such as spent fuel, heavy water moderator, uranium, and plutonium.
- Ground was broken in July for the new Tritium Extraction Facility, which will extract tritium-containing gasses from Tritium Producing Burnable Absorber Rods (TPBARS) that have been irradiated in the Tennessee Valley Authority's Watts Bar and Sequoyah reactors. The gasses will be used to meet nuclear weapons stockpile requirements.

THE Savannah River Site (SRS), a facility in the U.S. Department of Energy (DOE) complex, encompasses approximately 310 square miles in South Carolina and is adjacent to the Savannah River.

The site was established by the U.S. Atomic Energy Commission (AEC) in 1950 to produce plutonium and tritium for national defense and additional special nuclear materials for other government uses and for civilian purposes. Production of these materials continued for about 40 years.

When the Cold War ended in 1991, DOE responded to changing world conditions and national policies by refocusing its mission. The site's priorities shifted toward waste management, environmental restoration, technology development and transfer, and economic development.

This chapter includes general information on the site's location, demographics, and environmental setting; mission; and areas, facilities, and operations.

Site Description

Location

SRS covers 198,344 acres in Aiken, Allendale, and Barnwell counties of South Carolina and borders the Savannah River. The site is approximately 12 miles south of Aiken, South Carolina, and 15 miles southeast of Augusta, Georgia (figure 1–1). It is included within the Central Savannah River Area, which is comprised of 18 counties surrounding Augusta.

The average population density in the counties surrounding SRS is 85 people per square mile, with the largest concentration in the Augusta metropolitan area. Based on 1990 U.S. Census Bureau data, the population within a 50-mile radius of SRS is approximately 620,100. About 70 percent of the site's employees live in South Carolina—primarily Aiken County—and 30 percent in Georgia.

Various industrial, manufacturing, medical, and farming operations are conducted near the site. Major industrial and manufacturing facilities in the area include textile mills, polystyrene foam and paper products plants, chemical processing facilities, and a

A history of the Savannah River Site, prepared to commemorate the founding of the site and to observe the site's 50th anniversary, begins on page xxv of this document.

commercial nuclear power plant. Farming is diversified and includes crops such as cotton, soybeans, corn, peaches, grapes, and small grains.

Climate

SRS has a relatively mild climate, 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 strong prevailing wind direction; however, there is a relatively high frequency of winds from the northeast during the late summer and early-to-mid fall and of winds from the south through northwest from late fall through spring [Hunter, 2001]. Except for the Savannah River, no unusual topographic features significantly influence the general climate.

Geology and Water Resources

SRS is on the upper coastal plain of South Carolina. Coastal plain deposits at SRS consist of 500 to 1,400 feet of sands, clays, and limestones of Tertiary and Cretaceous age. These sediments are underlain by 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 into the Savannah River, its tributaries, and the Savannah River Swamp. The older, underlying rocks are nearly impermeable and are not a water source.

SRS, bounded on its southwestern border by the Savannah River for about 35 river miles (as measured from the upriver boundary of the site, near Jackson, South Carolina, to the Lower Three Runs Creek corridor), is approximately 160 river miles from the Atlantic Ocean. Five major SRS streams feed into the river: Upper Three Runs Creek, Four Mile Creek (also referred to as Fourmile Branch), Pen Branch, Steel Creek, and Lower Three Runs Creek.

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

The two main bodies of water on site, PAR Pond and L-Lake, are manmade. PAR Pond, constructed in 1958 to provide cooling water for—and to receive heated cooling water from—P-Reactor and R-Reactor (hence the name PAR Pond), covers 2,640 acres and is approximately 60 feet deep. The 1,000-acre L-Lake was constructed in 1985 to receive heated cooling water from L-Reactor.

The Savannah River is used as a drinking water supply source for residents downriver of SRS in Port Wentworth, Georgia, and near Beaufort, South Carolina (Beaufort and Jasper counties). [Drinking water data are summarized in *SRS Environmental Data for 2000* (WSRC–TR–2000–00329), table 21.] The City of Savannah Industrial and Domestic Water Supply 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 river for irrigation by farming operations downriver of the site [Hamby, 1991]. SRS uses water from the river for some of its operations.

Land Resources

The SRS region is part of the Southern Bottomland Hardwood Swamp region, which extends south from Virginia to Florida and west along the Gulf of Mexico to the Mississippi River drainage basin. The main features are river swamps, rarely more than 5 miles wide.

Approximately 200 Carolina bays exist on SRS, ranging in size from about 0.2 acre to 125 acres. Carolina bays are unique, naturally occurring wetlands found only on the southeastern coastal plain. They are elliptical in shape and oriented northwest to southeast along their long axes; their origin is unknown. Carolina bays are shallow and may dry up seasonally. At SRS, they provide important habitat and refuge for many plants and animals.

Plant and Animal Life

In 1972, SRS was designated as the first National Environmental Research Park. These parks are used by government and university-related scientists as

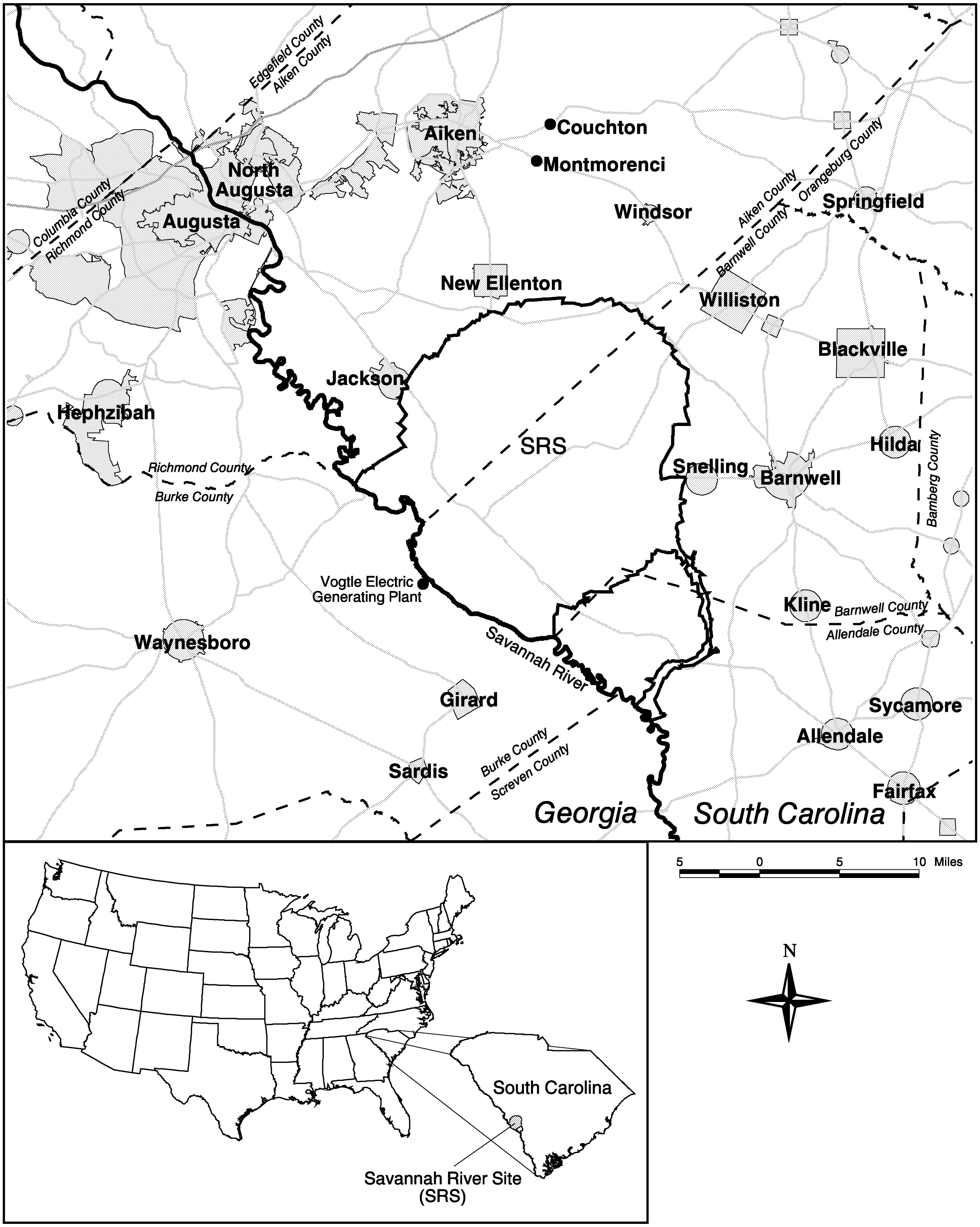


Figure 1–1 Regional Location of SRS

SRS is about 12 miles south of Aiken, South Carolina, and 15 miles southeast of Augusta, Georgia. The site, approximately 310 square miles in area, covers about 1 percent of the state of South Carolina.

Savannah River Site: A Unique Outdoor Laboratory

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. Research activities are conducted through site environmental organizations.

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 bottomland 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.

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

outdoor laboratories to study the impact of human activity on the environment. This designation has created a unique environment for preserving and studying vegetation and wildlife.

The site provides refuge for several endangered, threatened, and sensitive species of plants and animals, including the red-cockaded woodpecker, the southern bald eagle, the smooth purple coneflower, the Bachman's sparrow, the American alligator, the wood stork, the shortnose sturgeon, and the bog spice bush. Many site research projects are designed to protect and increase the populations of these species.

Vegetation

Most of the site's environs are rural. Approximately 40 percent of the countryside is 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 (hogs that have reverted to the wild state from domestication), turkeys, beavers, rabbits, foxes, raccoons, bobcats, river otters, and opossums. In 1952, there were fewer than three dozen white-tailed deer on site. Since then, however, the population has increased dramatically, and the site herd now is estimated at more than 3,300 deer [Fledderman, 1999]. Since 1965, managed public deer hunts have been held annually on site to reduce the number of animal-vehicle accidents and to maintain the health of the herd. The hunts are discussed in chapter 6 ("Radiological Environmental Surveillance").

More than 100 species of reptiles and amphibians—including turtle, alligator, lizard, snake, frog, and salamander—and more than 200 species of birds also inhabit the site.

Site Mission

The changing world caused a downsizing of the site's original defense mission; SRS's current mission is to fulfill its responsibilities safely and securely in the stewardship of the nation's nuclear weapons stockpile, nuclear materials, and the environment. These stewardship areas reflect current and future missions to

- meet the needs of the enduring U.S. nuclear weapons stockpile
- store, treat, and dispose of excess nuclear materials safely and securely
- treat and dispose of legacy wastes from the Cold War and clean up environmental contamination

"Stewardship" in the context of SRS's mission is defined as "responsibility for the careful use of money, time, talents, and other resources, especially with respect to the principles and/or needs of a community."

Future mission activities include the processing of plutonium, the radioactive material that fueled one of the bombs that ended World War II and was a component of the warheads of the Cold War. In January, DOE announced that the following facilities would be built at SRS:

- a pit disassembly and conversion facility—pit disassembly and conversion involves taking apart the core of nuclear weapons and converting the plutonium inside into a powdered oxide

- a mixed oxide (MOX) fuel fabrication facility—the powdered oxide from the pit disassembly and conversion facility comes to this facility (1) to be used in the manufacture of nuclear fuel for commercial nuclear reactors or (2) to be immobilized for long-term storage
- an immobilization facility—to immobilize the remaining plutonium oxide in ceramic material

The remainder of this chapter describes the site areas and some of the major facilities, operations, and activities that support these points.

Site Areas (Including Major Facilities, Operations, and Activities)

SRS was constructed to produce basic materials used in nuclear weapons, primarily tritium and plutonium-239. Five reactors—along with support facilities—were built to produce and purify these materials.

SRS is divided into several areas, based on production and other functions (figure 1–2):

- reactor materials area (M)
- reactor areas (C, K, L, P, and R)
- heavy water reprocessing area (D)
- separations areas (F and H)
- waste management areas (E, F, H, S, and Z)
- administration area (A)
- other areas (B, N, and TNX)

Since the end of the Cold War, SRS has shut down several facilities because of declining defense requirements. These included all five reactors and facilities in M-Area, D-Area, and TNX. However, S-Area, Z-Area, and E-Area opened to support waste management activities.

Data about emissions and discharges from the various areas and outfalls—occurring as a result of routine operations—can be found in the “Radiological Effluent Monitoring” and “Nonradiological Effluent Monitoring” sections of *SRS Environmental Data for 2000*.

The following sections describe the site areas and the major facilities. An attempt has been made to group operations and activities according to area, but some overlap prevents a distinct separation in all cases.

Reactor Materials Area (M)

The reactor materials area (M-Area) is home to three analytical laboratories, various offices, and the Vendor Treatment Facility. This facility, which completed its operations in 1999, processed 670,000 gallons of mixed-waste (both radioactive and hazardous) sludge into glass beads. These beads currently are classified as Resource Conservation and Recovery Act (RCRA) waste, but they are expected to be reclassified and moved from M-Area to a low-level repository elsewhere on site.

Reactor Areas (C, K, L, P, and R)

Production reactors are in five areas: C, K, L, P, and R. Each area houses one of the site’s five heavy water reactors. All five reactors, (R-Reactor, P-Reactor, L-Reactor, K-Reactor, and C-Reactor) are permanently shut down.

Facilities in C-Area, K-Area, and L-Area are being used to store heavy water. Heavy water was used as a coolant and moderator (material used to slow down neutrons from the high velocities at which they are created in the fission process) in the SRS reactors. K-Reactor and L-Reactor contain operating spent fuel storage basins. (More about spent fuel storage can be found in the Separations Areas section, page 7.) Some offices are located in C-Area, K-Area, and L-Area, also.

The K-Reactor building has been modified for use as an interim storage location for nuclear materials from other DOE facilities. The K-Area Materials Storage (KAMS) project modified a portion of the building to store drums of plutonium. The entire building has been renamed the K Nuclear Materials Management Facility to better reflect its current mission in providing storage and management of key nuclear assets—such as spent fuel, heavy water moderator, uranium, and plutonium.

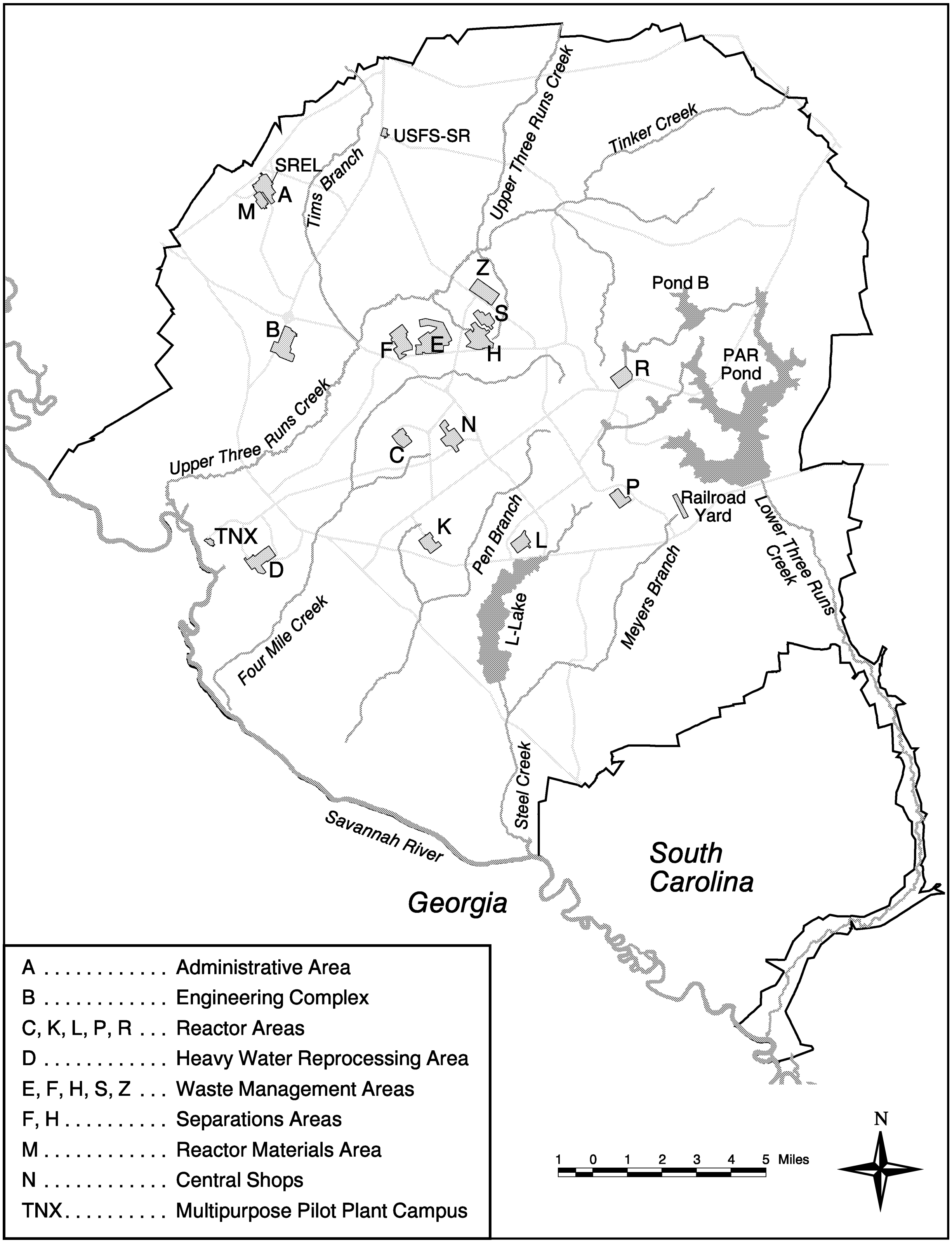
The ground level of C-Reactor has been modified to serve as a central decontamination facility for radiologically contaminated operations and maintenance equipment.

Although some of the areas are being used, no efforts are being expended to maintain any of the reactors themselves. P-Area and R-Area are shut down completely.

Heavy Water Reprocessing Area (D)

No operations are being conducted in D-Area, although some offices are housed there.

The Heavy Water Facility, where various contaminants were removed from the legacy heavy



EPD/GIS Map

Figure 1–2 The Savannah River Site

SRS includes nuclear materials production areas, which are primarily in the interior of the site, and several operating areas. SREL and USFS–SR also are located on site.

research reactors) is stored in the RBOF (located in H-Area). The spent fuel is repackaged for extended storage and/or shipment to an onsite or offsite facility. Planning is under way to deinventory the RBOF and transfer spent fuel to the L-Area Disassembly Basin, a much larger, water-filled, reinforced-concrete facility. The basin was modified and received its first shipment of foreign spent fuel in January 1997 [Fact Sheet, 2000a].

Storage will be a major issue for fuels that are not processed or that arrive after SRS reprocessing facilities are phased out. Many of the original storage facilities were not designed for the long interim storage period that may be required pending disposition. DOE is developing an integrated, long-term spent fuel management program that will address storage and treatment of all spent fuel until an ultimate disposition is determined.

Tritium

Tritium, one of the materials produced by the site for national defense, has a half-life of 12.3 years and must be periodically replenished to maintain weapons in readiness for use. SRS is the nation's only facility for recycling tritium remaining after decay from nuclear weapons reservoirs returned from service. This recycling allows the United States to use its tritium supplies effectively and efficiently [Fact Sheet, 2000a].

The SRS tritium facilities in H-Area consist of four main process buildings designed and operated to process tritium and to reclaim nuclear weapon reservoirs. Ground was broken in July for the new Tritium Extraction Facility, which will extract tritium-containing gasses from Tritium Producing Burnable Absorber Rods (TPBARS) that have been irradiated in the Tennessee Valley Authority's Watts Bar and Sequoyah reactors. The gasses will be used to meet nuclear weapons stockpile requirements.

Waste Management Areas (E, F, H, S, and Z)

Waste management activities are conducted in the following areas: E, F, H, S, and Z.

Weapons material production at SRS has generated unusable byproducts, such as highly radioactive waste. About 36 million gallons of this high-level radioactive waste is stored in tanks on site (chapter 4, "Environmental Management"). In addition, other wastes at the site include low-level solid and liquid radioactive wastes; transuranic waste (which contains alpha-emitting isotopes that have decay rates and concentrations exceeding specified levels); hazardous waste (which is any toxic, corrosive, reactive, or ignitable material—as defined by the South Carolina Hazardous Waste Management Regulations—that could negatively affect human health or the environment); mixed waste (which contains both hazardous and radioactive components); and sanitary waste (which is neither radioactive nor hazardous). An explanation of the various wastes and how the site manages them is discussed in chapter 4.

Facilities in waste management areas designed to store or treat the waste generated from onsite operations include the Solid Waste Management Facility (SWMF; also referred to in this report as the Solid Waste Disposal Facility); the Effluent Treatment Facility (ETF); the high-level waste storage tanks in F-Area and H-Area ("tank farms"); evaporators; the Extended Sludge Processing Facility; the Defense Waste Processing Facility (DWPF); the Saltstone Facility; and the Consolidated Incineration Facility (CIF).

SWMF is a disposal site for low-level radioactive solid waste items such as protective clothing, tools, and equipment contaminated with radioactive material. The low-level solid waste is disposed of permanently in the engineered concrete E-Area Vaults and trenches. Wastes contaminated with small amounts of radioactive material may be disposed of in engineered trenches, while wastes that require additional isolation are disposed of in concrete vaults.

Historically, seepage basins were used to dispose of wastewater from the separations facilities in F-Area and H-Area. The ETF, located in H-Area, treats the low-level radioactive wastewater formerly sent to the seepage basins. The ETF removes radioactive and nonradioactive contaminants, except tritium, from process effluents and discharges the water to Upper Three Runs Creek.

The F-Area and H-Area waste tank farms consist of large underground storage tanks that hold high-level liquid radioactive waste resulting primarily from the reprocessing of spent nuclear fuel. The waste is contained in 29 tanks in H-Area and 20 tanks in F-Area. Fresh waste that is received from the processing of the spent nuclear fuel separates into two parts—a sludge (which contains most of the radioactivity) that settles on the bottom of the tank, and a "watery" supernate that occupies the area above the sludge. The supernate is transferred into an evaporator system, where it is reduced to 30 percent of its original volume. The concentrated supernate that remains will eventually form a solid as it is cooled. This solid is commonly known as salt cake and generally resides in the evaporator concentrate remains. More about environmental restoration can be found in chapter 4.

Environmental Monitoring

Most onsite and offsite radiological and nonradiological environmental monitoring is conducted by the Environmental Monitoring Section (EMS) of WSRC's Environmental Protection Department (EPD). The environmental monitoring program is discussed briefly in chapter 3 ("Environmental Program Information") and more thoroughly in chapters 5, ("Radiological Effluent Monitoring"), 6, 8 ("Nonradiological Effluent Monitoring"), and 9 ("Nonradiological Environmental Surveillance").

Also, the Division of Environmental Research of the Academy of Natural Sciences of Philadelphia has performed biological and water quality surveys of the Savannah River since 1951. More about the academy's surveys can be found in chapter 9.

Research and Development

SRTC, the site's applied research and development laboratory, creates, tests, and puts into use solutions to SRS's technological challenges. SRTC researchers have made significant technological advances in hydrogen technology, nonproliferation, environmental characterization and cleanup, sensors and probes, use of glass for stabilizing and disposing of waste, etc.

SRTC's facilities include biotechnology laboratories, laboratories for the safe study and handling of radioactive materials, a field demonstration site for testing and evaluating environmental cleanup technologies, and laboratories for ultra-sensitive measurement and analysis of radioactive materials.

In recent years, SRTC's role has expanded and includes providing related support to DOE–Headquarters (DOE–HQ), other DOE sites, other federal agencies, and other customers. SRTC also forms strategic partnerships with private industry, academia, and other government agencies to apply the laboratory's unique expertise to challenges of mutual interest.

The laboratory also shares its expertise by licensing private companies to manufacture and/or market technologies created at SRTC.

Other Environmental Research

In addition, environmental activities are conducted by the SREL, the U.S. Department of Agriculture Forest Service–Savannah River (USFS–SR, formerly the Savannah River Natural Resource Management and Research Institute), and the Savannah River Archaeological Research Program (SRARP).

Savannah River Ecology Laboratory

SREL is operated by The University of Georgia and has been funded by DOE (and its predecessors) since 1951 to conduct research related to the impact of site operations on the environment. The laboratory's mission is to provide an independent evaluation of the ecological effects of SRS operations through a program of ecological research, education, and outreach. This program involves basic and applied environmental research, with emphasis on

- expanding the understanding of ecological processes and principles
- evaluating the impacts of industrial and land-use activities on the environment as well as developing remediation technologies

The laboratory's mission is accomplished

- through a broad-based program of field and laboratory research conducted on site and published in the peer-reviewed scientific literature
- by providing education and research training for undergraduate and graduate students from colleges and universities throughout the United States and abroad
- by engaging in community outreach activities and service to professional organizations

Current research programs are organized under four groups—the Advanced Analytical Center for Environmental Sciences; Ecological Stewardship; Ecotoxicology, Remediation, and Risk Assessment; and Radioecology.

Studies in the Advanced Analytical Center for Environmental Sciences address the physical, chemical, and biological processes controlling the mobility of organic and inorganic contaminants in the environment, particularly in soils and water of SRS and other DOE sites.

One objective of the Ecological Stewardship group is to document the ecosystem health of SRS by identifying patterns of biodiversity on site and the natural and anthropogenic processes that maintain or change them. A second objective is to develop the technology necessary to restore damaged ecosystems on site.

Research in the Ecotoxicology, Remediation, and Risk Assessment group seeks to measure or predict bioaccumulation of contaminants in natural populations of organisms. This program also seeks to evaluate genetic and demographic markers in various species for use as possible indicators of responses to environmental contaminants.

Radioecology research assesses the distribution, fate, and ecological risk associated with radionuclides in the environment, including the genetic effects on flora and fauna at SRS and highly contaminated sites such as the Chernobyl site in the Ukraine.

Additional studies are conducted on the site's deer herd, fish, reptiles, amphibians, waterfowl, and endangered species, such as the wood stork, bald eagle, and the smooth purple coneflower. Other studies evaluate the potential of various experimental approaches for remediating contaminated soils, Carolina bays, and other habitats.

Information about SREL's education outreach program can be found in chapter 3. More information about all programs can be obtained by contacting SREL at 803–725–2473 or by viewing its website at http://www.uga.edu/srel.

U.S. Department of Agriculture Forest Service–Savannah River

USFS–SR management practices reflect the changing missions of SRS. Major responsibilities include the following:

- Wildlife and botany personnel maintain and improve a variety of habitats that support native plants and animals.
- USFS–SR sells sawtimber (timber large enough to be sawed into lumber) and roundwood products (wood not big enough for lumber but useful for making paper, etc.). Forestry practices maintain or enhance productivity, forest health, and the diversity of stand conditions and are used to support specific wildlife objectives.
- USFS–SR control-burns thousands of acres each year to protect site facilities and improve a variety of forest resources. USFS–SR is responsible for suppressing any wildfires on site.
- Soil, water, and air personnel implement DOE's stewardship strategy by restoring watersheds. A variety of techniques are used to establish vegetation and control water flows. These personnel also provide direct and indirect assistance to environmental restoration programs.
- Engineers maintain all secondary roads, bridges, and site boundaries and provide aerial photography, cartography, and conventional surveying for engineering and environmental restoration projects.
- USFS–SR conducts a cooperative research program with the Southern Research Station, other federal and state agencies, universities, forest and related industries, and SRS organizations to support SRS and DOE missions.
- USFS–SR is also helping to develop new phytoremediation technologies, which use trees cost-effectively to absorb and decompose toxic chemicals.

Information about USFS–SR's education outreach program can be found in chapter 3. Information about other programs can be obtained by contacting USFS–SR at 803–725–0006.

Savannah River Archaeological Research Program

SRARP was formed in 1973 under a cooperative agreement with DOE and the South Carolina Institute of Archaeology and Anthropology, University of South Carolina. Its primary purpose is to make compliance recommendations to DOE that will facilitate the management of archaeological resources at SRS. Other functions include compliance activities involving site-use surveys, specific intensive surveys, data recovery, coordination with major land users, and reconstruction of the environmental history of the site. More information can be obtained by contacting SRARP at 803–725–3623.

Chapter 2

Environmental Compliance

Al Mamatey
Environmental Protection Department

Contributing authors' names appear on page 38.

To Read About . . . See Page . . .

2000 Highlights

- Consistent with FFA milestones, four signed RODs were submitted to EPA and SCDHEC for approval, as were site evaluation reports on 24 areas. Characterization was initiated at three units to determine if hazardous constituents were present in the environment, and remedial actions were initiated at four units. Previously initiated remedial actions were continued at five units. With these actions, more than 56 percent of the units are now complete or in remediation.
- SRS submitted its Toxic Chemical Release Inventory report for 1999 to EPA ahead of the July 1, 2000, deadline. Twelve chemicals, with releases totaling 281,056 pounds, were reported for 1999—compared with 10 chemicals (160,580 pounds) reported for 1998, and seven chemicals (280,649 pounds) reported for 1997.
- A total of 276 NEPA reviews of newly proposed actions at SRS were conducted and formally documented.
- SRS achieved a compliance rate of 100 percent under the CAA and 99.7 percent (above the DOE-benchmark of 98 percent) under NPDES (CWA)—with no NOVs under either. The site also received no NOVs under the SDWA and RCRA.
- The site had no CERCLA-reportable releases, compared with one such release in 1999, one in 1998, three in 1997, and two in 1996.
- Of the 495 SIRIM-reportable events in 2000, only one was categorized as environmental; it was classified as an unusual occurrence.

THE goal of the Savannah River Site (SRS)—and that of the U.S. Department of Energy (DOE)—is positive environmental stewardship and full regulatory compliance, with zero violations. The site's employees maintained progress toward achievement of this goal in 2000, as demonstrated by examples in this chapter.

The site's compliance efforts were exemplary again in 2000. For example, no notices of violation (NOVs) were received by SRS under the Clean Air Act (CAA), which had a compliance rate for the year of 100 percent; the Safe Drinking Water Act (SDWA); or the Resource Conservation and Recovery Act (RCRA). The site also received no NOVs in 2000—and had a National Pollutant Discharge Elimination System (NPDES) compliance rate of 99.7 percent—under the the Clean Water Act (CWA). The compliance rate was calculated by dividing the number of analyses not exceeding permit limits for the year (5,478) by the total number of analyses performed (5,496) to demonstrate compliance with the site's NPDES permits.

Some key regulations with which SRS must comply—and its compliance status on each—are noted in the chart on the next page.

Compliance Activities

Compliance with environmental regulations and with DOE orders related to environmental protection is a critical part of the operations at SRS. Assurance that onsite processes do not impact the environment adversely is a top priority, and management of the environmental programs at SRS is a major activity. All site activities are overseen by one or more regulatory bodies, including the U.S. Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC). Significant effort and funding have been dedicated to ensuring that site facilities and operations comply with all requirements.

Some of the Key Regulations SRS Must Follow

Legislation	What it Requires/*SRS Compliance Status*
RCRA Resource Conservation and Recovery Act (1976)	♦ The management of hazardous and nonhazardous wastes and of underground storage tanks containing hazardous substances and petroleum products – *In compliance*
FFCAct Federal Facility Compliance Act (1992)	♦ The development by DOE of schedules for mixed waste treatment to avoid waiver of sovereign immunity and to meet LDR requirements – *In compliance*
CERCLA; SARA Comprehensive Environmental Response, Compensation, and Liability Act (1980); Superfund Amendments and Reauthorization Act (1986)	♦ The establishment of liability, compensation, cleanup, and emergency response for hazardous substances released to the environment – *SRS placed on National Priority List in December 1989*
CERCLA/TITLE III (EPCRA) Emergency Planning and Community Right-to-Know Act (1986)	♦ The reporting of hazardous substances used on site (and their releases) to EPA, state, and local planning units – *In compliance*
NEPA National Environmental Policy Act (1969)	♦ The evaluation of the potential environmental impact of federal activities and alternatives; in 2000, WSRC conducted 276 reviews of newly proposed actions – *In compliance*
SDWA Safe Drinking Water Act (1974)	♦ The protection of public drinking water systems; enacted in 1974, amended in 1980, 1986 – *In compliance*
CWA; NPDES Clean Water Act (1977); National Pollutant Discharge Elimination System	♦ The regulation of liquid discharges at outfalls (e.g., drains or pipes) that carry effluents to streams – *In compliance*
CAA; NESHAP Clean Air Act (1970); National Emission Standards for Hazardous Air Pollutants	♦ The establishment of air quality standards for hazardous air emissions, such as radionuclides and benzene – *In compliance*
TSCA Toxic Substances Control Act (1976)	♦ The regulation of use and disposal of PCBs – *Nation has inadequate disposal capacity for radioactive PCBs generated and currently stored at SRS*

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 the management of solid and hazardous wastes, such as spent solvents, batteries, and many other discarded substances deemed potentially harmful to human health and the environment. Amendments to RCRA regulate nonhazardous solid waste and some underground storage tanks.

RCRA also is responsible for managing inactive land-based facilities that were operating in 1982 and nonland-based facilities that were operating in 1980. RCRA requires that these inactive facilities to be closed. If they cannot be clean-closed, RCRA issues permits for postclosure care and possible corrective actions. These facilities also are subject to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements; however, through the SRS Federal Facility Agreement (FFA) with EPA and SCDHEC, it was agreed that if the facilities met the RCRA closure and postclosure requirements, they would not be subject to any additional CERCLA requirements.

Under RCRA, hazardous waste generators are responsible for managing every aspect of the generation, treatment, storage, and disposal of the waste; this is referred to as "cradle-to-grave" management. Hazardous waste generators, including SRS, must follow specific requirements for handling these wastes. For many waste management activities, RCRA requires permits for owners and operators of operating facilities.

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 the EPA hazardous waste regulations. The state plan then must be approved by EPA. The agency has approved South Carolina's plan and delegated RCRA authority to SCDHEC. Similarly, the Federal Facility Compliance Act (FFCAct) gives the state authority to enforce land disposal restrictions (LDR) for mixed wastes, which contain both hazardous and radioactive wastes. Also, SCDHEC has been authorized by the FFCAct to play the key role in the implementation of the FFCAct statute and was the lead regulatory agency for implementation of the SRS Site Treatment Plan (STP), which addresses storage and treatment of mixed waste. More information on waste management at SRS can be found in chapter 4, "Environmental Management."

The FFCAct, LDRs, Upper Three Runs Projects, General Separations Projects, the management of transuranic waste, and the status of the Consolidated Incineration Facility (CIF) are among the current challenges facing SRS with respect to RCRA compliance. These subjects are covered in some detail elsewhere in this chapter and/or in chapter 4.

Land Disposal Restrictions

The 1984 RCRA amendments established LDRs to minimize the threat of hazardous constituents migrating to groundwater sources. Hazardous wastes were banned from land disposal unless certain treatment requirements were met. LDRs do not allow storage of hazardous wastes except for the purpose of accumulating such quantities as are necessary to facilitate proper recovery, treatment, or disposal.

The same restrictions apply to mixed wastes. Because SRS did not have the capacity to treat all mixed wastes according to the applicable LDR standards, an LDR 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). The FFCA was an independent compliance instrument initiated by SRS and was not part of the FFCAct statute described below. The goal of the FFCA was to address SRS mixed waste compliance with LDRs. The FFCA was terminated September 29, 1995—by mutual consent of SRS and EPA—when the STP consent order became effective.

Treatability variances are an option available to waste generation facilities if alternate treatment methods are appropriate for specific waste streams. SRS has identified certain 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. The STP references four additional treatability variances for mixed wastes with special problems that prevent treatment according to LDR standards. Two of the variances, completed and sent to EPA headquarters in September 1997, were for tritiated water with mercury and for silver saddles (silver nitrate-coated ceramic devices designed to take up iodine gas). A third variance, for plastic/lead/cadmium Raschig rings (packing material spacers used for criticality control), was submitted September 7, 1999. These three are pending approval. The fourth variance, for radioactively contaminated lead-acid batteries, is due to EPA by September 30, 2001, unless interpretation is received from EPA that no variance will be necessary to meet the LDR treatment standard.

Federal Facility Compliance Act

The FFCAct was signed into law in October 1992 as an amendment to the Solid Waste Disposal Act to add provisions concerning the application of certain requirements and sanctions to federal facilities. For mixed waste, the FFCAct provided a 3-year extension (until October 1995) of the LDR compliance date so that DOE sites could investigate mixed waste volumes in storage, evaluate treatment capacities, and develop STPs with schedules for mixed waste treatment for approval by their state or federal regulatory agencies.

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 [DOE, 1993]—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 provided an update to the mixed waste inventory report in April 1994.

On March 30, 1995, DOE–SR submitted an STP that addressed the development of capacities and technologies for treating SRS mixed wastes in accordance with LDRs, as required by the FFCAct. This plan was approved with modifications, and the STP consent order was executed September 29, 1995.

As required by the STP consent order, SRS issued an annual update to the STP by April 30, 2000. The update identified changes in the mixed waste treatment status, including the addition of new mixed waste streams. STP updates will continue to be produced annually unless the consent order is modified.

Underground Storage Tanks

The 20 underground storage tanks at SRS that house petroleum products—such as gasoline and diesel fuel—and hazardous substances, as defined by CERCLA, are regulated under Subtitle I of RCRA.

These tanks require a compliance certificate annually from SCDHEC to continue operations. SCDHEC conducts an annual compliance inspection and records audit prior to issuing the compliance certificate. The inspection/audit for 2001, originally scheduled for November 2000, will be conducted by SCDHEC in January 2001, at which time SRS is expected to receive compliance certificates on all 20 underground storage tanks.

In addition, SRS conducted six remedial investigations in 2000 for underground storage tank sites that had been closed during previous years and had been identified by SCDHEC as having recorded leaks or spills. These remedial investigations were conducted in accordance with the requirements specified in SCDHEC's *South Carolina Risk–Based Corrective Action For Petroleum Releases* document, and all six sites received "No Further Action" decisions by SCDHEC [SCDHEC, 1998b]. With the completion of these investigations, all previous underground storage tank closures—in addition to the current operating underground storage tanks, meet the requirements specified under Subtitle I of RCRA.

High-Level Radioactive Waste Tank Closure

The primary regulatory goal of SRS's waste tank closure process at the F-Area and H-Area high-level tank farms is to close the tank systems in a way that protects public health and the environment in accordance with South Carolina Regulation 61–82, "Proper Closeout of Wastewater Treatment Facilities." This must be accomplished in compliance with the requirements of RCRA and CERCLA, under which the high-level waste tank "farms" will be remediated. A general tank closure plan presents the environmental regulatory standards and guidelines pertinent to closure of the waste tanks and describes the process for evaluating and selecting the closure configuration (the residual source term and method of stabilizing the tanks systems' residual waste material). The plan also describes the integration of high-level waste tank system closure with existing commitments to remove waste from the tanks before closure and to ultimately remediate the entire area (including soils and groundwater) surrounding the tank farms.

Tank 20F, a 1.3-million-gallon, single-shelled, carbon steel vessel, and tank 17F, with the same construction and capacity, were closed in 1997. Prior to the initiation of closure activities, all but approximately 1,000–2,400 gallons of waste were removed from each tank and further processed.

The assessment of soils and groundwater around the waste tanks is being deferred until complete closure of a geographical grouping of tank systems and their associated support services. Currently, the tank 17F and tank 20F systems cannot be isolated practically from other operational systems (tanks 18F and 19F and the 1F evaporator) for the purpose of assessing potential remedial actions.

The FFA requires closure of tank 19F in 2003 and tank 18F in 2004. The removal of waste from tank 19F originally was scheduled for completion by October 2000. No new date has been set, but the removal will continue during 2001. A tank 19F closure module subsequently will be prepared and submitted to SCDHEC prior to the initiation of closure activities. The general plan for high-level waste tank system closure was revised and submitted in March 2000 to DOE–HQ, EPA, and SCDHEC for approval, as required by DOE Order 435.1 ("Radioactive Waste Management"). EPA and SCDHEC approved the plan in September 2000. DOE–HQ still was reviewing it at the end of the year.

DOE determined in October 1998 that SRS should perform a tank closure Environmental Impact Statement (EIS) before conducting any further closure activities. A Record of Decision (ROD) on this action, originally scheduled for December 1999, now is expected during 2001.

RCRA 3004(u) Program

The hazardous waste permit issued to SRS in September 1987 (and renewed in October 1995) requires that the site institute a program for investigating and, if necessary, performing corrective actions at solid waste management units under RCRA 3004(u). The RCRA 3004(u) requirements have been integrated with CERCLA requirements in the FFA. The integration of RCRA and CERCLA regulatory requirements is expected to 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 Program

The SRS Waste Minimization Program is part of a broad, ongoing effort to prevent pollution and minimize waste on site. The program is designed to meet the requirements of RCRA, of DOE orders, and of applicable executive orders. More information on the site's pollution prevention activities—including specific programs such as Waste Minimization—can be found in chapter 3, "Environmental Program Information," and chapter 4.

Notices of Violation (RCRA)

SRS received no RCRA-related NOVs during 2000, and one outstanding NOV was closed. SCDHEC had issued the NOV to WSRC and DOE–SR November 12, 1999, following an October 4, 1999, incident at SRTC in which the site allegedly had combined incompatible hazardous wastes, generating a violent reaction and uncontrolled toxic fumes in sufficient quantities to threaten human health or the environment. SCDHEC closed the NOV with a warning letter February 18, 2000. No fines or penalties were involved.

Comprehensive Environmental Response, Compensation, and Liability Act

SRS was placed on the National Priority List in December 1989, under the legislative authority of CERCLA (Public Law 96–510), as amended by the Superfund Amendments and Reauthorization Act of 1986 (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 the FFA, which became effective August 16, 1993. Declaration of the effective date resulted in the FFA being an enforceable agreement. The FFA sets the milestones for the investigation and remediation of waste management units at SRS and for the integration of CERCLA and RCRA 3004(u) requirements.

The FFA also identifies about 300 site evaluation units for which investigations are required. These are suspect areas that are screened to determine if additional investigation and possible remediation are warranted. Site evaluation reports on 24 areas were submitted to EPA Region IV and SCDHEC in 2000.

Releases or potential releases from RCRA/CERCLA waste management units are evaluated under the FFA. Work plans detailing the proposed investigations for the RCRA/CERCLA units must be approved by both EPA Region IV and SCDHEC prior to implementation.

Remediation under CERCLA imposes requirements in addition to existing RCRA requirements. CERCLA requires remedial decisions to be based on the results of a baseline risk assessment, which examines present and future risk to human health and the environment from the waste unit, using conservative, EPA Region IV-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. The plan also provides a brief analysis of remedial alternatives that were considered, identifies the preferred alternatives, and tells the public how it can participate in the remedy selection process. After consideration of public comments and further analysis, decisions are made and documented in a ROD, which 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.

Details of the site's environmental program are provided in the *Federal Facility Agreement Annual Progress Report for Fiscal Year 2000*, WSRC–RP–2000–4300 [WSRC, 2000d]. Preparation of this report is required under terms of the FFA.

SRS's 2000 environmental restoration activities were highlighted by

- the submittal to EPA Region IV and SCDHEC (for signatures) of RODs on (1) the A-Area Burning/Rubble Pits (731–A and –1A) and A-Area Rubble Pit (731–2A) Interim Action, (2) the K-Area Reactor Seepage Basin (904–65G)

Source Unit Plug-In Explanation of Significant Differences, (3) the L-Area and P-Area Bingham Pump Outage Pits (643–2G, –3G, and –4G), (4) the Miscellaneous Chemical Basin/Metals Burning Pit Interim Action, and (5) the SRL Seepage Basins (904–53G1, 904–53G2, 904–54G, and 904–55G)

- the issuance of signed RODs on (1) the L-Area and P-Area Bingham Pump Outage Pits (633–2G, –3G, and –4G), (2) the SRL Seepage Basins (904–53G1, –53G2, –54G, and –55G), (3) the CMP Pits (080–170G, –171G, –180G, –181G, –182G, –183G, and –190G) Interim Action, and (4) the In-Situ Stabilization With a Low Permeability Soil Cover System for Radiological Contaminants in Soil (plug-in ROD)
- the initiation of RCRA Facility Investigation/Remedial Investigation characterizations on (1) the L-Area Southern Groundwater, (2) the Road A Chemical Basin (904–111G), and (3) the Steel Creek Integrator Operable Unit
- the initiation of remedial actions at (1) the A-Area Burning/Rubble Pits (731–A and –1A) and A-Area Rubble Pit (731–2A), (2) the CMP Pits (080–17G, –17.1G, –18G, –18.1G, –18.2G, –18.3G, and –19G), (3) the K-Area Reactor Seepage Basin (904–65G), and (4) the Miscellaneous Chemical Basin/Metals Burning Pit (731–4A, –5A)
- the continuation of remedial actions initiated prior to fiscal year 2000 on (1) the F-Area Retention Basin (281–3F), (2) the L-Area Oil/Chemical Basin (904–83G), (3) the C-Area Burning/Rubble Pit (131–C) Interim Action, (4) Old F-Area Seepage Basin (904–49G), and (5) the TNX Groundwater Operable Unit (082–G) Interim Action

Table 2–7 (“SRS 2000 Environmental Restoration Activities”), beginning on page 36, includes a more complete presentation of the site environmental restoration program’s environmental restoration activities. A listing of all operable units at SRS can be found in appendix C (“RCRA/CERCLA Units List”) and appendix G (“Site Evaluation List”) of the FFA.

Emergency Planning and Community Right-to-Know Act

Two related federal acts were enacted within a period of 4 years to help protect the public and the environment. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 was enacted as a freestanding provision of SARA. EPCRA requires facilities to notify state and local emergency planning entities about their hazardous chemical inventories and to report releases of hazardous chemicals. The Pollution Prevention Act of 1990 expanded the Toxic Chemical Release Inventory report to include source reduction and recycling activities.

Tier II Inventory Report

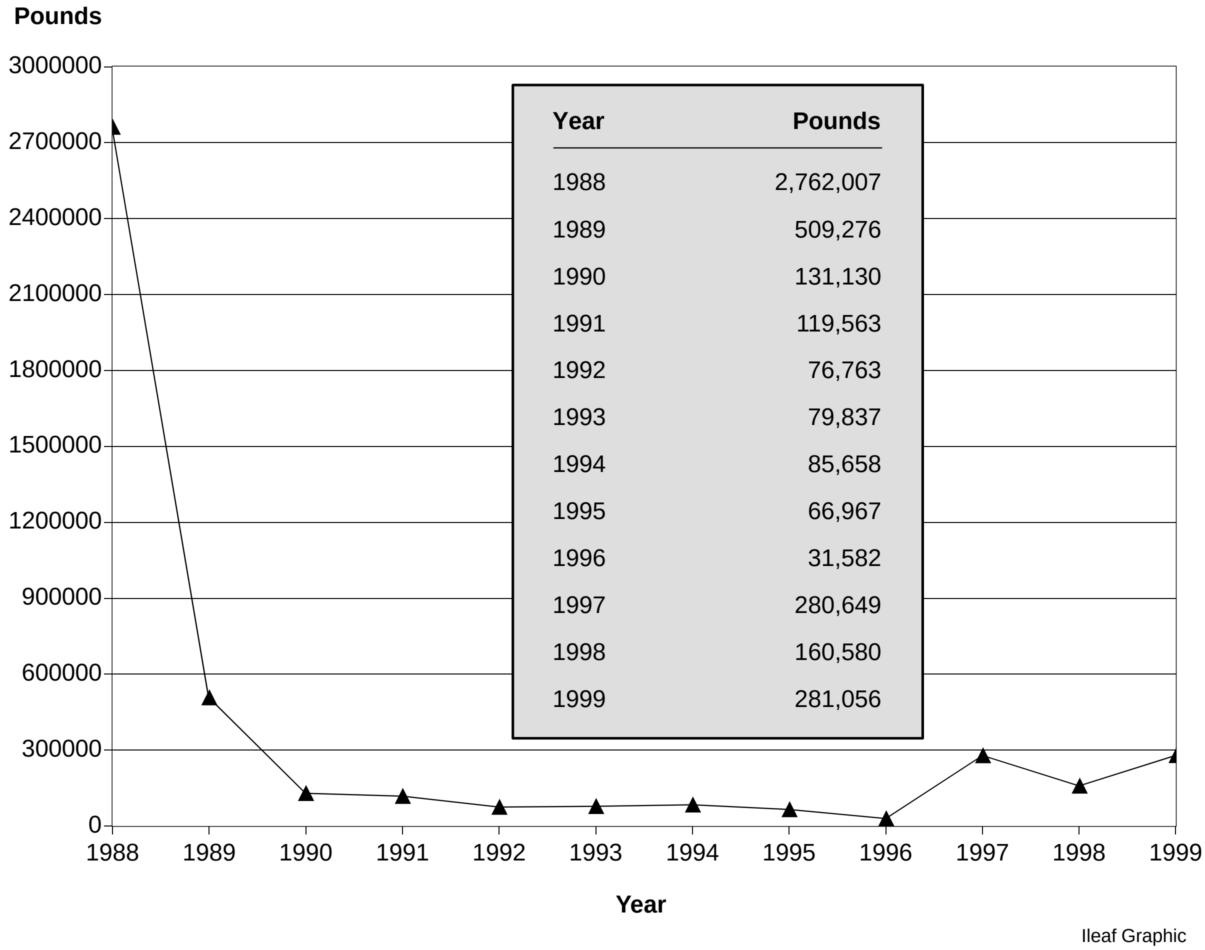
Under Section 312 of EPCRA, SRS completes an annual Tier II Inventory Report for all hazardous chemicals present at the site in excess of specified quantities during the calendar year. Hazardous chemical storage information is submitted to state and local authorities by March 1 for the previous calendar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

Toxic Chemical Release Inventory Report

Under Section 313 of EPCRA, SRS must file an annual Toxic Chemical Release Inventory report by July 1. SRS calculates chemical releases to the environment for each regulated chemical that exceeds its established threshold and reports the release values to EPA on Form R of the report. The release values include chemical releases to air, water, land, underground injection, and offsite transfers. EPA treats offsite transfers as releases to the environment for reporting purposes. The transfers actually are shipments of waste to EPA-approved facilities for further treatment, storage, disposal, or recycling.

Form R for 1999 was submitted to EPA in June 2000. Twelve chemicals, with releases totaling 281,056 pounds, exceeded the “manufactured,” “processed,” or “otherwise used” threshold and were reported to EPA for 1999. This compares with ten chemicals (160,580 pounds of releases) exceeding the threshold for 1998, and seven chemicals (280,649 pounds of releases) for 1997. For the 12-year period from 1988 through 1999, reportable releases of quantities declined by 90 percent (from 2,762,007 pounds in 1988 to 281,056 pounds in 1999). During this period, SRS experienced a substantial decrease in production operations and associated support activities, such as coal-fired steam production. Beginning in 1997, in response to EPA guidance, the site modified its calculation protocol for the estimation of metal emissions from coal-fired units. More than 80 percent of the reported increase from 1997 to 1999 can be attributed to this recalculation. Waste immobilization activities at the Defense Waste Processing Facility and the canyon facilities got under way during the same period but resulted in an average increase in releases of less than 5 percent over the 3 years.

Figure 2–1 shows the overall reduction in total toxic chemical releases at SRS for the period 1988–1999.



Year	Pounds
1988	2,762,007
1989	509,276
1990	131,130
1991	119,563
1992	76,763
1993	79,837
1994	85,658
1995	66,967
1996	31,582
1997	280,649
1998	160,580
1999	281,056

Figure 2–1 Total Toxic Chemical Releases at SRS, 1988–1999

Through 1999, total toxic chemical releases had been reduced by about 90 percent when compared to 1988. The sharpest drop occurred between 1988 and 1989, when EPA delisted nontoxic chemicals that did not meet toxic criteria for EPCRA Section 313. The decline between 1989 and 1990 represented curtailed nuclear production. The increase from 1996 to 1997 reflects active remediation of old waste sites by SRS and the transfer of contaminated soil to an EPA offsite treatment facility, both of which are considered “releases.” The increase from 1998 to 1999 was the result of process fluctuations and regulatory changes.

Several factors continue to contribute to this reduction. Pollution prevention programs have supported declines in the use and release of toxic chemicals, resulting in significant decreases for chemicals such as chlorine, lead, Freon 113, and 1,1,1-trichloroethane. Two primary reasons for the dramatic decline in reported totals during the late 1980s were as follows:

- EPA initially identified chemicals for reporting that did not meet the toxic criteria later developed for EPCRA Section 313. For example, EPA delisted nontoxic chemicals such as sodium sulfate; this resulted in a decline in reported releases for SRS.
- DOE curtailed nuclear production operations at SRS in 1989.

A breakdown of the comparison of toxic chemical releases from 1997 through 1999 is presented in table 2–1. Changes in chemicals and amounts reported are due to (1) process modifications and shutdowns and (2) waste site cleanups.

Nitrate, chromium, and zinc compounds were the largest contributors to the total reportable releases in 1999. Nitrates released via NPDES outfalls and metals-to-land disposal represented the two major receiving media. Wackenhut changed training ammunition in 1998 to environmentally friendly “green bullets” (lower lead content), which reduced the volume of lead discharged to land. Hexane, toluene, and xylene reappeared in 1999, while methyl tert-butyl ether was deleted because of a change in gasoline formulation used on site.

Table 2–1 Releases and Offsite Transfers of Toxic Chemicals (in Pounds) by SRS During 1997, 1998, and 1999 Reporting Years (Reported Under EPCRA Section 313)

1997

Chemical	Air Emissions	Water Discharges	Land Disposal	Offsite Transfers	Total
Formic acid	60	0	0	0	60
Lead	11	27	5,700	2,670	8,408
Nitrate compounds	25	25,157	0	1	25,183
Nitric acid	2,573	0	0	0	2,573
Sodium nitrite	2	0	0	12	14
Toluene	891	0	2	240,833	241,726
Xylene	1,937	0	8	740	2,685
Totals	**5,499**	**25,184**	**5,710**	**244,256**	**280,649**

1998

Chemical	Air Emissions	Water Discharges	Land Disposal	Offsite Transfers	Total
Chrome Compounds	168	3	2,203	236	2,610
Formic acid	7,400	0	0	0	7,400
HCFC 22	14,160	0	0	0	14,160
Lead	5	47	6,601	308	6,961
Lithium carbonate	16	0	0	0	16
Methyl tert-butyl ether	1	0	0	0	1
Nitrate compounds	26	19,721	95,000	9	114,756
Nitric acid	3,530	0	0	11	3,541
Sodium nitrite	2	0	8,000	0	8,002
Zinc compounds	577	621	1,933	2	3,133
Totals	**25,885**	**20,392**	**113,737**	**566**	**160,580**

1999

Chemical	Air Emissions	Water Discharges	Land Disposal	Offsite Transfers	Total
Chrome Compounds	1,001	10	31,100	27	32,138
Formic acid	6,832	0	12	0	6,844
n-Hexane	430	0	0	10	440
Lead	6	35	4,800	1,500	6,341
Lithium carbonate	7	0	0	0	7
Naphthalene	57	0	0	3	60
Nitrate compounds	201	28,165	0	86	28,452
Nitric acid	3,500	0	0	273	3,773
Sodium nitrite	7	0	3	8	18
Toluene	1,030	0	5	69	1,104
Xylene	350	0	0	400	750
Zinc compounds	4,046	4,034	193,000	49	201,129
Totals	**17,467**	**32,244**	**228,920**	**2,425**	**281,056**

Table 2–2 2000 SRS Reporting Compliance with Executive Order 12856

EPCRA Citation	Activity Regulated	Reported per Applicable Requirement
302–303	Planning Notification	Not Required[a]
304	Extremely Hazardous Substances Release Notification	Not Required[a]
311–312	Material Safety Data Sheet/ Chemical Inventory	Yes
313	Toxic Release Inventory Reporting	Yes

a Not required to report under provisions of "Executive Order 12856 and SARA Title III Reporting Requirements"

Executive Order 12856

Executive Order 12856 requires that all federal facilities comply with right-to-know laws and pollution prevention requirements. The order requires that federal facilities meet EPCRA reporting requirements and develop voluntary goals to reduce releases of toxic chemicals 50 percent on a DOE complexwide basis by the end of 1999—a goal accomplished by the complex. SRS complies with the applicable reporting requirements for EPCRA, as indicated in table 2–2, and the site incorporates the toxic chemicals on the Toxic Chemical Release Inventory report into its pollution prevention efforts.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) establishes policies and goals for the protection, maintenance, and enhancement of the human environment in the United States. NEPA's purpose is to provide the federal government with a process for implementing these goals. The act requires consideration of environmental factors during the planning process for all major federal activities that could significantly affect the quality of the environment. In practice, NEPA provides a means to evaluate the potential environmental impact of such proposed activities and to examine alternatives to those actions.

Although implemented at SRS by the Energy Research and Development Administration during the 1970s, a formal maintenance and operations NEPA compliance group was not established on site until 1982. The ongoing mission of this group is to make recommendations regarding the level of NEPA review of site-proposed action and to prepare draft documentation supporting DOE–SR compliance with NEPA at SRS.

In 2000, 276 reviews of newly proposed actions were conducted at SRS and formally documented through categorical exclusions (CXs), notifications of previous NEPA coverage, environmental assessments (EAs), NEPA values impact assessments (VIAs), or EISs. During the year, SRS also began preparation of its first engineering evaluation/cost analysis—a document prepared to ensure compliance with CERCLA and to meet the intent of NEPA requirements.

WSRC also provided technical support to DOE–SR for the preparation of supplemental environmental impact statements (SEISs) and programmatic environmental impact statements (PEISs).

The types and numbers of NEPA activities conducted at SRS during 2000 are presented in table 2–3. Among the specific activities were the following:

- The ROD for the Supplement to the Surplus Plutonium Disposition final EIS was issued January 11. This ROD covers the decision to implement the preferred alternative to construct and operate a new facility at SRS to produce mixed oxide fuel containing up to 33 metric tons of surplus weapons-usable plutonium for irradiation in existing domestic, commercial reactors. The fundamental purpose of this program is to ensure that plutonium produced for nuclear weapons and declared excess to national security needs (now and in the future) is never again used for nuclear weapons. The decision in

Table 2–3 Types/Quantity of NEPA Activities at SRS During 2000

Type of NEPA Documentation	Number
Categorical Exclusion (CX)	267
Tiered to Previous NEPA Documentation	9
Environmental Assessment (EA)	5
Engineering Evaluation/Cost Analysis	1
Values Impact Assessment	1
Environmental Impact Statement (EIS)	4
Supplemental Environmental Impact Statement (SEIS)	1
Programmatic Environmental Impact Statement (PEIS)	1
Total	289[a]

a Thirteen of the 289 NEPA activities were carryovers from 1999, leaving 276 newly proposed actions in 2000.

this ROD addresses both the immobilization and mixed oxide fuel approaches to surplus plutonium disposition, which includes the siting, construction, operation, and ultimate decontamination and decommissioning of the proposed facility at SRS.

- A revised FONSI for the centralization and upgrading of the sanitary wastewater system at SRS was issued February 3. The final EA and initial FONSI had been issued September 30, 1993. In an effort to conform to the standard commercial practice of allowing the disposal of low levels of radioactivity into sanitary sewerage, as regulated by the Nuclear Regulatory Commission and SCDHEC, a revision of the project scope was considered that would allow SRS to discharge small quantities of radionuclides into site sanitary sewerage. Based on existing SRS procedures and additional analyses on the human health impacts that could result from the proposed discharge of trace amounts of radionuclides to the sanitary wastewater treatment system at SRS, DOE concluded that the proposed revision would not result in significant impacts to the environment. Therefore, DOE issued the revised FONSI.

- DOE issued the fourth ROD related to the final PEIS on DOE Waste Management February 25. The first ROD dealt with decisions for the management of transuranic waste, while the second ROD involved the disposal of nonradioactive hazardous waste. The third ROD was concerned with decisions about the storage of high-level radioactive waste. This fourth ROD dealt with the management of low-level and mixed radioactive waste types within the DOE complex.

- A revised FONSI was issued April 28 for the SRS natural resources management activities EA. The EA and initial FONSI had been issued July 15, 1993. One of the key objectives of the original proposed action was the continuance of protection and recovery activities for Federally listed threatened and endangered species. The red-cockaded woodpecker was one of these endangered species. The U.S. Department of Agriculture Forest Service–Savannah River (USFS–SR, formerly the Savannah River Natural Resource Management and Research Institute) has revised the site's red-cockaded woodpecker management plan. Upon comparison with the 1993 EA, the implementation of the revised red-cockaded woodpecker management plan was determined to have impacts no greater than those described in that original (1993) NEPA evaluation. Therefore, DOE issued the revised FONSI.

- The ROD for the EIS on the spent nuclear fuel program at SRS was issued July 24. This EIS evaluated alternative utilization strategies for existing, modified, and new facilities or processes for managing spent nuclear fuel at SRS. The purpose of the proposed action is to identify and implement appropriate actions to safely and efficiently manage all aluminum-clad spent nuclear fuel and targets assigned to SRS, including placing these materials in forms suitable for disposition. This ROD presented DOE's decision to treat the majority of the spent nuclear fuel at SRS using melt-and-dilute technology.

- The final EA and FONSI on the proposed highly enriched uranium blend-down project at SRS were issued November 3. This EA evaluated the potential for significant impacts associated with the proposed construction and operation of a low enriched uranium loading station and modifications to the existing highly enriched uranium blend-down facilities, the SRS Central Analytical Laboratory, and the K-Area facilities. The purpose of the proposed action is to enable SRS to ship the blended-down low enriched uranium off site for further processing, thereby eliminating the onsite inventory and the weapons usability of this material. The conversion and transportation of the low enriched uranium solution already were addressed in broad terms in the final EIS on the disposition of surplus highly enriched uranium.

Table 2–4 SRS Project NEPA Documentation Activities During 2000

Project Name	Level of NEPA Documentation
DOE Waste Management	PEIS
Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada	EIS
High-Level Waste Salt Disposition Alternatives at SRS	EIS
SRS High-Level Waste Tank Closure	EIS
SRS Spent Nuclear Fuel	EIS
Supplement to the Surplus Plutonium Disposition EIS	SEIS
Alternative Approach for the DWPF Glass Waste Canister Storage Facility at SRS	EA
Construction and Operation of the Low Enriched Uranium Loading Station and Modification to the Existing Highly Enriched Uranium Blending Facilities at SRS	EA
Offsite Transportation of Certain Low-Level and Mixed Radioactive Waste from SRS for Treatment and Disposal at Commercial Facilities	EA
Natural Resources Management Activities at SRS	EA
Centralization/Upgrading of the Sanitary Wastewater System at SRS	EA
Closure of the R-Reactor Disassembly Basin at SRS	EE/CA
Remediation of TNX-Area Operable Unit at SRS	VIA

Key: PEIS — Programmatic Environmental Impact Statement
EIS — Environmental Impact Statement
SEIS — Supplemental Environmental Impact Statement
EE/CA — Engineering Evaluation/Cost Analysis
EA — Environmental Assessment
VIA — Values Impact Statement

Table 2–4 contains a complete list of NEPA documentation activities conducted at SRS during 2000.

Eleven new department NEPA coordinators completed the SRS certification program during 2000, bringing the total to 37 certified department NEPA coordinators supporting various contractor organizations on site.

The SRS NEPA Program continues to improve the sitewide computerized NEPA database/tracking system, which was developed for reporting and analysis purposes. An SRS NEPA home page is available to offsite computer users by means of the Internet at the following address: *http://www.srs.gov/general/sci-tech/nepa/nepa.html.* The home page contains (1) electronic copies of SRS EAs and EISs, (2) monthly NEPA reports, and (3) hot links to other NEPA web sites.

Safe Drinking Water Act

The federal SDWA—enacted in 1974 to protect public drinking water supplies—was amended in 1980, 1986, and 1996. SRS drinking water is supplied by 18 separate systems, all of which utilize groundwater sources. The number of drinking water systems at the site was reduced from 27 to 18 in 1997 by a project that consolidated 12 major drinking water systems into three: A-Area, D-Area, and K-Area. These three systems are actively regulated by SCDHEC and are classified as nontransient/noncommunity systems because each serves more than 25 people. The remaining 15 site water systems, each of which serves fewer than 25 people, receive a lesser degree of regulatory oversight.

During 2000, no lead and copper compliance sampling was performed for the A-Area consolidated system. Under the SCDHEC-approved, ultrareduced monitoring plan, lead and copper sampling will not be required for this system again until 2001.

The D-Area and K-Area consolidated water systems qualified in 1997 for an ultrareduced monitoring plan. Sampling for lead and copper was conducted in 2000. Results (computed at the 90th percentile) were substantially below the SCDHEC action levels of 15 parts per billion for lead and 1,300 parts per billion for copper. Compliance samples will not be required again from these systems until 2003.

The B-Area Bottled Water Facility, which was approved for operation in 1998, is listed as a public water system by SCDHEC. Quarterly sampling for bacteriological analyses began in January 2000. Annual complete chemical analyses were performed in October 2000 in accordance with FDA regulatory requirements; results met all FDA standards. Unlike at the A-Area, D-Area, and K-Area consolidated water systems, monitoring for lead and copper is not required at the B-Area facility.

SCDHEC performed its biannual sanitary survey of the B-Area Facility in July 2000. The results of the survey indicated a “satisfactory” rating. The biannual survey of the A-Area, D-Area, and K-Area domestic water systems will be conducted in 2001.

All bacteriological and chemical compliance samples for SRS domestic water systems met the primary drinking water standards in 2000.

No NOVs were issued to SRS in 2000 under the SDWA.

Clean Water Act

National Pollutant Discharge Elimination System

The CWA of 1972 created the NPDES program, which is administered by SCDHEC under EPA authority. The program is designed to protect surface waters by limiting releases of nonradiological effluents into streams, reservoirs, and wetlands. Radiological effluents are limited under DOE orders. Discharge limits are set for each facility to ensure that SRS operations do not adversely impact water quality.

SRS had four NPDES permits in 2000, as follows:

- *One permit for industrial wastewater discharge (SC0000175)* – SRS received a modification of this permit from SCDHEC January 1, 1998. The site removed outfalls L–08 and M–04 from this permit in 2000.
- *One general permit for utility water discharge (SCG250162)* – SRS no longer is covered under this permit, having removed the one outfall (001) covered under it in October 2000.
- *Two general permits for stormwater discharge (SCR000000 for industrial and SCR100000 for construction)*

More information about the NPDES permits can be found in chapter 8, “Nonradiological Effluent Monitoring.”

All results of monitoring for compliance with the industrial wastewater discharge permit and the general permit for utility water discharge were reported to SCDHEC in the monthly Discharge Monitoring Reports, as required by the permits.

In October 2000, SCDHEC personnel conducted a 2-week audit in which SRS wastewater facilities were inspected and the permitted NPDES outfalls were sampled. During this audit, SCDHEC reviewed the site’s stormwater program for the first time. The final audit report was not completed by the end of the year, but several problems were noted at the audit closeout meeting in October, as follows:

- One sanitary plant outfall (X–8A) had a flow meter that did not meet the required accuracy criteria of ± 10 percent.
- Two pumping stations, in D-Area, and K-Area, were found with high-level alarm problems.
- One backflow preventer in K-Area was not functioning.
- One administrative outfall (A–7A, under the stormwater program) was found to have a process (nonstormwater) discharge, which was turned off the same day. A plan has been developed to reroute it.
- One permit limit (for total suspended solids) was exceeded at the A–01 outfall.

All monitoring for compliance with the industrial stormwater discharge permit was evaluated and recorded in the pollution prevention plan for each outfall, as required by that permit. The individual outfall pollution prevention plans were combined to form a site pollution prevention plan, which was developed and implemented in 1993 and updated in 1996 for identified stormwater outfalls. Effective in 1998, individual outfall pollution prevention plans are kept at specific operations facilities, where they can be updated as needed. They are submitted to the Environmental Protection Department (EPD) annually. Each 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. (More about pollution prevention programs can be found in chapter 3.)

The outfalls covered by the modified industrial stormwater permit (SCR000000) were reevaluated in 1998. This resulted in the development of a new sampling plan, which was implemented in 1999 and underwent only minor modifications in 2000.

All construction activity that would result in a land disturbance of 5 or more acres must be permitted. The 11 land areas associated with industrial activity from construction were permitted as required in 2000 under permit SCR100000. The pollution prevention plan for this permit also requires a sediment reduction and erosion control plan.

Under the Code of Federal Regulations (CFR) 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 2000.

SRS has an agreement with SCDHEC to report petroleum product discharges of 25 gallons or more to the environment. Four such incidents in this category occurred at the site during 2000 and were reported appropriately.

Notices of Violation (NPDES)

SRS's 2000 compliance rate for NPDES under the CWA was 99.7 percent. The site received no NPDES-related NOVs from SCDHEC or EPA in 2000.

In a 1998 NOV, SCDHEC had cited 13 violations involving flow, total suspended solids, fecal coliform, copper, and toxicity that occurred from January through July of that year. Corrective actions were implemented in all the cases, but because no resolution could be reached on SRS's toxicity problems, SCDHEC turned over the enforcement action to EPA, which issued an NOV to the site August 3, 1999. The NOV, which detailed exceedances (including toxicity) and missing samples from 1996 through 1999, was discussed during an August 25, 1999, meeting (involving SRS, EPA, and SCDHEC) at which site representatives offered explanations for each point cited. EPA still had not determined a course of action by the end of 2000.

A toxicity problem at outfall A-11 resurfaced in October 1999, and a toxicity identification evaluation was implemented at that time. The evaluation was still under way at the end of 2000. Results of 2000 toxicity tests at SRS NPDES outfalls are presented in table 47, *SRS Environmental Data for 2000*, and additional discussion of the site's toxicity problems appears in chapter 8.

SCDHEC issued SRS a consent order October 11, 1999, addressing compliance with the site's NPDES permit at outfall A–01. The consent order gave SRS until October 2001 to comply with lead, copper, chlorine, and toxicity parameters at this outfall and until April 2002 to comply with the mercury parameter. During 2000, a wetland treatment system was designed and built to address these problems. The system, which began operating in November, will be fine-tuned between January and October 2001 to ensure compliance with permit limits.

SRS had 18 exceedances of permit parameters in 2000. A list of these—including outfall locations, probable causes, and corrective actions—can be found in chapter 8 (table 8–5).

Dredge and Fill; Rivers and Harbors

The CWA, Section 404, "Dredge and Fill Permitting," as amended, and the Rivers and Harbors Act, Sections 9 and 10, "Construction Over and Obstruction of Navigable Waters of the United States," protect U.S. waters from dredging and filling and construction activities by the permitting of such projects. Dredge and fill operations in U.S. waters are defined, permitted, and controlled through implementation of federal regulations in 33 CFR (U.S. Army Corps of Engineers) and 40 CFR (EPA). In 2000, SRS conducted activity under one nationwide permit (a general permit under Section 404) as part of the nationwide permits (NWP) program, but under no individual Section 404 permits. The activity was dam construction on an unnamed tributary to Fourmile Branch for the Mixed Waste Management Facility Groundwater Interim Measures project, which was conducted under NWP 38, "Hazardous Waste Cleanup."

Construction in Navigable Waters

SCDHEC Regulation 19–450, "Permit for Construction in Navigable Waters," protects the state's navigable waters through the permitting of any dredging, filling, construction, or alteration activity in, on, or over state navigable waters, in or on the beds of state navigable waters, or in or on land or waters subject to a public navigational servitude. The only state navigable waters at SRS are Upper Three Runs Creek (through the entire site) and Lower Three Runs Creek (upstream to the base of the PAR Pond Dam).

No projects were permitted or work conducted at SRS under Regulation 19–450 in 2000.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act restricts the application of pesticides through a state-administered certification program. SRS complies with these requirements through procedural guidelines, and the site's pesticide procedure provides guidelines for pesticide use and requires that applicators of restricted-use pesticides 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 impacts on the environment are minimal. The task group also

- maintains records of pest control activities
- assists in disseminating pesticide-use information to site contractors

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

Clean Air Act

Regulation, Delegation, and Permits

The CAA provides the basis for protecting and maintaining air quality. Some types of SRS air emissions, such as radioactive sources and ozone-depleting substances (ODSs), are regulated by EPA, but most are regulated by SCDHEC, which must ensure that its air pollution regulations are at least as stringent as the CAA's. This is accomplished through SCDHEC Regulation 61–62, "Air Pollution Control Regulations and Standards."

Under the CAA, and as defined in federal regulations, SRS is classified as a "major source" and, as such, is assigned one permit number (0080–0041) by SCDHEC. In this permit, each emission source is identified by the area designation, by a point identification number, and by a source description. SRS holds operating and construction permits or exemptions from SCDHEC's Bureau of Air Quality, which regulates nonradioactive toxic and criteria pollutant emissions from approximately 199 point sources, several of which have specific emission limits.

As of May 1994, SCDHEC had completed renewal of all SRS operating permits, which are valid for 5 years. Because of ongoing work on the Title V permit, SCDHEC granted extensions of the operating permits in 1998 and 1999 and of the construction permits in 2000. The extensions will be valid until the new Title V permit is issued. Of the 199 point sources, 137 operated in some capacity during 2000. The remaining 62 either were under construction or were being maintained in a "cold standby" status.

During 2000, SCDHEC conducted compliance inspections of 66 permitted sources at SRS, reviewing 182 permitted parameters. The inspections included

- biennial stack tests
- quarterly inspection of CIF continuous-emission monitors
- annual compliance inspections

As indicated earlier, the site achieved a compliance rate of 100 percent—and received no NOVs—under the CAA in 2000.

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 air pollutants, such as radionuclides, benzene, and asbestos. The NESHAP regulations found in 40 CFR 61 are divided into subparts based on specific hazardous pollutant categories, such as Subpart H for radionuclides and Subpart M for asbestos. The Clean Air Act Amendments (CAAA) of 1990 revised the original list of hazardous air pollutants. The revised list of 189 air pollutants includes all radionuclides as a single item. Regulation of these pollutants has been delegated to SCDHEC; however, EPA Region IV continues to partially regulate radionuclides.

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—e.g., off-the-shelf bug sprays, correction fluids, paints, sealers, janitorial cleaning supplies, gasoline for vehicles—as well as a number of typical industrial chemicals, such as degreasers, solvents, metals, batteries, and diesel fuel. 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.

NESHAP Radionuclide Program Subpart H of NESHAP was issued December 15, 1989, after which an evaluation of all air emission sources was performed to determine compliance status. DOE–SR and EPA Region IV signed an FFCA October 31, 1991, providing a schedule to bring SRS's emissions monitoring into compliance with regulatory requirements. An amendment to the FFCA, signed

August 16, 1993, provided an extension to the original FFCA through February 10, 1995, to accomplish additional monitoring equipment upgrades. The upgrades were completed on time, and the FFCA was officially closed—and the site declared compliant—by EPA Region IV May 10, 1995. 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.

During 2000, the maximally exposed individual effective dose equivalent, calculated using the NESHAP-required CAP88 computer code, was estimated to be 0.05 mrem (0.0005 mSv), which is 0.5 percent of the 10-mrem-per-year (0.10-mSv-per-year) EPA standard (chapter 7, "Potential Radiation Doses").

NESHAP Nonradionuclide Program SRS uses many chemicals identified as toxic or hazardous air pollutants, but most of these chemicals are not regulated under the CAA or under federal NESHAP regulations. Except for asbestos, SRS facilities and operations do not fall into any of the "categories" listed in the subparts. Under Title III of the federal CAAA of 1990, EPA in December 1993 issued a final list of hazardous air pollutant-emitting source categories potentially subject to maximum achievable control technology standards. These standards were being developed and issued over a 10-year period that ended in November 2000; however, because of the number and complexity of the new standards to be developed, EPA was not able to meet the original schedule, which was arranged according to

- the effects of each pollutant
- the industry group source category
- the abatement technology available

EPA is not issuing another schedule, but rather is assigning revised due dates for the remaining new regulations in what is referred to as a "unified agenda."

In an attempt to regulate hazardous or toxic air pollutants in South Carolina, SCDHEC established Air Pollution Control Regulation 61–62.5, Standard No. 8, "Toxic Air Pollutants," in June 1991. To demonstrate compliance with this standard, SRS completed and submitted an air emissions inventory and air dispersion modeling data for all site sources in 1993. The submitted data demonstrated compliance by computer modeling the accumulated ambient concentration of individual toxic air pollutants at the boundary line and comparing them to the Standard No. 8 maximum allowable concentrations. To ensure continued compliance with Standard No. 8, new sources of toxic air pollutants must be permitted, which requires submittal of appropriate air permit applications and air dispersion modeling. Sources with emissions below a threshold of 1,000 pounds per month of any single toxic air pollutant may be exempted from permitting requirements. During 2000, six sources of toxic air pollutants either were issued a construction permit or exempted from permitting requirements.

NESHAP Asbestos Abatement Program Asbestos is a naturally occurring mineral. Because of its availability, low cost, and unique properties, the U.S. construction industry used asbestos extensively from after World War II through the mid 1970s. The construction of SRS began in the early 1950s, and asbestos-containing material can be found throughout the site. The danger from exposure to airborne asbestos fibers was virtually unknown during the early years at the site. Today, however, it is well established that unprotected exposure to airborne asbestos fibers can lead to asbestosis, lung cancer, mesothelioma, and other diseases.

SRS began an asbestos abatement program in 1988 and continues to manage asbestos-containing material by "best management practices." Site compliance in asbestos abatement, as well as demolitions, falls under South Carolina and federal regulations, including SCDHEC Regulation R.61–86.1 ("Standards of Performance for Asbestos Projects") and 40 CFR 61, Subpart M ("National Emission Standards for Asbestos").

Asbestos-containing material is managed at SRS through the following control options:

- an operations and maintenance program
- enclosure
- encapsulation
- repair
- removal

Many site demolition, renovation, and maintenance projects require the removal of asbestos-containing material. During 2000, SRS personnel removed and disposed of an estimated 1,915 square feet and 1,570 linear feet of regulated asbestos-containing material. In addition, contractors removed and disposed of an estimated 25,300 square feet and 10,040 linear feet of regulated asbestos-containing material. Only qualified, asbestos-trained personnel are permitted to handle the material, and they must follow Occupational Safety and Health Administration standards and practices for its removal and disposal.

Radiological asbestos waste, removed by SRS personnel and contractors who are not permanent SRS employees, was disposed of at the SRS low-level burial ground, which is approved by SCDHEC as a disposal site. Nonradiological asbestos waste removed by SRS personnel was disposed of at the Three Rivers Landfill, located on site. Nonradiological asbestos waste removed by contractors was disposed of at SCDHEC-approved offsite landfills.

Other CAA Requirements

Only a few of the major sections of the CAA and its 1990 amendments and regulations have had—or are expected to have—a significant impact on SRS sources and facilities. These include Title V, “Permits,” and Title VI, “Stratospheric Ozone Protection.” The other regulations impacting SRS facilities are implemented primarily in SCDHEC Regulation 61–62 and in existing operating or construction permits.

Title V Operating Permit Program As previously indicated**,** the CAAA of 1990 also include, under Title V, a major new permitting section expected to have a significant impact on the site through increased reporting and monitoring requirements. The primary purpose of this permitting program is to establish federally enforceable operating permits for major sources of air emissions. The implementation plan for this program was submitted to EPA in 1993 by the State of South Carolina and subsequently approved by EPA in June 1995. SRS then submitted an extensive application package for site air emission sources by the March 15, 1996, deadline set forth in the implementation plan, Regulation 62.70, “Title V Operating Permit Program.”

SRS and SCDHEC have been developing the Title V (Regulation 62.70) operating air permit since 1996. In September 1998, SRS received a draft Part 70 permit from SCDHEC and subsequently submitted comments back to SCDHEC on October 1 of that year. However, the permitting process has been on hold for the past 2 years because of the departure of SCDHEC’s permit engineer for SRS and because of higher priority permitting needs in the state during calendar year 2000. The site finally was notified in October 2000 that SCDHEC was resuming its efforts to expedite the Part 70 operating air permit. At SCDHEC’s request, SRS transmitted its final amendment to the original permit application in December 2000 and—at the end of the year—still was awaiting issuance of a final draft permit, which then will undergo a 30-day public comment period and a concurrent 45-day EPA comment period.

Ozone-Depleting Substances Title VI of the CAAA of 1990 addresses stratospheric ozone protection. This law requires that EPA establish a number of regulations to phase out the production and consumption of ODSs. The substances commonly are used as refrigerants in air conditioning and cooling systems; as degreasers and cleaners; as spray can propellants; as fire suppressants (Halon); as laboratory extractions; and in many other common consumer products.

Several sections of Title VI of the CAAA of 1990, along with recently established EPA regulations found in 40 CFR 82, apply to the site. The ODSs are regulated in three general categories, as follows:

- *Class I substances* – chlorofluorocarbons (CFCs), Halons, carbon tetrachloride, methyl chloroform, methyl bromide, and hydrobromofluorocarbons (HBFCs)
- *Class II substances* – hydrochlorofluorocarbons (HCFCs)
- *Substitute substances*

Class I ODSs are about 10 times more ozone-depleting than HCFCs and thus are more strictly regulated. As required by the CAAA of 1990, most Class I Halons were phased out of production by January 1, 1994, and other Class I ODSs were phased out by January 1, 1996. This means that several very important refrigerants (CFC–11, –12, –114, and –502) used on site essentially may become unavailable for purchase. Many of the large chillers on site that use these refrigerants are being scheduled for total replacement or for retrofits that will use HCFCs or other chemical substitutes. The site also is scheduling fire suppression (Halon) system replacements. Many common degreasers are Class I ODSs and have been targeted for replacement. Most major degreasing applications already have been eliminated or replaced with non-ODSs. Smaller ODS-degreasing applications, such as those used in maintenance and electrical shops, are being targeted for phaseout. ODSs used in laboratory extraction procedures have been replaced with newly developed processes that use non-ODSs.

The SRS CAAA of 1990 Title V operating air permit application includes ODS emission sources. All large (greater than or equal to 50-pound charge) heating, ventilation, and air conditioning/chiller systems for which there are recordkeeping requirements are included as fugitive emission sources.

In 1994, the site formed a CFC steering committee of participants from all the major users of these substances to provide initial direction in the phaseout of Class I ODSs on the site. A number of technical subcommittees also were initiated at that time to address particular applications, such as refrigeration, fire suppression, degreasers, laboratory applications, and environmental compliance. The ODS Subcommittee of the Central Environmental Committee was created in 1995 to communicate to site organizations—through field representatives—any changes in Title VI regulations that could affect established programs. The "Savannah River Site Refrigerant Management Plan," completed and issued in September 1994, provides guidance to assist SRS and DOE in the phaseout of CFC refrigerants and equipment.

The site has

- purchased certified recycling equipment
- trained and certified technicians where required
- implemented required recordkeeping and leak-tracking for large cooling systems
- implemented proper labeling and other recordkeeping requirements

In 1996, SRS let a subcontract for the offsite reclamation of used refrigerants. The site also eliminated the use of CFC–114 by completing replacement of the 789–A chiller plant with a new plant that uses a non-CFC refrigerant. The 55,000 pounds of CFC–114 were sold in 1997 as part of a decontamination and decommissioning contract and shipped to a Defense Logistics Agency facility in Richmond, Virginia. Additionally, Executive Order 12856 required a 50-percent reduction in CFC usage by the end of 1999, based on 1993 data. SRS surpassed the 21,116-pound 1999 goal in 1996 by reducing CFC refrigerant usage to 12,570 pounds, but incurred a 1997 increase to 12,930 pounds—still surpassing the goal set in the executive order. In 1998, the site cut CFC usage sharply, to 6,430 pounds, then further reduced the number to 4,040 pounds in 1999. This achievement exceeded the federal goal by 40 percent. The SRS reduction in CFC usage, based on 1993 data, was 90 percent by 1999, compared to the federal goal of 50 percent by 1999. The site continued working toward elimination of CFC refrigerants in 2000. Usage was reduced to 480 pounds—or by 99 percent, based on the 1993 data.

CFC refrigerant system replacement projects that were in various stages of implementation during 2000 included the following:

- HB-Line system replacement
- 221–S system replacement
- new source recovery facility system upgrades
- a central system for F-Canyon and associated support labs
- 235–F refrigerant system upgrade
- B-Area central chiller facility upgrade

The 235–F project was completed in 2000, and work continued on the F-Canyon project, the HB-Line and 221–S replacements, the new source recovery facility system upgrades, and the B-Area central chiller facility upgrade.

SRS is phasing out its use of Halon as a result of the January 1994 ban on Halon production. A Halon system prioritization study was completed in December 1993 for use as the basis for the managed phaseout of fixed Halon 1301 fire suppression systems. Of the 372 active Halon 1301 systems in use on site at the end of the study, 47 were determined to be essential (not to be replaced), 179 were identified as nonessential and prioritized for systematic replacement, and 146 were determined to be no longer necessary. An additional 85 systems were reactivated in F-Area in 1995, however, and based on further facility review and new guidance, the 1995 Halon Replacement Implementation Plan identified 141 systems to be removed (without replacement) and added the 47 systems originally deemed essential to the list of those to be replaced.

A halon alternative study was completed in November 2000 by the site's fire protection and systems engineering groups. The purpose of the study was to

- recommend alternative fire suppression agents to replace Halon 1301
- provide a method for assigning modification priorities to site fire protection systems that use Halon 1301

As part of the study, an audit of site Halon 1301 systems was completed that identified systems in operation, systems abandoned in place, and systems that had been dismantled and taken to the DOE complex's halon repository, located at SRS. At the end of 2000, there were 110 Halon 1301 systems operating and 79 systems abandoned in place; two systems had been taken to the repository. Funding for the preconceptual design and planning stage of the replacement project is being explored for fiscal year 2001.

Portable Halon 1211 fire extinguishers are being replaced as they reach the end of their useful lives. Approximately 16,065 pounds of Halon 1211 have been shipped to the Defense Logistics Agency facility in Richmond. At the end of 2000, approximately 2,723 pounds remained in use on site, and 803 pounds were in storage. Although no Halon 1211 was shipped to the agency in 2000, 2,714 pounds were prepared for shipment. Shipment of all 1211 extinguishers is scheduled for early 2001.

Halon 1301 usage on site also has decreased—from 75,089 pounds in 1995 to 23,352 pounds in 2000. However, at the end of 2000, the site still had an inventory of 48,146 pounds of stored Halon 1301, including 2,810 pounds received from other DOE sites during 2000. In addition, 14,392 pounds of Halon 1301 is contained in systems that have been abandoned in place.

As is the case with refrigerants, all personnel working with the site's nine Halon 1301 fire suppression systems and its Halon 1301 recycling and recharging operations have been trained in Halon emissions reduction. Training is based on vendor information for specific systems and on National Fire Protection Association-recommended practices required by Halon emissions reduction regulations.

Air Emissions Inventory

SCDHEC Regulation 61–62.1, Section III ("Emissions Inventory"), requires compilation of an air emissions inventory for the purpose of locating all sources of air pollution and defining and characterizing the various types and amounts of pollutants. To demonstrate compliance, SRS personnel conducted the 1993 comprehensive air emissions inventory, compiling source information from as far back as 1985. Guidelines and procedures were written to

- ensure that all radiological and nonradiological sources had been accounted for
- ensure documentation of all vents and stacks for each building
- better characterize emission points from site processes
- calculate emissions based on design capacity, maximum potential emissions, and actual emissions for a selected period of time
- provide consistency in recording appropriate data

The inventory identified approximately 5,300 radiological and nonradiological air emission sources. Source operating data and calculated emissions from 1990 were used to establish the SRS baseline emissions and to provide data for air dispersion modeling. This modeling was required to demonstrate sitewide compliance with Regulation 61–62.5, Standard No. 2, "Ambient Air Quality Standards," and Standard No. 8.

Regulation 61–62.1, Section III, requires that inventory data be updated and *recorded* annually but only *reported* every even calendar year. The emissions inventory is updated each year in accordance with SRS procedures and guidelines. Calendar year 1999 operating data for *permitted and other significant* sources were *reported* to SCDHEC in 2000. Because data collection for all SRS sources begins in January and requires up to 6 months to complete, this report provides emissions data for calendar year 1999 (table 8–4 of this document for criteria pollutants and table 45, *SRS Environmental Data for 2000*, WSRC–TR–2000–00329, for toxic/hazardous air pollutants). Compilation of 2000 data will be completed in 2001 and reported in the *SRS Environmental Report for 2001*.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) gives EPA comprehensive authority to identify and control chemical substances manufactured, imported, processed, used, or distributed in commerce 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. EPD and Industrial Hygiene personnel coordinate reporting and recordkeeping requirements under TSCA.

Polychlorinated biphenyls (PCBs) have been used in various SRS processes. The use, storage, and disposal of these organic chemicals are specifically regulated under 40 CFR 761, which is administered by EPA. SRS has a well-structured PCB program that complies with this TSCA regulation, with DOE orders, and with WSRC policies.

The site's 1999 PCB document log was completed prior to the July 1, 2000, deadline in full compliance with 40 CFR 761. Also, SRS's report on 1999 PCB disposal activities (ESH–FSS–2000–00145) was prepared and submitted to EPA Region 4 prior to the July 15, 2000, deadline. The disposal of nonradioactive PCBs routinely generated at SRS is conducted at EPA-approved facilities within the regulatory time frame. For many forms of radioactive PCB wastes, disposal capacity is not yet available, and the wastes must remain in long-term storage. Such wastes are held in TSCA-compliant storage facilities in accordance with 40 CFR 761. Site plans call for the disposal of incinerable radioactive PCB wastes at the TSCA incinerator in Oak Ridge, Tennessee, when the State of Tennessee approves the disposal plan.

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 RCRA Part B Permit Application to address the discovery of PCBs was submitted to SCDHEC in December 1993. Any waste generated was handled according to the appropriate TSCA and RCRA requirements. Savannah River Technology Center (SRTC) personnel continue to study ways to remediate the dense nonaqueous phase liquids.

In 1996 and subsequent years, site personnel discovered PCBs in certain painted surfaces and in other solid forms within several facilities constructed prior to TSCA. As such discoveries were made, SRS worked with EPA—as necessary—on related TSCA compliance issues. Current TSCA regulations prohibit the use and distribution in commerce of these forms of PCBs above specified concentrations. In December 1999, however, EPA issued a proposed rule to authorize the continued use of these forms of PCBs.

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 protects and conserves the ecosystems on which such species depend.

Several threatened and endangered species exist at SRS. The site conducts research on the wood stork, the red-cockaded woodpecker, the bald eagle, the shortnose sturgeon, and the smooth purple coneflower. Programs designed to enhance the habitat of such species are in place.

No biological assessments and/or biological evaluations were prepared for NEPA documents for new projects at SRS in 2000. However, to ensure the protection of threatened and endangered species, biological assessments and biological evaluations—which are required under NEPA—were conducted by the USFS–SR to evaluate potential impacts of environmental restoration and forestry related activities at:

- R-Area Burning Rubble Pit and Rubble Pile
- R-Area Old Discharge Canal
- F-Area Plutonium Disposition Mission Area
- red-cockaded woodpecker management plan

None of these activities was found to have had any significant potential impact on threatened and endangered species.

The biological assessment for the river water system shutdown EIS concluded in 1996 that the proposed action could affect the bald eagle, the alligator, and the wood stork. Subsequent consultations conducted by SRS in 1996–97 with U.S. Fish and Wildlife Service personnel generated a cooperative agreement in which SRS would perform studies on the bald eagle. The site completed the studies in 1999, and work is continuing on a report of the findings. The results of this report will determine if a mitigation plan should be implemented.

National Historic Preservation Act

The National Historic Preservation Act (NHPA) of 1966, Section 106, governs the protection and preservation of archaeological and historical resources. SRS ensures that it 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 Savannah River Archaeological Research Program (SRARP) group to ensure that archaeological or historic sites are not impacted. Reviews of timber compartment prescriptions include surveying for archaeological concerns and documenting areas of importance with regard to historic and prehistoric significance.

SRARP personnel reviewed 46 site-use packages and surveyed 2,745 acres in support of SRS project activities during 2000. Most of the site-use packages were found to have no activities of significant impact in terms of the NHPA, but 11 of them resulted in surveys being conducted because of the potential for land alteration in 2000. SRARP personnel also surveyed 1,738 acres during 2000 in support of onsite forestry activities.

The surveys of all 4,483 of these acres resulted in the investigations of 55 new archaeological sites and in revisits to 35 previously recorded sites for cultural resources management.

Three archaeological sites on the proposed Surplus Plutonium Disposition Facility, formerly the Plutonium Immobilization Plant, were combined into two sites in 2000, and the South Carolina historic preservation officer determined that the sites were eligible for nomination to the National Register of Historic Places.

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 Orders 11988, “Floodplain Management,” and 11990, “Protection of Wetlands”

Executive Order 11988, “Floodplain Management,” was established to avoid long- and short-term impacts associated with the occupancy and modification of floodplains. The 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, the USDA FS–SR, and the Savannah River Ecology Laboratory (SREL), as well as by professionals from other organizations.

Executive Order 11990, “Protection of Wetlands,” was established to mitigate adverse impacts to wetlands caused by the 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.

No floodplain or wetland assessments were conducted at SRS during 2000.

Environmental Release Response and Reporting

Response to Unplanned Releases

Environmental Monitoring Section (EMS) personnel respond to unplanned environmental releases—both radiological and nonradiological—upon request by area operations personnel.

No unplanned environmental releases that occurred at SRS in 2000 required the sampling and analysis services of EMS. If the services of EMS personnel are requested, the samples collected are given priority in preparation and, if radiological in nature, priority in the counting room. Data are validated, and a determination is made as to whether there has been an actual release. If there has been, then consequences to the public and the environment are determined.

Occurrences Reported to Regulatory Agencies

“Federally permitted” releases comply with legally enforceable licenses, permits, regulations, or orders. 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.

If a nonpermitted release to the environment of a reportable quantity (RQ) or more of a hazardous substance (including radionuclides) occurs, CERCLA requires notification of the National Response Center. Also, the CWA requires that the National Response Center be notified if an oil spill causes a “sheen” on navigable waters, such as rivers, lakes, or streams. Oil spill reporting 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 federally permitted or covered by a continuous-release notification. A continuous-release notification provides an exemption from reporting each release of a specific hazardous substance greater than an RQ. The site submitted two continuous-release notifications in 1992—for ethylene glycol and for asbestos, each of which had a statutory RQ of 1 pound. SRS withdrew the request for continuous-release notification status for ethylene glycol in 1995, when EPA made an adjustment to that RQ. The asbestos continuous-release notification request was retracted during 1999 with the completion of deactivation and decommissioning activities at the D-Area Heavy Water Facility.

SRS had no CERCLA-reportable releases in 2000. This performance compares with one such release reported during 1999, one during 1998, three during 1997, and two during 1996.

Five notifications—not required by CERCLA—were made by the site to regulatory agencies during 2000. Three of these were “courtesy notifications” made to inform the agencies, principally SCDHEC, of storm damage and equipment failure. The other two were the result of an agreement to notify SCDHEC about sewage and petroleum product releases. The agreement requires reporting of sewage releases “equal to or greater than 100 gallons” and of petroleum product releases “equal to or greater than 25 gallons” unless the releases come in contact with

Table 2–5
Environmentally Related Unusual Occurrence Reported Through SIRIM in 2000

Discovery Date	Occurrence	Report No. (SR–WSRC–)	Cause/Explanation[a]
June 22	Ferric nitrate container pressurization; no release to the environment	TNX–2000–002	Inadequate material storage

a SRS takes followup corrective actions to minimize the impact on the environment.

"waters of the state." In these cases, releases in any amount are to be reported—whether for sewage or for petroleum products. The two agreement-based notifications were for oil releases.

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. No EPCRA-reportable releases occurred in 2000.

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. In 1997, SRS expanded the plan for the courtesy notifications in response to a request by local governments. The expanded notification plan includes such occurrences as shelter alarms and stack monitoring alarms, even though they may be false alarms.

Site Item Reportability and Issues Management Program

The Site Item Reportability and Issues Management (SIRIM) program, mandated by DOE Order 232.1A (which superceded DOE Order 232.1), "Occurrence Reporting and Processing of Operations Information," is designed to ". . . establish a system for reporting of operations information related to DOE-owned or operated facilities and processing of that information to provide for appropriate corrective action. . . ." It is the intent of the order that DOE be ". . . kept fully and currently informed of all events which could: (1) affect the health and safety of the public; (2) seriously impact the intended purpose of DOE facilities; (3) have a noticeable adverse effect on the environment; or (4) endanger the health and safety of workers."

The SIRIM program at SRS is designed to meet the requirements of DOE Order 232.1A by ensuring that

- all occurrences specified are identified in a timely manner, categorized, and reported
- proper corrective actions are taken in a timely manner
- all reportable occurrences are reviewed to assess significance and root causes
- occurrence reports to DOE operations are disseminated to prevent the recurrence of similar events

All SIRIM events are classified in one of the following categories: (1) facility condition; (2) environmental; (3) personnel safety; (4) personnel radiation protection; (5) safeguards and security; (6) transportation; (7) value-based reporting; (8) facility status; (9) nuclear explosive safety (not applicable at SRS); or (10) cross-group items. The impact—or the anticipated impact—of each event is categorized as follows (based on criteria in site procedures):

- *Emergency* – the most serious event; requires increased alert status for onsite and, in specific cases, offsite authorities
- *Unusual occurrence* – a nonemergency event that has significant impact or potential for impact on safety, environment, health, security, or operations
- *Off-normal occurrence* – an abnormal or unplanned event or condition that deviates from established standards or specifications

Of the 495 SIRIM-reportable events in 2000, only one was categorized as environmental; it was classified as an unusual occurrence (table 2–5).

Assessments/Inspections

The SRS environmental program is overseen by a number of organizations, both outside and within the DOE complex. In 2000, the WSRC environmental appraisal program consisted of self and independent assessments. The program employs total-quality management concepts that support the site's four imperatives of safety, disciplined operations, continuous improvement, and cost effectiveness. It also ensures recognition of noteworthy practices, identification of performance deficiencies, and initiation and tracking of associated corrective actions until they are satisfactorily completed. The primary objectives of the WSRC assessment program are to ensure compliance with regulatory requirements and to foster continuous improvement. The program is an integral part of the site's Integrated Safety Management System and supports the SRS Environmental Management System, which continues to be certified to the standards of International Organization for Standardization (ISO) 14001. (ISO 14000 is a family of voluntary environmental management standards and guidelines.)

WSRC conducted seven environmental program-level assessments in 2000. Areas assessed included groundwater protection program management, CERCLA health and safety plans, air quality protection (facility air permits), spill prevention management, management of investigation-derived wastes, and PCB program management. Also, a special assessment was performed to verify that the locations of the site NPDES outfalls met regulatory requirements and site business needs.

During 2000, personnel from DOE–SR's Environmental Quality and Management Division again performed direct oversight and evaluation of WSRC's self-assessment program to help ensure that the program continues to meet the needs and expectations of DOE Order 5482.1B, "Environment, Safety, and Health Appraisal Program"; Savannah River Implementation Procedure (SRIP) 200, chapter 223.4, "SR Technical Assessment Program"; and SRIP 450.1, "SR Environmental Protection Program." Completed assessments have met with positive results; routine assessments have promoted improvement and helped ensure the adequacy of environmental programs and operations at SRS.

SCDHEC also inspects the SRS environmental program for regulatory compliance. Agency representatives performed four comprehensive compliance inspections in 2000, as follows:

- SCDHEC performed its biannual sanitary survey of the B-Area Bottled Water Facility July 26. The facility received a "satisfactory" rating.
- SCDHEC conducted an annual assessment of the site's air emission sources against its air construction and operating permits April 22–25. Operating records, current operating conditions and parameters, and the operability of required monitoring equipment were reviewed to verify compliance with conditions specified in the permits. For systems in operation during the inspections, opacity was evaluated according to EPA Method 9, "Visual Emissions Evaluations." Inspection reports written for each area indicated that SRS air emission sources were operating in compliance with all permit requirements and that no response was required.
- SCDHEC performed a comprehensive groundwater monitoring evaluation October 13–27, sampling all the industrial permitted outfalls and performing operation and maintenance inspections of the industrial and stormwater discharge permits. Minor deficiencies were identified at the sanitary outfalls, and a nonstormwater process discharge was identified at an administrative outfall. The minor deficiencies at the sanitary outfalls were addressed immediately by facility personnel. The discharge at the administrative outfall was stopped the same day, and a plan was developed to reroute it.
- The 2000 Comprehensive Monitoring Evaluation (a RCRA inspection) of SRS was conducted June 12–20 by SCDHEC. Approximately 135 areas were visited during the evaluation, which is aimed at ensuring compliance with state solid and hazardous waste management regulations, and no deficiencies were noted.

SCDHEC also performed monthly compliance inspections during the year, with no deficiencies noted.

Environmental Permits

SRS had 655 construction and operating permits in 2000 that specified operating levels for each permitted source. This compares with 684 such permits in 1999, 697 in 1998, 675 in 1997, and 668 in 1996. Table 2–6 summarizes the permits held by the site during the past 5 years. These numbers reflect only permits obtained by WSRC for itself and for other SRS contractors that requested assistance in obtaining permits. It also should be noted that these numbers include some permits that were voided or closed some time during the calendar year (2000).

Environmental Training

The site's environmental training program identifies training activities to teach job-specific skills that protect the employee and the environment while satisfying regulatory training requirements. Chapter 3 contains more information about the training program.

Table 2–6
SRS Construction and Operating Permits, 1996–2000

Type of Permit	Number of Permits				
	1996	1997	1998	1999	2000
Air	196	198	202	200	199
U.S. Army Corps of Engineers 404	0	1	1	0	0
Army Corps of Engineers Nationwide Permit	8	6	6	4	1
Domestic Water	178	186	194	203	203
Industrial Wastewater	87	84	83	86	77
NPDES–Discharge	2	1	1	1	1
NPDES–General Utility	0	1	1	1	1
NPDES–No Discharge	1	1	1	1	1
NPDES–Stormwater	2	2	2	2	2
RCRA	1	1	1	1	1
Sanitary Wastewater	135	137	139	141	133
SCDHEC 401	1	2	2	1	1
SCDHEC Navigable Waters	4	4	4	0	0
Solid Waste	6	5	5	5	5
Underground Injection Control	18	17	31	18	23
Underground Storage Tanks	29	29	24	20	7[a]
Totals	668	675	697	684	655

a This number has been revised to reflect the actual number of permits that include requirements for 20 underground storage tanks.

Facility Decommissioning

With the rapidly declining need for a large nuclear weapons stockpile, many SRS facilities no longer are needed to produce or process nuclear materials. They have become surplus and must be dispositioned safely and economically. Many of them are large and complex and contain materials that, if improperly handled or stored, could be hazardous. SRS faces a major task in the cleanup, reuse, safe storage, and demolition of these facilities. The Facilities Decommissioning Division (later renamed the Facilities Disposition Division) was established in 1996 to meet this challenge. The site's 2000 deactivation and decommissioning activities are discussed in chapter 4.

Table 2–7 SRS 2000 Environmental Restoration Activities

Page 1 of 2

Operable Unit	Activity Description
Fourmile Branch Watershed	
Burial Ground Complex Groundwater (also in Upper Three Runs Watershed)	Continued characterization, completed retention dam construction
C-Area Burning/Rubble Pit	Continued interim remedial action
C-Area Reactor Seepage Basins	Issued source unit remedy explanation of significant differences (plug-in ROD)
Central Shops Burning/Rubble Pits (631–1G, –3G)	Completed characterization
Central Shops Sludge Lagoon	Initiated remedy selection
F-Area Retention Basin (281–3F)	Continued remedial action
F-Area Seepage Basin Groundwater	Continued remediation system operation
Ford Building Seepage Basin	Completed characterization
H-Area Retention Basin (281–3H)	Performed treatability study
H-Area Seepage Basin Groundwater	Continued remediation system operation
H-Area Groundwater	Continued characterization
Heavy Equipment Wash Basin and Central Shops Burning/Rubble Pit (631–5G)	Developed characterization work plan
Old Radioactive Waste Burial Ground, including Solvent Tanks	Continued remedy identification and evaluation
Lower Three Runs Watershed	
P-Area Bingham Pump Outage Pit	Issued ROD
R-Area Reactor Seepage Basins	Completed characterization
R-Area Acid/Caustic Basin	Completed characterization
R-Area Bingham Pump Outage Pits	Completed characterization
Pen Branch Watershed	
CMP Pits	Continued interim remedial action
K-Area Burning/Rubble Pit and Rubble Pile	Issued ROD
K-Area Reactor Seepage Basin	Issued source unit remedy explanation of significant differences (plug-in ROD)
L-Area Burning/Rubble Pit, Rubble Pile, and Gas Cylinder Disposal Facility	Initiated remedy selection
L-Area Bingham Pump Outage Pit	Issued ROD
Savannah River and Floodplain Swamp Watershed	
D-Area Expanded Operable Unit (Ash Basin, Coal Pile Run–off Basin, Waste Oil Facility, and Upgradient Sources)	Continued characterization
D-Area Oil Seepage Basin	Continued remedial action
Road A Chemical Basin	Initiated characterization
Savannah River and Floodplain Swamp IOU	Continued Phase I IOU characterization planning

Table 2–7 SRS 2000 Environmental Restoration Activities

Page 2 of 2

Operable Unit	Activity Description
Savannah River and Floodplain Swamp Watershed (cont.)	
TNX Operable Unit	Continued interim action and resumed characterization
TNX Outfall Delta, Lower Discharge Gulley, and Swamp	Continued characterization
Steel Creek Watershed	
L-Area Hot Shop	Initiated characterization
L-Area Oil and Chemical Basin	Continued remedial action
L-Area Reactor Seepage Basin	Issued source unit remedy explanation of significant differences (plug-in ROD)
L-Area Southern Groundwater	Initiated characterization
P-Area Burning/Rubble Pit	Initiated remedy selection
Upper Three Runs Watershed	
A-Area Burning/Rubble Pits and Rubble Pit	Initiated interim-action
A-Area Miscellaneous Rubble Pile	Initiated remedy selection
M-Area HWMF – A/M Groundwater	Continued remediation system operation
M-Area HWMF – Vadose Zone	Continued remediation system operation
Met Lab Basin/Carolina Bay	Continued remediation system operation
Miscellaneous Chemical Basin/Metals Burning Pit	Initiated interim action
Mixed Waste Management Facility (including RCRA-regulated portions of LLRWDF)	Initiated interim corrective action measures
Old F-Area Seepage Basin	Completed remedial action
Sanitary Landfill Groundwater	Continued interim-measure remediation system operation
SRL Seepage Basins	Completed remedial action
West of SREL “Georgia Fields” Site	Issued ROD

Editors' note: The "Environmental Compliance" chapter is unique in that its number of contributing authors is far greater than the number for any other chapter in this report. Space/layout constraints have prevented us from listing all of them on the chapter's first page; until last year, they appeared in the report's acknowledgments section instead. This year, however, we're again listing them here. Their contributions, along with those of the report's other authors, play a critical role in helping us produce a quality document—and are very much appreciated.

Paul Carroll, EPD

Carl Cook, EPD

Lori Coward, EPD

Keith Dyer, EPD

Larry Eldridge, EPD

Ross Fanning, EPD

Tim Faugl, EPD

Doris Hoel, EPD

Bruce Lawrence, EPD

David Lester, EPD

Nancy Lowry, EPD

Bill Maloney, EPD

Jack Mayer, EPD

Jeff Newman, EPD

Vernon Osteen, EPD

Donald Padgett, EPD

Paul Rowan, EPD

Gerry Stejskal, ERD

Curt Walker, EPD

Chapter 3

Environmental Program Information

Pete Fledderman and Donald Padgett
Environmental Protection Department

Timothy Jannik
Savannah River Technology Center

2000 Highlights

- SRS maintained its ISO 14001 (Environmental Management System standard) certification. The SRS Environmental Management Systems Policy provides the basis for environmental programs and emphasizes vigilance in protecting human health and the environment.
- Solid waste generators identified more than 70 waste reduction initiatives with potential to reduce forecasted waste generation by more than 11,780 cubic meters over a 12-month period.
- The annualized radioactive and hazardous solid waste generation volumes (non-cleanup and stabilization operations) decreased by about 72 percent, or almost 17,000 cubic meters, from 1991 to 2000. (In calendar year 1991, 22,780 cubic meters of radioactive and hazardous solid waste was generated; in fiscal year 2000, 6,426 cubic meters of radioactive and hazardous solid waste was generated from routine ongoing operations.)
- In fiscal year 2000, almost 4,400 metric tons of nonradioactive, nonhazardous materials were recycled at SRS, including 814 metric tons of paper, cardboard, and aluminum cans;1,325 metric tons of recyclable materials through WSRC's Salvage Operations group; and about 2,200 metric tons of wood used as chips and compost. SRS also recycled more than 62 metric tons of potentially hazardous materials.
- A comprehensive energy conservation program and site mission changes helped drive down facility energy consumption in BTU per gross square foot by more than 78 percent from 1985 (baseline year) through 2000.
- The Chemical Commodity Management Center received 79,000 pounds of excess chemicals but disbursed more than 108,000 pounds of excess chemicals from its total inventory. Excess chemical disbursements resulted in the receipt of usable products by offsite institutions and the avoidance of substantial waste disposal costs by the site.
- WSRC sponsors programs designed to bring science and mathematics to local teachers and students. For the 1999–2000 school year, an estimated 55,000 contacts were made with students in surrounding communities through these programs. One educational initiative was the Research Intern Program, which placed 152 students, teachers, and faculty members in research intern positions in fiscal year 2000. Another program, the School-to-Work Program, provided 84 high school and postsecondary students with work-based learning experiences at SRS in fiscal year 2000.

Beginning with preconstruction in the early 1950s, the Savannah River Site (SRS) has been concerned with stewardship of the environment as shown through its policies, procedures, and performance. Through the years, environmental programs have evolved to complement site missions. Policies related to these programs were formalized in recent years in the SRS Environmental Management System Policy, which emphasizes vigilance in protecting human health and the environment. The full text of this policy is provided in appendix A, "Applicable Guidelines, Standards, and Regulations." Information in this chapter exemplifies SRS's adherence to this policy. Included are

- particulars about the International Organization for Standardization (ISO) 14000 series and SRS's ISO 14001 Environmental Management System Standard certification within the 14000 series.
- a general overview of environmental programs, including monitoring. Two goals of the environmental monitoring program are to measure concentration or quantity of

contaminants (both radiological and nonradiological) released from site operations and to provide a technical basis for any needed corrective action. The data that are generated document compliance with federal, state, and local standards, as well as U.S. Department of Energy (DOE) orders.

- an overview of the SRS Dose Reconstruction Study, which is an evaluation of historical monitoring data and other site records. An objective of this study is to provide an independent assessment of potential human health risk to populations exposed to radioactive materials and chemicals released into the surrounding environment since site operations began in the 1950s.
- a description of the site's pollution prevention program. The goal of this program is to reduce the impact of site operations on the environment by focusing on source reduction, on recycling, and on increasing employee awareness of — and participation in — waste minimization.
- an account of public involvement activities, a fundamental part of DOE's decision-making process. Included in this section is a summary of the SRS Citizens Advisory Board (CAB) stakeholder functions and its recommendations.
- descriptions of activities — i.e., employee training, information exchange, and public outreach — that offer ways to provide job-related knowledge and develop job-related skills; share information about site operations, programs, and objectives; and address public concerns.

Various site organizations have lead responsibility for the environmental programs. These groups are

- Westinghouse Savannah River Company's (WSRC) Environmental Protection Department (EPD), Safety and Health Operations (S&HO), and Savannah River Technology Center (SRTC)
- Savannah River Ecology Laboratory (SREL)
- U.S. Department of Agriculture Forest Service–Savannah River (USFS–SR, formerly the Savannah River Natural Resource Management and Research Institute)
- Savannah River Archaeological Research Program (SRARP)

SRTC, SREL, USFS–SR, and SRARP are discussed briefly in chapter 1, "Introduction." However, the education outreach programs of SREL, USFS–SR, and SRARP, as well as that of WSRC, are discussed in this chapter.

ISO 14001

The ISO is composed of standards groups from 120 member countries. Founded in 1947, ISO has set international standards for things as varied as paper sizes and automotive parts.

ISO 14000 is a family of voluntary environmental management standards and guidelines. ISO 14001 is the Environmental Management System Standard within the 14000 series. Application of the ISO 14001 environmental management principles increases environmental awareness, cost effectiveness, and environmental compliance efficiency.

ISO 14001 certification provides evidence to stakeholders that SRS is committed to an environmentally safe site, pollution prevention, environmental compliance, and continual improvement. SRS was initially registered in conformance with ISO 14001 in September 1997. The site was recertified to the ISO 14001 standard as the result of a third-party audit conducted by Kema Registered Quality, Inc., during September 2000.

Environmental Monitoring

SRS environmental monitoring, which includes both onsite and offsite activities, is the responsibility of EPD's Environmental Monitoring Section (EMS). Also, the Division of Environmental Research of the Academy of Natural Sciences of Philadelphia has performed biological and water quality surveys of the Savannah River since 1951.

The two components of environmental monitoring are effluent monitoring and environmental surveillance. Additional environmental monitoring information is provided in chapters dealing specifically with

- radiological effluent monitoring (chapter 5)
- radiological environmental surveillance (chapter 6)
- nonradiological effluent monitoring (chapter 8)
- nonradiological environmental surveillance (chapter 9)
- groundwater monitoring (chapter 10)
- special surveys and projects (chapter 12)

Effluent Monitoring

Effluent monitoring is conducted by collecting and analyzing onsite samples of liquid and airborne effluents taken at or very near their points of discharge to the environment. Radiological effluent

Effluent Monitoring and Environmental 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 the 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.

monitoring meets regulatory requirements and provides source terms for calculating potential offsite radiation doses. More information about calculations can be found in chapter 7, "Potential Radiation Doses." In 2000, approximately 4,200 radiological samples were taken at 70 points of discharge.

SRS handles plutonium, tritium, and other special nuclear materials. Therefore, one focus of the environmental program is to detect possible releases of these radioactive materials from routine operations. This is done by collecting and analyzing samples of airborne and liquid effluents. Radioactive materials are monitored or sampled at their points of discharge. EMS performs most of the radiological analyses on the samples. Following validation, results of these analyses are recorded in a monthly radioactive releases report. Data from the monthly reports are summarized in an annual data publication (in 2000, *SRS Environmental Data for 2000*, WSRC–TR–2000–00329).

The major nonradiological airborne emissions of concern from SRS stacks include — but are not limited to — sulfur dioxide, oxides of nitrogen, particulate matter, and toxic air pollutants such as trichloroethylene, perchloroethylene, benzene, and hydrochloric acid. Data generated from monitoring nonradioactive contaminants in airborne effluents at SRS provide evidence as to whether or not requirements of permits issued by the South Carolina Department of Health and Environmental Control (SCDHEC) are being met. Permits are discussed further in chapter 2, "Environmental Compliance."

As part of a network associated with the federal Clean Air Act, Georgia and South Carolina environmental agencies maintain several monitoring stations near SRS. These stations monitor ambient air to ensure state compliance with federal ambient air quality standards and — because of their proximity to SRS — demonstrate site compliance as well.

Nonradioactive liquid effluents generally are sampled at National Pollutant Discharge Elimination System (NPDES) outfalls (points of discharge) and reported to SCDHEC in a monthly discharge monitoring report, as required by the Clean Water Act. Monitoring requirements for liquids may vary at each outfall, depending on the type of facility and the known characteristics of the wastewater. A typical setup for liquid effluent monitoring is shown in figure 3–1.

Environmental Surveillance

Environmental surveillance is conducted by collecting and analyzing onsite and offsite samples taken at various distances from points of discharge. In 2000, approximately 10,000 radiological analyses were performed on approximately 5,000 samples (not including groundwater). In 2000, approximately 27,000 radiological analyses were performed on groundwater samples collected from approximately 1,300 monitoring wells.

Data from radiological environmental surveillance are evaluated to

- detect and characterize contaminants that could adversely affect the environment
- provide a way to verify dose calculations and predictions from mathematical models

Because most radiological contaminants are released in such small amounts that they cannot be readily measured in environmental samples, SRS uses mathematical models to estimate contaminant concentrations in environmental media. The data obtained at the point of discharge (e.g., stack, pipe, or outfall) — where the concentration would be highest if a contaminant were present — is used to calculate the estimated contaminant concentration in sampled media, such as water, soil, or vegetation. More information about modeling can be found in chapter 7.

Nonradiological environmental surveillance is conducted by collecting and analyzing samples from site streams and the Savannah River to verify the outfall sampling data and to ensure the detection and characterization of materials that could adversely affect the environment. Adverse conditions resulting from the presence of such materials are identified and evaluated to provide a basis for corrective action.

In 2000, approximately 6,300 nonradiological analyses for specific chemicals and metals were performed on about 1,200 samples, not including groundwater. In 2000, approximately 134,000 nonradiological analyses were performed on groundwater samples collected from approximately 1,300 monitoring wells.

Objectives

One purpose of environmental regulations is to protect human health and the environment. In support of this purpose, the SRS environmental monitoring objectives are to

- assess actual or potential exposures of radioactive and nonradioactive materials to critical groups and populations from normal site operations or from accidents
- demonstrate compliance with authorized limits and regulatory requirements or need for corrective action
- verify the adequacy of each facility in containing radioactivity and controlling effluents
- notify appropriate officials of unusual or unforeseen conditions and, if necessary, activate a special environmental monitoring program
- communicate accurate and effective EMS monitoring results to DOE, to other government agencies, and to the general public
- maintain an accurate and continuous record of the effects of SRS operations on the environment
- determine concentrations of radioactive and nonradioactive contaminants in environmental media for the purpose of assessing the immediate and long-term consequences of normal and accidental releases
- distinguish between environmental contamination and effects from SRS operations and those from other sources
- evaluate and revise the environmental monitoring program in response to changing conditions in transport pathways and to the site's changing mission (the site's mission is discussed in chapter 1)

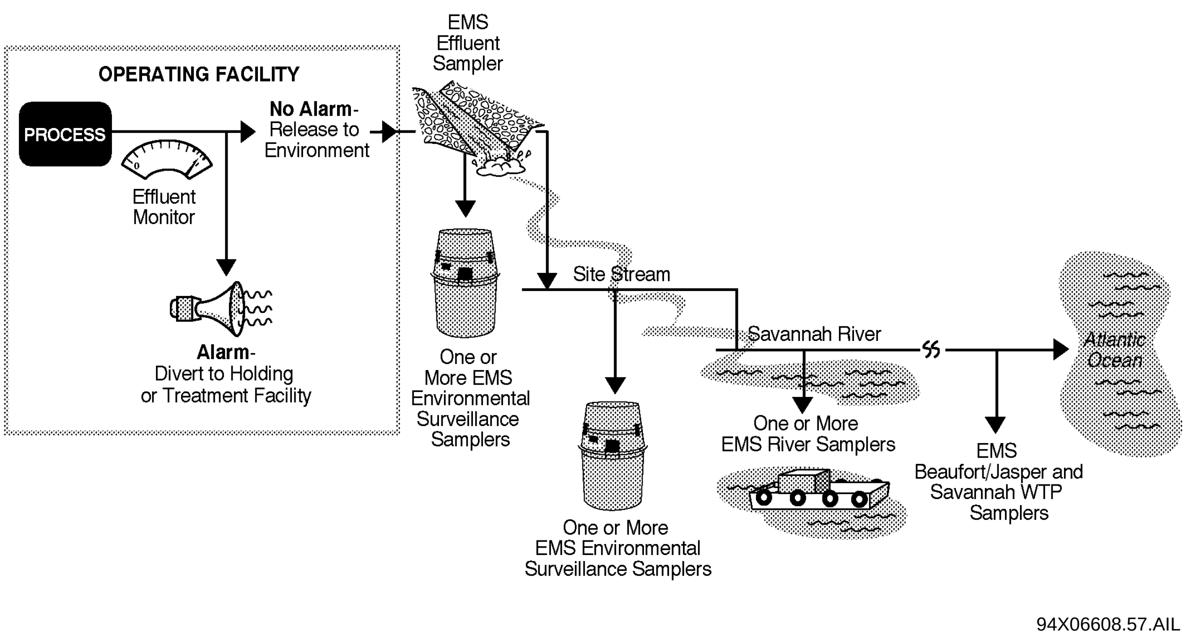


Figure 3–1 Typical Liquid Effluent Monitoring and Environmental Surveillance
Effluents are monitored at points of discharge. Released materials of concern are tracked in the environment from discharge to site stream to river to water treatment plants at Beaufort/Jasper and Savannah.

- provide site-specific data for risk assessment and uncertainty analyses for human populations near SRS
- assess the validity and effectiveness of models used to predict the concentration of pollutants in the environment
- conduct scientific studies on the transport pathways of radioactive and nonradioactive contaminants in the environment

These objectives incorporate the recommendations of the International Commission on Radiological Protection ("Principles of Monitoring for the Radiation Protection of the Public," ICRP Publication 43), of DOE Order 5400.1 ("General Environmental Protection Program"), and of DOE/EH–0173T ("Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance").

As a result of the environmental monitoring program, SRS seeks to

- determine any long-term buildup of — and predict environmental trends from — site-released contaminants
- establish baselines of environmental quality so that trends in the physical, chemical, and biological condition of environmental media can be characterized
- identify and quantify new or existing environmental quality problems, then assess the need for corrective actions or mitigation measures
- pinpoint exposure pathways in which contaminants are accumulated and transmitted to the public

Rationale

Many factors are considered in the determination of monitoring activities at SRS, including responsible environmental stewardship. Sampling locations, sample media, sampling frequency, and types of analysis are selected on the basis of environmental regulations, exposure pathways, public concerns, and measurement capabilities. More detailed information about the site's environmental monitoring program is documented in sections 1101–1111 (SRS EM Program) of the *SRS Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1. This document is reviewed annually and updated every 3 years.

Environmental Regulations

Environmental monitoring at SRS is designed to meet state and federal regulatory requirements for radiological and nonradiological programs. These requirements are stated in

- DOE orders 5400.1 and 5400.5 ("Radiation Protection of the Public and the Environment")
- the Clean Air Act — for example, National Emission Standards for Hazardous Air Pollutants (NESHAP)
- the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA — also known as the Superfund)
- the Resource Conservation and Recovery Act (RCRA)
- the Clean Water Act — for example, Section 402, NPDES

SCDHEC, the U.S. Environmental Protection Agency (EPA), and DOE conduct audits to verify that the site complies with environmental regulations. Chapter 2 summarizes the site's compliance status for 2000.

Exposure Pathways

Materials released from SRS reach the environment and people in a variety of ways. The routes that materials follow to get from an SRS facility to the environment and then to people are called exposure pathways. Some potential exposure pathways are illustrated in figure 3–2, which shows that materials released into the air may be taken into a human body when a person breathes air or eats food grown near the site — for example, vegetables or beef products. Similarly, materials released into site streams may be taken into the body if a person drinks Savannah River water or eats fish taken from the river. However, the released amounts of radioactive and nonradioactive materials from SRS meet — and are significantly below — all regulatory standards. Thus, the released materials present no known danger to the environment, to site workers, or to the public.

The method used to determine exposure pathways is called a critical pathways analysis. A thorough critical pathways analysis for radioactive materials released from SRS operations identified tritium and cesium-137 as the primary contributors to offsite exposures. As expected, potential exposure pathways for tritium released into air were through breathing air and eating food, whereas potential exposure pathways for tritium and cesium-137 released into site streams were through drinking river water and eating fish from the river.

Critical pathway analyses for nonradioactive materials released from SRS operations identified

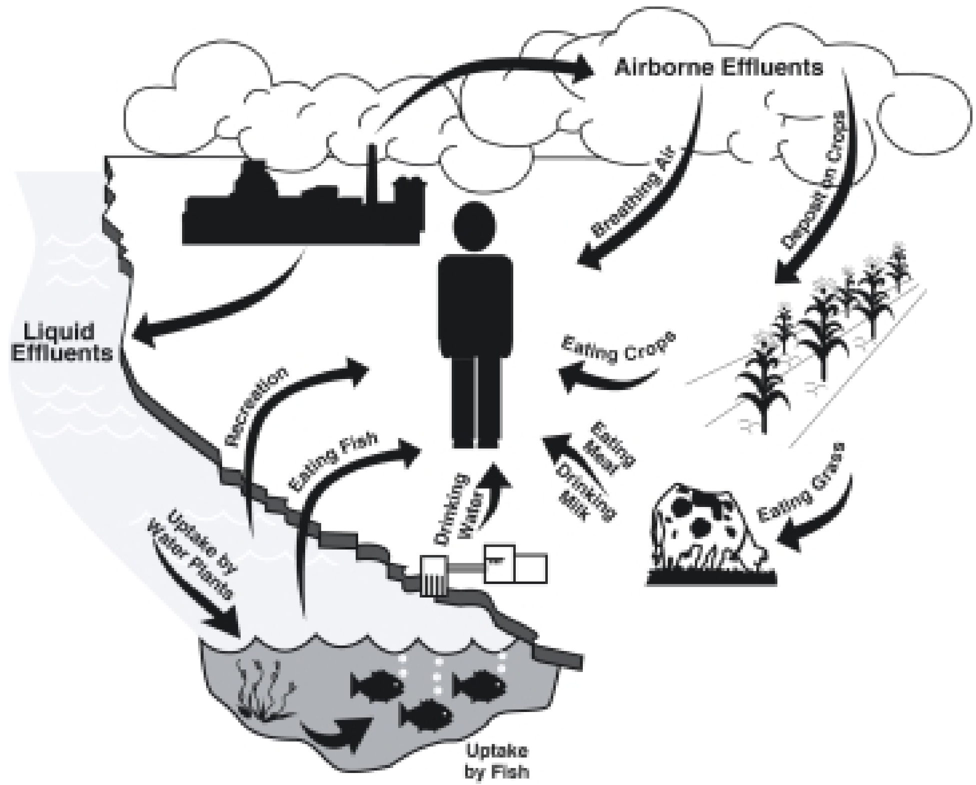


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Figure 3–2 Some Potential Exposure Pathways
Airborne and liquid materials released from SRS operations can reach people in a variety of ways. These ways, or routes, are called exposure pathways.

arsenic and benzene as the primary potential contributors to offsite exposure.

Critical pathways analysis results are used as part of the site's environmental monitoring activities to make decisions about sampling locations, sample media, and sampling frequency. Results from modeling exposure pathways can help

- verify that sampling programs perform as required
- make the best use of sampling and analysis resources

Public Concerns

Public concerns influence the site's environmental monitoring activities. The public wants to know about releases and their potential health effects. All aspects of the environmental monitoring program are designed and implemented with public concerns in mind. Some examples include (1) offsite monitoring at air surveillance and population centers with thermoluminescent dosimeters (TLDs) — devices used to measure external gamma radiation that provide a quick, reliable method of determining the dose from gamma-emitting radionuclides in the event of an unplanned release of radioactive material; (2) public drinking water supply monitoring; and (3) fish monitoring in the Savannah River.

Measurement Capabilities

Many materials released from SRS exist in such low concentrations in the environment that they cannot be readily measured. Thus, the ability to measure low levels of concentrations becomes a significant factor in the rationale for monitoring certain materials. In these cases, modeling with nationally accepted computer programs is used to predict or estimate concentration levels. More information on modeling can be found in chapter 7, and more on measurement capabilities can be found in tables 1–3 in *SRS Environmental Data for 2000.*

Dose Reconstruction Study

SRS has conducted environmental monitoring of radioactive materials and chemicals released to the environment since the beginning of site operations in the early 1950s. Historical data from this environmental monitoring and from site operations are being evaluated independently by the federal Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, as part of the SRS Dose Reconstruction Study, to determine the effects these materials may have had on people living near the site.

Phase I of the study — the location and review of records — was completed in 1995 and is discussed briefly in the *SRS Environmental Report for 1996* (WSRC–TR–97–0171) and the *SRS Environmental Report for 1997* (WSRC–TR–97–00322). Phase II of the study — the source term calculation — was completed in 1998. In Phase II, the CDC reconstructed the historical releases of radioactive materials and chemicals to calculate the total amounts and types released from the site to the environment. The draft results and reports from Phase II were released to the public by the CDC in February 1999.The report is titled *DRAFT FINAL REPORT, Savannah River Site Environmental Dose Reconstruction Project, Phase II: Source Term Calculation and Ingestion Pathway Data Retrieval, Evaluation of Materials Released from the Savannah River Site (January 28, 1999)*. The report was being reviewed by the CDC, the scientific community, and the public. Comments from the review are being addressed, and the final report is expected to be issued in 2001. Inquiries can be made about the study, or a copy of the draft report may be obtained by writing to Centers for Disease Control and Prevention, 1600 Clifton Road NE, MS E39, Atlanta, GA 30333; by calling 888–619–6738; or by faxing 404–639–2575.

Pollution Prevention

Pollution prevention at SRS is designed to reduce the impact of site operations on the environment, reduce operational costs, and reduce employee exposure to hazardous materials. Pollution prevention at the site includes

- source reduction activities
- recycling of potential wastes and pollutants
- reduction in the use of materials, energy, water, and other resources
- protection of human health and natural resources through conservation and more efficient use
- disposal of waste in an environmentally safe manner

Pollution prevention programs are a major focus of many activities, organizations, and implementation teams. Improvements in the coordination of and communication between these program areas are ongoing; employee awareness of and management emphasis on pollution prevention remain strong. Highlights of some of the 2000 SRS pollution prevention activities are discussed in the following paragraphs. Certain aspects of pollution prevention also are discussed in chapter 2.

Waste Minimization

The SRS Waste Minimization Program continued in 2000 to reduce the generation of solid wastes that require costly treatment, storage, and disposal. The annualized radioactive and hazardous solid waste generation volumes resulting from routine onsite cleanup and stabilization operations decreased by about 72 percent, or almost 17,000 cubic meters, from 1991 to 2000. (In calendar year 1991, 22,780 cubic meters of radioactive and hazardous solid waste was generated; in fiscal year 2000, 5,426 cubic meters of radioactive and hazardous solid waste was generated from routine ongoing operations.)

The decrease is attributed largely to waste minimization efforts initiated as a site program in 1991. In fiscal year 2000, solid waste generators identified more than 70 waste reduction initiatives with potential to reduce forecasted waste generation by more than 11,780 cubic meters over a 12-month period. Key initiatives included incorporation of commercial in situ environmental restoration processes; emphasis on reduction in the size of radioactive contamination areas; increased use of recyclable — versus disposable — materials for radioactive jobs; and the surveying, decontaminating, and subsequent free-release of previously contaminated materials.

More about waste minimization can be found in chapter 4, ”Environmental Management”).

Solid Waste Recycling

In fiscal year 2000, 4,400 metric tons of nonradioactive, nonhazardous materials were recycled at SRS, including

- 814 metric tons of paper, cardboard, and aluminum cans
- approximately 1,325 metric tons of recyclable materials through WSRC’s Salvage Operations group

- 2,200 metric tons of wood reused as chips and compost

The total number of metric tons recycled in fiscal year 2000 was more than twice that recycled in fiscal year 1999 (1,900 metric tons).

Also in fiscal year 2000, SRS recycled more than 62 metric tons of other potentially hazardous materials, such as lead, fluorescent light bulbs, and photographic silver fixative.

Energy Conservation

Reducing site demand for energy in turn reduces emissions and conserves resources (e.g., coal) associated with energy production. A comprehensive energy conservation program and site mission changes helped drive down facility energy consumption in British Thermal Units (BTU) per gross square foot by more than 78 percent from 1985 (baseline year) through 2000.

The Energy Savings Performance Contract, awarded in 1998, was the primary focus of the SRS Energy Management Team in 2000. Under this contracting mechanism, the Energy Services Company (ESCO) incurs the cost of implementing energy savings measures, including — but not limited to — performing energy audits and studies; designing, acquiring, and installing equipment; and training personnel. The ESCO is required by federal law to guarantee a minimum cost savings resulting directly from implementation of such measures during the term of the contract and is at risk to ensure that this minimum guarantee is achieved. In exchange for providing these services, the ESCO receives a percentage of the cost savings.

The design and construction of Task Order #1 under the contract was completed during the year and consisted of upgrades in 16 administrative area facilities. Conservation measures installed were energy management control systems and heating, ventilation, and air conditioning (HVAC) improvements.

Development of Task Order #3 — the remainder of facilities within the site's main administrative area — will be initiated during fiscal year 2001.

Reduction of Chemical Releases

Under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA), SRS has filed Toxic Chemical Release Inventory reports annually since 1987. The site calculates chemical releases to the environment and reports aggregate quantities for each regulated chemical that exceeds threshold amounts. More about Toxic Chemical Release Inventory reports, including summary data results, can be found in chapter 2.

Affirmative Procurement of Recycled Products

The SRS Affirmative Procurement Program — under federal Executive Order 13101, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition," and RCRA Section 6002 — promotes the purchase of products made from recycled materials to help conserve natural resources. The program is based on DOE guidelines for implementing affirmative procurement requirements at federal facilities. The fiscal year 2000 program continued to expand recycled product purchasing in several areas, including paper, re-refined oil, retread tires, office supplies, and construction and building materials.

Excess-Chemical Management

The Chemical Commodity Management Center was created and staffed in 1994 to ensure environmentally sound, safe, and cost-effective acquisition, distribution, and reuse of chemicals/excess chemical products for the site. An "excess chemical product" is defined as any reusable material that can be sold, donated, or redistributed on site, that requires a material safety data sheet, and that is in its original form and concentration as received as a stock supply item from a supplier.

During 2000, the Chemical Commodity Management Center received 79,000 pounds of excess chemicals but disbursed more than 108,000 pounds of excess chemicals from its total inventory. The disbursements were made to offsite institutions as part of the site's excess chemical sales, recycling, and donation programs. Excess chemical disbursements resulted in the receipt of usable products by offsite institutions and the avoidance of substantial waste disposal costs by the site.

Ozone-Depleting Substances

The Clean Air Act Amendments of 1990 require that EPA publish a number of regulations to phase out the production and consumption of ozone-depleting substances. SRS has produced an internal guidance document designed to assist the site in the phaseout of ozone-depleting refrigerants, the largest use of ozone-depleting substances on site. The main objective of the plan is to reduce the use of chlorofluorocarbon (CFC) refrigerants by (1) replacement or retrofit of CFC equipment, (2) sound refrigerant containment practices (such as reducing leaks), and (3) controlling distribution of refrigerants from inventories. The site also has identified all Halon fire suppression systems on site and is looking at alternatives and priorities in eliminating the use of Halon as a fire suppressant.

More about ozone-depleting substances can be found in chapter 2.

Public Involvement

DOE considers public involvement a fundamental component in program operations, planning activities, and decision making in DOE. The public is encouraged to play a role in DOE decision making. Public involvement is a major focus in every operational division at SRS and has been established as one of the major goals in the site's strategic plan.

Stakeholder involvement at SRS follows the legal requirements of the National Environmental Policy Act (NEPA), RCRA, and CERCLA, but also reaches beyond to provide opportunities to support the SRS CAB and special meetings and focus groups.

The site's public involvement program offers a comprehensive approach to citizen participation as suggested by DOE policy. The ultimate goal is that the program be dynamic and accessible to any person or organization wishing to have a voice in site activities.

Environmental Restoration

Within the environmental restoration program, the public is consulted frequently about decisions on closure of waste sites. In 2000, approximately 17 participation opportunities were provided.

Public notices and comments were provided for remedial and limited actions and for no action waste units. Public comment periods were held also for sections of the Federal Facility Agreement- and CERCLA-proposed plans for several SRS operable units. Notices of Availability for two Records of Decision, one Interim Record of Decision, one interim Action Proposed Plan, three Statement of Basis Proposed Plans, five Preconstruction Fact Sheets, four Explanation of Significant Differences, and one RCRA Part B Permit Modification were provided in area newspapers, using both display and legal advertisements.

National Environmental Policy Act Activities

During 2000, NEPA local and national Environmental Impact Statement (EIS) activities focused on treating and stabilizing spent nuclear materials; closing high-level waste tanks; finding an alternative to SRS's In-Tank Precipitation process; and identifying the technology for and the location to disposition surplus plutonium. Local stakeholders participated in the following EIS activities by attending public meetings and providing individual comments to DOE:

- Surplus Plutonium Disposition Final EIS and Record of Decision
- SRS Spent Nuclear Fuel Management Final EIS and Record of Decision
- High-Level Waste Tank Closures Draft EIS

The public also could participate in a stakeholder process by attending CAB meetings that focused on specific NEPA activities.

Several Environmental Assessments (EAs) were developed and distributed for public comment in 2000. EAs are initiated to determine if a particular action has significant environmental impacts. If there are no major impacts, a Finding of No Significant Impact (FONSI) is issued and the activity proceeds. If potential consequences are determined, then DOE prepares the more detailed EIS. The following EAs/FONSIs were addressed in 2000:

- Revised FONSI for Centralization and Upgrading of the Sanitary Wastewater System at SRS
- Revised FONSI for the Natural Resource Management Activities
- Draft EA to Evaluate an Alternative Approach for the DWPF Glass Waste Canister Storage Facility at SRS (The DWPF is the Defense Waste Processing Facility.)
- Draft EA for the Proposed Offsite Transportation of Certain Low-Level and Mixed Radioactive Waste from the SRS for Treatment and Disposal at Commercial and Government Facilities
- Final EA and FONSI for the Construction and Operation of the Highly Enriched Uranium Blend-down facilities at SRS

Solid Waste Activities

Although the bulk of public involvement activities dealing with solid waste issues are channeled through the SRS CAB and its various committees and focus groups, some public involvement efforts were independent of the CAB. In July 2000, SRS notified the public through a public meeting of its intent to comply with the federal Maximum Achievable Control Technology (MACT) standard for hazardous waste incinerators, specifically, the Consolidated Incineration Facility (CIF).

In 2000, the Department of Energy–Savannah River (DOE–SR) requested that its RCRA permit be renewed. A public meeting was held in February to inform the public of solid waste facility operations and any proposed changes prior to the permit. The permit application was divided into 10 volumes; General Information, Hazardous Waste Storage Facility, M-Area Hazardous Waste Management Facility (HWMF) & Metallurgical Laboratory HWMF, F-Area HWMF, H-Area HWMF, Organic Waste Storage Tank, Mixed Waste Management Facility, Mixed Waste Storage Buildings, CIF, and Sanitary Landfill. At the public meeting, stakeholders were given the opportunity to view displays and discuss operational changes on an informal level with SRS personnel.

Citizens Advisory Board

The CAB is an independent group of citizens officially chartered by DOE to provide recommendations and stakeholder insight on site activities to DOE, EPA, and SCDHEC. It provides SRS with advice to help guide decisions consistent with stakeholder values and opinions. Thus, it complements regulatory and program stakeholder input. The CAB is composed of 25 South Carolina and Georgia individuals who reflect the cultural diversity of the population affected by SRS. Membership applications are accepted year-round from stakeholders living in an area ranging from the Central Savannah River Area (CSRA) to Georgia and South Carolina coastal communities downriver of SRS. Applications are placed in membership categories representing labor, environmental, political, educational, and minority groups as well as public officials and the general public. Voting by ballot is held once a year at a full board meeting. Members serve a two-year term. They can serve two additional terms (six consecutive years) if elected.

Recommendations

The citizens group, composed of four issues-based committees, provided 26 recommendations to DOE, EPA, and SCDHEC in 2000. A few of the recommendations are summarized here. More information about the SRS CAB and its recommendations in 2000 may be obtained by calling the SRS CAB administrator at 800–249–8155 or from the Savannah River Operations Public Activities web page (http://sro/pubact1.htm).

Environmental Remediation Committee The Environmental Remediation Committee sponsored seven recommendations, several of which were primarily directed to SRS regulatory agencies.

Regarding total maximum daily loads (TMDLs) for mercury in the Savannah River, the SRS CAB asked EPA to formally request an extension of no fewer than 6–10 months to a court-imposed date regarding TMDLs for mercury in the Savannah River Basin. The CAB asked EPA to take this time to collect analytical data from the river to formulate a site specific TMDL to evaluate whether the Savannah River Basin needs to be placed on the impaired waters body list. The board also asked DOE to identify which SRS outfalls meet the proposed TMDL limit without further treatment; those that will require further treatment; potential SRS treatment technologies available; and costs and feasibility to comply with the proposed TMDL.

In another issue impacting SRS outfalls, the Environmental Restoration Committee — concerned that the Whole Effluent Toxicity test method used for controlling toxic pollutants in wastewater discharges may be unreliable and inaccurate — requested information regarding an Alternate Species Investigation Plan and Toxicity Identification Evaluation. The CAB is interested in making cost comparisons and evaluating whether a proposed alternate species would be better suited for the WET test method.

Strategic and Long-Term Issues Committee This committee submitted a recommendation based on the *Savannah River Site Strategic Plan* (00J00526). Several members of this committee attended the national advisory board workshop on stewardship. Other areas of interest of this committee include budget, development and deployment of technology, future land use, facility disposition, and relevant national environmental policy.

Nuclear Materials Committee One of the recommendations from the Nuclear Materials Committee was that the Yucca Mountain Repository open on schedule as outlined in the Yucca Mountain draft EIS. The committee also requested a comparative cost benefit analysis of commercial spent fuel, DOE spent fuel, and DOE high-level waste to establish the optimum order of shipment of materials to the repository.

Waste Management Committee (Solid Waste and High-Level Waste) The path forward for the CIF was a major issue of concern for the SRS CAB in 2000. The board recommended that

- DOE reverse its decision to suspend CIF operations
- DOE reinstitute the necessary funds to continue operation of CIF until DOE can fully justify its decision and until such time that an alternative

treatment option is available, cost effective, and can be implemented

The board also recommended to SCDHEC that its CIF permit modification recognize the need for adequate time for the full development, implementation, and operation of an alternative treatment technology before CIF closes.

Regarding transuranic waste, the CAB recommended that DOE accept transuranic waste shipments from the Mound Site, thus allowing closure of this site and accelerated shipments of SRS transuranic waste to the Waste Isolation Pilot Plant (WIPP). The board requested that DOE provide non-SRS funding to transfer the Mound waste to SRS and for all activities necessary to accelerate SRS transuranic waste shipments to WIPP.

The SRS CAB recommended that DOE reevaluate the scope of an EA regarding storage of glass waste canisters for the DWPF. The board recommended that before DOE decides on which approach (a second glass waste storage building or dry above ground storage), it reassess the EA based on various general and specific CAB comments. Many of the general comments focus on an escrow account and the ability of a vendor to revert disposal responsibility back to DOE.

Other Activities

An element of the SRS CAB mission is to improve communication with communities potentially impacted by SRS and ensure that stakeholders are given an opportunity to become involved in the decisions made at SRS. The SRS CAB uses a variety of techniques including

- the “Board Beat,” a semiannual newsletter about SRS and CAB activities
- holding of essay contests in conjunction with full board meetings
- a speakers’ bureau to offer presentations to various groups

CAB members provided a dozen presentations to various civic groups and organizations in 2000 and participated in one technical conference as well. During 2000, the CAB participated in several national stakeholder meetings in which individuals from 10 DOE site-specific advisory boards met to discuss issues, such as long-term stewardship. Primarily, these workshops were educational in nature, with final reports provided to DOE Headquarters (DOE–HQ).

Employee Training

SRS environmental training programs help achieve 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 training program identifies training activities to teach job-specific skills that protect the environment and satisfy regulatory requirements.

Environmental training at SRS addresses good environmental stewardship, which includes compliance with federal and state regulations. The focus is on required training and recommended education courses for employees (based on responsibility) involved with environmental oversight, hazardous materials, and waste management at the site.

DOE–SR and WSRC are working closely with the National Environmental Training Office to determine and/or develop “best-in-class” environmental training courses while reducing costs. These will be made available to SRS environmental professionals and others within the DOE complex.

The Training Subcommittee of the WSRC Environmental Management Council completed the “Environmental Compliance Authority (ECA) Training Program,” which established the minimum training requirements necessary for WSRC professionals assigned as ECAs (formerly environmental coordinators). New ECAs are required to take a laws and regulations course and an environmental modules course, with modules ranging from site waste management practices to wetlands and endangered species concerns, and must read 30 site environmental procedures. The subcommittee redefined and upgraded the roles, responsibilities, and position description of the ECA and is developing and making available continuing education courses that will allow for development of an environmental professional career path at SRS.

Environmental training activities in 2000 included the following:

- Site ECAs (60) were trained in responsibilities for reporting occurrences having environmental consequences. Training also was provided for DOE and ECA representatives.
- Site environmental systems operators (23) received and/or maintained water/wastewater certification. In 2000, South Carolina began requiring water distribution operators to be

certified. SRS operators already were in a voluntary certification program for water distribution, and these individuals were allowed to “grandfather in” and receive state certification.

- ECAs (15) attended required ECA training courses to learn their duties and responsibilities in identifying, interpreting, and implementing environmental compliance requirements in WSRC-operated facilities.
- Site workers (615) attended Hazardous Waste Operations courses (29 CFR 1910.120), which provide health and safety training in hazardous-waste cleanup activities and in working at RCRA treatment, storage, and disposal facilities.
- Site workers (579) attended RCRA training.
- More than 200 site workers attended other environment-related courses, such as Site Generator Certification, Spill Control, Radiological Determination for Hazardous and Toxic Substances Control Act (TSCA), and ISO 14000 & the SRS Environmental Management System.

Information Exchange

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

DOE–SR representatives attend technical information exchange workshops sponsored by DOE–HQ, which provide a way to enhance the exchange of technical information among DOE sites.

Environmental awareness and information exchange tours are conducted for many special-interest groups, including environmental activists and representatives of other GOCOs, DOE–HQ, Washington Group International (parent company of WSRC), EPA, and SCDHEC. Tours are designed to meet the needs of a particular group. For example, EPA and SCDHEC tours might focus on regulatory issues, while tours for other GOCOs might cover activities applicable to their programs.

Initiated in 1996, the Interagency Information Exchanges are public forums that enable state and federal regulators and SRS to address environmental compliance issues. At these forums, EPA, SCDHEC, and SRS representatives discuss cleanup plans and draft RCRA permit changes while soliciting public comments. Public input is considered by the agencies and used to develop final remedial approaches.

The SRS CAB provides recommendations to DOE, EPA, and SCDHEC on environmental remediation, waste management, and related issues. More information about the CAB and its 2000 recommendations can be found beginning on page 48.

The Environmental Advisory Committee, which is comprised of 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. In 2000, this group formally reviewed the *SRS Environmental Report for 1999* (WSRC–TR–99–00299) and *SRS Environmental Data for 1999* (WSRC–TR–99–00301).

The CSRA Radiological Environmental Monitoring Program is a data exchange program involving representatives of SCDHEC, the Georgia Department of Natural Resources (GDNR), Georgia Power Company, Chem-Nuclear Systems, DOE, and WSRC. This group has met semiannually since 1987 to share technical environmental program information and data. These meetings provide an open forum in which to review and possibly improve each organization’s monitoring program.

Public Outreach

Public Notice Requirements

Various regulations require that SRS notify the public of its environmental plans and activities. RCRA, CERCLA, NEPA, and the Clean Water Act have public notice and/or meeting requirements. SRS meets these requirements by using various community involvement tools, including public meetings for certain RCRA permit application modification requests and notices to contiguous landowners, media, local and state government agencies, and any other interested stakeholders. Such notices — and the status of documentation — typically are sent in a monthly newsletter called the *Environmental Bulletin* and in separate mailings, as required. NEPA documentation generated by SRS and various construction and operating permits held by SRS are available to the public. Chapter 2 lists 2000 SRS project NEPA documentation activities.

Environmental Justice

Environmental justice principles set forth in Executive Order 12898, “Environmental Justice Strategy,” are incorporated in the design of community-specific risk communication programs and their delivery to the targeted audience.

In carrying out these programs, DOE–HQ and EPA provided funding through SRS to continue a grant to Savannah State University in Georgia for the Savannah-based Citizens for Environmental Justice activities through fiscal year 2000. This project provides a tool to strengthen the capacity of communities to interface with the government (DOE and EPA) in environmental decision making and environmental monitoring associated with federal facilities. The Citizens for Environmental Justice applies monies toward community workshops, informational literature on radiation and health effects, radio programs, newsletters, and EIS workshops on spent nuclear fuel. Meetings are held in area communities to solicit and answer questions on the potential impacts of SRS. Savannah State University applies this grant toward improving academic programming in environmental studies. A final report from Savannah State was received in 2000 and transmitted to DOE–HQ.

Additional information on SRS environmental justice activities can be obtained by calling the DOE–SR Office of Environment, Science, and Technology at 803–725–5351.

Education

Westinghouse Savannah River Company

WSRC assists in conducting competitions such as the CSRA Science and Engineering Fair and the DOE Savannah River Regional Science Bowl to encourage student interest in engineering, science, and mathematics. In partnership with the Ruth Patrick Science Education Center, WSRC offers the Traveling Science Demonstration Program, which provides hands-on science kits demonstrated by working scientists and engineers to local elementary, middle, and high schools. Other education initiatives include the Research Intern Program, which placed 152 students, teachers, and faculty members in research intern positions in fiscal year 2000, and the School-to-Work Program, which provided 84 high school and postsecondary students with work-based learning experiences at SRS in fiscal year 2000.

WSRC was instrumental in the development and implementation of a Memorandum of Understanding with local technical colleges for the Industrial Process Technician/Technology Certificate Program, which meets core competency requirements for four skill areas at SRS. As a result of this initiative, 10 individuals were hired into permanent positions. Tabulations on the 1999–2000 school year show that WSRC programs had more than 55,000 contacts with various programs and events in science and mathematics.

U.S. Department of Agriculture Forest Service–Savannah River

Using the natural resources of SRS, the USFS–SR conducts two education programs on site:

- a program for 3rd through 12th grade students and teachers
- an undergraduate-level college program

Outreach projects — including fire prevention projects, school visits, and participation in community events — support USFS–SR's natural resource management of the site. Those efforts produced approximately 19,000 contacts in fiscal year 2000.

- The Natural Resources Science, Math, and Engineering Education Program is a partnership among USFS–SR, the University of South Carolina-Aiken, and 100 schools in the CSRA. In this program, students apply science, mathematics, and engineering principles in a hands-on setting. More than 13,000 students and 500 teachers visited SRS in fiscal year 2000 and benefitted from specialized outdoor and classroom settings that this program provides. Readers may obtain more information about this program from the following web address: http://rpsec.usca.sc.edu/NRSMEEP
- The Savannah River Environmental Sciences Field Station is a partnership among the USFS–SR, South Carolina State University, and other higher education institutions providing undergraduate education for minority students. Student participants are from historically black colleges and universities.
- In support of SRS's designation as a National Environmental Research Park, USFS–SR collaborates with federal and state agencies, universities, industrial and private landowners, and conservation organizations throughout the region for natural resource research.
- USFS–SR supports a corporate perspective through training and onsite and offsite courses offered to the community in natural resource areas — erosion control technologies, constructed wetlands, ecosystem management, Global Positioning System/Geographic Information System, and controlled burning and wildfire suppression.
- USFS–SR provides planning and other assistance to local rural communities to develop natural resource assets.

More information about USFS–SR education and outreach projects can be obtained by calling 803–725–0006 or 803–725–0237.

Savannah River Ecology Laboratory

SREL's Environmental Outreach and Education Program addresses the laboratory's overall mission of acquiring and communicating environmental knowledge and DOE's focus on environmental issues. The program emphasizes (1) the importance of environmental awareness in decision making regarding ecological problems and (2) the natural history of SRS and the southeastern United States. During 2000, the program reached approximately 60,000 people while promoting environmental awareness through tours of the laboratory, lectures to students and civic and special interest groups, teacher workshops, and various exhibits. Presentation topics include animal ecology, outdoor safety, plants and wetlands, the environment, conservation, and careers in ecology and research. SREL also promotes the professional development of undergraduate and graduate students through research participation and training programs, with emphasis on conducting ecological research important to the SRS environmental stewardship mission. During 2000, 17 undergraduate students and 37 graduate students participated in SREL programs. More information can be obtained by contacting SREL at 803–725–2473 or by visiting the SREL website at http://www.uga.edu/srel.

Savannah River Archaeological Research Program

SRARP continued its heritage education activities in 2000 with a full schedule of classroom education, public outreach, and onsite tours. In addition, in a cultural resource management effort to protect unidentified archaeological sites on SRS from future impacts, SRARP surveyed more than 4,400 acres at SRS.

Two open houses were held, with participants touring the SRARP facility and hearing presentations on archaeological compliance. Some 83 presentations, displays, and tours were provided for schools, historical societies, civic groups, and environmental and historical awareness day celebrations; an estimated 10,000 individuals took part in these outreach activities. "Discovering Archaeology" and "Classroom Dig," two outreach programs with public schools, brought methods and practices of archaeology to the classroom in a hands-on approach. More information can be obtained by contacting SRARP at 803–725–3623.

Communications

SRS public outreach activities — such as public meetings, the Visitors Program, and the Speakers Bureau — provide communication channels between the site and the public. Local newspaper, television, and radio advertisements also inform the public about environmental activities. More information can be obtained by contacting the WSRC Public Affairs group at 803–725–0193 or DOE's Office of External Affairs at 803–725–2889.

When topics involve unusually complex issues, DOE may conduct workshops that give special-interest groups or citizens the opportunity to meet with site representatives.

Chapter 4

Environmental Management

Bruce Cadotte and Dean Campbell
Site Information Programs Department

Carroll Lofty
Environmental Restoration Division

Al Mamatey
Environmental Protection Department

David Yannitell
Facilities Disposition Division

To Read About . . . See Page . . .

2000 Highlights

- ERD personnel completed cleanup work on 17 more inactive waste units at SRS, bringing the total number of waste sites cleaned up or in remediation through the end of the year to 289 out of the 515 (56 percent) that have been identified. The division also achieved 59 enforceable agreement milestones (43 of them ahead of schedule), the 11th straight year it has not missed a milestone.
- Under the site's hazardous waste program, SWD personnel reduced in-storage legacy waste by more than 16 percent and in-storage hazardous waste by almost 40 percent.
- DWPF employees marked a milestone with their production of 271 canisters of immobilized high-level waste during the year. The effort brought their total to 1,026 canisters since radioactive processing began in March 1996. Crossing the 1,000-canister production level makes DWPF one of the most productive glassification plants in the world.
- FDD personnel removed enough highly enriched uranium from the Fuel Manufacturing Building (321–M) to eliminate the potential for criticality and to allow reclassification of the facility from "radiological" to "other industrial. This will allow subsequent deactivation activities to proceed without the costly, time-consuming criticality controls.

ENVIRONMENTAL restoration, waste management, and facility disposition at the Savannah River Site (SRS) are part of the U.S. Department of Energy's (DOE) Environmental Management program, which was established in 1989 to address the environmental legacy of nuclear weapons production and other sources of potential pollutants, such as nuclear research. Progress continued in all three facets of the environmental management program during 2000. This chapter provides a brief overview of these activities and describes some of their major 2000 milestones. These programs reflect the site's ongoing efforts to ensure the safety of its workers, the public, and the surrounding environment.

"Environmental restoration" involves the assessment and cleanup of inactive waste units and groundwater (remediation). "Cleanup" means actions taken to deal with the release or potential release of hazardous substances. This may refer to complete removal of a substance, or it may mean stabilizing, containing, or otherwise treating the substance so it will not affect human health or the environment [DOE EM, 1991]. Determining the most environmentally sound methods of cleaning up waste units is a major focus of the SRS environmental restoration program.

"Waste management" refers to the safe, effective management of various kinds of nonhazardous, hazardous, and radioactive waste generated on site. Identifying the need for appropriate waste management facilities and ensuring their availability have been major components of the SRS waste management program.

"Facility disposition" encompasses the management of SRS excess facilities—from completion of operations shutdown through final disposition—in a way that minimizes facility life cycle costs without compromising health, safety, or environmental quality.

Regulatory Compliance

Applicable environmental management guidelines can be found in appendix A, "Applicable Guidelines, Standards, and Regulations."

Environmental Restoration

SRS began its remediation program in 1981, before many of the regulations requiring environmental restoration were written. The site's current environmental restoration program, however, was not officially established until 1990. By the end of 2000, 515 inactive waste and contaminated groundwater units had been identified for consideration under the site's environmental restoration program.

SRS has three principal technical challenges that need to be addressed in conducting a remediation program—solvents in groundwater, tritium in ground and surface water, and radioactive metals in soils (especially in the soils of old seepage and settling basins). Progress was made on all three fronts in 2000, often by deploying new, cost-saving technologies. The Environmental Restoration Division (ERD) achieved 59 enforceable agreement milestones in 2000 (43 of them ahead of schedule), the 11th straight year it has not missed a milestone.

Accomplishments

ERD accomplishments in 2000 included

- the achievement by division employees of more than 3 years (1,211 days, or about 2.7 million hours) since the last "lost time" injury—a work-related injury/illness involving a day or more of work missed
- the stabilization of contaminated soils through *in situ* grouting at the F-Area retention basin and the L-Area oil and chemical basin
- the completion of remedial actions at the four Savannah River Laboratory (SRL, now Savannah River Technology Center) seepage basins
- the completion of cleanup work on 17 inactive waste units, which means 289 out of 515 have been completed or are in remediation
- the start of operations at the Dynamic Underground Stripping (DUS) project in M-Area to remove concentrated solvent contamination
- completion of the installation of all components of a phytoremediation project for the tritium plume from the Burial Ground complex
- the completion of consent order requirements at the F-Area and H-Area groundwater treatment units and the meeting of required cleanup criteria
- the removal of almost 56,000 pounds of solvents—out of an inventory estimated at 3.5 million pounds—from groundwater in A-Area and M-Area, bringing the total removed to date to approximately 1 million pounds

Also, 14 new technologies were deployed for environmental restoration in 2000, and 19 technologies were redeployed to new sites.

To manage its resources as effectively as possible, the environmental restoration program follows a risk-based, balanced program involving high, medium, and low risk sites. The 289 units that have been addressed under the program represent a cross section of all three risk levels. The highest priority, however, is given to any site that might pose an immediate risk to workers, the public, or the environment.

Upper Three Runs Projects

SRL Seepage Basins

ERD employees completed remedial activities in 2000 at the four seepage basins that received low-level radioactive wastewater from labs at SRL. Remedial actions required

- the removal of a 104-meter section of process sewer line
- the removal and shipment of about 4,700 cubic meters of contaminated soil
- backfilling the basins to grade
- covering the basins with selected plantings (vegetation was removed the previous year)

The soil was shipped safely to a disposal facility in Utah in approved 7.3-cubic-meter lift liners, saving $1.7 million when compared with the alternative—much smaller steel boxes.

DUS Operations

Operations at the DUS project began in June. This system is designed to inject steam into the groundwater zone and the unsaturated zone above the water table around the target area to mobilize contaminants. (In this case, the contaminants are concentrated solvents in the groundwater below a former solvent tank storage area.) Operators then extract the contaminants from a central well. The steam reached the central extraction point in November. Meanwhile, operators can follow progress with an imaging system that is combined with temperature sensors. Oxygen and steam injection will

An ERD senior engineer checks the filter assembly for a new phytoremediation project located southwest of SRS's Burial Ground complex. A sheetpile dam impounds tritiated water seeping toward Fourmile Branch; pumps then feed the water to an adjacent 30-acre irrigation system. The irrigated trees in turn transfer the tritium to the air in extremely low concentrations that pose no health or environmental risk.

Steve Ashe Photo (2000–01395–5)

be used for final cleanup. The DUS process interacts with the contaminants to increase their mobility, thereby greatly accelerating cleanup.

Other A-Area/M-Area Activities

Other A-Area and M-Area activities continued in 2000, including both above-ground air stripping and the operation of recirculation wells in the M-Area Southern Sector to remove solvent contamination. The goal of the recirculation wells, which act as underground air strippers, is the safe, economical, in-place treatment of groundwater for the purpose of effectively intercepting migrating contamination. A recirculation well bubbles air through contaminated water down in the well, releasing solvents at the surface.

General Separations Projects

Within the General Separations Project area are the Burial Ground complex, the F-Area and H-Area groundwater treatment facilities, and the F-Area retention basin. The Burial Ground complex occupies approximately 194 acres in the central section of SRS between F-Area and H-Area separations facilities; its principal mission was the disposal of low-level radioactive and mixed wastes.

Old F-Area Seepage Basin

Project crews completed the *in situ* soil solidification remedial action at the Old F-Area seepage basin in the spring of 2000. The basin is an unlined 200- by 300-foot seepage basin that received low-level radioactive wastewater from the F-Area chemical separations facility until 1969. The primary radioactive constituent of the liquids discharged to the basin was uranium.

In situ, or in place, solidification was accomplished in this case with a large auger that injected grout as it drilled down into the soil. A series of overlapping grouted columns resulted. Grouting protects the groundwater by preventing contaminant migration and also protects workers by minimizing personnel exposure to contaminated material. After the grouting was completed, a low-permeability soil cover was built over the basin.

F-Area Retention Basin

Production grouting was completed in September at a similar project, the F-Area retention basin—an unlined basin used until 1973. The basin received emergency releases of contaminated cooling water from F-Canyon and storm sewer drainage from the F-Area Tank Farm. At the end of the year, work was nearing completion on placement of the low-permeability soil cover over the basin.

Mixed Waste Management Facility

The Mixed Waste Management Facility (part of the Burial Ground complex) groundwater plume entered remediation in 2000. A small sheetpile dam was built to impound tritium-contaminated water that seeps from this plume. Crews installed an irrigation system to pump and redistribute the water to naturally forested areas upstream. Water impoundment began toward the end of October. The trees will "consume" most of this water by absorption and evapotranspiration. This phytoremediation process allows for safe uptake and the release of tritium to the air in extremely low concentrations that pose no health or environmental risk. Once tritium irrigation stops, rainwater flushing will restore the trees to their natural state. The system is intended to greatly reduce tritium concentrations in Fourmile Branch, the greatest contributor of tritium to the Savannah River.

Reactor Area Projects

C-Area Burning/Rubble Pit

A soil vapor extraction system was begun at the C-Area burning/rubble pit, and extensive time was devoted to improving flow in the extraction wells, conducting zone-of-influence testing, and developing operational criteria. By the end of 2000, about 1,300 pounds of trichloroethylene had been removed. An air sparging system began operating late in the year.

L-Area Oil and Chemical Basin

Auger-injection production grouting at the L-Area oil and chemical basin was completed during 2000. The basin is in the southeastern portion of L-Area, just outside the perimeter fence. The basin—118 feet by 79 feet—is an unlined seepage basin that was built to dispose of small volumes of radiologically contaminated solvents and water. It operated from 1961 to 1979.

Because of SRS's success with auger-injected grout, standard designs now are used to remediate radioactive seepage basins using grout and an engineered cover. Contracts were awarded at the end of 2000 to remediate both the K-Area and C-Area reactor seepage basins with the same basic method.

Work began early in the year on the installation of soil vapor extraction and air sparging equipment at the Chemicals, Metals, and Pesticide pits to remove volatile organic compounds from the subsurface. These seven unlined disposal pits were used from 1971 through 1979. Soil contaminated with polychlorinated biphenyls from the pits was shipped offsite for incineration.

Operations Department

ERD's new Operations Department runs and maintains remediation systems and waste management programs for the division, which centralized its approach to these functions in 2000.

Operations personnel exceeded production goals as well as regulatory compliance mandates in 2000. The F-Area and H-Area groundwater treatment units and three air strippers (M–1, TNX, and A–2) treated more than a half-billion gallons of groundwater. The F-Area and H-Area groundwater treatment units exceeded expectations by operating 95 percent of the time, which is 10 percent above the regulatory mandated performance baseline.

Waste management activities in 2000 included waste certification and offsite waste shipments. A full solid waste certification assessment and an internal quality assurance audit were completed. The Facility Evaluation Board assessed environmental restoration program elements and their implementation and recommended full waste certification. Two large waste-generating projects were managed in 2000, and approximately 8,217 tons of Comprehensive Environmental Response, Compensation, and Liability Act waste was sent off site to commercial disposal units.

Solid Waste Management

SRS solid waste management facilities conduct a number of important waste management and environmental restoration efforts on site.

Accomplishments

The accomplishments of Solid Waste Division (SWD) personnel during 2000 included the following:

- They led an SRS effort to implement DOE Order 435.1 ("Radioactive Waste Management"). Issued in July 1999, the order mandated complete compliance within one year; SRS successfully met this mandate July 7.
- They enabled the site to recycle almost 2,400 tons of sanitary waste.
- They assisted in completing remediation of the SRL seepage basins by arranging the shipment of basin soils to a disposal facility in Utah.
- They established a benchmark for disposal of large equipment in trenches by disposing of a contaminated trailer formerly used for waste transfer operations.
- They constructed and began operating the Transuranic (TRU) Waste Visual Examination

Facility for inspection of TRU waste shipments bound for the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico.

- They completed the characterization of 30 drums of TRU waste for shipment to WIPP.
- They treated and released more than 13 million gallons of contaminated wastewater.
- They received approximately 416,000 cubic feet of radioactive and hazardous waste from routine operations.

The SRS solid waste program continues to support the site's transition from production to cleanup activities by managing large volumes of backlog wastes at various site facilities. Proper handling of the waste requires that it be categorized as sanitary, low-level, TRU, hazardous, mixed, or high-level (high-level waste discussion begins on page 59).

Sanitary Waste

Sanitary waste includes office waste, food, garbage, refuse, and other solid wastes that can be disposed of in landfills. SRS uses in-house forces for the collection, hauling, and disposal of its sanitary waste.

SWD continues to use the City of North Augusta (South Carolina) Material Recovery Facility to meet some of the needs of its recycling program. The facility recovered 945 tons of compactible sanitary waste in 2000, enabling SRS to recycle about 44 percent of this part of the waste stream. A total of 1,419 tons of industrial wastes were recycled on site through SRS Salvage and BSRI Construction during the year.

SWD, in partnership with the site's Administrative and Infrastructure Division, also has initiated a program to produce fuel cubes from sanitary waste to fuel the A-Area boiler. The operating equipment for the cubing facility was shipped from Idaho National Engineering Laboratory and installed at SRS in 2000. Westinghouse Savannah River Company (WSRC) is working with the South Carolina Department of Health and Environmental Control (SCDHEC) in an effort to bring the facility into full operation by the end of 2001.

At SRS's Three Rivers Landfill, SWD personnel introduced a change in the procedure for handling and disposing of excess untreated pallets and wood waste. This waste now is shredded through a tub grinder, then piled in long rows. Landfill leachate water then is sprayed onto the material to treat the leachate and to accelerate the biological breakdown of the primarily wood waste stream into compost for recycling.

SWD personnel also introduced a change in the technique used to dispose of "green is clean" waste at the landfill. This waste previously was shredded before disposal, but now is just surveyed before disposal to make sure it is clean, then control-dumped at the landfill. More than 7,157 bags of sanitary waste were processed in 2000 as a result of this change in procedure, resulting in a savings of about $100,000.

Low-Level Waste

Low-level waste is any radioactive waste not classified as high-level or TRU waste. Examples of SRS low-level wastes include protective clothing, job control waste, equipment, tools, filters, rags, and papers. Most wastes certified as low-level are stored or disposed of in the E-Area Vaults.

The emphasis on volume reduction and the offsite shipment of waste continued in 2000. SWD personnel accepted 8,367 cubic meters of solid low-level waste for disposal from waste generators on site. They also reduced in-storage legacy waste by more than 16 percent—from 14,674 to 12,244 cubic meters—through treatment and disposal.

SWD personnel assisted ERD in the remediation of four SRL seepage basins in 2000 by removing contaminated soil and shipping it to a disposal facility in Utah. The shipment comprised 25 rail car loads of contaminated soil.

SWD also initiated activities to gain certification for shipping low-level waste to the Nevada Test Site.

Certain 1994 radiological waste procedures were revised during 2000 to allow for the safe disposal of a variety of waste types in trenches. This was because trench burial for selected materials has proven to be environmentally and financially sound and conserves vault space for materials that require extra isolation. Following this development SWD personnel successfully disposed of a contaminated trailer formerly used for waste transfer operations. The trailer was crane-lifted to a trench in the E-Area Burial Ground and encased in grout.

Hazardous Waste

Under RCRA, hazardous waste is any toxic, corrosive, reactive, or ignitable material that could damage the environment or negatively affect human health. Examples of SRS hazardous wastes include oils, solvents, acids, metals, and pesticides.

Under the site's hazardous waste program in 2000, SWD personnel reduced the hazardous waste inventory in storage at the hazardous waste facilities from 464 to 216 cubic meters. They also reduced

SWD personnel successfully disposed of a contaminated trailer by crane-lifting it to a trench in the E-Area Burial Ground and encasing it in grout. The trailer formerly was used to haul solvent from SRS canyons to the E-Area Burial Ground. The trench was excavated specifically for its disposal.

Larry McCollum Photo (SWD9823329)

nonradioactive polychlorinated biphenyl waste in storage from 15 to 0.4 cubic meters. These reductions were accomplished by shipping about 248 cubic meters of legacy hazardous waste off site for treatment and disposal at approved facilities.

Mixed Waste

Mixed waste is both radioactive and hazardous and is subject to regulations governing both waste types.

SRS's mixed waste program met all of its Site Treatment Plan (STP) commitments in 2000. The STP is an agreement between DOE, the South Carolina Department of Health and Environmental Control, and the Environmental Protection Agency to properly treat SRS's mixed waste on a specific schedule.

To support waste stream characterization for future waste treatment, SWD personnel sampled 58 containers of STP waste streams in 2000, as well as 43 drums of radioactive waste oil.

The containment structure for the mixed-waste processing facility was completed in July 2000. Work continues on the internal design, and processing is expected to begin in 2001.

Transuranic Waste

TRU waste is radioactive waste that contains or is contaminated with certain isotopes that have decay rates and activity levels exceeding defined standards. It contains manmade elements that are heavier than uranium, some of which decay slowly, thus requiring thousands of years of isolation. TRU waste at SRS is largely made up of contaminated equipment, protective clothing, and tools.

In 2000, SWD personnel accepted 60 cubic meters of solid TRU waste for storage at the the site's Solid Waste Management Facility. Thirty 55-gallon drums of TRU waste were characterized for shipment and disposal at the WIPP facility. The initial shipment of waste to WIPP is scheduled for 2001.

To prepare for waste characterization and the shipment of waste packages to WIPP, SWD completed construction of the TRU Waste Visual Examination Facility—a ventilated radiological confinement area used to visually inspect TRU waste. Unrestricted operations at the facility began in August 2000.

Consolidated Incineration Facility

The Consolidated Incineration Facility (CIF) was designed and constructed to thermally treat and reduce the volume of certain incinerable low-level and mixed wastes such as oils, paint solids, solvents, and organic wastes. Incineration at CIF reduces waste volume by 90 percent, eliminates the chemical toxicity of waste, and converts the residual ash to an environmentally immobile form.

During 2000, the CIF processed 3,156 gallons of liquid waste. Operations at the facility were suspended in October as a result of a decision to fund higher priority SRS programs for 2001.

Effluent Treatment Facility

The Effluent Treatment Facility (ETF) collects and processes low-level radioactive and chemically contaminated wastewater from the high-level waste tank farm evaporator overheads and from reprocessing facility evaporators. The ETF process uses microfiltration, organic removal, ion exchange, and reverse osmosis to concentrate contaminants in about 1 percent of the original volume. This liquid is transferred to a storage tank for eventual disposal at the Saltstone Facility. The remaining 99 percent of the water is released to the environment through a National Pollutant Discharge Elimination System (NPDES)-permitted outfall.

ETF personnel met the site demand for effluent water treatment by processing more than 13 million gallons of water in 2000. They also treated 94 tanker loads of CIF liquid waste and 19,406 gallons of environmental restoration liquid waste.

Saltstone Facility

The Saltstone Facility treats and disposes of low-level radioactive salt solutions that are the byproduct of the high-level waste treatment process at SRS.

After the salt solutions are received at the facility, they are mixed with cement, fly ash, and furnace slag to form a grout, which then is pumped into a large concrete vault (one of three at the facility) divided into sections, or cells. There, the grout cures into a stable form called “saltstone.” After it is filled, the vault will be capped with clean grout to isolate it from rain and weathering. Final closure of the vault disposal area entails covering each vault with a clay cap and backfilling it with earth.

Radioactive operations began at the Saltstone Facility in June 1990; since that time, it has processed approximately 2.5 million gallons of salt solutions, creating more than 4 million gallons of saltstone. The facility has been in “standby” mode since September 1998 because of a decision to seek an alternative process for the separation of high-level waste solutions.

Pollution Prevention/Waste Minimization

During 2000, SRS waste generators implemented more than 70 projects that curbed the generation of both hazardous and radioactive waste. As a consequence, waste receipts of radioactive and hazardous solid waste (low-level, hazardous, mixed, and TRU wastes) from routine operations represented the lowest volume since inception of the P2 program in 1991; approximately 416,000 cubic feet of radioactive and hazardous solid waste was avoided.

Contamination area rollbacks continued to reduce low-level waste generation and employee risk in 2000 while increasing productivity. Rollbacks reclaimed about 76,000 square feet of radiologically contaminated areas for unrestricted use in 2000.

More about pollution prevention/waste minimization can be found in chapter 2 (“Environmental Compliance”) and chapter 3, (“Environmental Program Information”).

High-Level Waste Management

“High-level waste” is highly radioactive waste material that results primarily from the reprocessing of spent nuclear fuel. This category includes liquid waste produced directly in reprocessing, any solid waste derived from that liquid, and both transuranic waste and fission products in concentrations requiring permanent isolation from the environment.

High-level waste from the F-Area and H-Area canyons is segregated according to radionuclide and heat content. High-heat waste, generated primarily during the first extraction cycle in these canyons, contains a major portion of the radioactivity. Low-heat waste is generated primarily from the second and subsequent canyon extraction cycles.

SRS continues to manage approximately 36 million gallons of high-level liquid radioactive waste (about 431 million curies), which is stored in 49 large, shielded, and partially underground tanks grouped into two “tank farms.” Twenty-nine tanks are located in the H-Area Tank Farm and 20 in the F-Area Tank Farm. All SRS tanks are built of carbon steel inside reinforced concrete containment vaults.

The major waste streams in the F-Area and H-Area tank farms include transfers from the canyons, receipts from the Receiving Basin for Offsite Fuels, and a low-activity waste stream from the Defense Waste Processing Facility (DWPF).

High-Level Waste Facilities

The F-Area and H-Area tank farms consist of large underground storage tanks that hold high-level liquid radioactive waste. Fresh waste that is received from the processing of the spent nuclear fuel separates into two parts, as follows:

- a sludge (which contains most of the radioactivity) that settles on the bottom of the tank

Twenty-nine underground storage tanks are located in SRS's H-Area Tank Farm. The tanks, built of carbon steel inside reinforced concrete containment vaults, hold high-level liquid radioactive waste. Twenty similar tanks are located in the site's F-Area Tank Farm.

Steve Ashe Photo (99–1119–22)

- a watery "supernate" that occupies the area above the sludge

The supernate is transferred into an evaporator system, where it is processed further. The evaporator system reduces this supernate to 30 percent of its original volume. During this reduction process, the concentrated supernate that remains eventually will form a solid as it is cooled. This solid is commonly known as salt cake and generally resides in the evaporator concentrate tanks. The sludge layer remains in its original receipt tank until a sludge processing campaign is executed.

Both F-Area and H-Area have their own evaporator systems. F-Area has one operating system (2F) while H-Area has two (2H and 3H), one of which has been referred to as the new Replacement High-Level Waste Evaporator (3H). The new evaporator, which achieved hot startup status in December 1999, actually began to recover space in May 2000. These evaporators reclaimed about 1.3 millions gallons of tank farm space in 2000.

SRS has successfully conducted this space reclamation operation in the tank farms since 1960, when the first evaporator facilities began operation. More than 100 million gallons of space have been reclaimed during this time. Without these evaporator systems, SRS would have required 86 additional waste storage tanks—at $50 million apiece—to store waste produced over the site's lifetime.

The Extended Sludge Processing Facility, one of two DWPF pretreatment operations in the High-Level Waste Division, washes sludge (unsettled insoluble waste) to reduce the concentration of sodium salts and dissolves and removes aluminum to ensure glass quality for DWPF. In 2000, the facility continued to process the second of 10 sludge batches that will be required to vitrify all the high-level waste sludge, and began preparation of the third sludge batch. Three million gallons of sludge must be pretreated in this manner.

The washed and decanted sludge is transferred to DWPF as part of "sludge only" operations. DWPF then processes the sludge from the original waste by combining it with glass frit. The mixture is heated until it melts, then is poured into stainless steel canisters to cool. The glass-like solid that forms contains the highly radioactive material and seals it off from the environment. Another word for this process is "vitrification." The sealed canisters will be stored at SRS until a federal repository is established.

The Salt Processing Facility (not the Saltstone Facility described on page 59), the second pretreatment operation for DWPF, was expected to process the salt cake and highly concentrated supernate waste (the result of the evaporation process) in tanks. The work was suspended in February 1998, however, to address safety issues arising from the excess generation of benzene during the process. In March of that year, a team began evaluating options for redirection of the salt processing design and configuration. A systems engineering review of approximately 140 options has narrowed the salt processing technologies to three viable alternatives, as follows:

- small-tank precipitation
- crystalline silicotitanate ion exchange
- caustic side solvent extraction

All three options split the salt stream into two streams. In precipitation, the highly radioactive portion, called "precipitate," would go to DWPF for vitrification, while the remainder, called "filtrate" (about 95 percent of the salt waste), would be low-level waste to be grouted into a solid form at the Saltstone Facility.

In ion exchange, the crystalline silicotitanate incorporating the highly radioactive constituents—including cesium, strontium, and other actinides—would go to DWPF for vitrification, while the lower level waste stream would be sent for grouting at the Saltstone Facility.

Solvent extraction works in a manner similar to ion exchange, but it uses a liquid solvent to strip cesium from the waste, instead of a solid filter.

A technology examined but not selected was direct disposal in grout. In this method, low-level waste is separated from high-level waste, then bound in grout and sent directly into a permitted facility for storage.

Science and technology work on the three options, including research and development efforts on a pilot facility, continued in 2000. A decision on which new option to use is expected in 2001.

Accomplishments

SRS continued to manage its high-level waste facilities in support of the integrated high-level waste removal program in 2000.

Tank Farms

The tank farm evaporators recovered more than 1.25 million gallons of tank space in 2000 through evaporation of the watery supernate that floats atop the sludge in the tanks. The 2H evaporator system did not contribute to the recovery of space during 2000 because of operational problems. However, the 3H evaporator (new replacement evaporator) system recovered more than 780,000 gallons while the 2F evaporator system recovered more than 500,000 gallons. One of the keys to this achievement was an interarea line used to transfer waste from H-Area to F-Area via a 2-mile underground system. Approximately 340,000 gallons of radioactive waste were transferred via the interarea line during 2000.

Modifications to the evaporator systems and tank farms continued in 2000 to enhance safe operations without affecting productivity.

DWPF

The successful processing of radioactive sludge continued during 2000. DWPF produced 271 canisters of immobilized high-level waste during the year, bringing the total to 1,026 canisters since radioactive processing began in March 1996.

DWPF will continue processing sludge until the "precipitate" from one of the salt processing alternatives is available. Approximately 220 canisters of glass are expected to be produced in fiscal year 2001.

Facility Disposition

Disposition of Inactive Facilities

With the reduced need for a large U.S. nuclear weapons stockpile, many SRS facilities no longer are required to produce or process nuclear materials. These inactive facilities must be placed in a safe, low-cost condition and properly maintained until they can be safely disposed.

SRS has approximately 150 inactive facilities, and many others are expected to be declared inactive within the next decade. These facilities range in size and complexity from large nuclear reactors to small storage buildings. Many site facilities have underground structures, storage tanks, and piping that require a large amount of excavation to access; some are more than 100 feet high. Many contain residual materials that could be hazardous to workers, the public, and the environment if improperly handled or stored. Others are located within the site's nuclear industrial areas—surrounded by buildings that are occupied or still being used, which makes their demolition extremely hazardous and difficult. SRS faces a significant challenge in the safe maintenance, surveillance, cleanup, and ultimately disposition of these surplus facilities.

Facilities Disposition Division (FDD, formerly the Facilities Decommissioning Division) personnel manage the disposition phase of a surplus facility's life cycle in a manner that considers life cycle costs without compromising either (1) the health or safety of workers and the public or (2) the quality of the environment. The disposition phase begins upon completion of operations shutdown and extends through establishment of the facility's end state.

The facility disposition process consists of three activities, as follows:

- *Deactivation*, which places a facility in a known, safe, and stable configuration by removing hazardous chemical and radioactive materials, shutting down or mothballing the equipment, and mitigating other hazardous conditions.
- *Safe storage*, which is a dormant period involving only surveillance and maintenance (S&M) of the facility to ensure the continued safety of workers, the public, and the environment. (S&M activities are performed during the entire disposition process to ensure that all structures, systems, and materials are monitored adequately and that a safe configuration is maintained.)
- *Decommissioning*, which places the facility in its end state. This could involve decontamination, dismantlement, or some other activity to make the land available for either unrestricted use or limited applications. If not released for unrestricted use, a long-term stewardship program will provide institutional controls to ensure the safety of the public and the environment.

Despite the complexity of the facilities and the nature of the hazards, SRS has continued to safely manage the disposition of its surplus facilities through its Inactive-Facilities Risk Management Program. The immediate goal is to remove hazardous materials from surplus facilities and to place the facilities in a safe and stable condition. The site continues to seek opportunities to reuse these facilities for mission-related activities, as well as for other industrial uses. An S&M program is established and maintained to ensure that no facility deteriorates to the point that it becomes dangerous to workers or threatens the public and the environment with a release of hazardous materials.

Accomplishments

Disposition Program Management

The WSRC Facility Disposition Procedure Manual, developed and issued in September 1999, provides a consistent, disciplined process for facility disposition activities. The procedures are consistent with DOE's Life Cycle Asset Management System requirements and employ a graded approach to ensure cost effectiveness. FDD continues to provide management and direction to the WSRC Facilities and Assets Disposition Management Council, which coordinates the disposition processes across the site's operating divisions.

Facility Disposition Long-Range Planning

In 2000, FDD developed and implemented a standardized facility disposition long-range planning process integrated with DOE's long-term stewardship program. The process was developed to form a consistent basis for planning and estimating the cost of long-range facility disposition activities. The National Deactivation and Decommissioning Committee is pursuing use of this program to form the basis for a standardized facility disposition long-range planning process for DOE complexwide application.

Facility Transitions

FDD accepted custodial responsibility for an additional 16 facilities from other operating divisions during 2000. Five facilities were transferred from P-Area and 11 facilities were transferred from T-Area as part of a three-year program to transfer personnel out of the T-Area.

The seamless transition of the TNX facilities was a team effort involving representatives of FDD and the Technical Services Division. The team developed a formal Memorandum of Understanding, conducted key activities to reduce hazards and surveillance and maintenance costs, and transferred custodial responsibility to FDD. The transfer of 17 additional TNX facilities is planned for 2001.

During the past 4 years, the cost to provide S&M for facilities in C-Area, D-Area, M-Area, P-Area, and R-Area has been reduced from more than $39 million to less than $12 million through similar shutdown and deactivation activities (figure 4–1).

Inactive-Facilities Risk Management Program

The WSRC Inactive-Facilities Risk Management Program augments the more traditional approach of conducting complete facility deactivation projects with a program that ensures that the limited funding

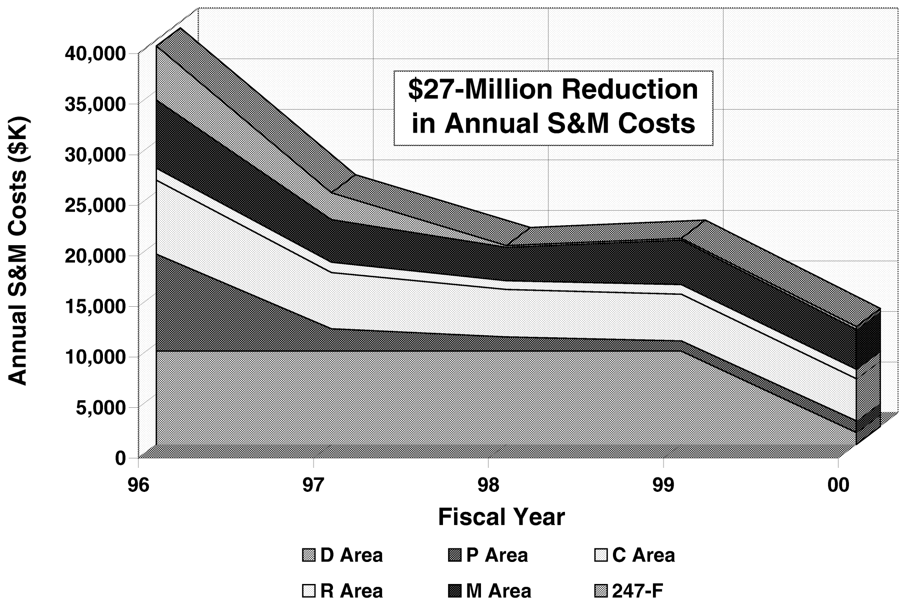


Figure 4–1 Reducing S&M Costs

Through a combination of facility shutdowns, risk reduction actions, and deactivation and decommissioning projects, the annual cost to perform surveillance and maintenance of FDD's inactive facilities has dropped from more than $39 million to less than $12 million since 1996.

FDD Graphic (modified)

available is directed toward reducing the greatest hazards, regardless of the facility in which the hazards are located.

Twenty-nine risk reduction actions were accomplished at 12 different facilities in 2000. These actions have reduced the risk assessment score for these facilities by more than 82 percent (figure 4–2).

As part of the annual program process, FDD personnel

- performed 31 detailed facility assessments
- updated the Inactive-Facilities Risk Ranked Priority List
- developed corrective action plans for the significant hazards identified
- planned 39 risk reduction actions for 2001

Disposition of Inactive Facilities

Several facility disposition activities were completed or initiated at SRS in 2000, as follows:

- Highly enriched uranium was removed from the Fuel Manufacturing Building (321–M) to the extent necessary to eliminate any potential for criticality and to allow reclassification of the facility from "radiological" to "other industrial." Subsequent deactivation actions now can proceed without the costly and time consuming criticality controls.

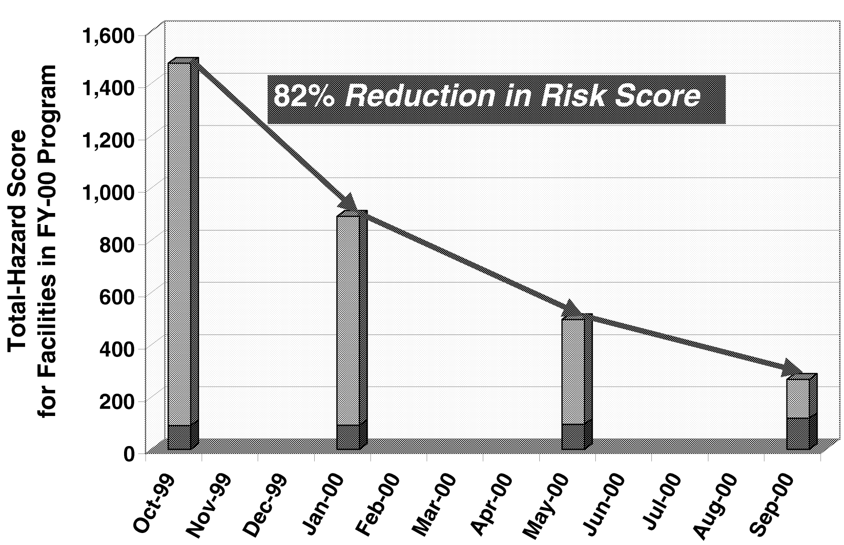


Figure 4–2 Facility Risk Management

Twenty-nine risk reduction actions were accomplished at 12 SRS facilities during 2000 as part of the site's Inactive-Facilities Risk Management Program. These actions reduced the risk assessment score for the facilities involved by more than 82 percent.

FDD Graphic (modified)

Removal of the 284–F Powerhouse eliminated one of the highest-risk-ranked inactive facilities at SRS. Use of the assets-for-services concept resulted in a cost saving of approximately $2.7 million for complete removal of the powerhouse.

Joseph Trahan Photo (NFN)

- Deactivation of the Dilute Effluent Treatment Facility, the 320–M Alloy Building, and the 313–M Canning Building was completed. Surveillance round frequency for these facilities was reduced from weekly to semiannually.
- Stabilization of the 717–C Hot Shop was completed.
- Deactivation of the Vendor Treatment Facility was initiated. This project is expected to be completed in 2001.
- The operation of two parallel selective ion-exchange process systems to remove cesium and strontium from the R-Reactor Basin was initiated. These systems were deployed as an Accelerated Site Technology Deployment project, sponsored by the DOE Environmental Management Office of Science and Technology. The systems are expected to reduce the concentrations of cesium and strontium to below the DOE release limits by the end of 2001.
- An Alternative Analysis for the closure of the R-Reactor Disassembly Basin was performed. This analysis will be used to prepare the regulatory basis for disposal of the radioactive water in the basin, as well as for closure of the basin and that portion of the 105–R Reactor Building housing the basin.
- An Integrated Project Management Plan for deactivation of the F Canyon and FB Line was completed. The plan was developed by the Nuclear Materials Stabilization and Storage Division, with technical support from FDD and the National Facilities Deactivation Initiative.

Removal of 284–F Powerhouse

WSRC placed a contract in May 2000 to dismantle and remove the 284–F Powerhouse—one of the highest-risk-ranked inactive facilities at SRS. The contract employed an Assets-for-Services approach that applied surplus government assets from the K-Area Cooling Tower and the 247–F Naval Fuels Manufacturing Facility to partially offset the cost of removing the powerhouse. The contract was placed for less than $600,000—a savings of about $2.7 million over the estimated cost of $3.3 million to remove the powerhouse and other surplus equipment using site personnel. The contractor completed approximately 90 percent of the work in 2000 and is expected to finish in 2001.

During the past 3 years, FDD personnel have successfully used the assets-for-services approach to accomplish approximately $11 million in disposition services for an expenditure of about $1 million. This program has reduced surplus facilities at SRS by approximately 46,000 square feet.

Operation of Decontamination Facility

FDD also operates the Decontamination Facility to provide cost-effective decontamination and size reduction services for all WSRC divisions, as well as for FDD’s own operations. These operations provide a valuable service for the SRS recycling and waste minimization programs.

Approximately 11,000 cubic feet of materials were processed through the Decontamination Facility in 2000, resulting in savings of more than $900,000. Also, more than 1,600 square feet of contaminated areas were covered with protective polyurethane coating to eliminate the potential for contamination spread.

Deactivation and Decommissioning Technology Deployments

As part of FDD's continuous improvement program, FDD personnel seek opportunities to add state-of-the-art technologies that will improve the effectiveness of deactivation and decommissioning operations. The following items are examples of the use of improved technologies sponsored by the DOE Environmental Management Office of Science and Technology and demonstrated during 2000.

- FDD successfully demonstrated a sponge-jet blasting system to decontaminate both stainless steel and lead. This technology blasts an open-celled polyurethane particle, impregnated with abrasives, onto the contaminated surface. The pliant nature of the soft media allows its particles to flatten on impact, exposing the abrasives. After leaving the surface, the media constricts, pulling and entrapping what would have become airborne contaminants under most traditional dry or wet blasting technologies. This system offers a safe, flexible surface decontamination at a cost lower than traditional blasting technologies.
- FDD successfully demonstrated a vortex amplifier, which is a variable ventilation system flow control device. The demonstration confirmed the ability of the vortex amplifier to maintain constant negative pressure and prevent over-pressurization of a containment hut during simulated upset conditions. Because the vortex amplifier has no moving parts, it is not subject to mechanical failure and requires no maintenance.

Contaminated-Large-Equipment Disposition Program

The Decontamination Facility has been designated as the site lead for conducting decontamination and size reduction activities for a new site initiative, the Contaminated-Large-Equipment Disposition (CLED) program. The CLED program was developed to dispose of approximately 750,000 square feet of large, contaminated equipment that has accumulated at numerous locations around the site over the past several years. Continuing to delay the disposition of this equipment has resulted in operational impacts and in the expenditure of site resources on containers and on maintenance of stored equipment.

Chapter 5

Radiological Effluent Monitoring

Pete Fledderman
and Donald Padgett
Environmental Protection Department

Timothy Jannik
Savannah River Technology Center

To Read About . . . See Page . . .

2000 Highlights

- In the 2000 radiological effluent monitoring program, approximately 4,000 samples were collected and analyzed. Data results were used as the primary basis for determining annual release totals from the site.
- Tritium in elemental and oxide forms (about 46 percent) and krypton-85 (about 54 percent) accounted for nearly all of the total radioactivity released to the atmosphere from SRS operations. About 44,800 Ci of tritium were released from SRS, compared to about 51,600 Ci in 1999.
- Tritium also accounted for most of the radioactivity discharged in liquid effluents. In 2000, 1,660 Ci were directly released to site streams from process areas, compared to 1,120 Ci for 1999.

THIS chapter describes the Savannah River Site (SRS) radiological effluent monitoring program and summarizes the 2000 effluent monitoring data results. Objectives and rationale for the SRS radiological effluent monitoring program are discussed in chapter 3, "Environmental Program Information."

Radiological effluent monitoring results are a major component in determining compliance with applicable dose standards, which can be found in chapter 7, "Potential Radiation Doses," and in appendix A, "Applicable Guidelines, Standards, and Regulations." Also, SRS management philosophy is that potential exposures to members of the public and to onsite workers be kept as far below regulatory standards as is reasonably achievable. This philosophy is known as the "as low as reasonably achievable" (ALARA) concept.

SRS airborne and liquid effluents that potentially contain radionuclides are monitored at their points of discharge by a combination of direct measurement and/or sample extraction and analysis. Each operating facility maintains ownership of and is responsible for its radiological effluents. Safety and Health Operations (S&HO) and the Environmental Protection Department's Environmental Monitoring Section (EMS) perform most of the radiological effluent monitoring functions. S&HO personnel collect and screen air and liquid samples from regulated (radiologically controlled) areas and maintain monitoring equipment on stacks and at some liquid effluent discharge points. EMS personnel collect and analyze most liquid effluent samples and analyze most of the airborne effluent samples. Results of these analyses are compiled and reported in monthly radioactive releases reports.

Approximately 4,000 radiological effluent samples were collected at 67 points of discharge and analyzed during 2000.

A complete description of the EMS sampling and analytical procedures used for radiological effluent monitoring can be found in sections 1102 and 1103 of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1 (SRS EM Program). A summary of data results is presented in this chapter; more detailed data can be found in *SRS Environmental Data for 2000* (WSRC–TR–2000–00329).

Airborne Emissions

Process area stacks that release or have the potential to release radioactive materials are monitored continuously by applicable online monitoring and/or sampling systems [SRS EM Program, 1999]**.** Filter paper samples, used to collect radioactive particles, generally are gathered daily and screened initially for radioactivity by S&HO personnel. Charcoal canisters, used to collect radioiodines, are gathered weekly at some locations and monthly at locations with lower potential for release. S&HO personnel routinely transfer the filter paper samples and charcoal canisters weekly to EMS sampling personnel for transport to, and analysis in, the EMS laboratories.

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

Description of Monitoring Program

Sample Collection Systems

Sample collection systems vary from facility to facility, depending on the nature of the radionuclides being discharged. Generally, S&HO personnel are responsible for ensuring that the sampling systems are maintained and for collecting the filter papers and charcoal filter samples.

The following effluent sampling and monitoring changes were made during 2000:

- Air effluent sampling at the 321–M machining room stack was discontinued in June to accommodate deactivation work. All air sample flow is now through 321–M stacks.
- Air effluent sampling at 728–N was discontinued in November because of lack of work in Central Shops.
- Air effluent sampling at 261–H was discontinued after the facility was placed on standby at the end of August.
- Air effluent sampling at the 250–S glass waste storage buildings (4) is now on an annual basis (as of May) per agreement with the South Carolina Department of Health and Environmental Control (SCDHEC).

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 molecular sieve.

Laboratory Analysis

EMS provides most of the necessary radioanalytical laboratory services required to conduct the site airborne effluent monitoring program. However, tritium in airborne effluents is measured at each applicable operating facility. Also, specific low-level analyses for iodine-129 were performed by an onsite laboratory during 2000.

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 radioactive materials released.

Diffuse and Fugitive Sources

Estimates of radionuclide releases from unmonitored diffuse and fugitive sources also are included in the SRS radioactive release totals. These unmonitored sources include ponds, contaminated land areas, and structures without ventilation—or with ventilation but without well-defined release points.

Diffuse and fugitive releases are calculated using the U.S. Environmental Protection Agency's (EPA's) recommended methods. The methods produce conservative estimates of release levels having a large uncertainty associated with them. However, for consistency with other reported data, the estimates are reported to three significant figures.

Monitoring Results

The total amount of radioactive material released to the environment is quantified by using data obtained from continuously monitored airborne effluent releases points and estimates of diffuse and fugitive sources in conjunction with calculated release

Diffuse and Fugitive Sources

Emissions from DOE facilities include those from point sources (stacks or vents) and those from diffuse and fugitive sources. A diffuse source is defined as an area source. Examples of diffuse sources include resuspension of contaminants deposited on open fields and evaporation from holding ponds and basins. A fugitive source is defined as an undesigned localized source. Process leaks that discharge to the atmosphere by a path other than a stack or vent are fugitive releases. Unmonitored evaporation releases from open tanks and drums also are considered fugitive releases.

estimates of unmonitored radionuclides from the separations areas.

The unmonitored radionuclides are fission product tritium, carbon-14, and krypton-85. These radionuclides cannot be measured readily in the effluent streams; therefore, the values are calculated on an annual basis and are based on production levels in the separations areas.

Because of increased operations in F-Canyon, the amount of krypton-85 estimated to have been released increased 41 percent. It went from 37,400 Ci in 1999 to 52,800 Ci in 2000 and accounts for about 54 percent of the total radioactivity released to the atmosphere from SRS operations. However, because krypton is a noble gas and is not absorbed by the human body, it therefore results in only a small amount of dose, even though the released amount is relatively high (table 33, *SRS Environmental Data for 2000*).

The data in table 5–1 on page 73 (and in table 4, *SRS Environmental Data for 2000)* are a major component in the determination of offsite dose estimations from SRS operations. The calculated individual and collective doses from atmospheric releases are presented in chapter 7, as is a comparison of these offsite doses to EPA and the U.S. Department of Energy (DOE) dose standards.

Beta- and Alpha-Emitting Radionuclides

Unspecified alpha and beta emissions have become large contributors (on a percentage basis) to offsite doses, especially for the airborne pathway from diffuse and fugitive releases. Because some (if not most) of these emissions are from naturally occurring radionuclides, these emissions are accounted for separately from actual strontium-90 and plutonium-239 emissions.

Therefore, for 2000, releases of unspecified alpha emissions and nonvolatile beta emissions were listed separately in the source term. In previous years, these emissions were included in plutonium-239 and strontium-89,90 releases.

For dose calculations, the unspecified alpha releases were assigned the plutonium-239 dose factor, and the unspecified nonvolatile beta releases were assigned the strontium-90 dose factor (chapter 7).

Tritium

Tritium in elemental and oxide forms accounts for about 46 percent of the total radioactivity released to the atmosphere from SRS operations. As an isotope of hydrogen, tritium acts the same as hydrogen chemically and physically and thus is extremely difficult to remove selectively from air effluent streams. During 2000, about 44,800 Ci of tritium were released from SRS, compared to about 51,600 Ci in 1999. This 13 percent decrease was due mainly to completion of the deactivation of D-Area heavy water facilities in 1999.

Because of improvements in facilities, processes, and operations and because of changes in the site’s mission, the amount of tritium (and other atmospheric radionuclides) released has been reduced throughout the history of SRS. During the early years at SRS, large quantities of tritium were discharged to the atmosphere. The maximum yearly release of 2.4 million Ci of tritium occurred during 1958. In recent years, because of the changes in the site’s missions and the existence of the Replacement Tritium Facility, the total amount of tritium released has fluctuated but has remained less than 100,000 Ci per year (figure 5–1).

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 derived concentration guides (DCGs) in DOE Order 5400.5, “Radiation Protection of the Public and the Environment.”

DCGs are used as reference concentrations for conducting environmental protection programs at all DOE sites. Based on a 100-mrem exposure, DCGs 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 undiluted air effluent 24 hours a day, 365 days a year. However, because of the distance between most SRS operating facilities and the site boundary, and because the wind rose at SRS shows no strong prevalence (chapter 7), this scenario is highly improbable.

Average annual radionuclide concentrations in SRS air effluents can be referenced to DOE DCGs as a screening method to determine if existing effluent treatment systems are proper and effective. The 2000 atmospheric effluent 12-month average concentrations, their comparisons against the DOE

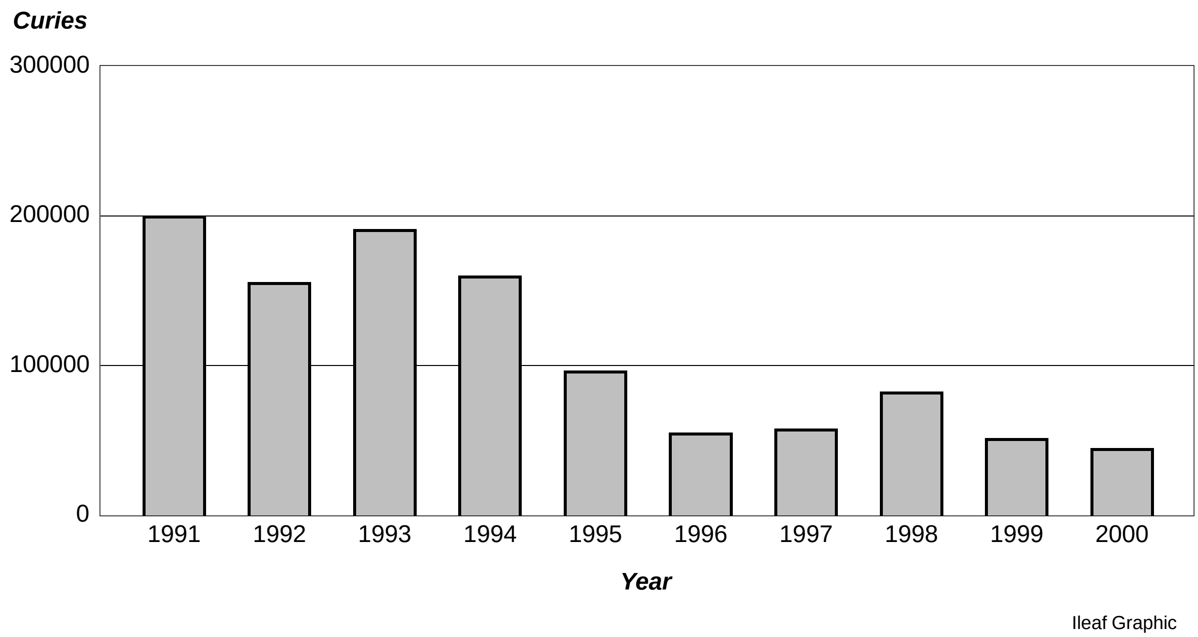


Figure 5–1 Ten-Year History of SRS Annual Atmospheric Tritium Releases

DCGs, and the quantities of radionuclides released are provided, by discharge point, in table 5, *SRS Environmental Data for 2000*.

Most of the SRS radiological stacks/facilities release small quantities of radionuclides at concentrations below the DOE DCGs. However, certain radionuclides—tritium (in the oxide form) from the reactor facilities and the tritium facilities; americium-241 and plutonium-239 in F-Area from the 6.1 and 6.4 dissolvers; plutonium-238, plutonium-239, americium-241, and curium-244 in H-Area from 261–H (off gas); and americium-241 from the 244–H vessel vent exhaust—were emitted at concentration levels above the DCGs. Because of the extreme difficulty involved in removing tritium and because of current facility designs, site missions, and operational considerations, this situation is unavoidable. The offsite dose consequences from all atmospheric releases during 2000, however, remained well below the DOE and EPA annual atmospheric pathway dose standard of 10 mrem (0.1 mSv) (chapter 7).

Liquid Discharges

Each process area liquid effluent discharge point that releases or has potential to release radioactive materials is sampled routinely and analyzed for radioactivity [SRS EM Program, 1999]. The radiological liquid effluent sampling locations at SRS are shown, along with the surface water surveillance sampling locations, in chapter 6, “Radiological Environmental Surveillance” (page 84, figure 6–4).

Site streams also are sampled upstream and downstream of seepage basins to obtain data 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.

Description of Monitoring Program

Sample Collection Systems

Liquid effluents are sampled continuously by automatic samplers at, or very near, their points of discharge to the receiving streams. EMS personnel normally collect the liquid effluent samples weekly and transport them to the EMS laboratory for analysis.

Continuous Monitoring Systems

Depending on the processes involved, liquid effluents also may be monitored by area operations and/or S&HO personnel with real-time instrumentation to ensure that instantaneous releases stay within established limits. Because the instruments have limited detection sensitivity, online monitoring systems are not used to quantify liquid radioactive releases from SRS.

Laboratory Analysis

EMS provides most of the necessary radioanalytical laboratory services required to conduct the site liquid effluent monitoring program.

Flow Rate Measurements

Liquid effluent flows generally are determined by one of two methods: U.S. Geological Survey flow stations or commercial flow meters. Effluent flow rates are used to determine the total radioactivity released.

Monitoring Results

Data from continuously monitored liquid effluent discharge points are used in conjunction with site seepage basin and Solid Waste Disposal Facility migration release estimates to quantify the total radioactive material released to the Savannah River from SRS operations. SRS liquid radioactive releases for 2000 are shown by source in table 5–2, page 147, and in table 6, *SRS Environmental Data for 2000)*.

The data in this table are a major component in the determination of offsite dose consequences from SRS operations. The calculated individual and collective doses from site liquid releases are presented in chapter 7, as is a comparison of these offsite doses to EPA and DOE dose standards.

Beta- and Alpha-Emitting Radionuclides

Unspecified alpha and beta emissions have become large contributors (on a percentage basis) to offsite doses, especially for the liquid pathway from diffuse and fugitive releases. Because some (if not most) of these emissions are from naturally occurring radionuclides, these emissions are accounted for separately from actual strontium-90 and plutonium-239 emissions.

For 2000, releases of unspecified alpha emissions and nonvolatile beta emissions were listed separately in the source term. In previous years, these emissions were included in plutonium-239 and strontium-89,90 releases.

For dose calculations, the unspecified alpha releases were assigned the plutonium-239 dose factor, and the unspecified nonvolatile beta releases were assigned the strontium-90 dose factor (chapter 7).

Direct Discharges of Liquid Effluents

Direct discharges of liquid effluents are quantified at the point-of-release to the receiving stream, prior to dilution by the stream. The release totals are based on measured concentrations and flow rates.

Tritium accounts for nearly all of the radioactivity discharged in SRS liquid effluents. The total amount of tritium released directly from process areas (i.e., reactor, separations, heavy water rework) to site streams during 2000 was 1,660 Ci**,** which was 48 percent more than the 1999 total of 1,120 Ci.

Direct releases of tritium to site streams for the years 1991–2000 are shown in figure 5–2, where it can be seen that the total amount of tritium released has fluctuated up and down but has remained less than 2,000 Ci per year in recent years.

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. These considerations are applicable to direct discharges but not to seepage basin and Solid Waste Disposal Facility migration discharges. 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 screening values for “best available technology” investigations and for determining whether existing effluent treatment systems are proper and effective.

According to DOE Order 5400.5, exceedance of the DCGs at any discharge point may require an investigation 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 for all radionuclides detectable in the effluent is less than 1.00, based on consecutive 12-month average concentrations.

DCGs, 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 effluent and consumes 2 liters of the effluent every day, 365 days a year. However, because of security controls and the distance between most SRS operating facilities and the site boundary, this scenario is highly improbable.

For each site facility that releases radioactivity, EMS compares the monthly liquid effluent concentrations and 12-month average concentrations against the DOE DCGs. The 2000 liquid effluent 12-month average concentrations, their comparisons against the DOE DCGs, and the quantities of radionuclides released are provided, by discharge point, in table 7, *SRS Environmental Data for 2000*.

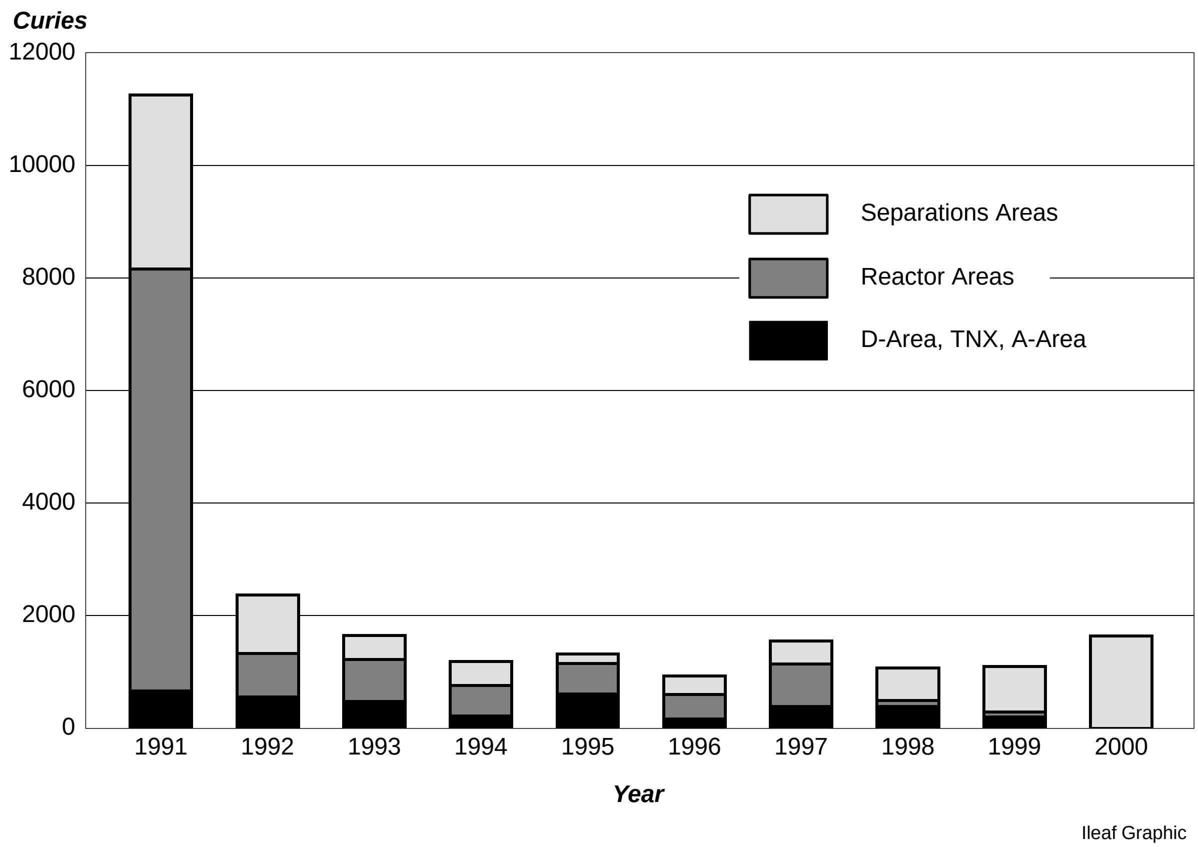


Figure 5–2 Direct Releases of Tritium to SRS Streams, 1991–2000
The 1991 total includes an accidental release in December of 5,700 Ci from K-Reactor.

The data show that the U3R–2A ETF outfall at the Road C discharge point exceeded the DCG guide for 12-month average tritium concentrations during 2000. However, as noted 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. In 1992, in consideration of ALARA principles for tritium discharges and while reviewing, analyzing, and modifying the process for controlling liquid releases of radioactive effluents, SRS identified several options and alternatives to continuing with these discharges at the U3R–2A ETF outfall. None of these alternatives was considered viable on a cost/benefit basis. No other discharge points exceeded the DOE DCGs during 2000.

Table 5–1 Radioactive Atmospheric Releases by Source

Page 1 of 3

Radio-nuclide	Curies[a] Reactors	Separa-tions[b]	Reactor Materials	Heavy Water	SRTC[c]	Diffuse and Fugitive[d]	Total
Note: Blank spaces indicate no quantifiable activity.							
GASES AND VAPORS							
H-3(oxide)	3.11E+03	2.87E+04				6.12E+02	3.24E+04
H-3(elem.)		1.24E+04					1.24E+04
H-3 Total	3.11E+03	4.11E+04				6.12E+02	4.48E+04
C-14		1.33E–01				8.39E–05	1.33E–01
Kr-85		5.28E+04				2.00E–03	5.28E+04
I-129						1.71E–03	1.71E–03
I-131					6.96E–06		6.96E–06
I-133					1.18E–04		1.18E–04
PARTICULATES							
Cr-51						1.21E–04	1.21E–04
Co-57		3.26E–07				3.61E–10	3.26E–07
Co-58						1.27E–04	1.27E–04
Co-60		1.78E–06				8.58E–04	8.60E–04
Ni-59						4.17E–13	4.17E–13
Ni-63						5.09E–06	5.09E–06
Zn-65						2.23E–05	2.23E–05
Sr-89,90		1.74E–04				3.72E–03[e]	3.89E–03
Zr-95						1.68E–05	1.68E–05
Zr-85						1.07E–09	1.07E–09
Nb-94						3.95E–10	3.95E–10
Nb-95						1.13E–04	1.13E–04
Tc-99						8.75E–05	8.75E–05
Ru-103						4.23E–05	4.23E–05
Ru-106						1.04E–05	1.04E–05
Sb-124						5.63E–10	5.63E–10
Sb-125						5.34E–05	5.34E–05
Sn-113						6.20E–10	6.20E–10
Sn-126						6.45E–14	6.45E–14

a One curie equals 3.7 E+10 Becquerels.
b Includes separations, waste management, and tritium facilities
c Savannah River Technology Center
d Estimated releases from minor unmonitored diffuse and fugitive sources
e The major contributors of diffuse and fugitive Sr-90 during 2000 were the L-Area Oil and Chemical Basin and the F-Area Wastewater Treatment Facility.

Table 5–1 Radioactive Atmospheric Releases by Source

Page 2 of 3

Radio-nuclide	Curies[a] Reactors	Separa-tions[b]	Reactor Materials	Heavy Water	SRTC[c]	Diffuse and Fugitive[d]	Total
Cs-134		2.38E–08				1.31E–04	1.31E–04
Cs-137	1.22E–05	6.07E–03	3.36E–07		8.85E–08	2.07E–03	8.15E–03
Ce-141						4.16E–05	4.16E–05
Ce-144						1.44E–04	1.44E–04
Pa-233						2.23E–10	2.23E–10
Pr-144						3.68E–13	3.68E–13
Pr-144m						4.43E–15	4.43E–15
Pm-147						1.30E–05	1.30E–05
Eu-152						4.13E–05	4.13E–05
Eu-154		1.31E–06				1.51E–05	1.64E–05
Eu-155		3.34E–06				6.81E–07	4.02E–06
Hg-203						2.23E–10	2.23E–10
Ra-226						1.74E–05	1.74E–05
Ra-228						2.74E–05	2.74E–05
Ac-228						1.80E–06	1.80E–06
Th-228						5.76E–07	5.76E–07
Th-230						1.74E–05	1.74E–05
Th-232						2.58E–06	2.58E–06
Th-234						1.04E–04	1.04E–04
Ba-133						5.40E–10	5.40E–10
U-233						1.50E–08	1.50E–08
U-234		3.35E–05	5.13E–06			3.59E–04	3.98E–04
U-235		2.84E–06	7.71E–07			1.44E–05	1.80E–05
U-236						4.16E–11	4.16E–11
U-238		7.29E–05	5.41E–07			4.47E–04	5.20E–04
Np-237						2.26E–10	2.26E–10
Pu-238		2.83E–04	2.29E–08			7.57E–05	3.59E–04
Pu-239		1.88E–04	2.39E–08			1.86E–03[e]	2.05E–03
Pu-240						1.99E–07	1.99E–07
Pu-241						4.09E–06	4.09E–06

a One curie equals 3.7 E+10 Becquerels.
b Includes separations, waste management, and tritium facilities
c Savannah River Technology Center
d Estimated releases from minor unmonitored diffuse and fugitive sources
e The major contributors of diffuse and fugitive Pu-239 during 2000 were the L-Area Oil and Chemical Basin and the F-Area Wastewater Treatment Facility.

Table 5–1 Radioactive Atmospheric Releases by Source

Page 3 of 3

	Curies[a]						
Radio-nuclide	**Reactors**	**Separa-tions[b]**	**Reactor Materials**	**Heavy Water**	**SRTC[c]**	**Diffuse and Fugitive[d]**	**Total**
Pu-242						7.03E–09	7.03E–09
Am-241		2.19E–05	9.31E–09			1.24E–04	1.46E–04
Am-243						6.02E–06	6.02E–06
Cm-242						4.47E–07	4.47E–07
Cm-244		1.49E–05	4.83E–09			6.19E–05	7.68E–05
Cm-245						1.04E–13	1.04E–13
Cm-246						3.98E–06	3.98E–06
Ar-39						3.30E–05	3.30E–05
Na-22						7.90E–11	7.90E–11
Mn-54						1.30E–10	1.30E–10
Se-79						4.47E–09	4.47E–09
Alpha	7.65E–05	5.83E–05	1.28E–05		9.16E–07	5.86E–04	7.35E–04
Beta-Gamma	8.31E–04	1.16E–04	3.19E–05			3.47E–02	3.57E–02

a One curie equals 3.7 E+10 Becquerels.
b Includes separations, waste management, and tritium facilities
c Savannah River Technology Center
d Estimated releases from minor unmonitored diffuse and fugitive sources

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

Page 1 of 1

	Curies[a]					
Radio-nuclide	**Reactors (C,K,L,P,R)**	**Separations[b] (F-Area, H-Area.**	**Reactor Materials (M-Area)**	**Heavy Water (D-Area, TNX)**	**SRTC[c] (A-Area)**	**Total**
Note: *Blank spaces indicate no quantifiable activity.*						
Site						
H-3	1.25E+03	4.09E+03		1.29E–01	1.18E+00	5.34E+03
Sr-90	2.84E–05	5.44E–02				5.44E–02
Co-60	1.13E–03	4.94E–04				1.62E–03
I-129		7.82E–02				7.82E–02
Cs-137	2.16E–04	8.79E–02				8.81E–02
U-234		2.05E–05	4.88E–06	3.35E–06	1.31E–04‘	2.87E–05
U-235		1.20E–06		5.20E–08	4.93E–06	6.18E–06
U-238		4.70E–05	1.13E–05	4.67E–06	1.34E–04	1.97E–04
Pu-238		8.12E–06	7.57E–06	2.25E–06	4.17E–06	2.21E–05
Pu-239		1.36E–05	2.41E–06	1.77E–07	5.76E–07	1.68E–05
Am-241		5.01E–06	6.93E–06			1.19E–05
Cm-244		7.01E–06				7.01E–06
Alpha	1.44E–03	1.13E–02	2.81E–03	4.93E–04	3.57E–03	1.96E–02
Beta-Gamma	2.01E–02	1.92E–02	5.13E–04	1.02E–03	3.55E–03	4.44E–02

a One curie equals 3.7 E+10 Becquerels.
b Includes separations, waste management, and tritium facilities
c Savannah River Technology Center

Chapter 6

Radiological Environmental Surveillance

Pete Fledderman, Chuck Hayes, Bill Littrell, Phillip Miller, Chet Nichols, and Donald Padgett
Environmental Protection Department

Timothy Jannik
Savannah River Technology Center

To Read About . . . See Page . . .

2000 Highlights

- Results of the comprehensive radiological surveillance program conducted near the site for air, surface water, groundwater, drinking water, soil, sediments, game animals, and foodstuffs were within historical trends and did not yield any new issues of concern.
- Tritium released from SRS via groundwater migration totaled 4,200 Ci, compared to 4,990 Ci in 1999. Groundwater migration accounts for most of the site's liquid tritium releases.
- Tritium is the predominant radionuclide detected above background levels in the Savannah River. The average concentration at RM–118.8, located at U.S. Highway 301 below SRS, was 1,180 pCi/L—less than 6 percent of the 20,000-pCi/L derived drinking water standard set by EPA for tritium in drinking water.
- No drinking water samples exceeded the 20,000-pCi/L EPA derived drinking water standard for tritium. The average tritium concentration in finished water at Beaufort-Jasper, 1,000 pCi/L, was 5 percent of the EPA derived drinking water limit; the average tritium concentration at Port Wentworth, 950 pCi/L, was slightly less than 5 percent of the drinking water limit.

THE Savannah River Site (SRS) radiological environmental surveillance program 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 represented an extensive network in 2000 that covered approximately 2,000 square miles and extended up to 25 miles from the site. In conjunction with the radiological effluent monitoring program (chapter 5, "Radiological Effluent Monitoring"), the program enables SRS to monitor ambient radiological conditions and determine site contributions of radioactive materials to the environment.

Routine radiological surveillance activities are performed by the Environmental Protection Department's Environmental Monitoring Section (EMS) and by 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. This chapter summarizes surveillance results of the atmosphere (air and rainwater), surface water (seepage basins, site streams, and the Savannah River), drinking water, food products (terrestrial and aquatic), wildlife, soil, sediment, and vegetation. Also summarized are results of monitoring of ambient gamma radiation levels performed on site, at the site boundary, and in population centers (surrounding communities). A description of the surveillance program and 2000 results for groundwater can be found in chapter 10, "Groundwater."

Analytical results for 2000 appear in *SRS Environmental Data for 2000* (WSRC–TR–99–00301). Representative minimum detectable concentrations (MDCs) for the types of analyses being performed on the various environmental surveillance media can be found in table 2 of *SRS Environmental Data for 2000*. Information on the rationale for the radiological environmental surveillance program can be found in chapter 3, "Environmental Program Information." Data from earlier years can be found in previous SRS environmental reports and data publications.

A complete description of the SRS radiological environmental surveillance program can be found in section 1105 of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1 (SRS EM Program).

Air

Description of Surveillance Program

EMS maintains an extensive network of 17 sampling stations in and around SRS to monitor the concentration of radioactive materials in the air. These locations are divided into four subgroups, as follows:

- onsite
- site perimeter
- a control location at 25 miles
- selected major population centers at 25 and 100 miles

Figure 6–1 shows all the sampling locations except the 25- and 100-mile stations.

The air surveillance program helps determine the impact (if any) of site operations on the environment and evaluates trends in airborne radionuclide concentrations. The program also is used to verify atmospheric transport models and to support emergency response activities in the event of an unplanned release of radioactive material to the atmosphere.

Surveillance Results

Chapter 5 details the types and quantity of radioactive material released to the environment from SRS activities in 2000. Except for tritium, specific radionuclides were not routinely detectable at the site perimeter (table 8, *SRS Environmental Data for 2000*). Both onsite and offsite activity concentrations were similar to levels observed in previous years.

Gross Alpha and Gross Beta

Gross alpha and gross beta activity analyses are performed on glass fiber filter papers. Although they cannot provide concentrations of specific radionuclides, these measurements are useful in providing information for trending of the total activity in an air sample or in screening samples.

A summary of the monitoring results from 1996–2000 is presented in table 6–1. Average gross alpha and beta results were slightly higher in 1999 and 2000 than in 1997 and 1998. However, no significant differences between onsite and offsite locations were observed for either type of radiation. An investigation into the exact cause of significant 1999 increases in gross alpha results was conducted in 2000. Results of the investigation were inconclusive, but it is believed that laboratory error or long-term cyclic variability caused the increases. Regardless of the reason for the observed increases, no significant differences between onsite and offsite locations were observed.

As in previous years, no significant difference was seen between the average concentrations measured on site near the operating facilities and the average concentrations observed at the site perimeter.

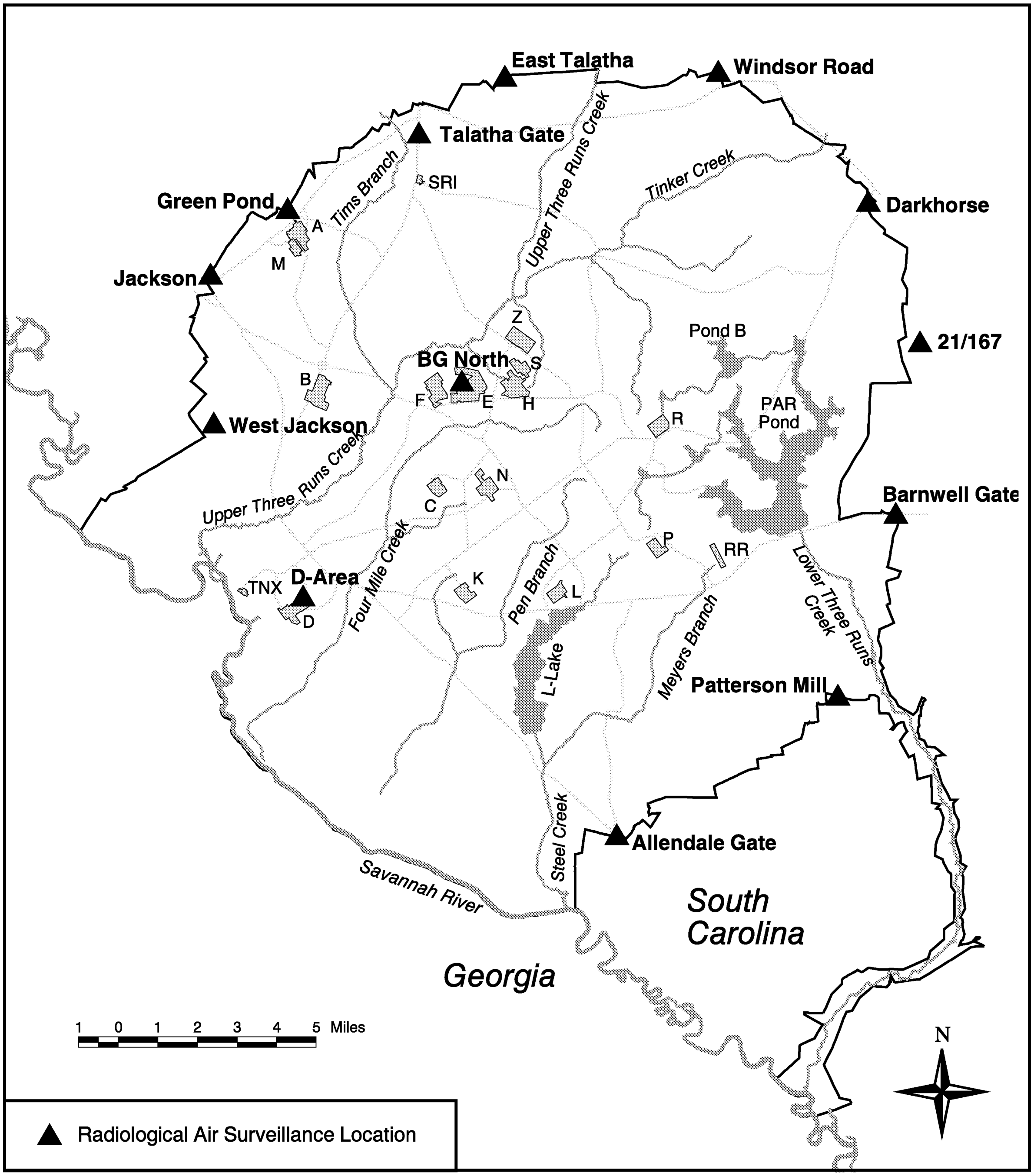
Gamma-Emitting Radionuclides

Glass fiber filters and activated charcoal canisters are collected weekly. The glass fiber filters are analyzed weekly and the activated charcoal canisters are analyzed annually. No manmade gamma-emitting radionuclides were observed in 2000. These results are consistent with historical results, which indicate only a small number of samples with detectable activity.

Tritium

Tritium-in-air analyses are conducted on biweekly silica gel samples. Tritium is released as part of routine SRS operations and becomes part of the natural environment. Monitoring ensures that there will be information available to determine whether any potential health risk to the surrounding population is created.

Results of studies on silica gel as a sampling medium for water in air were published in the January 2000 issue of *Health Physics* [Rosson et al., 2000]. The studies indicate that the analytical method used



EPD/GIS Map

Figure 6–1 Radiological Air Surveillance Sampling Locations

The SRS air surveillance program consists of 13 stations located on site or along the site perimeter, as well as (not shown) three stations approximately 25 miles from the site perimeter (located near the Highway 301 Bridge over the Savannah River; the New Savannah Bluff Lock and Dam, also known as the Augusta Lock and Dam; and the Aiken airport) and one about 100 miles from the site perimeter (near Savannah, Georgia).

underestimates water concentrations, yielding tritium levels that are lower than actual, and that corrections must be applied. The research results have been incorporated into the SRS surveillance program, and the required corrections have been applied to the analytical results for 1999 and 2000. Consequently, 1999 and 2000 results appear higher than those of

Table 6–1
Average Gross Alpha and Gross Beta Measured in Air (pCi/m^3), 1996–2000

Locations	1996	1997	1998	1999	2000
Average Gross Alpha					
On site	1.1E–03	1.2E–03	1.1E–03	2.0E–03	1.6E–03
Site perimeter	1.0E–03	9.8E–04	1.4E–03	1.9E–03	1.7E–03
25-mile radius	1.0E–03	1.0E–03	1.5E–03	1.9E–03	1.7E–03
100-mile radius	9.4E–04	1.1E–03	[a]	2.1E–03	1.6E–03
Average Gross Beta					
Locations	**1996**	**1997**	**1998**	**1999**	**2000**
On site	1.5E–02	1.7E–02	1.6E–02	1.9E–02	2.0E–02
Site perimeter	1.5E–02	1.5E–02	1.8E–02	1.9E–02	2.0E–02
25-mile radius	1.6E–02	1.6E–02	1.9E–02	1.9E–02	2.0E–02
100-mile radius	1.4E–02	1.1E–02	[a]	1.9E–02	1.8E–02

a Could not be sampled in 1998

previous years, for which no corrections have been applied.

In February 2000, EMS learned that the type of silica gel used for the tritium-in-air surveillance program was no longer produced. As a result, EMS had to implement an unanticipated change in the silica gel used to collect atmospheric moisture. Because of this abrupt change, EMS was not able to fully evaluate available replacement silica gel types, or to characterize the field and laboratory performance of the new silica gel type selected. After changing the silica gel type, significant increases in both the variability and the concentrations of the analytical results were observed. EMS initiated an investigation—still underway at the end of 2000—into this problem.

As a result of the silica gel problems, tritium-in-air concentrations for 2000 are significantly higher than for 1999. Although it is not believed that the 2000 results accurately reflect true tritium-in-air concentrations, it is likely that general concentration trends are accurate. Within the relatively high variability of analytical results, no readily apparent trend reflecting an increase or decrease was observed. However, the results do indicate that, consistent with the previous year's results, the 2000 concentrations generally decreased with increasing distance from the tritium facilities near the center of the site.

Also, because of the uncertainty in the analytical results, no comparison of the measured tritium-in-air concentrations to the SRS transport and dose assessment model was possible.

Alpha-Emitting Radionuclides

The analysis of glass fiber filter paper was expanded in 1999 to include uranium isotopes (uranium-234, uranium-235, uranium-238), americium-241, and curium-244—in addition to plutonium isotopes (plutonium-238, plutonium-239). These radionuclides are released in small quantities as part of routine site operations—primarily from the separations areas.

The analysis of glass fiber filter paper for alpha-emitting radionuclides is performed on one sample per year from each location. Generally, concentrations of alpha-emitting radionuclides in 2000 were similar to those of 1999. Small but detectable quantities of naturally occurring uranium isotopes (uranium-234, uranium-235, and/or uranium-238) were observed in samples from several locations. Plutonium-238 was the only other nuclide detected—in two perimeter samples; as with other nuclides, the concentrations were similar to historical levels. No readily apparent distribution pattern or difference between onsite and offsite locations was observed.

Strontium

Strontium analysis is performed on one sample per year from each monitoring site. Because of programmatic delays (delays in submitting the appropriate glass fiber filter papers to the laboratory and in laboratory analysis), results of the strontium analysis of glass fiber filter papers were available in time for inclusion in this report from only seven of 17 locations. None of these results showed detectable activity. Also, as detailed earlier, gross beta results showed no unusual concentrations; this indicates no significant strontium activity. No readily apparent distribution pattern or difference between onsite and offsite locations was observed.

Rainwater

SRS maintains a network of rainwater sampling sites as part of the air surveillance program. These stations are used to measure deposition of radioactive materials.

Description of Surveillance Program

Rainwater collection pans are located at each routine air surveillance station (figure 6–1). Ion-exchange resin columns are placed at seven of these locations. At each of these locations, rain passes through the column and into a collection bottle. Both the ion-exchange resin column and the collected liquid are returned to the laboratory for analysis. The column is analyzed weekly for gamma-emitting radionuclides, gross alpha, and gross beta and annually for plutonium-238, plutonium-239, and strontium-89,90, while the rainwater is analyzed for tritium.

At all other locations, the collected rainwater is returned to the laboratory and analyzed for tritium only. Ion-exchange column sampling is performed monthly, while rainwater sampling is performed biweekly.

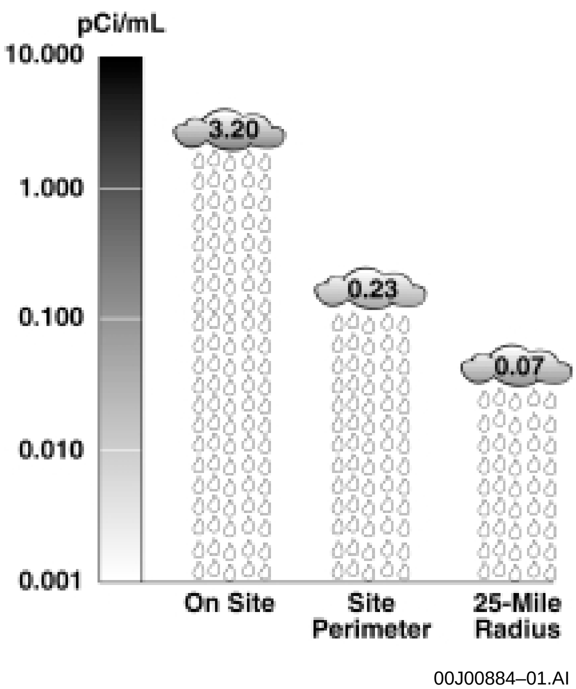


Figure 6–2 Average Concentration of Tritium in Rainwater, 2000
Tritium concentrations in rainwater (shown here in pCi/mL), generally decrease as the distance from the site increases.

Surveillance Results

Detailed results of rainwater analyses can be found in tables 9 and 10 of *SRS Environmental Data for 2000*.

Gamma-Emitting Radionuclides

As in 1999, no detectable manmade gamma-emitting radionuclides were observed in rainwater samples during 2000.

Gross Alpha and Gross Beta

The gross alpha and gross beta results were consistent with those of 1999. Although the 2000 results generally were slightly higher than those of 1999, no long-term increasing or decreasing trend was evident. This implies that the observed values are natural background and does not indicate any contribution directly attributable to SRS.

Alpha-Emitting Radionuclides

The analysis of rain ion columns was expanded in 1999 to include uranium isotopes (uranium-234, uranium-235, uranium-238), americium-241, and curium-244—in addition to plutonium isotopes (plutonium-238 and plutonium-239). Most isotopes were below detection levels in 2000; however, low levels of uranium-234 were observed at two locations. Generally, these onsite and offsite concentrations were similar, which is consistent with historical results.

Strontium

As in 1999, no detectable levels of strontium-89,90 were observed in rainwater samples during 2000.

Tritium

As in previous years, tritium-in-rain values were highest near the center of the site. This is consistent with the H-Area effluent release points that routinely release tritium. As with tritium in air, concentrations generally decreased as distance from the effluent release point increased (figure 6–2); this observation also is consistent with the source term and with atmospheric transport.

Gamma Radiation

Description of Surveillance Program

Ambient gamma exposure rates in and around SRS are monitored by an extensive network of dosimeters. The site uses the thermoluminescent dosimeter (TLD) to quantify integrated gamma exposure on a quarterly basis. The TLD performs this function accurately, reliably, and relatively inexpensively.

SRS has been monitoring ambient environmental gamma exposure rates with TLDs since 1965. The information provided by this program is used primarily to determine the impact (if any) of site operations on the gamma exposure environment and to evaluate trends in environmental exposure levels. Other potential uses include

- support of routine and emergency response dose calculation models
- assistance in determining protective action recommendations in the event of an unplanned release of gamma-emitting radionuclides
- confirmatory accident assessment

The SRS ambient gamma radiation monitoring program is divided into four subprograms, as follows: site perimeter stations, population centers, air surveillance stations, and Vogtle (stations that monitor potential exposures from Georgia Power's Vogtle Electric Generating Plant). All TLDs are exchanged quarterly.

Most gamma exposure monitoring is conducted on site and at the site perimeter. Monitoring continues to be conducted in population centers within approximately 9 miles (15 km) of the site boundary, but only limited monitoring is conducted beyond this distance and at the 25- and 100-mile air surveillance stations.

Surveillance Results

In general, the 2000 ambient gamma radiation monitoring results indicated gamma exposure rates slightly higher than those observed at the same locations in 1999. However, these results generally are consistent with previously published historical results, as indicated in figure 6–3.

Exposures at all TLD monitoring locations show some variation based on normal site-to-site and year-to-year differences in the components of natural ambient gamma exposure levels. Generally, this phenomena also is observed at both onsite and offsite locations. Table 6–2 summarizes the 2000 surveillance results, which show no significant differences in average gamma exposure rates from one monitoring network to another. During the past 3 years, the highest exposure rate consistently has been at the burial ground. Detailed analytical results from the TLD monitoring program can be found in tables 11, 12, 13, and 14 of *SRS Environmental Data for 2000*.

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 onsite streams. The practice of discharging water to seepage basins was discontinued in 1988, but stormwater accumulating in the basins continues to be monitored by EMS because of potential contamination from the basin soil.

Description of Surveillance Program

Seepage basin water is analyzed for gross alpha, gross beta, tritium, strontium, gamma-emitting radionuclides, and actinides. Analyses for specific radionuclides are determined by the makeup of previous releases to the basins.

Table 6–2
TLD Surveillance Results Summary for 2000

Monitoring Subprogram	Mean Exposure (mrem per year)	Maximum Exposure (mrem per year)	Maximum-Exposure Location
Site perimeter	78	92	Perimeter #65-D
Air surveillance	87	129	Burial Ground North
Population centers	103	123	Williston, SC
NRC/Vogtle	80	101	NRC #5

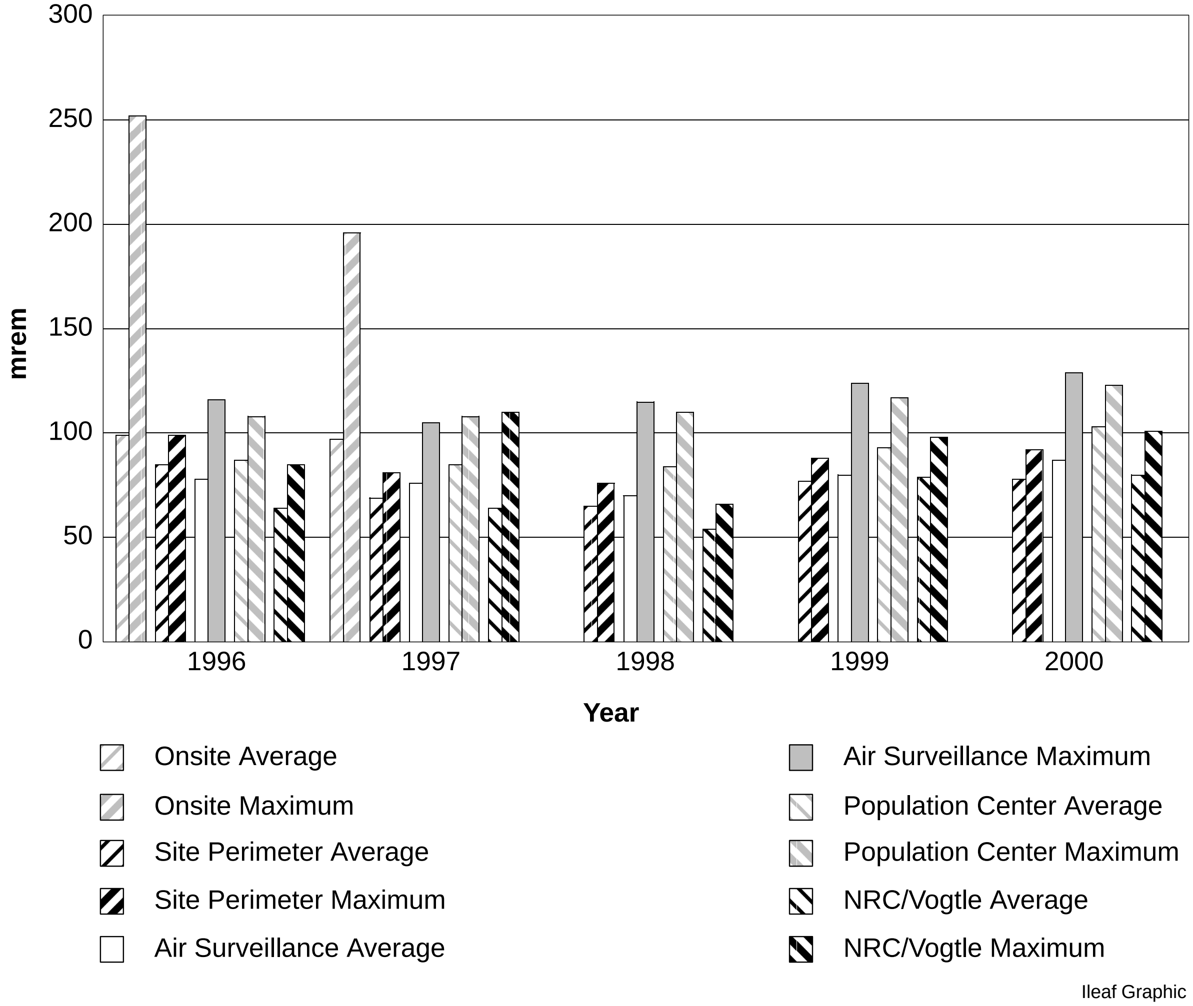


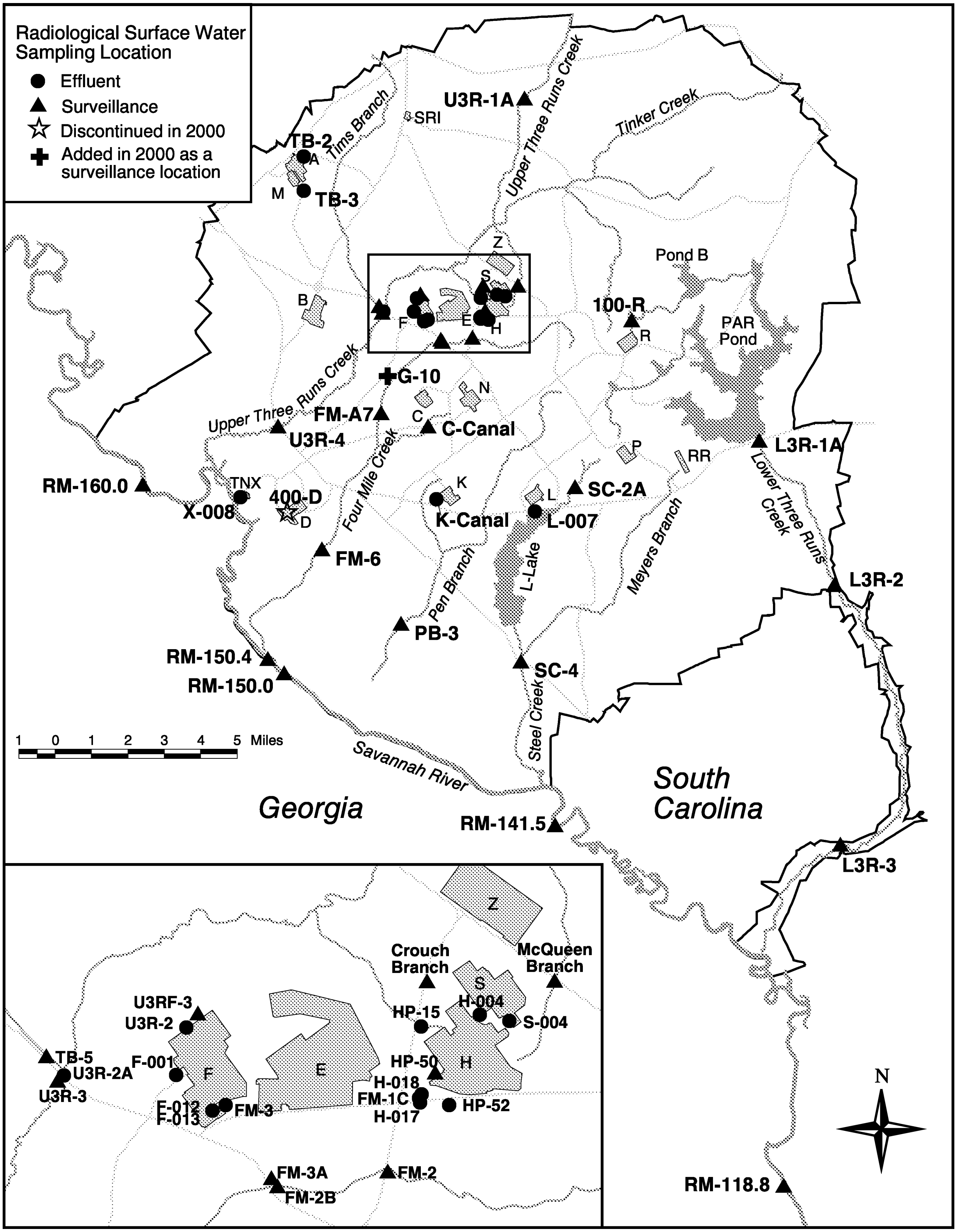
Figure 6–3 Annual Average/Maximum Gamma Exposure Grouped by Program Element, 1996–2000
Natural background gamma exposure levels remain fairly constant with time. With the exception of a few locations, onsite gamma exposure levels at SRS are similar to regional background levels.

Surveillance Results

Because of dry conditions, no samples were obtained from either the E–06 or E–003 (EAV Basin South) locations in 2000. The remaining locations—E–001, E–002, E–004, and E–05—were sampled monthly. Because there are no active discharges to site seepage basins, the primary contributor to seepage basin water is from rainwater. As a result, there has been little variation in seepage basin results in recent years (table 15, *SRS Environmental Data for 2000*). In 2000, the highest mean tritium concentration, (7.54 ± 1.08)E+03 pCi/L, was found in SWDF Basin North (E–002). This represents a decrease from the highest 1999 mean concentration—(1.19 ± 0.22)E+04 pCi/L, found at E–001. The data suggest that tritium levels in the seepage basins reflect tritium concentrations in rainwater and are remaining relatively constant. Mean cobalt-60, cesium-137, and gross alpha concentrations all were below the representative MDC for rainwater.

Site Streams

Continuous surveillance is used on several SRS streams (figure 6–4), including Tims Branch, Upper Three Runs, Four Mile Creek (also known as Fourmile Branch), Pen Branch, Steel Creek, and Lower Three Runs. 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 2000, 22 such locations on SRS streams served as environmental surveillance points.



EPD/GIS Map

Figure 6–4 Radiological Surface Water Sampling Locations
Surveillance and effluent sampling points are at SRS seepage basins and streams and on the Savannah River.

Description of Surveillance Program

The site's stream surveillance program monitors six streams—Tims Branch, Upper Three Runs, Four Mile Creek, Pen Branch, Steel Creek, and Lower Three Runs.

- Tims Branch is a tributary of Upper Three Runs, receiving effluents from M-Area and SRTC and stormwater runoff from A-Area and M-Area. The surveillance point on Tims Branch, TB–5, is located downstream of all release points and before entry into Upper Three Runs.
- Upper Three Runs receives discharges from the Effluent Treatment Facility (ETF) and S-Area; flow from Tims Branch; stormwater runoff from F-Area, H-Area, Z-Area, and S-Area; and water that has migrated from E-Area and is outcropping into the stream. Tritium, the predominant radionuclide detected in Upper Three Runs, is discharged primarily from the ETF.
- Four Mile Creek receives effluents from F-Area, H-Area, and the Central Sanitary Wastewater Treatment Facility (CSWTF); stormwater runoff from E-Area, C-Area, F-Area, and H-Area; and water that has migrated from seepage basins and E-Area and is outcropping into the stream.
- Pen Branch receives discharges and stormwater runoff from K-Area. Because K-Reactor has not operated since 1992, tritium detected in Pen Branch is attributed to groundwater seepage. The tritium sources are (1) the K-Area percolation field and seepage basins and (2) a migration source that enters the stream above PB–3.
- Lower Three Runs receives overflow from PAR Pond, a manmade pond that receives seepage from R-Area basins and stormwater runoff from P-Area and R-Area.
- Steel Creek receives releases from L-Area effluents, tritium migration from P-Area seepage basins, and stormwater runoff from P-Area and L-Area.

For all locations except U3R–1A (the control location), which is sampled weekly, sampling for gross alpha and gross beta, tritium, and gamma is performed on a biweekly composite. Actinide analyses are performed annually on grab samples from all locations, while strontium-89,90 analyses are performed annually on grab samples from all except four locations on Four Mile Creek—4M–A7, 4MC–2B, 4MC–2, and 4MC–3A. Strontium analyses at these locations are performed on biweekly composite samples. Outfall G–10 the discharge point for the CSWTF, was added as a surveillance location in 2000 to establish a baseline for monitoring radiological effluents to sanitary sewers. Sampling for gross alpha, gross beta, tritium, gamma, actinides, and strontium-89,90 is performed on a weekly composite at G–10.

Surveillance Results

The average gross alpha, gross beta, and tritium concentrations for 2000 at downstream locations near the creek mouths are presented in table 6–3. Figure 6–5 is a graph showing the average tritium concentration over a 10-year period in the five major site streams. The locations of these stations, well below all points at which radioactivity is introduced

Table 6–3
Average 2000 Concentration of Radioactivity in SRS Streams (pCi/L)

Location[a]	Gross Alpha	Gross Beta	Tritium
Onsite Downstream Locations			
Tims Branch (TB–5)	(4.31 ± 0.58)E+00	(1.53 ± 0.19)E+00	(8.46 ± 0.60)E+02
Lower Three Runs (L3R–3)	(4.81 ± 0.80)E–01	(1.50 ± 0.15)E+00	(1.28 ± 0.07)E+03
Steel Creek (SC–4)	(9.02 ± 1.51)E–01	(1.16 ± 0.14)E+00	(7.10 ± 0.29)E+03
Pen Branch (PB–3)	(2.47 ± 0.67)E–01	(8.76 ± 1.02)E–01	(9.82 ± 4.19)E+04
Four Mile Creek (FM–6)	(1.97 ± 0.55)E+00	(9.95 ± 1.16)E+00	(1.74 ± 0.08)E+05
Upper Three Runs (U3R–4)	(2.48 ± 0.31)E+00	(1.28 ± 0.15)E+00	(1.53 ± 0.31)E+04
Onsite Control Location (for comparison purposes)			
Upper Three Runs (U3R–1A)	(4.04 ± 0.28)E+00	(2.17 ± 0.21)E+00	(1.99 ± 1.85)E+02

a Site surveillance locations are near mouths of streams.

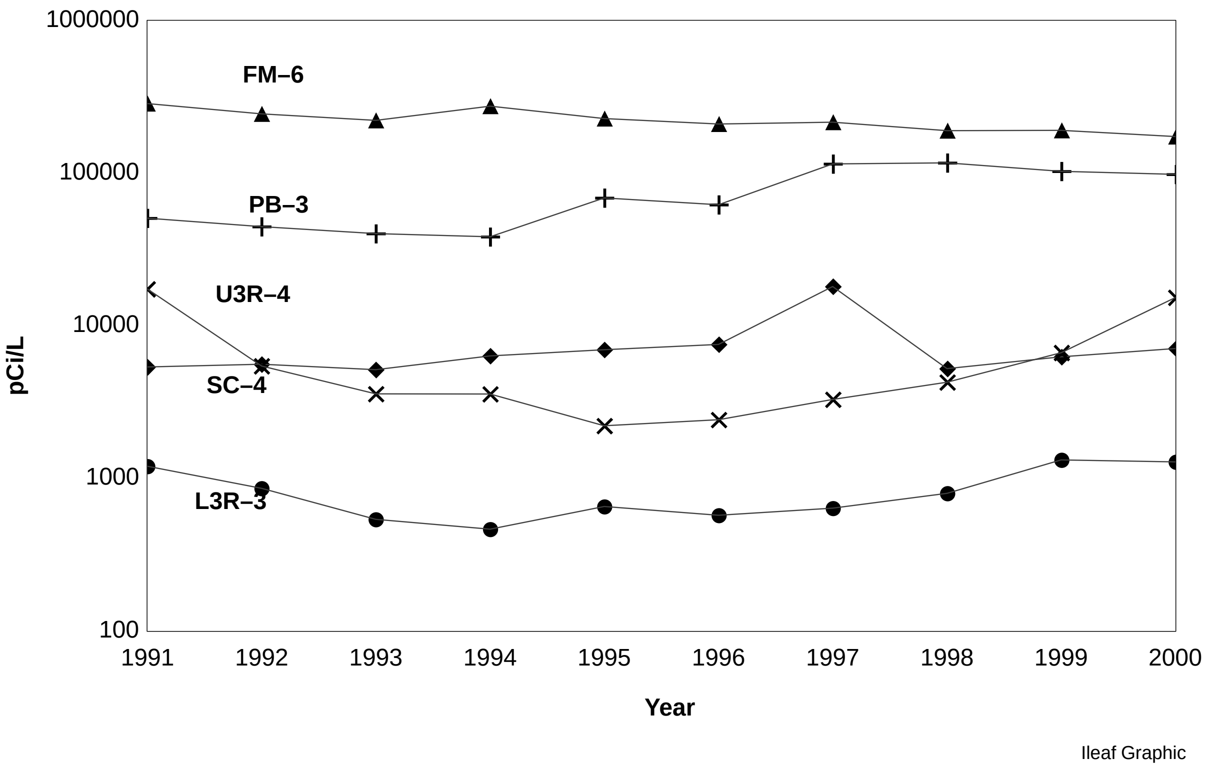


Figure 6–5 Average Tritium Concentrations in Major SRS Streams, 1991–2000
Recent trends in stream water analysis show an increase in tritium concentrations in three SRS streams.

into the respective streams, ensure that adequate mixing has taken place and that a representative sample is being analyzed.

Concentrations at control location U3R-1A (above process effluents and runoff locations on Upper Three Runs) are listed for comparison purposes in table 6–3. Detailed results of stream water analyses appear in table 16 of *SRS Environmental Data for 2000*. Five-year trend charts showing gross alpha, gross beta, and cesium-137 concentrations for each major site stream appear in figure 6–6. The results in each chart are from the monitoring point nearest the stream's discharge to the Savannah River.

Although 2000 gross alpha mean concentrations at all five major stream locations were lower than in 1999, they remained consistent with historical data.

The highest gross alpha mean concentration in 2000, found at TB–5, was (4.31 $\pm$ 0.58)E+00 pCi/L.

Mean gross beta concentrations were consistent with historical data. Strontium-89,90 and cesium-137 are contributors to gross beta activity.

Mean tritium concentrations at downstream locations were consistent with historical values except at U3R–4, where the concentration increased 130 percent over the 1999 level primarily because of increased processing at the ETF.

Seepage Basin and Solid Waste Disposal Facility Migration

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 the Solid Waste Disposal Facility (SWDF) as part of its stream surveillance program. During 2000, tritium, strontium-89,90, and cesium-137 were detected in migration releases (table 17, *SRS Environmental Data for 2000*). As noted in chapter 5 ("Radiological Effluent Monitoring"), measured iodine-129 results were not available from EMS and the value measured in 1996 was used for dose calculation. This value is reported in table 5–2 in chapter 5 and in tables 6 and 17, *SRS Environmental Data for 2000*.

Figure 6–7 is a graphical representation of releases of tritium via migration to site streams for the years 1991–2000. During 2000, the total quantity of tritium migrating from the seepage basins and SWDF was about 4,200 Ci, compared to 4,990 Ci in 1999.

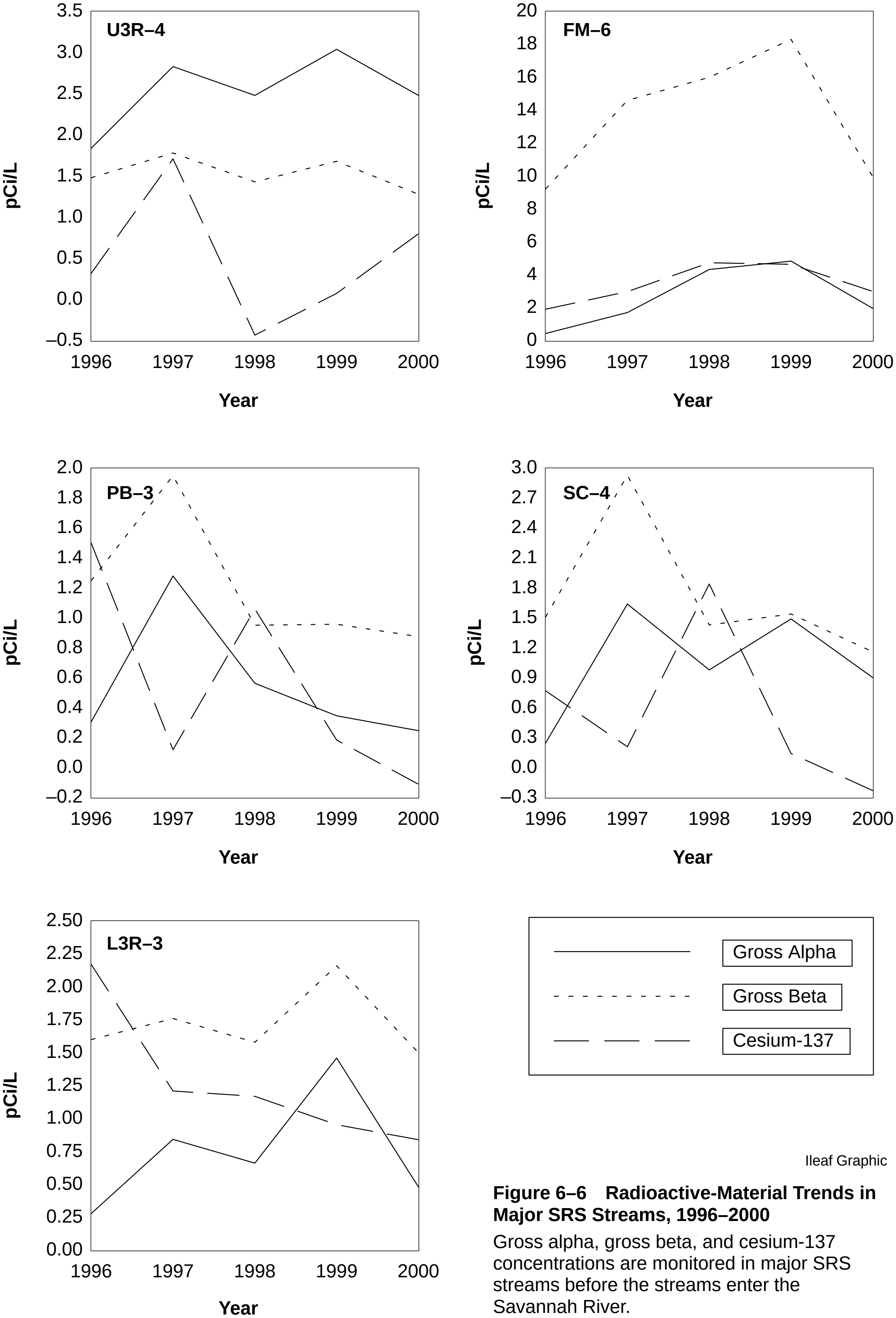


Figure 6–6 Radioactive-Material Trends in Major SRS Streams, 1996–2000

Gross alpha, gross beta, and cesium-137 concentrations are monitored in major SRS streams before the streams enter the Savannah River.

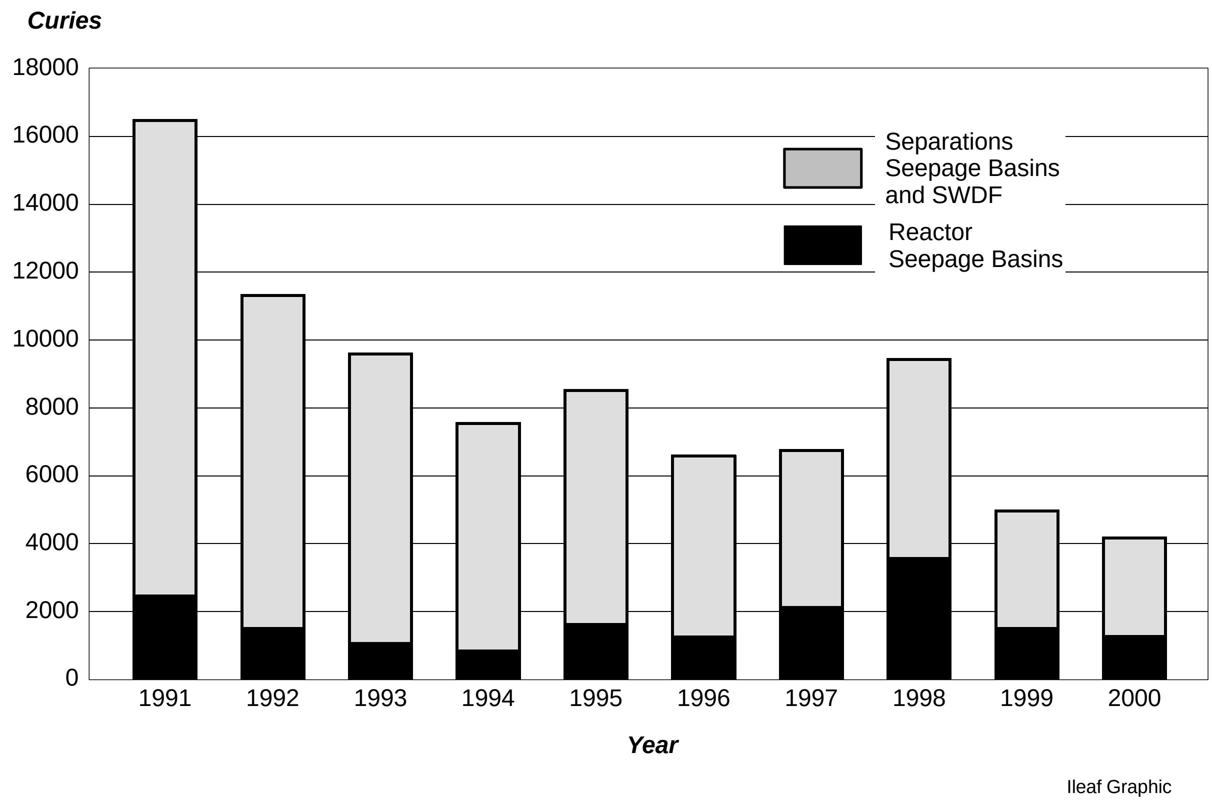


Figure 6–7 Tritium Migration from Seepage Basins and SWDF to SRS Streams, 1991–2000

The total combined tritium releases in 2000 (direct discharges and migration from seepage basins and SWDF) were about 6,000 Ci, compared to about 6,110 Ci in 1999 (table 18, *SRS Environmental Data for 2000*). Figure 6–8 shows 1991–2000 total combined tritium releases.

F-Area and H-Area Seepage Basins and SWDF

Radioactivity previously deposited in the F-Area and H-Area seepage basins and SWDF continues to migrate via the groundwater and to outcrop into Four Mile Creek (also known as Fourmile Branch) and into Upper Three Runs.

Groundwater migration from the F-Area seepage basins enters Four Mile Creek between sampling locations FM–3A, FM–2B, and FM–A7. Most of the outcropping from H-Area seepage basins 1, 2, and 3 occurs between FM–1C and FM–2B. Outcropping from H-Area seepage basin 4 and part of SWDF occurs between FM–3 and FM–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. Four Mile Creek sampling locations are shown in figure 6–4.

Measured migration of tritium from F-Area seepage basins was 353 Ci in 2000. This is a 46-percent decrease from the 1999 total of 648 Ci. The measured migration from H-Area seepage basin 4 and SWDF was 1,920 Ci, an 8-percent decrease from the 1999 total of 2,090 Ci. The measured migration from H-Area seepage basins 1, 2, and 3 was 139 Ci, a 46-percent decrease from the 1999 total of 258 Ci. Figure 6–9 shows 1991–2000 tritium migration releases from the F-Area and H-Area seepage basins and from the SWDF.

Generally, 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 [Looney, 1993]. Tritium migration from SWDF has fluctuated between 2,000 and 6,500 Ci during the past 10 years. Based on recent assessments of the operational history of SWDF and the geology and hydrology of the site, it is anticipated that, with no corrective actions, SWDF tritium migration into Four Mile Creek will continue, but slowly decrease for the next 20 to 25 years [Flach, 1996].

The measured migration from the north side of SWDF and the General Separations Area (GSA) into Upper Three Runs in 2000 was 483 Ci, a 3-percent increase from the 1999 total of 467 Ci. (The GSA is in the central part of SRS and contains all waste disposal facilities, chemical separations facilities, associated high-level waste storage facilities, and numerous other sources of radioactive material.)

A 10-year history of tritium migration releases into Upper Three Runs is shown in figure 6–10. Except for the years 1990 and 1991, tritium migration into Upper Three Runs has remained between 150 and 500 Ci per year. However, since 1996, the migration rate of tritium has been increasing. A computer-modeled groundwater migration study predicts increased tritium migration to Upper Three Runs during the next 20 years [Cook, 1997]. This analysis assumes all current and future tritium inventories will migrate relatively fast without considering past migration releases or potential corrective actions; these assumptions are considered to be conservative. A complete and thorough assessment of tritium migration into Upper Three Runs that is based on measured groundwater concentrations and movement has not yet been performed.

As required by the Resource Conservation and Recovery Act (RCRA) Part B Permit, SRS is developing SWDF groundwater corrective action plans for South Carolina Department of Health and Environmental Control (SCDHEC) approval. Portions of SWDF also are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA characterization and assessment continued in 2000. 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, or are currently being implemented, as components of SWDF remediation. Remediation is discussed in chapter 4, “Environmental Management.”

The total amount of strontium-89,90 entering Four Mile Creek from the GSA seepage basins and SWDF during 2000 was estimated to be 53 mCi. This was a 32-percent decrease from the 1999 level of 78 mCi.

In addition, a total of 70.4 mCi of cesium-137 was estimated to have migrated from the GSA seepage basins and SWDF in 2000. As discussed previously, iodine-129 was not measured in Four Mile Creek

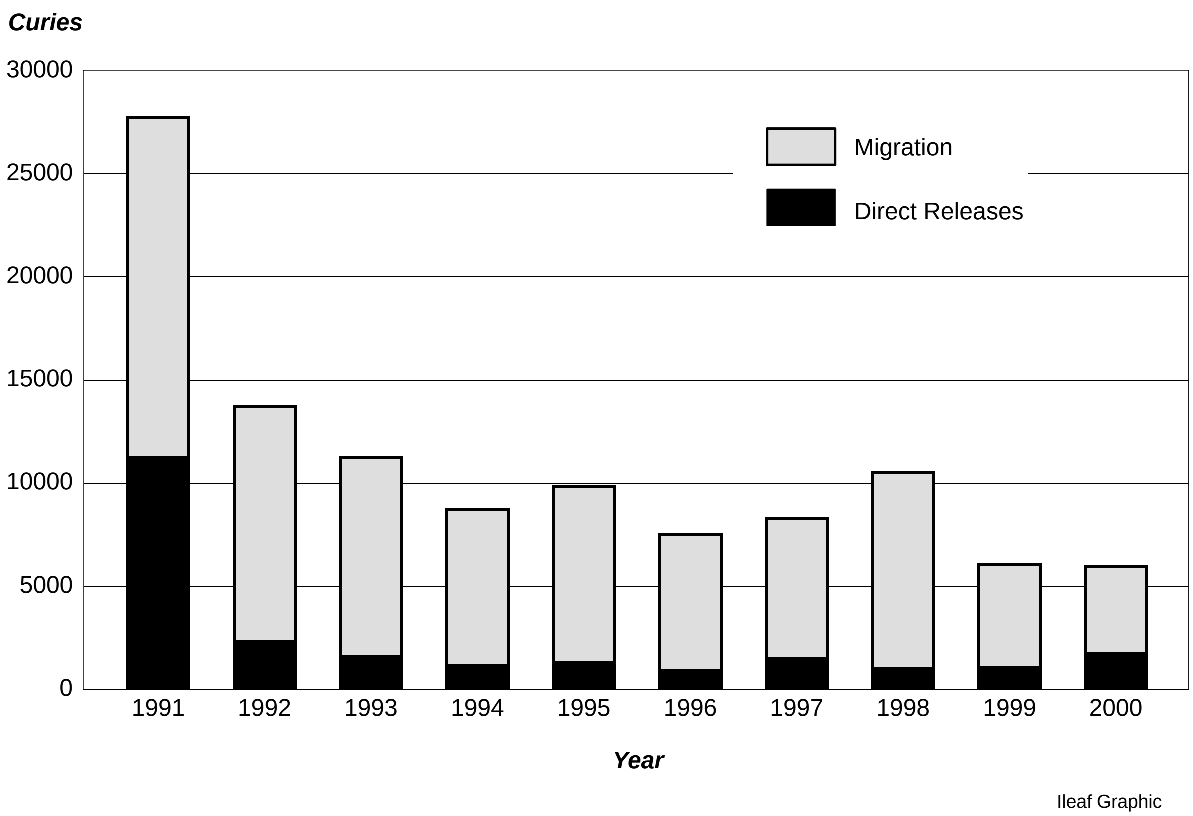


Figure 6–8 Total Tritium Releases to SRS Streams (Direct Discharges and Migration), 1991–2000, Based on Point-of-Release Concentrations and Flow Rates

water samples during 2000. It was assumed that 78.2 mCi migrated from the GSA seepage basins in 2000. This was the amount last measured (during 1996).

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. No discharges were made in 2000. Tritium migration from the seepage basin and the percolation field is measured in Pen Branch. The 2000 migration total of 1,040 Ci represents a 10-percent decrease from the 1,160 Ci recorded in 1999.

P-Area, C-Area, and L-Area Seepage Basins

Liquid purges from the P-Area, L-Area, and C-Area disassembly basins were released periodically to their respective seepage basins from the 1950s until 1970. Purge water was released to the reactor seepage basins to allow a significant part of the tritium to decay before the water outcropped to surface streams and flowed into the Savannah River. The delaying action of the basins reduced the dose that users of water from downriver water treatment plants received from SRS tritium releases. Between 1970 and 1978, disassembly basin purge water was released directly to SRS streams. However, 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, and the periodic release of liquid purges to the seepage basins was resumed. But because of subsequent mission changes at the site, these basins no longer are in service for receiving liquid purges from disassembly basins.

No radionuclide migration was attributed to the C-Area seepage basin in 2000. 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 265 Ci of tritium migrated from the P-Area seepage basin during 2000, 28 percent less than the 369 Ci of tritium in 1999. No migration of

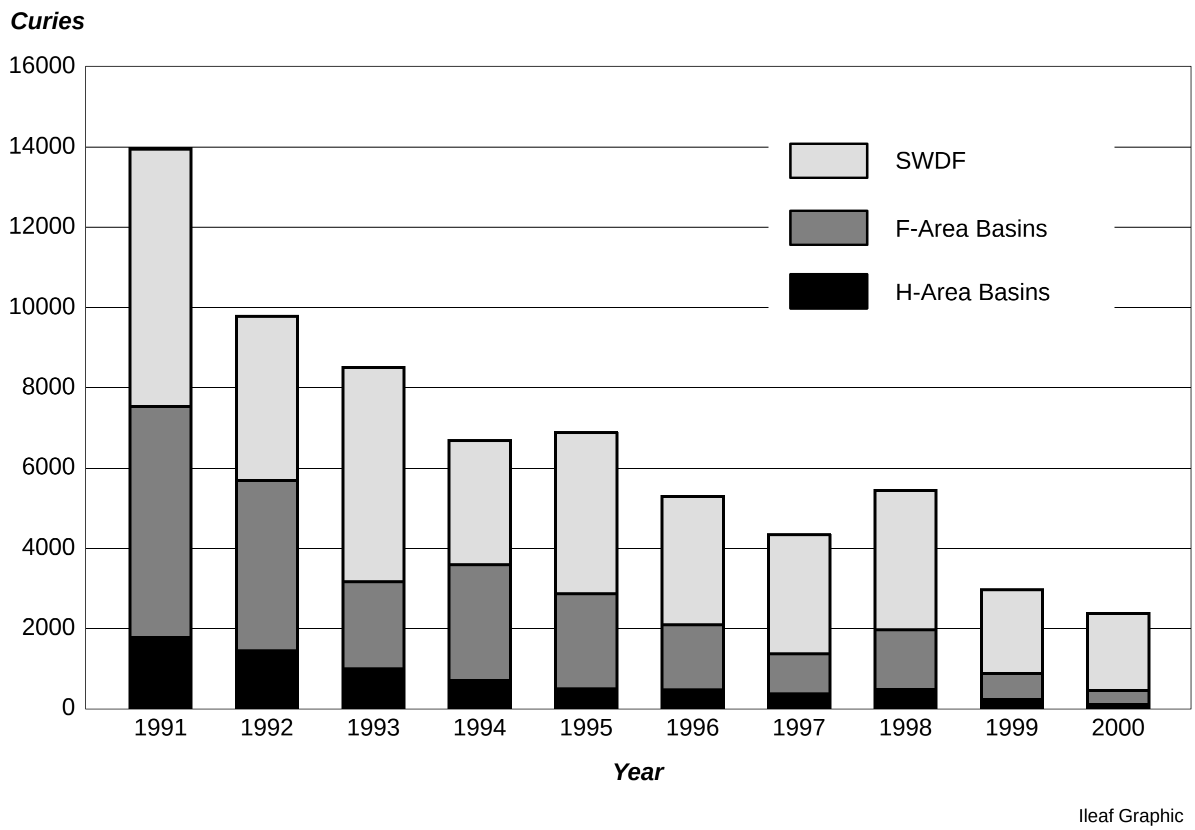


Figure 6–9 Tritium Migration Releases to Four Mile Creek from the F-Area and H-Area Seepage Basins and SWDF, 1991–2000

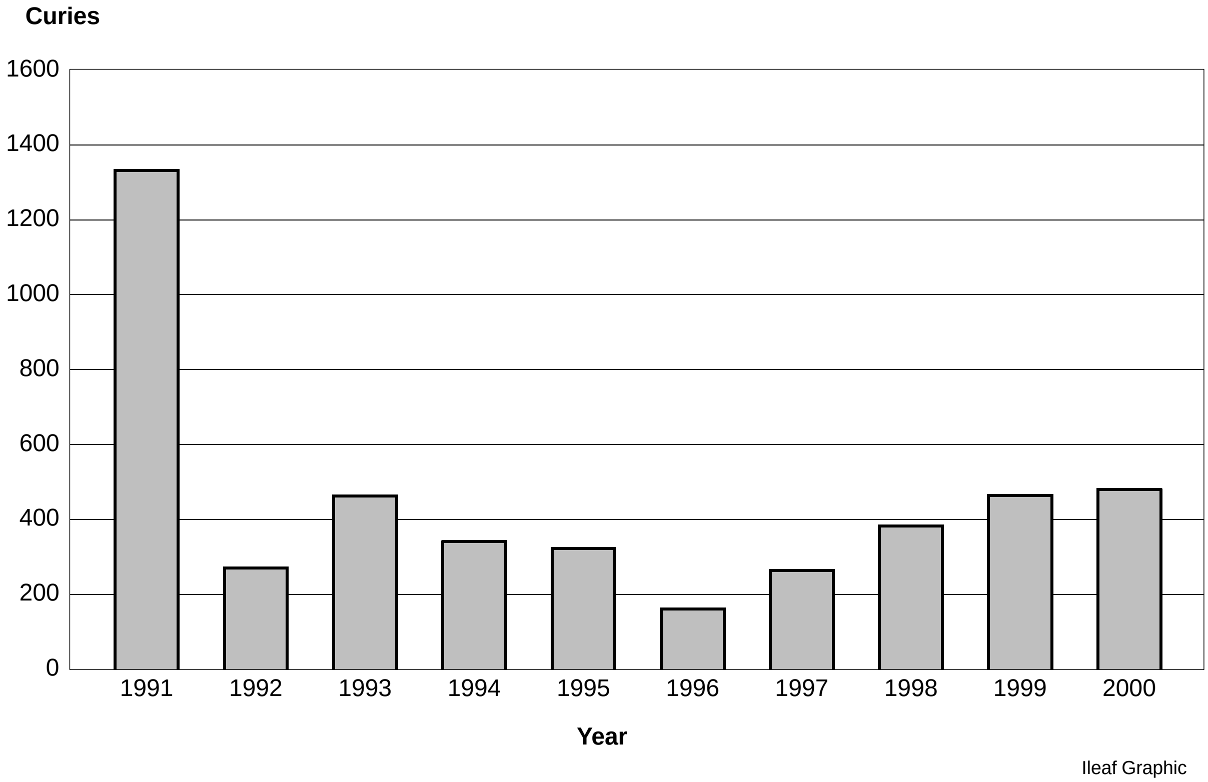


Figure 6–10 Tritium Migration Releases to Upper Three Runs from the General Separations Area and SWDF, 1991–2000

radionuclides from the L-Area seepage basin was detected in site streams.

Transport of Actinides in Streams

In 1996, a new and more sensitive analytical method for actinides was implemented for the analysis of uranium, plutonium, americium, and curium. As a result of the increased sensitivity, trace amounts of uranium and plutonium were detected at the stream transport locations FM–6, PB–3, L3R–2, and U3R–4. Uranium was in most stream samples at approximately natural uranium-234/uranium-238 ratios. Plutonium-238, plutonium-239, americium-241, and curium-244 were found at low concentrations at HP–50. A few other samples had some of these radionuclides at barely detectable levels. Because the levels remained relatively low from 1996 through 1999, analysis of biweekly samples from these four locations was discontinued in 2000. Uranium, plutonium, americium, and curium now are analyzed on an annual grab sample from each stream location. Values for 2000 (table 16, *SRS Environmental Data for 2000*) were consistent with historical data.

Savannah River

Continuous surveillance is performed along the Savannah River at points above and below SRS and below the point at which Plant Vogtle liquid discharges enter the river.

Description of Surveillance Program

In 2000, five locations along the river continued to serve as environmental surveillance points. River sampling locations are shown in figure 6–4. Composite samples are collected weekly at the five river locations and analyzed for gross alpha, gross beta, tritium, and gamma-emitting radionuclides. An annual grab sample is obtained at each location and analyzed for strontium-89,90 and actinides.

Surveillance Results

Detailed results of Savannah River water analyses can be found in table 19 of *SRS Environmental Data for 2000*.

Gross Alpha, Gross Beta, and Tritium

The average concentrations of gross alpha, gross beta, and tritium at river locations are presented in table 6–4. The order of the locations begins at RM (river

Table 6–4
Average 2000 Concentration of Radioactivity in the Savannah River (pCi/L)

Location	Gross Alpha	Gross Beta	Tritium
RM–160.0	(2.14 ± 0.54)E–01	(2.13 ± 0.14)E+00	(1.10 ± 0.16)E+02
RM–150.4	(1.00 ± 0.17)E+00	(2.72 ± 0.15)E+00	(2.22 ± 0.44)E+03
RM–150.0	(1.99 ± 0.47)E–01	(1.97 ± 0.10)E+00	(2.13 ± 0.07)E+03
RM–141.5	(2.70 ± 0.58)E–01	(2.02 ± 0.10)E+00	(1.42 ± 0.08)E+03
RM–118.8	(1.55 ± 0.41)E–01	(2.01 ± 0.09)E+00	(1.18 ± 0.07)E+03

mile)–160.0, above the site, and ends at RM–118.8, after all site streams enter the Savannah River. Samplers situated between RM–160.0 and RM–118.8 are located at regular intervals along the SRS boundary and where Plant Vogtle's discharges feed into the river. RM–118.8 is the location of the site's hypothetical maximally exposed individual (chapter 7, "Potential Radiation Doses").

Tritium is the predominant radionuclide detected above background levels in the Savannah River. The annual mean tritium concentration at RM–118.8 was (1.18 ± 0.07)E+03 pCi/L, which is about 6 percent of the drinking water standard.

The average alpha concentration at each river location was below the representative MDC in 2000, which demonstrates the absence of significant alpha-emitting radionuclides in the river. However, the concentrations from two weekly samples collected at RM–150.4 were above historical levels; the maximum concentration was (6.69 ± 1.23)E+00 pCi/L. The average alpha activity level at RM–118.8 was about the same as the level at RM–160.0, which is the sampling location upstream of all SRS discharge points.

Gross beta activities at all locations were slightly above the representative MDC for the analysis in 2000. Mean and maximum concentrations were similar at all locations, indicating that there was no significant release of beta-emitting nuclides attributable to SRS discharges.

Cesium-137, Cobalt-60, Strontium-89,90, and Actinides

The mean concentrations for cesium-137 and cobalt-60 were below the representative MDC for analysis in 2000. However, the maximum concentrations at RM 150.4 were slightly above the representative MDC. Activity levels for strontium-89,90—as well as for all actinides, including isotopes of uranium and plutonium—were at or slightly above the MDC.

Tritium Transport in Streams and River

Tritium is introduced into SRS streams and the Savannah River from 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 (table 20, *SRS Environmental Data for 2000*). The balance is evaluated among the following alternative methods of calculation:

- tritium releases from effluent release points and calculated seepage basin and SWDF migration (direct releases; totals appear on page 88)
- 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 of SRS after subtraction of any measured contribution above the site (river transport)

During 2000, the total tritium transport in SRS streams decreased by approximately 5 percent (from 6,290 Ci in 1999 to 5,960 Ci in 2000). The 2000 measured tritium transport in the Savannah River (5,420 Ci) was less than the stream transport total. Estimated tritium releases in SRS streams and the Savannah River can be found in table 18 of *SRS Environmental Data for 2000*.

SRS tritium transport data for 1960–2000 are detailed in table 20, *SRS Environmental Data for 2000*, and depicted in figure 6–11, which shows summaries of the past 41 years of direct releases, stream transport, and river transport determined by EMS.

General agreement between the three calculational methods of annual tritium transport—measurements

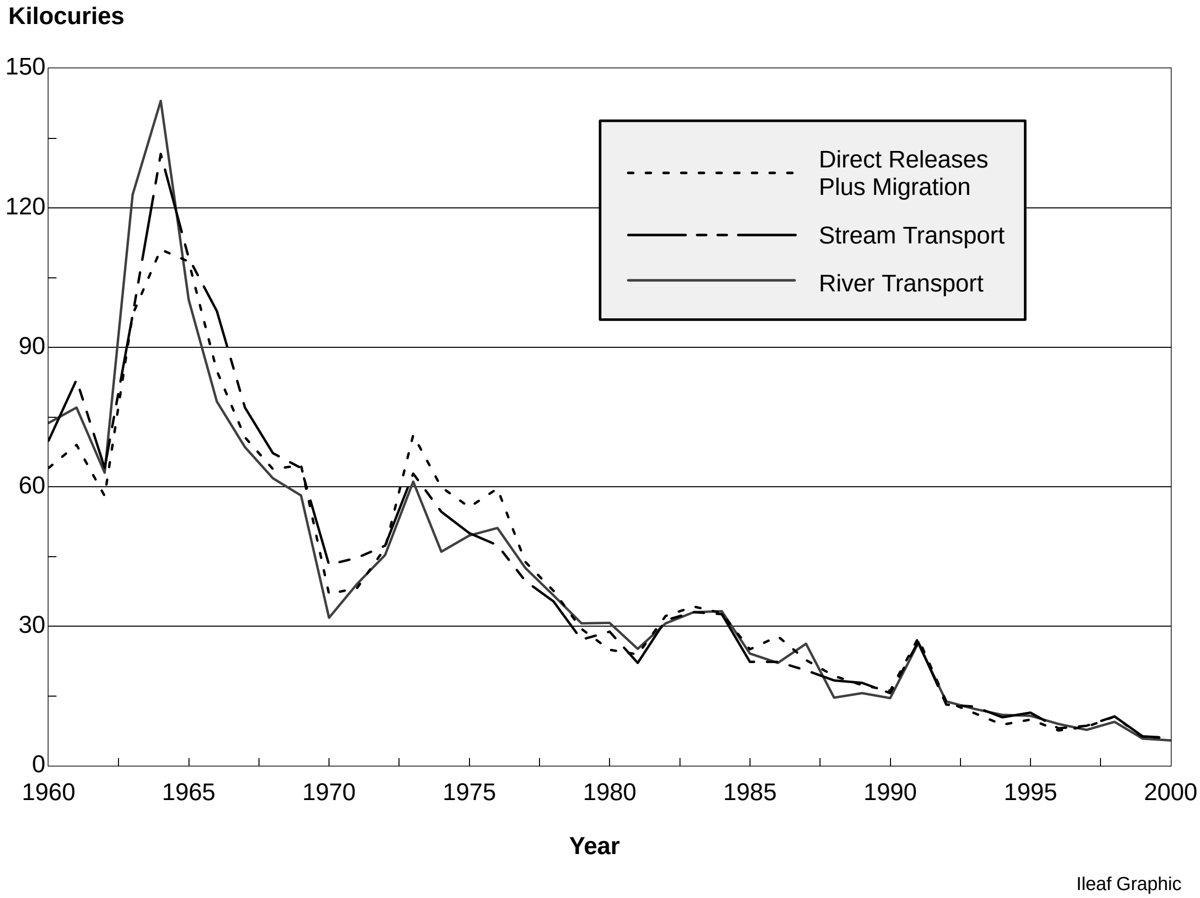


Figure 6–11 SRS Tritium Transport Summary, 1960–2000
SRS has maintained a tritium balance of direct releases plus migration, stream transport, and river transport since 1960 in an effort to account for and trend tritium releases in liquid effluents from the site. The general downward slope over time indicates that tritium transport has decreased as production has slowed and effluent controls have been developed.

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 the determination of water flow rates and of varying transport times.

In calculating doses from tritium, the stream transport value is used instead of the the river transport value or the direct-plus-migration value (chapter 5). This is because the stream transport value—measured in site streams just prior to their discharge to the Savannah River—most accurately reflects the actual amount of aqueous tritium leaving the site (chapter 7).

Drinking Water

EMS collects drinking water samples from locations at SRS and at water treatment facilities that use Savannah River water. Potable water is analyzed at offsite treatment facilities to ensure that SRS operations are not adversely affecting the water supply and to provide voluntary assurance that drinking water does not exceed EPA drinking water standards for radionuclides.

Description of Surveillance Program

Onsite sampling consists of quarterly grab samples at large treatment plants in A-Area, D-Area, and K-Area and annual grab samples at wells and small systems. Collected monthly off site are composite 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
- the North Augusta (South Carolina) Water Treatment Plant

At all the offsite facilities, raw and finished water samples are collected daily and composited for analysis by EMS. All drinking water samples are screened for alpha, beta, and gamma emitters and analyzed specifically for tritium. The onsite samples also are analyzed once a year for actinides and strontium-89,90.

Surveillance Results

Gross Alpha and Gross Beta

All drinking water samples collected by EMS are screened for gross alpha and gross beta concentrations to determine if activity levels warrant further analysis (table 21, *SRS Environmental Data for 2000*). No samples collected in 2000 exceeded EPA's 1.50E+01-pCi/L alpha activity limit or 5.00E+01-pCi/L beta activity limit. In 2000, the highest alpha concentration in SRS drinking water was (0.88 ± 0.21)E+01-pCi/L—at the 701-5G Aiken Barricade (Talatha Gate). No samples have exceeded 8.00E+00 pCi/L of beta activity—the EPA limit for strontium-90, which is the most restrictive beta-emitting radionuclide.

Tritium

No onsite or offsite drinking water samples collected and analyzed by EMS in 2000 exceeded the 2.00E+04-pCi/L EPA tritium limit. The highest level observed was (2.24 ± 0.13)E+03 pCi/L—at 701–13G (Patrol Gate 6). 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 2000, (9.98 ± 1.04)E+02 pCi/L, was 4.99 percent of the EPA drinking water limit. The average tritium concentration at Port Wentworth, (9.55 ± 0.90)E+02 pCi/L, was 4.83 percent of the EPA drinking water limit. The levels of tritium at both treatment facilities were not significantly different than those measured in 1999.

Strontium

Only one drinking water sample collected and analyzed by EMS for strontium 89,90 in 2000 exceeded the 1.40E+00-pCi/L representative MDC.

Other Radionuclides

No cobalt-60, cesium-137, plutonium-238, or plutonium-239 were detected in any drinking water samples collected during 2000. Samples from some locations showed detectable levels of ranium isotopes and/or americium-241 and curium-244.

Terrestrial Food Products

The terrestrial food products surveillance program consists of radiological analyses of food product samples typically found in the Central Savannah River Area (CSRA). Because radioactive materials can be transported to man through the consumption of milk and other food products containing radioactivity, food product samples are analyzed to determine what effects, if any, SRS operations have on them. Data from the food product surveillance program are not used to show direct compliance with any dose standard; however, the data can be used as required to verify dose models and determine environmental trends.

Description of Surveillance Program

Meat, Fruit, and Greens

The food products surveillance program divides the area that surrounds the SRS, approximately 9 miles (15 km) beyond its perimeter, into four quadrants: northeast, southeast, southwest, and northwest. Samples of food—including meat (beef or chicken), fruit (peaches or melons), and green vegetables (collards)—are collected from one location within each of the quadrants and from a control location within an extended (to 25 miles beyond the perimeter) southeast quadrant. All food samples are collected annually except milk.

Food samples are analyzed for the presence of gamma-emitting radionuclides, tritium, strontium-89,90, plutonium-238, and plutonium 239.

Milk

During 2000, EMS collected milk samples at five dairies within a 25-mile radius of SRS and from locally produced inventories of a major distributor.

Milk samples are collected monthly to be analyzed for the presence of tritium and gamma-emitting radionuclides, primarily cesium-137 and iodine-131. Additional samples are collected quarterly to be analyzed for the presence of strontium-89,90.

Surveillance Results

The 10 samples of milk collected during two quarters were analyzed for strontium-90, rather than strontium-89,90, in 2000 because of a laboratory error. Detailed results of all food sample analyses can be found in tables 22 and 23 in *SRS Environmental Data for 2000*.

Gamma-Emitting Radionuclides

The only manmade gamma-emitting radionuclide detected in food products, excluding milk, was cesium-137, which was found in four beef samples and two greens samples. The maximum concentration, (2.66 ± 1.44)E–02 pCi/g, was measured in beef from the 0–10-mile southwest quadrant. Generally, concentrations of cesium-137 in indicator samples were similar to those measured at the control location. These concentrations were similar to those observed in previous years.

Cesium-137 also was the only manmade gamma-emitting radionuclide detected in milk samples during 2000. Measured maximum concentrations ranged from a high of (4.27 ± 1.92)E+00 pCi/L at the Gracewood, Georgia, location to lows below the representative MDC at several locations. The mean concentrations measured in 2000 were similar to those measured in 1999.

Iodine-131 was not detected in any 2000 milk samples. Because of its short physical half-life (8 days), iodine-131 generally is not detected, except

- shortly after tests of nuclear weapons
- in the wake of events such as the Chernobyl incident
- during reactor operations
- when processing fresh fuel
- when the isotope is used medically, industrially, or for research.

Tritium

Tritium in milk and other samples is attributed primarily to releases from SRS. Tritium concentrations in food products, excluding milk, ranged from a high of (1.88 ± 0.03)E–00 pCi/g, measured in greens from the 0–10-mile northwest quadrant, to lows below the representative MDC in several samples. The concentrations were similar to those measured in 1999.

No tritium was detected above the representative MDC in any milk samples collected during 2000. The tritium concentrations measured in milk during 2000 were slightly lower than in 1999 and generally reflected atmospheric releases from the site.

Strontium

The highest strontium-89,90 concentration detected in food products, excluding milk, during 2000 was (3.33 ± 0.19)E–01 pCi/g—found in greens from the northeast quadrant; the lowest was below the representative MDC at several locations. Strontium-89,90 levels generally were within the ranges observed during past years.

The 2000 results from the analysis of milk for strontium-89,90 and strontium-90 showed concentrations ranging from above the representative MDC to below the representative MDC in samples from all locations. The maximum concentration, (6.24 ± 4.89)E+00 pCi/L, was in a sample from the Denmark, South Carolina, location dairy.

Plutonium

No plutonium-238 or plutonium-239 concentrations in food products, excluding milk, were detected above the representative MDC during 2000.

Aquatic Food Products

Description of Surveillance Program

The aquatic food product surveillance program includes both fish (freshwater and saltwater) and shellfish. To determine the potential dose and risk to the public from consumption of these fish, both are sampled.

Nine surveillance points for the collection of freshwater fish are located on the Savannah River (figure 6–12). These points are at

- the New Savannah Bluff Lock and Dam area (the control location), above the site
- five areas where site streams enter the Savannah River
- the U.S. Highway 301 bridge area, below the site
- Stokes Bluff Landing, below the site
- the U.S. Highway 17 bridge area, below the site

Nine surveillance points for freshwater fish collection also are located within the SRS boundary. These points are at PAR Pond, L-Lake, Pond B, Lower Three Runs, Upper Three Runs, Beaver Dam Creek, Pen Branch, Steel Creek, and Four Mile Creek. Freshwater fish are grouped into one of three categories: bass, panfish (bream), or catfish.

Saltwater fish are collected downstream from the U.S. Highway 17 bridge area and include composites of sea trout, red drum (spottail bass), and mullet. The fish are selected for sampling 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 GDNR’s Wildlife Resources Division.

For analysis purposes, five fish from each category at each collection location are combined to create a composite. Composites are divided into edible (meat and skin only) and nonedible (scales, head, fins, viscera, bone) portions; however, catfish are skinned

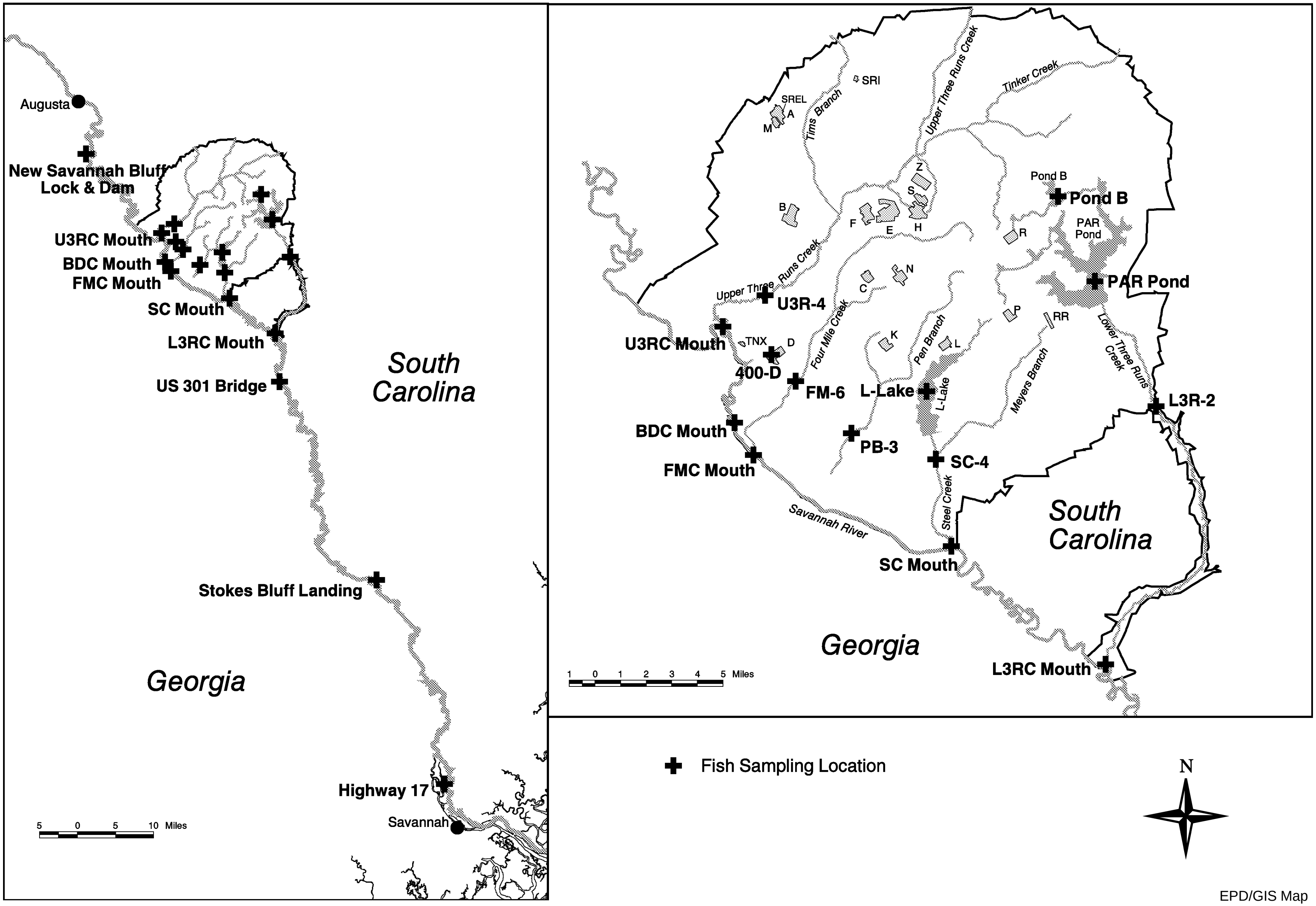


Figure 6–12 SRS Fish Sampling Locations

SRS collects fish (for both radiological and nonradiological analyses) from the Savannah River above, adjacent to, and below the site, as well as at Stokes Bluff Landing and near Savannah, Georgia.

and the skin becomes part of the nonedible composite. Analyses are conducted for gross alpha and gross beta on edible portions for all locations and on nonedible portions for all offsite locations except those at Stokes Bluff Landing and at the U.S. Highway 17 bridge area. Freshwater fish collected from the New Savannah Bluff Lock and Dam location downstream through the U.S. Highway 301 bridge area also are analyzed for strontium-89,90; plutonium-238 and plutonium-239 and tritium (edible portions only); and gamma-emitting radionuclides. Freshwater fish (edible portions only) from river locations at Stokes Bluff Landing and the U.S. Highway 17 bridge area and from onsite streams and ponds are analyzed for gross alpha, gross beta, and gamma-emitting radionuclides.

Saltwater fish (edible portions only) also are analyzed for gross alpha, gross beta, and gamma-emitting radionuclides.

In the shellfish surveillance program, samples of oysters and crabs are collected on the coast near Savannah. The shellfish are analyzed for gross alpha, gross beta, strontium-89,90, and gamma-emitting radionuclides.

Calculations of risk from the consumption of fish from the Savannah River can be found in chapter 7.

Surveillance Results

In the following surveillance results discussion, uncertainty values are provided because most measurements were at or near the lower limit of detection (LLD).

One sample of fish from Lower Three Runs was inadvertently used by lab personnel for method development, rather than standard analysis, so only two samples were analyzed from this location.

Freshwater Fish

Detailed analytical results from freshwater fish composites can be found in table 24 of *SRS Environmental Data for 2000*.

Savannah River All categories of freshwater fish from all nine Savannah River locations were collected during 2000.

Gross alpha activity in Savannah River edible and nonedible composites was below the LLD at all nine sampling locations.

Gross beta activity in Savannah River edible composites was detectable at all nine locations and was attributed primarily to the naturally occurring radionuclide potassium-40. The values ranged from a high of $(4.93 \pm 0.15)E+00$ pCi/g in bass from the mouth of Four Mile Creek to lows below the LLD in several composites. Gross beta activity in river nonedible composites was detectable at all seven locations, ranging from a high of $(4.59 \pm 1.25)E+00$ pCi/g in bass from the mouth of Four Mile Creek to lows below the LLD in several composites.

Cesium-137 was the only manmade, gamma-emitting radionuclide detected in 2000 fish composites. Cesium-137 activity in Savannah River edible composites was detectable at all nine sampling locations, ranging from a high of $(1.58 \pm 0.09)E+00$ pCi/g in bass from the mouth of Steel Creek to lows below the LLD in several composites. Cesium-137 activity in river nonedible composites was detectable at all seven sampling locations, ranging from a high of $(4.20 \pm 0.38)E–01$ pCi/g in bass from the mouth of Lower Three Runs to lows below the LLD in several composites.

Strontium-89,90 activity in Savannah River edible fish in 2000 was detectable at all seven sampling locations, ranging from a high of $(5.36 \pm 1.40)E–02$ pCi/g in bream from the mouth of Four Mile Creek to lows below the LLD in several composites. Strontium-89,90 in river nonedible composites was detectable at all seven sampling locations, ranging from a high of $(4.21 \pm 0.44)E–01$ pCi/g in catfish from the mouth of Beaver Dam Creek to a lows below the LLD in several composites.

Tritium activity in Savannah River edible composites in 2000 was detectable at all of the seven sampling locations and ranged from a high of $(1.09 \pm 0.04)E+00$ pCi/g in bream from the mouth of Four Mile Creek to lows below the LLD in several composites.

Onsite Streams and Ponds Not enough fish of appropriate size could be collected from onsite streams and ponds in 2000 for any composite samples (five from the same category per location) from Four Mile Creek, Pen Branch, Steel Creek, Beaver Dam Creek, or Upper Three Runs.

Gross alpha activity in fish composites (edible portions only) from onsite streams and ponds was below the LLD at all of the four sampled locations. Gross beta activity, on the other hand, was detectable at all of these locations and ranged from a high of $(5.89 \pm 0.14)E+01$ pCi/g in bass from Pond B to below the LLD in bass from L-Lake.

Cesium-137—the only manmade, gamma-emitting radionuclide found in 2000 fish composites from onsite streams and ponds—was detectable at all four sampled locations. The activity ranged from a high of

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EMS personnel monitor animals during SRS's 2000 deer/feral hog hunt. All animals harvested during the annual hunts are monitored prior to being turned over to the hunters to ensure compliance by the site with DOE radiological release limits.

(7.88 ± 0.40)E+01 pCi/g in bass from Pond B to a low of (3.73 ± 0.41)E–01 pCi/g in bream from L-Lake.

Saltwater Fish

In the saltwater fish category, red drum (spottail bass) sea trout, and mullet were collected in 2000 from the U.S. Highway 17 bridge area; the only composite sample of sea trout collected had to be discarded after the freezer housing it broke down, resulting in the decay of the sample. All gross alpha concentrations measured in saltwater fish composites during 2000 were below the representative MDC. Gross beta concentrations, however, were detectable in all six composites analyzed (out of the seven collected) and ranged from a high of (6.97 ± 1.18)E–01 pCi/g in spottail bass to a low of (4.27 ± 1.04)E–01 pCi/g, in mullet.

Cesium-137—at a concentration of (5.81 ± 1.77)E–02 pCi/g—was detected in one red drum sample. Concentrations in the other two red drum samples were below the representative MDC. Detailed analytical results from saltwater fish composites can be found in table 25 of *SRS Environmental Data for 2000*.

Shellfish

A sample of oysters and a sample of crabs—both from near the mouth of the Savannah River—were collected in 2000. Analytical results showed that no manmade radionuclides above the LLDs were present in these samples (table 26, *SRS Environmental Data for 2000*).

Deer and Hogs

Description of Surveillance Program

Annual hunts, open to members of the general public, are conducted at SRS to control the site's deer and feral hog populations and to reduce animal-vehicle accidents. Before any animal is released to a hunter, EMS uses portable sodium iodide detectors to perform field analysis for cesium-137. The dose resulting from consumption is calculated for each animal, and each hunter's cumulative total is tracked to ensure compliance with the DOE dose limit for the general public. Media samples (muscle and/or bone) are collected periodically for laboratory analysis based on a set frequency, on cesium-137 levels, and/or on exposure limit considerations.

Surveillance Results

During 2000, a total of 294 deer and 38 feral hogs were taken from the site as part of the controlled hunt program. This compares with 1,003 deer and 45 feral hogs taken during the 1999 hunts. The number of hunts, which is determined each year by site safety and wildlife management concerns, increased from 12 to 14 in 2000. However, the 2000 deer hunts were limited largely to bucks as part of the site's herd management program. This is the main reason for the significant drop in animals harvested.

Gamma-Emitting Radionuclides

In 2000, the maximum field measurement of cesium-137 in deer muscle was approximately 57 pCi/g, while the mean cesium-137 concentration was approximately 2 pCi/g. In feral hogs, the maximum field measurement of cesium-137 in muscle was approximately 17 pCi/g, while the mean concentration was approximately 3 pCi/g.

Each animal is monitored prior to release, and the field measurements are supplemented by laboratory analyses. Samples are collected from approximately 10 percent of the animals processed, including every 10th animal monitored and any animal that it is estimated will result in a hunter's annual dose exceeding 25 mrem (approximately 25 percent of the DOE limit)—either alone or in combination with previous animals killed by the hunter. In 2000, 30 samples from 30 animals were collected and analyzed for gamma-emitting radionuclides.

As observed during previous hunts, cesium-137 was the only manmade gamma-emitting radionuclide detected during laboratory analysis. Generally, the cesium-137 concentrations measured by the field and lab methods were comparable. Field measurements ranged from approximately 1 pCi/g to 57 pCi/g, while lab measurements ranged from approximately 1 pCi/g to 68 pCi/g.

Strontium

Strontium levels are determined in some of the animals analyzed for cesium-137. Typically, muscle and bone samples are collected for analysis from the same animals checked for cesium-137, and the samples are analyzed for strontium-89,90.

In 2000, five muscle samples from five animals were collected for strontium-89,90 analysis. Consistent with observations from previous years, none of the samples contained detectable Sr-89,90 activity. Because of the reduced size of the 2000 harvest, no bone samples were collected.

Turkeys

Description of Surveillance Program

Wild turkeys are trapped on site by the South Carolina Wildlife and Marine Resources Department and used to repopulate game areas in South Carolina and other states. All turkeys are monitored for cesium-137 with portable sodium iodide detectors before leaving SRS. No turkey with a reading above 25 pCi/g is released off site.

Surveillance Results

EMS monitored 43 turkeys in 2000. Concentrations of cesium-137 generally were similar to those measured in the past, with all results 5.0 pCi/g or less. This compares to maximum concentrations in 1999 of 4.0 pCi/g, in 1998 of 5.0 pCi/g, in 1997 of 6.0 pCi/g, and in 1996 of 5.0 pCi/g. All concentrations below the LLD are assigned a value of 1.0 pCi/g.

Beavers

Description of Surveillance Program

The U.S. Forest Service administers a contract for the trapping of beavers in selected areas within the SRS perimeter. The purpose of this 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, to primary and secondary roads, and to railroad beds. All beavers are monitored for cesium-137 with portable sodium iodide detectors and disposed of in the SRS sanitary landfill.

Surveillance Results

Twenty-three beavers were monitored at SRS in 2000; the highest concentration of cesium-137 found in one of these animals was 47 pCi/g. This compares with concentrations of less than 1.0 pCi/g in all 11 beavers monitored in 1998 (none were monitored in 1999). Maximum concentrations for previous years included 12.5 pCi/g in 1997 and 10.5 pCi/g in 1996.

Soil

The SRS soil monitoring program provides

- data for long-term trending of radioactivity deposited from the atmosphere (both wet and dry deposition)

- information on the concentrations of radioactive materials in the environment

Routine and nonroutine SRS atmospheric releases, as well as worldwide fallout, are monitored in this program. The concentrations of radionuclides in soil vary greatly among locations because of differences in rainfall patterns and in the mechanics of retention and transport in different types of soils. Because of this program's design, a direct comparison of data from year to year is not appropriate.

Description of Surveillance Program

Soil samples were collected in 2000 from four uncultivated and undisturbed onsite locations—in E-Area (burial ground), F-Area, H-Area, and Z-Area (one sample from each area)—and from one offsite control location, near the U.S. Highway 301 bridge over the Savannah River, as shown in figure 6–13. Another offsite location—approximately 100 miles from SRS, near Savannah—also was sampled.

Hand augers or other similar devices are used in sample collection to a depth of 3 inches. The samples are analyzed for gamma-emitting radionuclides, strontium-89,90, plutonium-238, and plutonium-239. The rationale for each sampling site is explained in the SRS EM Program.

Surveillance Results

Detailed analytical results from soil samples collected during 2000 can be found in table 27, *SRS Environmental Data for 2000*.

Gamma-Emitting Radionuclides

Cesium-137 was observed at levels above the representative MDC in 2000 at both offsite locations and two of the onsite ones. The highest onsite concentration detected, (1.62 ± 0.27)E–01 pCi/g, was in a sample taken from F-Area, and the lowest was below the representative MDC. The highest offsite concentration was (1.00 ± 0.08)E+00 pCi/g, at the U.S. Highway 301 bridge area.

Plutonium

Two of the four onsite soil sampling locations showed concentrations of plutonium-238 above the representative MDC in 2000. The highest concentration, at (2.29 ± 0.28)E–02 pCi/g, was in F-Area. Two of the onsite locations had concentrations of plutonium-239 above the representative MDC—F-Area, at (8.65 ± 0.74)E–02 pCi/g, and H-Area, at (1.26 ± 0.18)E–02 pCi/g. Both offsite locations had concentrations above the representative MDC, as follows: (2.81 ± 0.93)E–03 pCi/g at the U.S. Highway 301 bridge area and (3.59 ± 1.22)E–03 pCi/g near Savannah.

Strontium

Soil samples from all locations were analyzed for strontium-89,90 in 2000, and all results were slightly above the representative MDC. The highest concentration, (3.73 ± 0.72)E–01pCi/g, was from a sample collected at the U.S. Highway 301 bridge area.

Sediment

Sediment sample analysis measures the movement, deposition, and accumulation of long-lived radionuclides in stream beds and in the Savannah River bed. Significant year-to-year differences may be evident because of the continuous deposition and remobilization occurring in the stream and river beds—or because of slight variation in sampling locations—but the data obtained can be used to observe long-term environmental trends.

Description of Surveillance Program

Sediment samples (annual) were collected at 21 locations in 2000—eight in the Savannah River and 13 in site streams (figure 6–14). Samples are obtained with a Ponar dredge or an Emery pipe dredge and analyzed for gamma-emitting fission and activation products, strontium-89,90, plutonium-238, and plutonium-239.

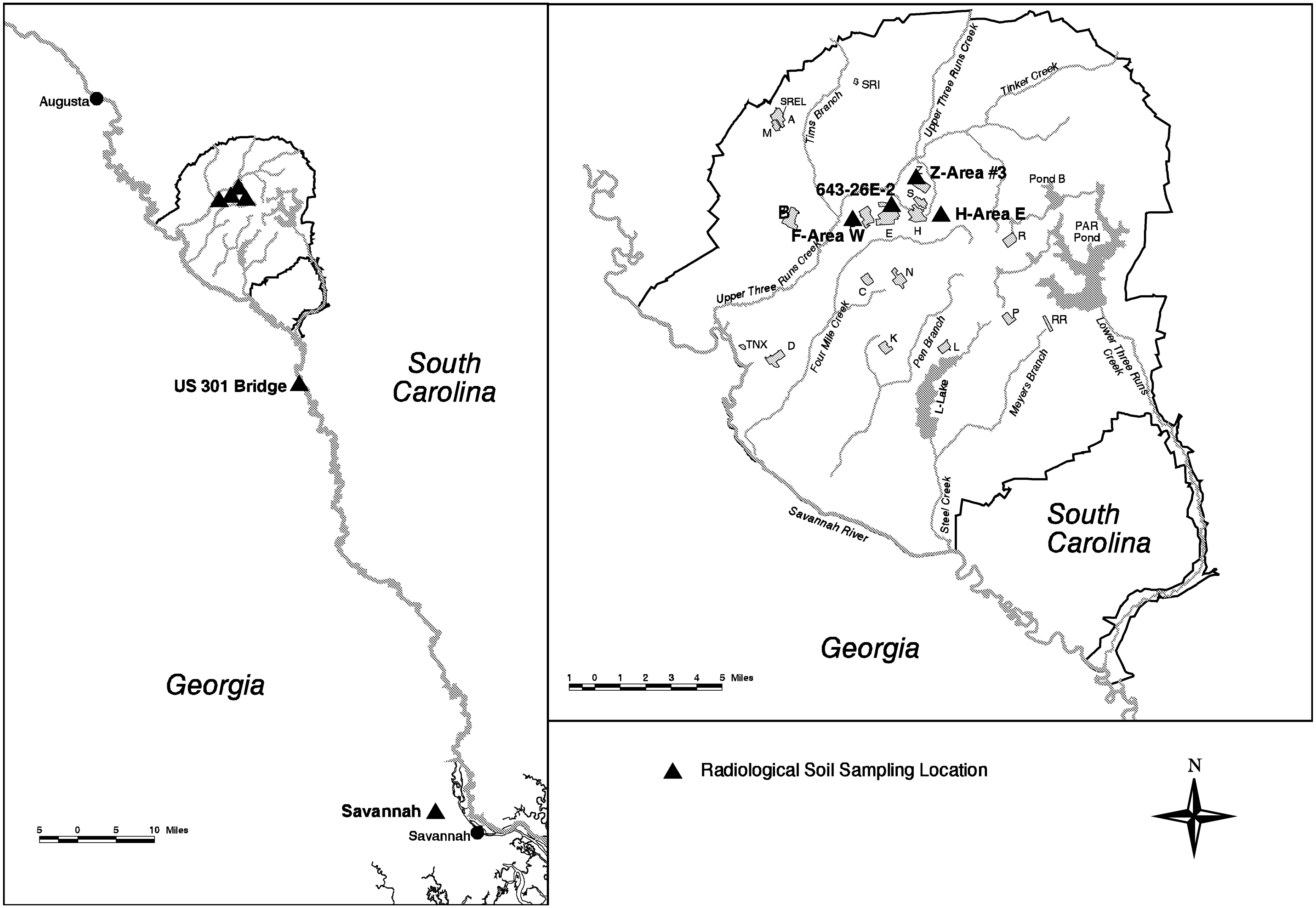
Surveillance Results

Concentrations of radionuclides in river sediment during 2000 were similar to those of past years. Detailed analytical results from all sediment samples collected during the year can be found in table 28, *SRS Environmental Data for 2000*.

Gamma-Emitting Radionuclides

Cesium-137 and Cobalt-60 were the only manmade gamma-emitting radionuclides observed in river and stream sediments during 2000.

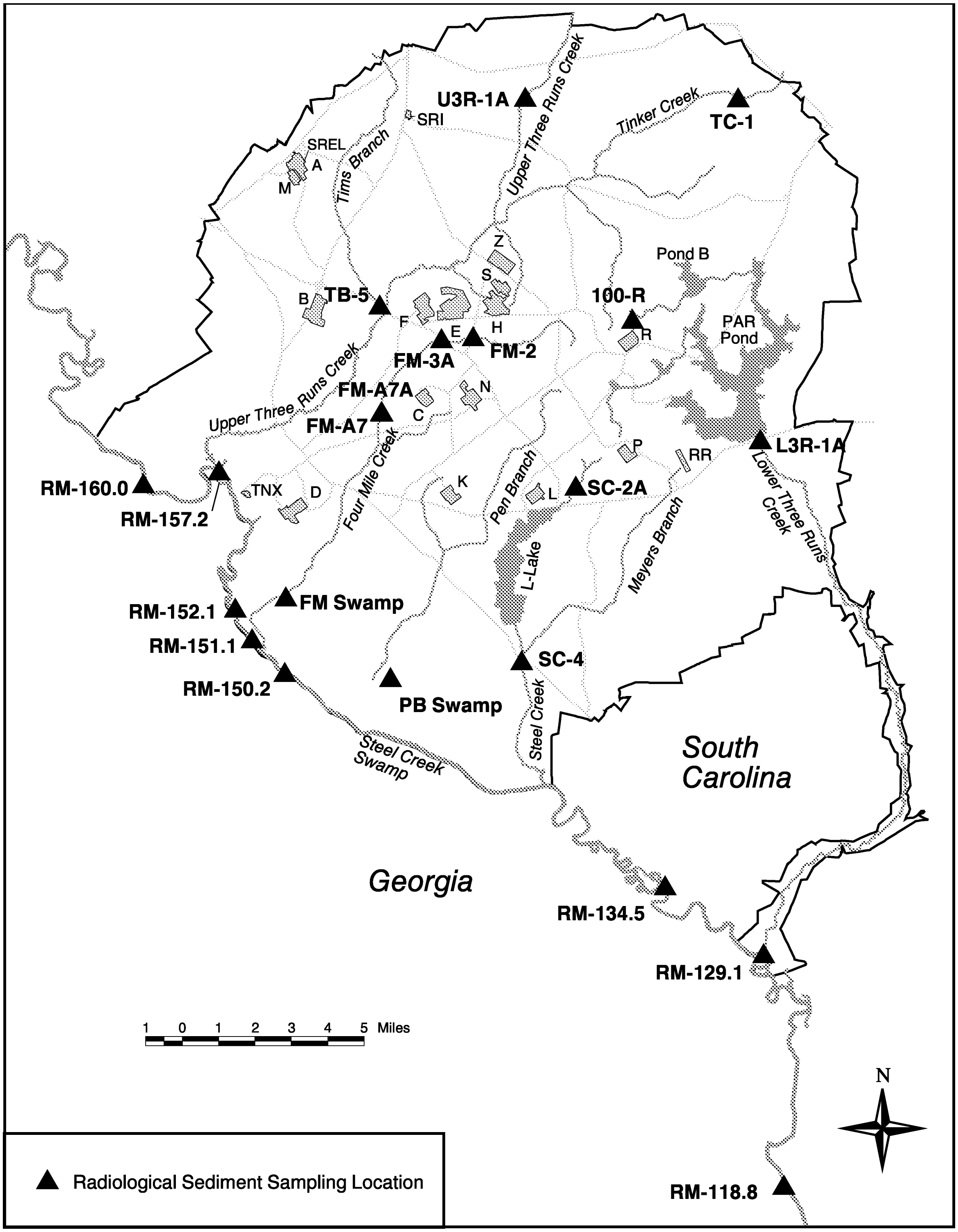
The highest cesium-137 concentration in streams, (1.01 ± 0.04)E+02 pCi/g, was detected in sediment from R-Area Downstream of R–1; the lowest concentrations were below the representative MDC at Tims Branch 5 near Road C and at U3R–1A. The highest level found on the river, (2.27 ± 0.14)E+00 pCi/g, was at the mouth of Lower Three Runs; the lowest level was (6.89 ± 2.27)E–02 pCi/g at RM 160.5. Generally, cesium-137 concentrations were higher in stream sediments than in river sediments. This is to be expected because the streams receive radionuclide-containing liquid effluents from



EPD/GIS Map

Figure 6–13 Radiological Soil Sampling Locations

SRS collected soil samples in 2000 from four onsite locations and two offsite locations—one near the U.S. Highway 301 bridge over the Savannah River and one near Savannah, Georgia.



EPD/GIS Map

Figure 6–14 Radiological Sediment Sampling Locations

Sediment samples were collected in 2000 at eight Savannah River locations—upriver of, adjacent to, and downriver of the site—and 13 site stream locations.

the site. Most radionuclides settle out and deposit on the stream beds or at the streams' entrances to the swamp areas along the river.

Cobalt-60 was detected above the representative MDC in sediment from the following locations:

- Four Mile Creek Swamp Discharge
- Four Mile A–7A
- Pen Branch Swamp Discharge
- River Mile 152.1
- R-Area Downstream of R–1

The highest Cobalt-60 concentration, (3.00 ± 0.20)E–01 pCi/g, was measured at R-Area Downstream of R–1; concentrations at the other 16 sediment sampling locations were below the representative MDC.

Plutonium/Uranium

Concentrations of plutonium-238 in sediment ranged from a high of (2.17 ± 0.17)E–01 pCi/g at the Four Mile A–7A location to lows below the representative MDC at several locations. Concentrations of plutonium-239 ranged from a high of (1.13 ± 0.09)E–01—at the Four Mile A–7A location—to lows below the representative MDC at several locations. Uranium-235 was not detected in sediment from any sampling location in 2000.

As expected, concentrations of these isotopes in streams generally were higher than concentrations in the river; all concentrations in the river were below the representative MDC. Differences observed when these data are compared to those of previous years probably are attributable to the effects of resuspension and deposition, which occur constantly in sediment media.

Strontium

Despite multiple reruns, analytical difficulties resulted in unacceptably low recovery rates for strontium-in-sediment analysis in 2000. Results of this analysis could not be obtained from the laboratory; thus, they are not included in this year's report.

Grassy Vegetation

The radiological program for grassy vegetation is designed to collect and analyze samples from onsite and offsite locations to determine radionuclide concentrations. Vegetation samples are obtained to complement the soil and sediment samples in order to determine the environmental accumulation of radionuclides and help confirm the dose models used by SRS. The program also provides information that can be used to determine the effects, if any, of various radioactive material operations on the surrounding vegetation.

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

Description of Surveillance Program

Vegetation samples are obtained from

- locations containing soil radionuclide concentrations that are expected to be higher than normal background levels
- locations receiving water that may have been contaminated

An onsite location is near the geographical center of the site, and four perimeter locations are situated near air monitoring stations that provide sampling within each 30-degree sector around the site boundary. Two offsite locations—selected as control sites—are in the vicinity of the environmental air monitoring stations at the U.S. Highway 301 bridge over the Savannah River and near the city of Savannah. All the vegetation locations, which continue to be sampled annually, are shown in figure 6–15.

In addition to actinides, vegetation samples are analyzed for gross alpha and gross beta, gamma-emitting radionuclides, tritium, plutonium, and strontium. Vegetation can be contaminated externally by the deposition of airborne radioactive contaminants (i.e., from fallout) and internally by uptake, from soil or water, by the roots. While the vegetation surveillance program makes no attempt to differentiate between contributions of the external and internal contaminations, contributions can be approximated when radionuclide concentrations in local soils are known.

The sampling and analysis programs for grassy vegetation are documented in WSRC–3Q1–2, Volume 1, Section 1105.3.10.2. Operational details of sample collection are in procedure manual WSRC–3Q1–3, while analytical procedures are in WSRC–3Q1–4 and WSRC–3Q1–6.

Surveillance Results

All surveillance results are based on dry weight. The 2000 grassy vegetation analysis results showed tritium, cesium, strontium, and uranium activity near or slightly above minimum detectable concentrations at several locations. Gross beta activity was detected

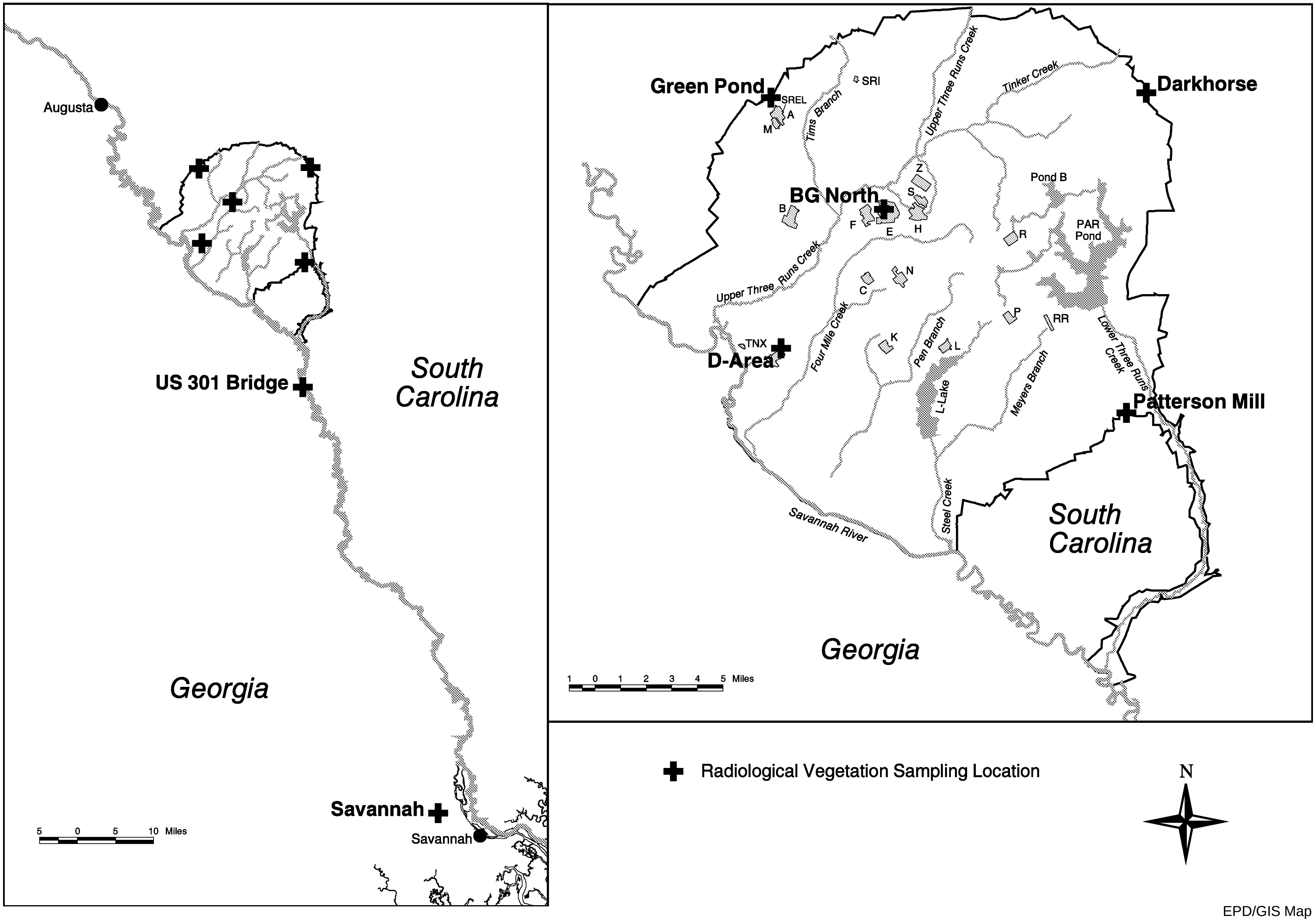


Figure 6–15 SRS Vegetation Sampling Locations

Vegetation samples were collected for radiological analysis in 2000 from five locations on site and two off site (near Savannah, Georgia, and at the U.S. 301 bridge over the Savannah River).

at all locations but was attributed primarily to the naturally occurring radionuclide potassium-40. Plutonium sample results were discarded because of laboratory error. Detailed analytical results from vegetation samples collected during 2000 can be found in table 29, *SRS Environmental Data for 2000*.

Burke County Well Sampling

Contamination of groundwater has been detected at several locations within SRS. Concern has been raised by State of Georgia officials over the possible migration of groundwater contaminated with tritium through aquifers underlying the Savannah River into Georgia by what is sometimes referred to as trans-river flow.

Previous Studies

The US Geological Survey (USGS), in cooperation with DOE and GDNR, began a study (the Trans-River Flow Project) in 1988 to describe groundwater flow and quality near the Savannah River and to determine the potential for movement beneath the river. The study area was bounded by the fall line, which is about 20 miles northwest of SRS, and extended to about 20 miles south of the site.

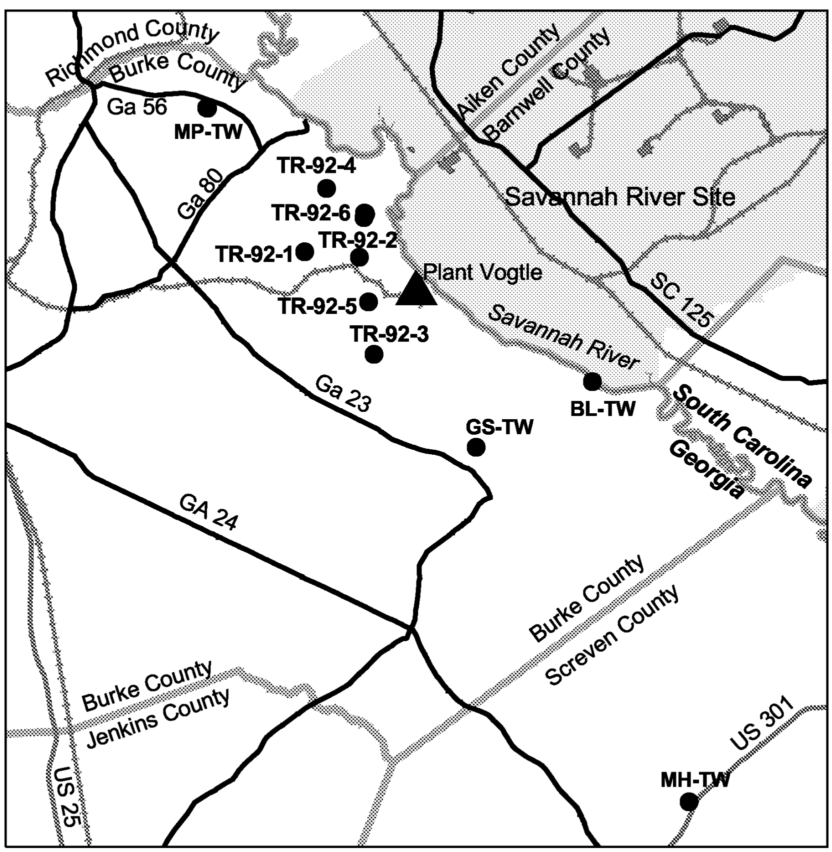
A wide expanse of swamp exists on both sides of the Savannah River as it meanders from one side of its flood plain to the other. In southern Richmond County, Georgia, and in most of Burke County, Georgia, a steep bluff with relief as much as 160 feet stands above the western bank of the river. The area on both sides of the flood plain is moderately well dissected by streams that flow into the river.

Summaries of the Trans-River Flow Project may be found in 1992-through-1996 SRS environmental reports, which concluded that there was no potential for groundwater with tritium contamination to flow under the river, and that the low levels of tritium found in Burke County came from rainfall.

Current Study and Results

In 2000, SRS acquired and performed pump maintenance on 14 USGS wells in Burke and Screven counties. The addition of these new wells to the 30 monitoring wells SRS acquired from GDNR in 1999 brings the total number of Georgia wells available for sampling to 44. Figure 6–16 shows the location of the 10 well clusters in the study.

Because of a 3-year lapse in use, significant maintenance was required to prepare the wells for sampling. EMS personnel have installed 16 new



EPD/GIS Map

Figure 6–16
Burke/Screven County Well Locations

Groundwater samples were collected for tritium analysis in 2000 from nine well clusters in Burke County, Georgia, and one in Screven County. Four of the clusters—BL–TW, MP–TW, and GS–TW in Burke, and MH–TW in Screven—were added to the Georgia tritium project in 2000.

pumps, replaced seven pumps, and repaired two wells that had broken casings.

EMS personnel sampled 17 wells during the third quarter of 1999 and 37 wells in November 2000 (table 30, *SRS Environmental Data for 2000*). There is a definite pattern indicating that tritium concentrations in the more recent samples were lower than in the previous year. All six of the wells with detectable values in 2000 are screened in the water table aquifer.

The highest value reported in 1999 was 916 pCi/L, which is less than 5 percent of the EPA drinking water standard of 20,000 pCi/L. In 2000, the highest value was 1,200 pCi/L, which is 6 percent of the drinking water standard and is consistent with conclusions in earlier studies that the tritium comes from rainfall. This value came from TR92–2A, a well screened in the water table. TR92–2A was not sampled in 1999, but its tritium values from 1994, 1995, and 1996 were 1,500 pCi/L, 1,300 pCi/L, and 1,700 pCi/L, respectively.

SRS will sample the Burke County wells for tritium again in February 2001.

Al Mamatey Photo (00J04599001)

SRS personnel install a well pump at the Girard site in Burke County, Georgia. The well is one of 37 that were sampled in 2000 to address the issue of potential tritium flow under the Savannah River from SRS to the Georgia side of the river.

Chapter 7

Potential Radiation Doses

Timothy Jannik, Patricia Lee, and Ali Simpkins
Savannah River Technology Center

To Read About . . . See Page . . .

2000 Highlights

- Using conservative methods, the calculated potential offsite radiation doses from site operations were below all applicable standards of radiation exposure to humans and aquatic organisms.
- The potential dose to the maximally exposed individual from liquid releases in 2000 was estimated at 0.14 mrem. This dose is 0.14 percent of DOE's 100-mrem all-pathway dose standard for annual exposure. The dose is about 36 percent less than the 1999 dose—primarily because of lower cesium-137 concentrations in the Savannah River.
- The estimated dose to the maximally exposed individual from airborne releases was 0.04 mrem. This dose is 0.4 percent of DOE's 10-mrem air pathway dose standard for annual exposure. The 2000 dose was about 33 percent less than the 1999 dose.
- The potential maximally exposed individual all-pathway dose was 0.18 mrem—0.04 mrem from the airborne pathway plus 0.14 mrem from the liquid pathway. This dose is about 36 percent less than the 1999 all-pathway dose of 0.28 mrem.
- The potential maximum dose that could have been received by an actual onsite hunter was estimated at 63 mrem, or 63 percent of DOE's 100-mrem all-pathway dose. This hunter harvested two deer, and it was assumed that he personally consumed the entire edible portion of both of them (91 pounds).
- The potential dose to a hypothetical recreational fisherman was based on the consumption of 19 kg (42 pounds) of Savannah River fish having the highest measured concentrations of radionuclides. Bass caught at the mouth of Steel Creek had the highest concentrations in 2000. Consumption of these bass could have resulted in a dose of 0.64 mrem, or 0.64 percent of DOE's 100-mrem all-pathway dose.

THIS chapter presents the potential doses to offsite individuals and the surrounding population from 2000 Savannah River Site (SRS) atmospheric and liquid radioactive releases. Additionally, potential doses from special-case exposure scenarios—such as the consumption of deer meat, creek mouth fish, goat milk, and crops irrigated with Savannah River water—are documented.

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. Use of the effective dose equivalent allows doses from different types of radiation and to different parts of the body to be expressed on the same relative basis.

Many parameters—such as radioactive release quantities, population distribution, meteorological conditions, radionuclide dose factors, human consumption rates of food and water, and environmental dispersion—are considered in the dose models used to estimate offsite doses at SRS. Descriptions of the effluent monitoring and environmental surveillance programs discussed in this chapter can be found in chapter 5, "Radiological Effluent Monitoring," and chapter 6, "Radiological Environmental Surveillance." A complete description of how potential doses are calculated can be found in section 1108 of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1 (SRS EM Program, 1999). Tables containing all potential dose calculation results are presented in *SRS Environmental Data for 2000* (WSRC–TR–2000–00329).

Applicable dose regulations can be found in appendix A, "Applicable Guidelines, Standards, and Regulations," of this document.

Calculating Dose

Potential offsite doses from SRS effluent releases of radioactive materials (atmospheric and liquid) are calculated for the following scenarios:

- hypothetical maximally exposed individual
- 80-kilometer (50-mile) population

Because the U.S. Department of Energy (DOE) has adopted dose factors only for adults, SRS calculates maximally exposed individual and collective doses as if the entire 80-kilometer population consisted of adults [DOE, 1988].

The International Commission on Radiological Protection (ICRP), in its Publications #56 and #67, has established age-specific dose factors for six age groups, ranging from 3-month-old infants to adults. However, dose factors for only a select group of radioisotopes were published, and these are applicable to only the ingestion pathway. In general, for most radioisotopes, the dose to an infant is more than to an adult. For the radioisotopes that constitute most of SRS's radioactive releases (i.e., tritium and cesium-137), the dose to infants would be approximately two to three times more 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, SRS will calculate doses 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 Environmental Data for 1999*). 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 (*SRS Environmental Data for 1999*), consumption rates for food products, and use of the Savannah River for drinking water and recreational purposes.

Dose Calculation Models

To calculate annual offsite doses, SRS uses transport and dose models developed for the commercial nuclear industry [NRC, 1977]. The models are implemented at SRS in the following computer programs [SRS EM Program, 1999]:

- MAXDOSE–SR: calculates maximum and average doses to offsite individuals from atmospheric releases.
- POPDOSE–SR: calculates collective doses from atmospheric releases.
- LADTAP XL©: calculates maximum and average doses to offsite individuals and the population from liquid releases.
- CAP88: calculates doses to offsite individuals from atmospheric releases to demonstrate compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) under the Clean Air Act.

For the 2000 dose calculations, SRS began using a personal computer (PC) version of POPGASP (POPDOSE–SR) instead of the IBM Mainframe version. A thorough comparison of POPGASP and POPDOSE–SR showed less than 1 percent difference between the two codes. This difference is attributed to slight differences in precision between the Mainframe FORTRAN computer language and the PC FORTRAN.

The CAP88 computer code is required under the Clean Air Act to calculate offsite doses from atmospheric releases from existing and proposed

Dose to the Hypothetical Maximally Exposed Individual

When calculating radiation doses to the public, SRS uses the concept of the maximally exposed individual; however, because of the conservative lifestyle assumptions used in the dose models, no such person is known to exist. The parameters used for the dose calculations are

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

For liquid releases: Someone who lives downriver of SRS (near River Mile 118.8) 365 days per year, drinks 2 liters of untreated water per day from the Savannah River, consumes a large amount of Savannah River fish, and spends the majority of time on or near the river

To demonstrate compliance with the DOE Order 5400.5 all-pathway dose standard of 100 mrem per year, SRS conservatively combines the airborne pathway and liquid pathway dose estimates, even though the two doses are calculated for hypothetical individuals residing at different geographic locations.

A 10-meter meteorological tower was erected at the Procter & Gamble plant (background) in Augusta, Georgia, in 2000. This monitoring station is one of four industrial sites that will provide real-time meteorological data to the local community through a Mutual Aid Agreement between SRS and Augusta/Richmond County. SRS's Atmospheric Technologies Group collects, stores, and disseminates all meteorological data through a central computer system at the site. This information can be used by users on and off the site to determine local weather conditions and as input into the group's emergency response atmospheric models. In the longer term, the archived data record the local climatological conditions of the region.

Byron Williams Photo (2000–01310)

facilities. SRS uses the CAP88 dose estimates to show NESHAP compliance, but not for routine dose calculations. The CAP88, MAXDOSE–SR, and POPGASP–SR codes use modeling based on U.S. Nuclear Regulatory Commission Regulatory Guide 1.109.

Meteorological Database

Meteorological data are used as input for the atmospheric transport and dose models.

For 2000, all potential offsite doses from releases of radioactivity to the atmosphere were calculated with quality-assured meteorological data for A-Area (used for A-Area and M-Area releases) and H-Area (used for releases from all other areas). The meteorological databases used were for the years 1992–1996, reflecting the most recent 5-year compilation period (*SRS Environmental Data for 1999*). Five-year average databases are used instead of the actual annual data because of the difficulty of compiling, inputting, and validating all the data in time to be used for the current-year dose calculations.

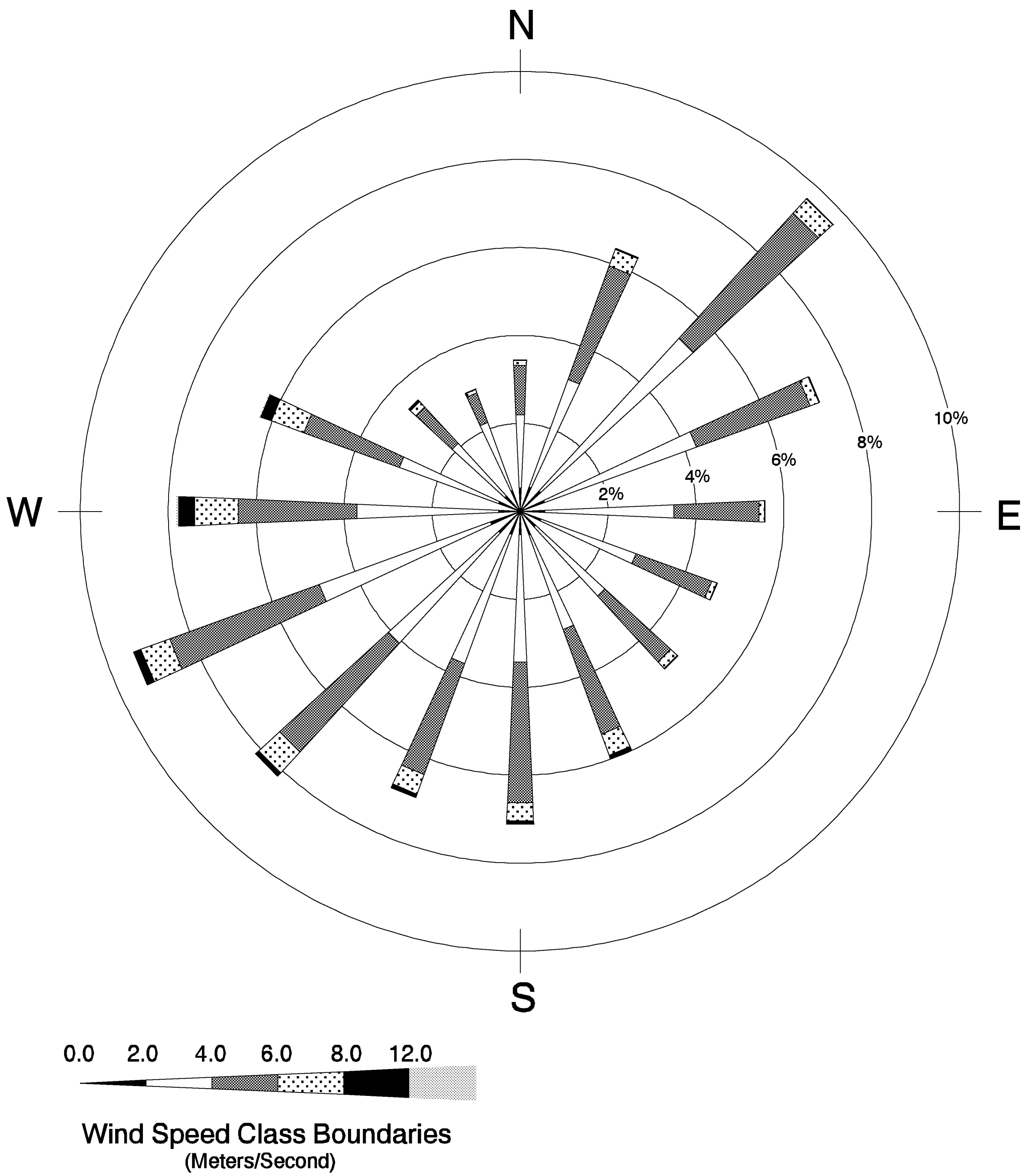
The wind rose developed from the 1992–1996 H-Area database is provided in figure 7–1. As shown, there is no prevailing wind at SRS, which is typical for the lower midlands of South Carolina. The maximum frequency that the wind blew in any one direction was 9.7 percent of the time, which occurred toward the southwest direction.

The meteorological measurements include all dispersion conditions observed during the 5-year period, ranging from unstable (considerable turbulence, which leads to rapid dispersion) to very stable (very little turbulence, which produces a narrow, undispersed plume). The data for 1992–1996 indicate that the SRS area experiences stable conditions (atmospheric stability classes E, F, G) about 18.4 percent of the time.

Population Database and Distribution

Collective, or population, doses from atmospheric releases are calculated for the population within a 80-kilometer (50-mile) radius of SRS.

For 2000 dose calculations, the 1990 population database prepared by the University of South Carolina was used. This database distributes the



EPD/GIS Graphic

Figure 7–1 Wind Rose for SRS, 1992–1996

This wind rose graphically depicts the percent of occurrence frequencies of six wind speed categories by 16 cardinal wind direction sectors at SRS. The wind speed categories are defined on the plot; direction is defined as the sector *from* which the wind blows. The data used to generate the wind rose consist of hourly averages of wind speed and direction at the H-Area meteorological tower for the 5-year period 1992–1996; measurements were taken 200 feet above the ground.

population into a grid of cells one-second latitude by one-second longitude. This database is transformed by the POPDOSE–SR Code into polar coordinates of 16 compass sectors and varying radial distances out to 80 kilometers. The POPDOSE–SR Code can prepare a polar coordinate database for any release point put 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 grid into polar coordinates. The population database generated by the POPDOSE–SR Code is centered on the geographical center of SRS (*SRS Environmental Data for 1999*).

Within the 80-kilometer radius, the total population for 1990 was 620,100, compared to 555,200 for 1980, a 12-percent population growth in 10 years.

Some of the collective doses resulting from SRS liquid releases are calculated for the populations served by the City of Savannah Industrial and Domestic Water Supply Plant, near Port Wentworth, Georgia, and by the Beaufort-Jasper Water Treatment Plant, near Beaufort, South Carolina. According to the treatment plant operators, the population served by the Port Wentworth facility during 2000 increased from approximately 10,000 to 11,000 persons, while the population served by the Beaufort-Jasper facility increased from approximately 75,000 to 97,000 persons because of the addition of new customers in Hilton Head, South Carolina.

River Flow Rate Data

Offsite dose from liquid effluents varies each year with the amount of radioactivity released and the amount of dilution (flow rate) in the Savannah River. Although flow rates are recorded at U.S. Geological Survey (USGS) gauging stations at the SRS boat dock and near River Mile 118.8 (U.S. Highway 301 bridge), these data are not used directly in dose calculations. This is because weekly river flow rates fluctuate widely (i.e., short-term dilution varies from week to week). Used instead are “effective” flow rates, which are based on measured concentrations of tritium in Savannah River water and measured concentrations in water used at the downstream water treatment plants. However, the USGS-measured flow rates are used for comparison to these calculated values.

For 2000, the River Mile 118.8 calculated (effective) flow rate of 5,640 cubic feet per second was used in determining doses to maximally exposed individuals, population doses from recreation and fish consumption, and potential doses from crops irrigated with river water. This flow rate was about 5 percent less than the 1999 effective flow rate of 5,920 cubic feet per second. For comparison, during 2000, the USGS-measured flow rate at River Mile 118.8 was 5,550 cubic feet per second.

The 2000 calculated (effective) flow rate for the Beaufort-Jasper facility was 6,670 cubic feet per second, which was about 8 percent less than the 1999 flow rate.

The 2000 calculated (effective) flow rate for the Port Wentworth facility was 7,030 cubic feet per second, which was about 4 percent less than the 1999 flow rate.

The 2000 calculated Savannah River estuary flow rate (6,100 cubic feet per second) was used only for calculation of dose from consumption of salt water invertebrates.

In figure 7–2, the annual average Savannah River flow rates, measured by the USGS at River Mile 118.8, are provided for the years of SRS operations (1954 to 2000). The 2000 rate of 5,550 cubic feet per second was the second lowest measured during this 47-year period.

Uncertainty in Dose Calculations

Radiation doses are calculated using the best available data. If adequate data are unavailable, then site-specific 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 assumed maximum meat consumption rate of 81 kg (179 pounds) per year for an individual. Some people will eat more than 81 kg, 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* [Hamby, 1993].

Dose Calculation Results

Liquid and air 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 feral hogs, which are nontypical exposure pathways. Finally, a dose is calculated for the aquatic biota found in SRS streams.

Liquid Pathway

This section contains information on liquid release quantities used as source terms in SRS dose

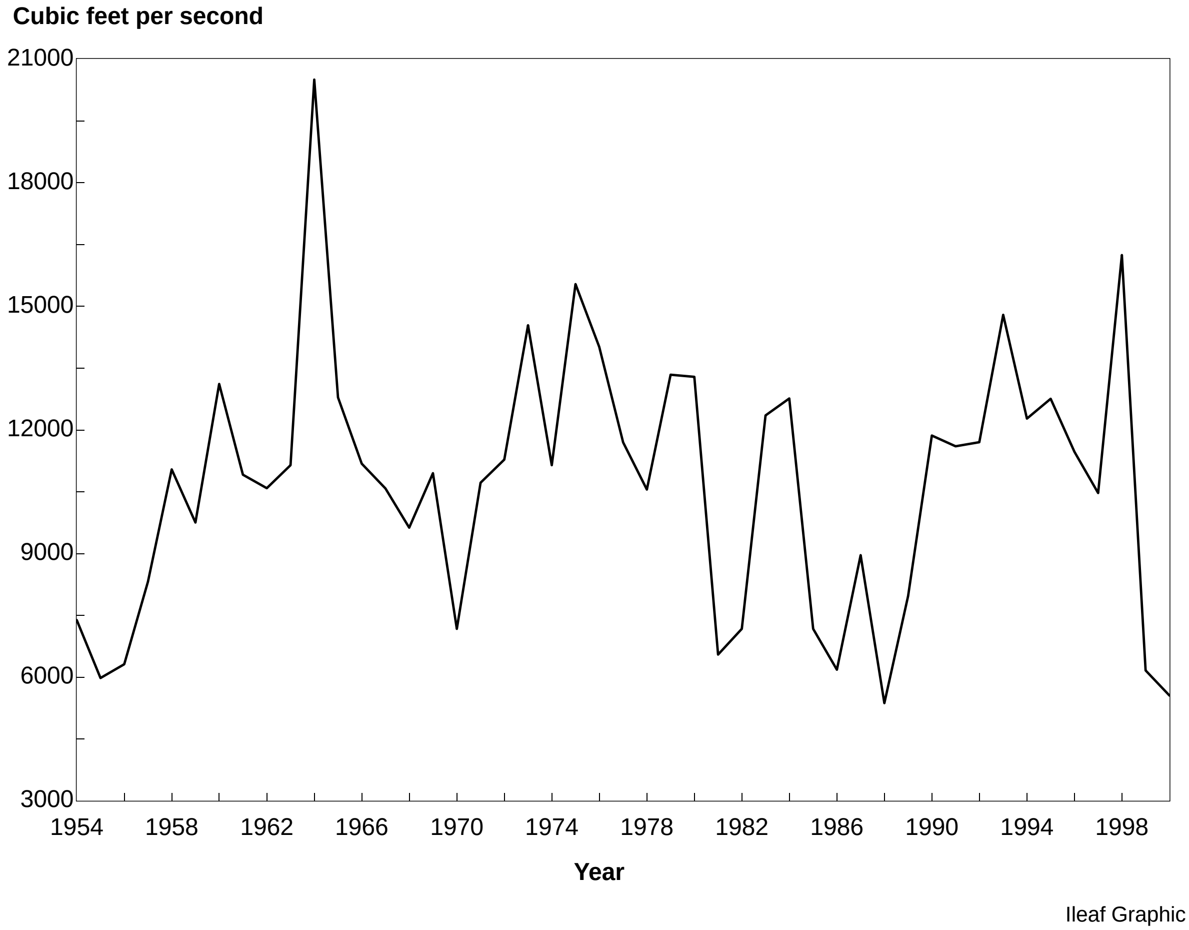


Figure 7–2 Savannah River Mile 118.8 Annual Average Flow Rates, 1954–2000
The 2000 River Mile 118.8 flow rate of 5,550 cubic feet per second was the second lowest measured during the 47-year operating history of SRS. River Mile 118.8 flow rates were not measured for the years 1971–1981; mean flow rates for those years are based on rates measured near Augusta, Georgia.

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 agricultural irrigation are presented.

Liquid Release Source Terms

The 2000 radioactive liquid release quantities used as source terms in SRS dose calculations are presented in chapter 5 and summarized by radionuclide in table 7–1.

As discussed in chapters 5 and 6, SRS measures tritium releases to the Savannah River using three methods. In calculating doses from tritium, the stream transport value is used instead of the the river transport value or the direct-plus-migration value (chapter 6). This is because the stream transport value—measured in site streams just prior to their discharge to the Savannah River—most accurately reflects the actual amount of aqueous tritium leaving the site. During 2000, the total tritium transport in SRS streams decreased by approximately 5 percent (from 6,290 Ci in 1999 to 5,960 Ci in 2000).

For 2000, releases of unspecified alpha emitters and nonvolatile beta emitters were listed separately in the source term. Prior to 1999, these alpha and beta emitters were included in plutonium-239 and strontium-89,90 releases, respectively.

For dose calculations, unspecified alpha releases were assigned the plutonium-239 dose factor, and unspecified nonvolatile beta releases were assigned the strontium-90 factor. Accounting for the alpha and beta emitters in this way generates an overestimated dose attributed to releases from SRS because

- plutonium-239 and strontium-90 have the highest dose factors among the common alpha- and beta-emitting radionuclides

- a part of the unidentified activity probably is not from SRS operations but from naturally occurring radionuclides, such as potassium-40 and radon progeny

Radionuclide Concentrations in Savannah River Water and Fish

For use in dose determinations and model comparisons, the concentrations of tritium in Savannah River water and cesium-137 in Savannah River fish are measured at several locations along the river. The amounts of all other radionuclides released from SRS are so small that they usually cannot be detected in the Savannah River using standard analytical techniques.

Radionuclide Concentrations in River Water and Treated Drinking Water The measured concentrations of tritium in the Savannah River near River Mile 118.8 and at the Beaufort-Jasper and Port Wentworth water treatment facilities are shown in table 7–1, as are the LADTAP XL©-determined concentrations for the other released radionuclides.

The 12-month average tritium concentrations measured in the Savannah River near River Mile 118.8 (1.18 pCi/mL), and at the Beaufort-Jasper (1.00 pCi/mL) and Port Wentworth (0.950 pCi/mL) water treatment plants, remained below the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 20 pCi/mL.

The 2000 River Mile 118.8 concentration was slightly less than the 1999 concentration of 1.19 pCi/mL.

Annual average tritium concentrations measured during the period 1991–2000 at River Mile 118.8 and at the Beaufort-Jasper and Port Wentworth facilities are compared to the EPA MCL in figure 7–3. The data for Beaufort-Jasper and Port Wentworth are the

Table 7–1
2000 Radioactive Liquid Release Source Term and 12-Month Average Downriver Radionuclide Concentrations Compared to EPA's Drinking Water Maximum Contaminant Levels (MCLs)

		12-Month Average Concentration (pCi/mL)			
Nuclide	**Curies Released**	**Below SRS[a]**	**Beaufort-Jasper[b]**	**Port Wentworth[c]**	**EPA MCL[d]**
H-3[e]	5.96E+03	1.18E+00[f]	1.00E+00[f]	9.50E–01[f]	2.00E+01
Co-60	1.13E–03	2.24E–07	1.90E–07	1.80E–07	1.00E–01
Sr-89,90	5.44E–02	1.08E–05	9.13E–06	8.67E–06	8.00E–03
I-129	7.82E–02	1.55E–05	1.31E–05	1.25E–05	1.00E–03
Cs-137[e]	1.00E–01	1.99E–05	1.68E–05	1.59E–05	2.00E–01
U-234	1.64E–04	3.26E–08	2.75E–08	2.61E–08	1.87E+02[g]
U-235	6.32E–06	1.26E–09	1.06E–09	1.01E–09	6.48E–01[g]
U-238	1.97E–04	3.91E–08	3.31E–08	3.14E–08	1.01E–02[g]
Pu-238	2.21E–05	4.41E–09	3.72E–09	3.54E–09	1.50E–02[h]
Pu-239	1.68E–05	3.34E–09	2.82E–09	2.68E–09	1.50E–02[h]
Am-241	1.19E–05	2.36E–09	2.00E–09	1.50E–09	1.50E–02[h]
Cm-244	7.01E–06	1.39E–09	1.18E–09	1.12E–09	1.50E–02[h]
Alpha	1.96E–02	3.89E–06	3.29E–06	3.12E–06	1.50E–02
Nonvolatile Beta	4.44E–02	8.82E–06	7.45E–06	7.08E–06	8.00E–03[i]
Sum of the Ratios =		7.73E–02	6.55E–02	6.23E–02	

a Near Savannah River Mile 118.8, downriver of SRS at the U.S. Highway 301 bridge
b Beaufort-Jasper, South Carolina, drinking water
c Port Wentworth, Georgia, drinking water
d From EPA, 2000
e Curies released based on measured environmental surveillance values (tritium stream transport, table 18, *SRS Environmental Data for 2000*, and cesium-137 in River Mile 118.8 fish, table 24, *SRS Environmental Data for 2000*).
f Measured concentrations; all other concentrations calculated using models verified with tritium measurements.
g MCL for uranium is 30 µg/L. These derived concentrations are based on the specific activity of each uranium isotope.
h There are no specific MCLs for plutonium, americium, or curium isotopes; the MCL for gross alpha emitters is used.
i There is no gross beta MCL; this is conservatively set at the MCL for strontium-90.

tritium concentrations measured in the finished drinking water at each facility.

Compliance With EPA's Maximum Contaminant Levels for Radionuclides in Drinking Water

In 2000, the EPA promulgated 40 CFR, Parts 9, 141, and 142, "National Primary Drinking Water Regulations; Radionuclides; Final Rule." This rule, applicable only to community drinking water systems, finalized maximum contaminant levels for radionuclides, including uranium (EPA, 2000).

The MCL for each radionuclide released from SRS during 2000 is provided in table 7–1. The table indicates that all individual radionuclide concentrations at the two downriver community drinking water systems, as well as at River Mile 118.8, were below the MCLs.

Because more than one radionuclide is released from SRS, the sum of the ratios of the observed concentration of each radionuclide to its corresponding MCL must not exceed 1.0.

As shown in table 7–1, the sum of the ratios was 0.0623 at the Port Wentworth facility and 0.0655 at the Beaufort-Jasper facility. These are below the 1.0 requirement.

For 2000, the sum of the ratios at the River Mile 118.8 location was 0.0773. This is provided here only for comparison because River Mile 118.8 is not a community water system location.

Radionuclide Concentrations in River Fish At SRS, an important dose pathway for the maximally exposed individual is from the consumption of fish.

Fish exhibit a high degree of bioaccumulation for certain elements. For the element cesium (including radioactive isotopes of cesium), the bioaccumulation factor for Savannah River fish is approximately 3,000. That is, the concentration of cesium found in fish flesh is about 3,000 times more than the concentration of cesium found in the water in which the fish live.

Because of this high bioaccumulation factor, cesium-137 is more easily detected in fish flesh than in river water. Therefore, the fish pathway dose from cesium-137 is based directly on the radioanalysis of the fish collected near Savannah River Mile 118.8, which is the assumed location of the hypothetical

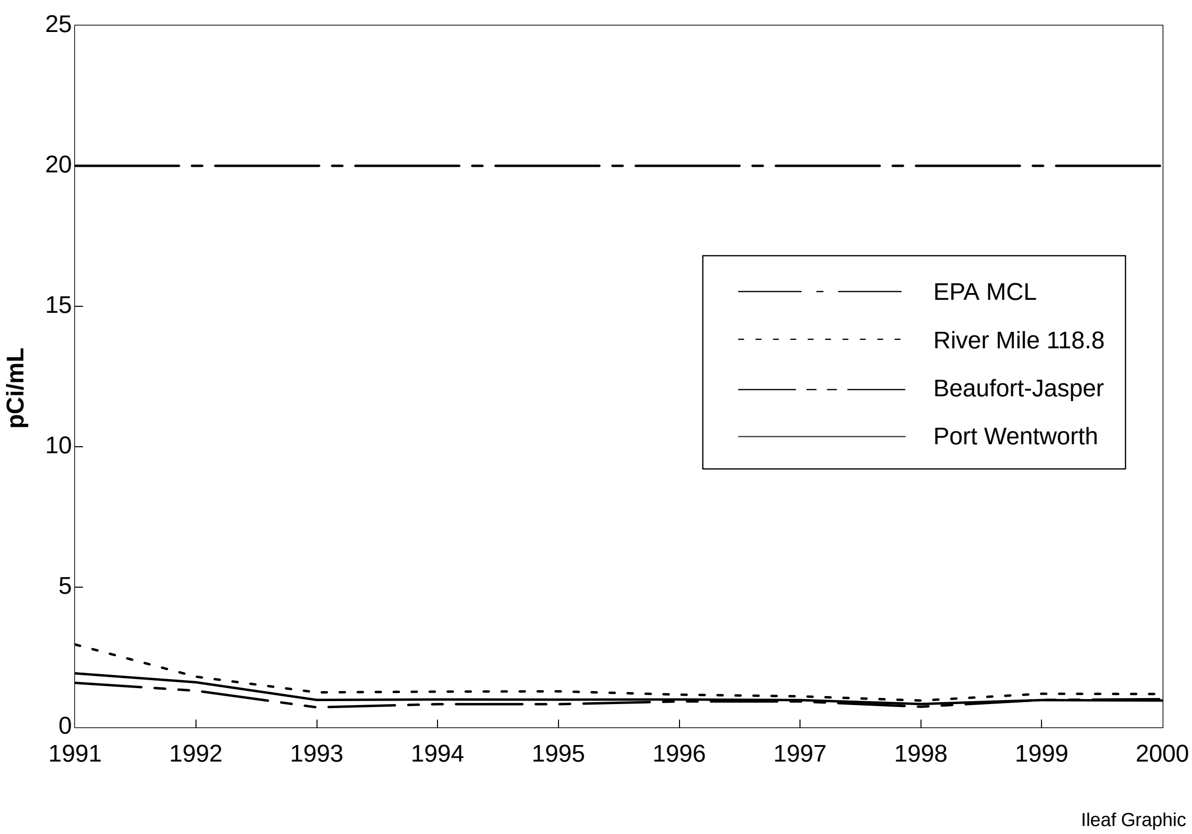


Figure 7–3 Annual Average Tritium Concentrations at River Mile 118.8, Beaufort-Jasper, and Port Wentworth (1991–2000) Compared to the EPA MCL for tritium of 20 pCi/mL.

Table 7–2
Potential Dose to the Maximally Exposed Individual from SRS Liquid Releases in 2000

	Committed Dose	Applicable Standard	Percent of Standard
Maximally Exposed Individual			
River Mile 118.8 (all liquid pathways)	0.14 mrem	100 mrem[a]	0.14
At Port Wentworth (public water supply only)	0.06 mrem	4 mrem[b]	1.5
At Beaufort-Jasper (public water supply only)	0.06 mrem	4 mrem[b]	1.5

a All-pathway dose standard: 100 mrem per year (DOE Order 5400.5)
b Drinking water pathway standard: 4 mrem per year (DOE Order 5400.5)

maximally exposed individual. The fish pathway dose from all other radionuclides is based on the calculated concentrations determined by the LADTAP XL© code. A consumption rate of 19 kg (42 pounds) of fish per year is used in the maximally exposed individual dose calculation [Hamby, 1991]. Some fraction of this estimated dose is due to cesium-137 from worldwide fallout and from neighboring Vogtle Electric Generating Plant; however, that amount is difficult to determine and is not subtracted from the total.

The dose determinations are accomplished in the LADTAP XL© code by substituting a cesium-137 release value that would result in the measured concentration in river fish, assuming the site-specific bioaccumulation factor of 3,000. A weighted average concentration (based on the number of fish in each composite analyzed) of cesium-137 in River Mile 118.8 fish was used for maximally exposed individual and population dose determinations. Using the above factors, the cesium-137 release value used for LADTAP XL© input was 0.10 Ci, which is more conservative than the measured effluent release value of 0.088 Ci and was about 53 percent less than the 1999 value of 0.24 Ci.

Dose to the Maximally Exposed Individual

The potential liquid pathway dose to the hypothetical maximally exposed individual living downriver of SRS, near River Mile 118.8, was determined based on adult intake and usage parameters discussed earlier in this chapter and on other site-specific physical parameters (table 37, *SRS Environmental Data for 2000*).

As shown in table 7–2, the highest potential dose to the maximally exposed individual from liquid releases in 2000 was estimated at 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 2000 potential maximally exposed individual dose was about 36 percent less than the 1999 dose of 0.22 mrem (0.0022 mSv)—primarily because of the 53-percent decrease in the amount of cesium-137 measured in Savannah River fish.

Approximately 43 percent of the dose to the maximally exposed individual resulted from the ingestion of cesium-137, mainly from the consumption of fish, and about 41 percent resulted from the ingestion (via drinking water) of tritium (table 38, *SRS Environmental Data for 2000*). About 10 percent of the liquid pathway maximally exposed individual dose was attributed to unspecified alpha emitters, which are conservatively assigned the dose factor for plutonium-239 in the dose calculations (chapter 5).

Drinking Water Pathway Persons downriver of SRS may receive a radiation dose by consuming drinking water that contains radioactivity as a result of liquid releases from the site. In 2000, tritium in downriver drinking water represented the majority of the dose (about 75 percent) received by persons at downriver water treatment plants.

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, located downriver of SRS, were determined for maximum (2 liters per day for a year) water consumption rates.

The maximum potential dose during 2000 was 0.06 mrem (0.0006 mSv) at both the Beaufort-Jasper Water Treatment Plant and the City of Savannah Industrial and Domestic Water Supply Plant (Port Wentworth) (tables 39 and 40, *SRS Environmental Data for 2000*).

As shown in table 7–2, the maximum dose of 0.06 mrem (0.0006 mSv) is 1.5 percent of the DOE standard of 4 mrem per year for public water supplies. The 2000 maximum potential drinking water dose was 14 percent less than the 1999 maximum dose of 0.07 mrem (0.0007 mSv).

The "Potential Dose" section of appendix A, "Applicable Guidelines, Standards, and Regulations," explains the differences between the DOE and EPA drinking water standards.

Collective (Population) Dose

The collective drinking water consumption dose is calculated for the discrete population groups at Beaufort-Jasper and Port Wentworth. The collective dose from other pathways is calculated for a diffuse population that makes use of the Savannah River. However, this population cannot be described as being in a specific geographical location.

Potential collective doses were calculated, by pathway and radionuclide, using the LADTAP XL© computer code (table 41, *SRS Environmental Data for 2000*). In 2000, the collective dose from SRS liquid releases was estimated at 3.9 person-rem (0.039 person-Sv). This was slightly less than the 1999 collective dose of 4.0 person-rem (0.04 person-Sv).

Potential Dose from Agricultural Irrigation

The 1990 update of land- and water-use parameters [Hamby, 1991] revealed that there is no known use of river water downstream of SRS for agricultural irrigation purposes. However, in response to public concerns, potential doses from this pathway are calculated for information purposes only and are not included in calculations of the official maximally exposed individual or collective doses.

For 2000, a potential offsite dose of 0.11 mrem (0.0011 mSv) to the maximally exposed individual and a collective dose of 7.7 person-rem (0.077 person-Sv) were estimated for this exposure pathway (table 42, *SRS Environmental Data for 2000*).

As in previous years, collective doses from agricultural irrigation were calculated for 1,000 acres of land devoted to each of four major food types—vegetation, leafy vegetation, milk, and meat. It is assumed that all the food produced on the 1,000-acre parcels is consumed by the 80-kilometer population of 620,100.

Air Pathway

This section describes the atmospheric source term 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 2000 radioactive atmospheric release quantities used as the source term in SRS dose calculations are presented in chapter 5. Releases of unspecified alpha emitters and nonvolatile beta emitters were listed separately in the source term. Prior to 1999, these alpha and beta emitters were included in the plutonium-239 and strontium-89,90 releases, respectively (table 4, *SRS Environmental Data for 2000*).

Unspecified alpha emissions decreased from 0.0021 Ci in 1999 to 0.00074 Ci in 2000—a 65-percent reduction. This relatively large decrease is attributed to the shutdown of the Consolidated Incineration Facility (CIF) and the D-Area coal pile runoff basin demonstration project.

In 2000, krypton-85 accounted for most of the radioactivity released to the atmosphere from SRS. Because krypton is an inert noble gas, which means it is chemically and biologically inactive, it is not readily assimilated or absorbed by the human body and it quickly disperses in the atmosphere. Therefore, it causes a relatively small amount of dose to humans (less than 1 percent of the maximally exposed individual dose in 2000).

For air pathway dose calculations—as in liquid dose calculations—unspecified alpha releases were assigned the plutonium-239 dose factor, and unspecified nonvolatile beta releases were assigned the strontium-90 dose factor.

Estimates of unmonitored diffuse and fugitive sources were considered, as required for demonstrating compliance with NESHAP regulations.

Airborne effluents are grouped by major release points for dose calculations. For the MAXDOSE–SR code, three release locations (center of site, M-Area,

Table 7–3
Ten-Year History of SRS Atmospheric Tritium and Tritium Oxide Releases and Average Measured Tritium Oxide Concentrations in Air Compared to Calculated Concentrations in Air

			Average Tritium Oxide Concentrations in Air		
	Total Tritium Released	Tritium Oxide Released[a]	Center of Site (measured)	Site Perimeter (measured)	Site Perimeter (calculated by dose model)[b]
Year	(Ci)	(Ci)	(pCi/m^3)	(pCi/m^3)	(pCi/m^3)
1991	200,000	137,000	310	21	42
1992[c]	156,000	100,000	420	27	30
1993	191,000	133,000	450	30	37
1994[d]	160,000	107,000	350	23	30
1995	97,000	55,000	300	16	16
1996	55,300	40,100	123	11	11
1997	58,000	39,100	162	12	10
1998	82,700	58,600	147[e]	12[e]	15
1999	51,600	33,900	148[f]	14[f]	9
2000	44,800	32,400	[g]	[g]	8

a Tritium oxide releases are included with elemental tritium releases in the “Total Tritium Released” column.

b MAXDOSE–SR

c During May 1992, the method for determining tritium oxide concentrations in air was changed to the use of measured humidity values (averaged biweekly) instead of a single generic value. The listed concentrations are for May to December 1992.

d During 1994, because of problems with measuring location-specific humidity values, a single generic value of 11.4 g/m^3 was used for absolute humidity.

e In 1998, the number of monitoring stations near the center of the site was reduced to one, and the number of monitoring stations at the site perimeter was reduced to 12.

f In 1999, the Environmental Monitoring Section changed the way that the tritium concentration in air is determined at SRS by incorporating a factor to correct for the dilution of tritium-in-air samples by intrinsic water in the silica gel sampling media (chapter 6).

g During 2000, because of problems with the analysis of silica gel sampling material, the uncertainty in the measured tritium-in-air concentrations was too high to allow a comparison (chapter 6).

and Savannah River Technology Center) with specific release heights were used (*SRS Environmental Data for 1999*).

The CAP88 code can calculate doses from collocated release heights but cannot combine calculations for releases at different geographical locations. Therefore, for CAP88 calculations, airborne effluents were grouped for elevated releases (61 meters) and ground-level releases (0 meters), and the geographical center of the site was used as the release location for both.

Atmospheric Concentrations

The MAXDOSE–SR 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 offsite locations. However, the concentrations of tritium oxide at the site perimeter locations usually can be measured and are compared with calculated concentrations as a verification of the dose models.

In 2000, SRS’s Environmental Monitoring Section experienced problems with the silica gel sampling media used to measure tritium-in-air concentrations (chapter 6). Because this led to large uncertainty in the analytical results, no comparison of the measured tritium-in-air concentrations to the SRS transport codes-calculated concentrations was possible.

In table 7–3, the average 1991–2000 tritium oxide concentrations in air—measured near the center of the site and at locations along the site perimeter—are compared to the average concentrations calculated for the site perimeter, using the MAXDOSE–SR code.

Table 7–4
Potential Dose to the Maximally Exposed Individual from SRS Atmospheric Releases in 2000

	MAXIGASP	CAP88 (NESHAP)
Calculated dose	0.04 mrem	0.05 mrem
Applicable standard	10 mrem[a]	10 mrem[b]
Percent of standard	0.4	0.5

a DOE: DOE Order 5400.5, February 8, 1990
b EPA: (NESHAP) 40 CFR 61 Subpart H, December 15, 1989

These data show that the calculated site-perimeter tritium oxide concentrations have consistently and reasonably approximated the measured values and therefore are appropriate for use in dose determinations.

The average tritium-in-air concentration at the site boundary calculated using the MAXDOSE–SR code was 8 pCi/m^3. The maximum concentration was calculated to be 14 pCi/m^3 in the southwest sector.

These concentrations compare favorably with the CAP88 code, which calculates an average concentration of 8 pCi/m^3 and a maximum site perimeter concentration of 12 pCi/m^3. This value is less than the MAXDOSE–SR code value because the CAP88 code assumes that all releases occurred from only one point, which is located at the center of the site.

Dose to the Maximally Exposed Individual

The potential air pathway dose to a hypothetical maximally exposed individual located at the site perimeter was determined using the MAXDOSE–SR computer code. The adult consumption and usage parameters used for the calculations were discussed earlier in this chapter.

In 2000, the estimated dose to the maximally exposed individual was 0.04 mrem (0.0004 mSv), which is 0.4 percent of the DOE Order 5400.5 (“Radiation Protection of the Public and the Environment”) standard of 10 mrem per year. This dose is 33 percent less than the 1999 dose of 0.06 mrem (0.0006 mSv). The decrease is attributed to the 65-percent decrease in the unspecified alpha emissions from the site—caused by the shutdown of CIF and the D-Area coal pile runoff basin demonstration project. Table 7–4 compares the maximally exposed individual’s dose with the DOE standard.

Tritium oxide releases accounted for about 50 percent of the dose to the maximally exposed individual.

Plutonium-239 emissions accounted for about 23 percent of the maximally exposed individual dose. More than 90 percent of the plutonium-239 releases were estimated to be from diffuse and fugitive sources (chapter 5).

For 2000, the MAXDOSE–SR code determined that the east-northeast sector of the site was the location of the highest maximally exposed individual dose. Figure 7–4 shows the potential dose to the maximally exposed individual residing at the site boundary for each of the 16 major compass point directions around SRS.

The major pathways contributing to the dose to the maximally exposed individual from atmospheric releases were inhalation (46 percent) and the consumption of vegetation (42 percent), cow milk (7 percent), and meat (3 percent) (table 31, *SRS Environmental Data for 2000*).

Additional calculations of the dose to the maximally exposed individual were performed substituting goat milk for the customary cow milk pathway. The potential dose using the goat milk pathway was estimated at 0.05 mrem (0.0005 mSv) (table 32, *SRS Environmental Data for 2000*).

Collective (Population) Dose

Potential doses also were calculated, by pathway and radionuclide, using the POPDOSE–SR computer code for the population (620,100 people) residing within 80 kilometers of the center of SRS.

In 2000, the collective dose was estimated at 2.3 person-rem (0.023 person-Sv)—less than 0.01 percent of the collective dose received from natural sources of radiation (about 186,000 person-rem) (table 33, *SRS Environmental Data for 2000*).

Tritium oxide releases accounted for 65 percent of the collective dose. The 2000 collective dose was approximately 12 percent less than the 1999 collective dose of 2.6 person-rem (0.026 person-Sv).

NESHAP Compliance

To demonstrate compliance with NESHAP (Clean Air Act, 40 CFR 61, Subpart H) regulations, maximally exposed individual and collective doses were calculated, and a percentage of dose contribution from each radionuclide was determined using the CAP88 computer code.

The dose to the maximally exposed individual, calculated with CAP88, was estimated at 0.05 mrem (0.0005 mSv), which is 0.5 percent of the 10-mrem-per-year EPA standard, as shown in table 7–4. Tritium oxide releases accounted for almost 88 percent of this dose (tables 34 and 35, *SRS Environmental Data for 2000*).

The CAP88 collective dose was estimated at 4.9 person-rem (0.049 person-Sv). Tritium oxide releases accounted for about 88 percent of this dose (table 36, *SRS Environmental Data for 2000*).

As the data in tables 35 and 36 show, the CAP88 code estimates a higher dose for tritium oxide than do the MAXDOSE–SR and POPDOSE–SR 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 MAXDOSE–SR and POPDOSE–SR codes use 50-percent equilibrium values, as recommended by the Nuclear Regulatory Commission [NRC, 1977]. A site-specific study indicated that the 50-percent value is correct for the atmospheric conditions at SRS [Hamby and Bauer, 1994].

Because tritium oxide dominates the doses determined using the CAP88 code, and because the CAP88 code is limited to a single, center-of-site release location, other radionuclides (such as plutonium-239) are less important—on a percentage-of-dose basis—for the CAP88 doses than for the MAXDOSE–SR and POPDOSE–SR doses.

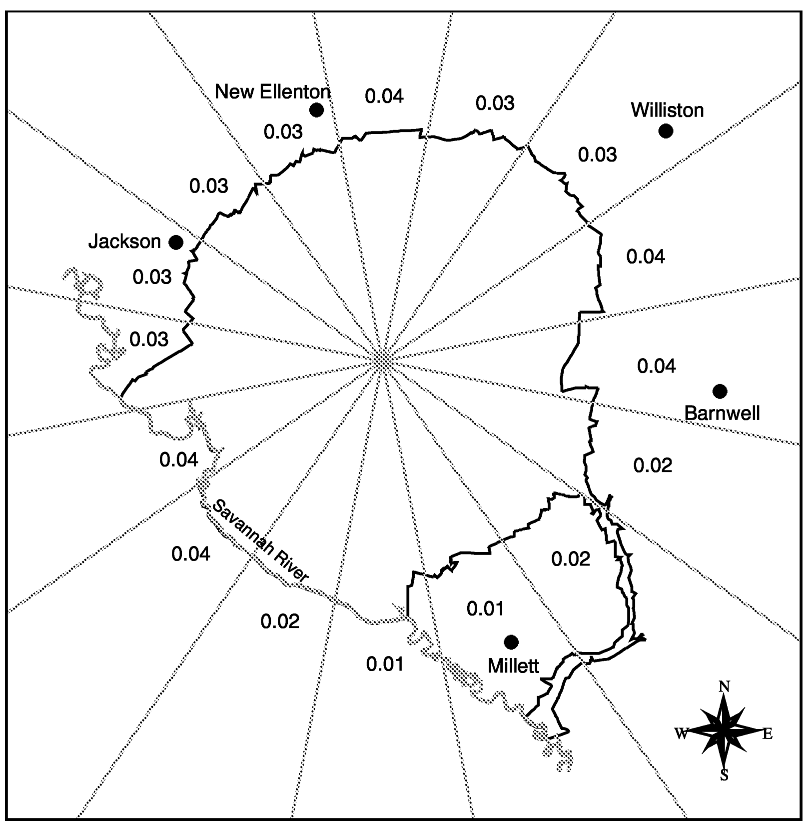
All-Pathway Dose

To demonstrate compliance with the DOE Order 5400.5 all-pathway dose standard of 100 mrem per year (1.0 mSv per year), SRS conservatively combines the maximally exposed individual airborne

Figure 7–4 Sector-Specific Adult Maximally Exposed Individual Air Pathway Doses (in mrem) for 2000

Maximally exposed individual site boundary doses from airborne releases are shown for each of the 16 major compass point directions surrounding SRS. For 2000, five sectors (N, ENE, E, SW, WSW) had essentially the same maximally exposed individual dose of 0.04 mrem. However, when the third decimal point was considered, the ENE sector was slightly higher than the other four sectors.

EPD/GIS Map



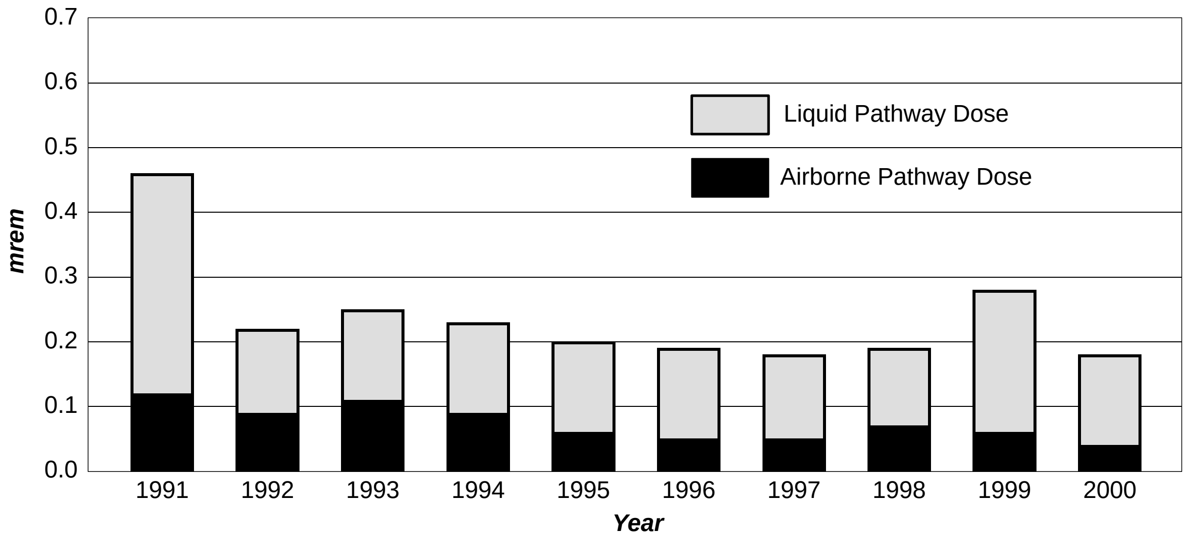


Figure 7–5 Ten-Year History of SRS Potential All-Pathway Doses to the Maximally Exposed Individual (Airborne plus Liquid Pathways)

pathway and liquid pathway dose estimates, even though the two doses are calculated for hypothetical individuals residing at different geographic locations.

For 2000, the potential maximally exposed individual all-pathway dose was 0.18 mrem (0.0018 mSv)—0.04 mrem from airborne pathway plus 0.14 mrem from liquid pathway. This dose is about 36 percent less than the 1999 all-pathway dose of 0.28 mrem (0.0028 mSv), primarily because of reduced cesium-137 levels in fish and reduced airborne emissions.

Figure 7–5 shows a 10-year history of SRS's all-pathway doses (airborne pathway plus liquid pathway doses to the maximally exposed individual).

As shown in table 7–5, the 2000 potential all-pathway dose of 0.18 mrem (0.0018 mSv) is 0.18 percent of the 100-mrem-per-year DOE dose standard.

Figure 7–6 shows a comparison of the 2000 maximum potential all-pathway dose attributable to SRS operations (0.18 mrem) with the average annual radiation dose received by a typical Central Savannah River Area (CSRA) resident from natural and manmade sources of radiation (360 mrem).

Sportsman Dose

DOE Order 5400.5 specifies radiation dose standards for individual members of the public. The dose standard of 100 mrem per year 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 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.

For 2000, in addition to deer and fish consumption, the following exposure pathways were considered for an offsite hunter and an offsite fisherman—both on a privately owned portion of the Savannah River Swamp (Creek Plantation):

- External exposure to contaminated soil
- Incidental ingestion of contaminated soil
- Incidental inhalation of resuspended contaminated soil

The Creek Plantation, a privately owned land area located along the Savannah River, borders the southeast portion of SRS. The land is primarily undeveloped and agricultural; it is used in equestrian-related operations and as a recreational hunt club. A portion of Creek Plantation along the Savannah River includes part of the Savannah River Swamp, a low-lying swamp that is uninhabited and not easily accessible.

In the 1960s, an area of the Savannah River Swamp on Creek Plantation—specifically, the area between Steel Creek Landing and Little Hell Landing—was contaminated by SRS operations.

Comprehensive and cursory surveys of the swamp have been conducted periodically since 1974. These surveys measure radioactivity levels to determine changes in the amount and/or distribution of radioactivity in the swamp. A comprehensive survey was conducted in 2000 (chapter 12, "Special Surveys and Projects").

Onsite Hunter Dose

Controlled hunts of deer and feral hogs are conducted at SRS every year for approximately 6 weeks. Hunt participants are volunteers. Before any harvested deer or hog is released to a hunter, SRS personnel perform a field analysis for cesium-137 on the animal at the hunt site, using a portable sodium iodide detector.

Deer and Hog Consumption Pathway The estimated dose from consumption of the harvested deer or hog meat is determined for each onsite hunter. During 2000, the maximum potential dose that could have been received by an actual onsite hunter was estimated at 63 mrem (0.63 mSv), or 63 percent of DOE's 100-mrem all-pathway dose standard (table 7–5). This dose was determined for a hunter who in fact harvested two deer during the 2000 hunts.

The hunter-dose calculation is based on the conservative assumption that the hunter individually consumed the entire edible portion—approximately 41 kg (91 pounds)—of the deer he harvested from SRS.

Offsite Hunter Dose

The potential doses to a hypothetical offsite hunter from deer consumption and contaminated soil exposure were calculated for 2000.

Deer Consumption Pathway The deer consumption pathway considered was for a hypothetical offsite individual whose entire intake of meat during the year was deer meat. It was assumed that this individual harvested deer that had resided on SRS, but then moved off site. The estimated dose was based on the assumed maximum annual meat consumption rate for an adult of 81 kg per year [Hamby, 1991].

Based on these low-probability assumptions and on the gross average concentration of cesium-137 (2.4 pCi/g) in deer harvested from SRS during 2000, the potential maximum dose from this pathway was estimated at 5.7 mrem (0.057 mSv). An average

Table 7–5
2000 Maximum Potential All-Pathway and Sportsman Doses Compared to the DOE All-Pathway Dose Standard

	Committed Dose (mrem)	Applicable Standard[a] (mrem)	Percent of Standard
Maximally Exposed Individual Dose			
All-Pathway (Liquid Plus Airborne Pathway)	0.18	100	0.18
Sportsman Doses			
Onsite Hunter	63	100	63
Offsite Hunter			
Deer Consumption	5.7		
Soil Exposure[b]	4.4		
Total Offsite Hunter Dose	10.1	100	10.1
Offsite Fisherman			
Fish Consumption	0.64		
Soil Exposure[b]	0.54		
Total Offsite Fisherman Dose	1.18	100	1.18

a All-pathway dose standard: 100 mrem per year (DOE Order 5400.5)

b Includes the dose from a combination of external exposure to—and incidental ingestion and inhalation of—Savannah River Swamp soil

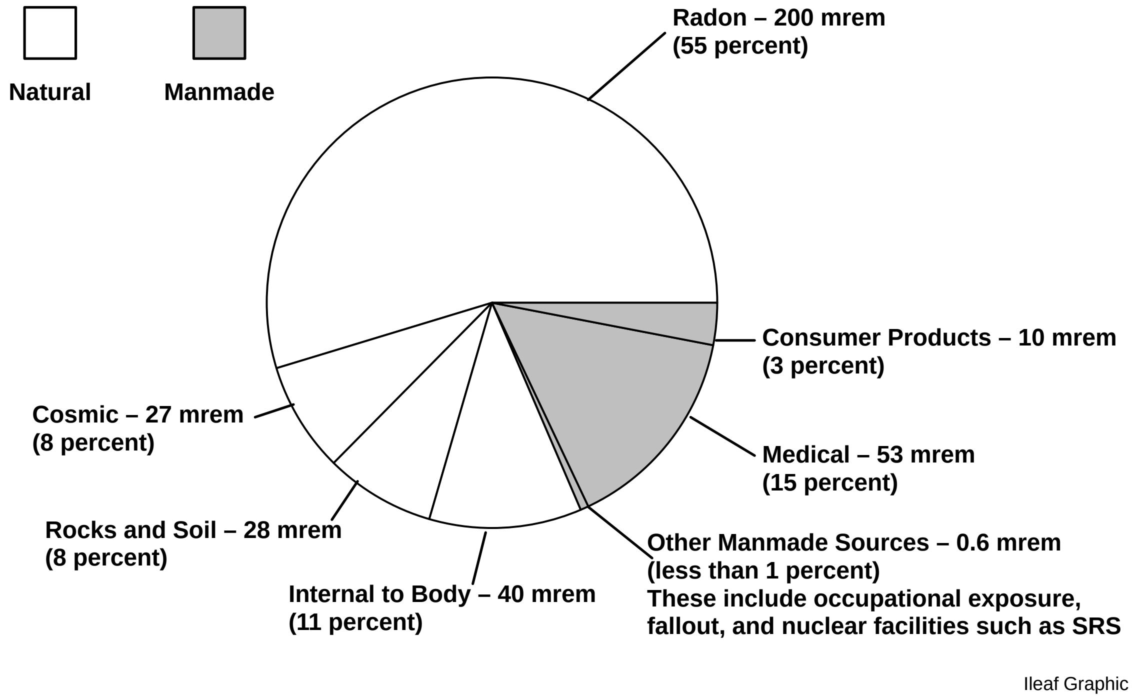


Figure 7–6 Contributions to the U.S. Average Individual Dose
The major contributor to the annual average individual dose in the United States, including residents of the CSRA, is naturally occurring radiation (about 300 mrem) [NCRP, 1987]. During 2000, SRS operations potentially contributed a maximum individual dose of 0.18 mrem, which is 0.05 percent of the 360-mrem total annual average dose (natural plus manmade sources of radiation).

80-km background cesium-137 concentration of 1 pCi/g is subtracted from the onsite gross average concentration before calculating the dose. The 80-km background concentration is based on previous studies performed at SRS (table 33, *SRS Environmental Data for 1994*, WSRC–TR–95–077).

As shown in table 7–5, the 2000 offsite hunter potential dose from deer consumption was 5.7 percent of DOE's 100-mrem all-pathway dose standard. This dose was 37 percent less than the 1999 dose of 9.1 mrem (0.91 mSv).

Savannah River Swamp Hunter Soil Exposure Pathway The potential dose to a recreational hunter exposed to SRS legacy contamination in Savannah River Swamp soil on the privately owned Creek Plantation in 2000 was estimated using the RESRAD dosimetry code (DOE Order 5400.5). It was assumed that this recreational sportsman hunted for 120 hours during the year (8 hours per day for 15 days) at the location of maximum radionuclide contamination.

During the 2000 survey of the Savannah River Swamp (chapter 12), the location with the worst-case combination of cesium-137, cobalt-60, and strontium-90 concentrations was on trail 2, at a distance of 3,100 feet from the Savannah River (table 60, *SRS Environmental Data for 2000*).

Using these radionuclide concentrations, the potential dose to a hunter from a combination of 1) external exposure to the contaminated soil, 2) incidental ingestion of the soil, and 3) incidental inhalation of resuspended soil was estimated to be 4.4 mrem (0.044 mSv).

As shown in table 7–5, the offsite deer consumption pathway and the Savannah River Swamp hunter soil exposure pathway were conservatively added together to obtain a total offsite hunter dose of 10.1 mrem (0.101 mSv). This potential dose is 10.1 percent of the DOE 100-mrem all-pathway dose standard.

Offsite Fisherman Dose

The potential doses to a hypothetical offsite fisherman from fish consumption and contaminated soil exposure were calculated for 2000.

Creek Mouth Fish Consumption Pathway For 2000, analyses were conducted of fish taken from the mouths of five SRS streams, and the subsequent estimated doses from the maximum consumption of

19 kg (42 pounds) per year [Hamby, 1991] of these fish were determined (table 43, *SRS Environmental Data for 2000*). Fish flesh was composited by species for each location and analyzed for tritium, strontium-89,90, cesium-137, plutonium-238, and plutonium-239.

As shown in table 7–5, the maximum potential dose from this pathway was estimated at 0.64 mrem (0.0064 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 2000, a fisherman consumed 19 kg of bass caught exclusively from the mouth of Steel Creek. About 97 percent of this potential dose was from cesium-137. Again, some fraction of this cesium-137 is from worldwide fallout and from neighboring Vogtle Electric Generating Plant effluent discharges; however, that amount is difficult to determine and is not subtracted from the total.

Savannah River Swamp Fisherman Soil Exposure Pathway The potential dose to a recreational fisherman exposed to SRS legacy contamination in Savannah River Swamp soil on the privately owned Creek Plantation in 2000 was estimated using the RESRAD dosimetry code (DOE Order 5400.5). It was assumed that this recreational sportsman fished on the South Carolina bank of the Savannah River near the mouth of Steel Creek for 250 hours during the year.

During the 2000 survey of the Savannah River Swamp (chapter 12), the location on Creek Plantation that was closest to the South Carolina bank of the Savannah River and the mouth of Steel Creek was on trail 1, at a distance of 0 feet from the Savannah River (table 60, *SRS Environmental Data for 2000*).

Using the radionuclide concentrations measured at this location, the potential dose to a fisherman from a combination of 1) external exposure to the contaminated soil, 2) incidental ingestion of the soil, and 3) incidental inhalation of resuspended soil was estimated to be 0.54 mrem (0.0054 mSv).

As shown in table 7–5, the offsite creek mouth fish consumption pathway and the Savannah River Swamp fisherman soil exposure pathway were conservatively added together to obtain a total offsite creek mouth fisherman dose of 1.18 mrem (0.0118 mSv). This potential dose is about 1.2 percent of the DOE 100-mrem all-pathway dose standard.

Potential Risk from Consumption of SRS Creek Mouth Fish

During 1991 and 1992, in response to a U.S. House of Representative Appropriations Committee request for a plan to evaluate risk to the public from fish collected from the Savannah River, SRS developed—in conjunction with EPA, the Georgia Department of Natural Resources (GDNR), and the South Carolina Department of Health and Environmental Control (SCDHEC)—the *Westinghouse Savannah River Company/Environmental Monitoring Section Fish Monitoring Plan*, which is summarized in SRS EM Program, 1999. Part of the reporting requirements of this plan are to perform an assessment of radiological risk from the consumption of Savannah River fish, and to summarize the results in the annual *SRS Environmental Report*. The following sections discuss the potential radiological risks from the consumption of Savannah River fish, using SRS-published data from 1993 through 2000. Potential radiological risks are determined using both the ICRP–60 [ICRP, 1991] and the EPA [EPA, 1991] methods.

Exposure Scenario In EPA's risk assessment guidance document [EPA, 1991], two fish consumption pathways are considered—the recreational fisherman scenario and the subsistence fisherman scenario. Because of SRS's relatively remote location, the recreational fisherman scenario—as opposed to the subsistence fisherman scenario—is considered the more reasonable exposure scenario and is used in this assessment.

It is assumed that a recreational fisherman fishes for a single species of fish—either panfish, such as bream; predators, such as bass; or bottom dwellers, such as catfish—from the mouth of the worst-case SRS stream. Access to upstream portions of SRS streams is prohibited by postings, fencing (where possible), and periodic patrols.

Per EPA guidance [EPA, 1991], the maximum consumption rate that should be used for determining risk to the recreational fisherman is 19 kilograms (42 pounds) per year. This is the same as the consumption rate used by SRS for demonstrating maximally exposed individual dose compliance [Hamby, 1991].

The EPA guidance document requires that critical subpopulations and fish species be considered in risk assessments. Currently, there are no known sensitive subpopulations (e.g., Native Americans) in the immediate SRS region who are known to regularly consume whole fish (edible and nonedible portions) as part of their typical diet. Also, there are no known species of fish, such as smelt, in the SRS region of the Savannah River that are commonly eaten whole. Therefore, it is reasonably assumed that the recreational fisherman consumes only the edible (fillet only) portion of the fish caught.

Risk Factors For the EPA method, estimates of potential risk are calculated directly by multiplying the amount of each radionuclide ingested by the appropriate risk (slope) factors provided in EPA's *Health Effects Assessment Summary Tables* (HEAST) [EPA, 1996]. The HEAST ingestion slope factors are best estimates of potential, age-averaged, lifetime excess cancer incidence (fatal and nonfatal) risk per unit of activity ingested.

For the ICRP–60 method, estimates of potential risk are determined first by calculating a radiation dose attributable to the amount of radionuclides ingested and then multiplying that dose by the ICRP–60 coefficient of risk of severe detriment of 7.3E–07 per mrem [ICRP, 1991]. Stated another way, if 10,000,000 people each received a radiation dose of 1 mrem, there would theoretically be—during their collective lifetimes—7.3 additional severe detrimental incidences (fatal/nonfatal cancer or severe hereditary effects), which is small compared to the 2,000,000 or more expected fatal cancer incidences from other causes during their lifetimes [NRC, 1990].

The ICRP–60 risk coefficient includes factors for

- fatal cancers (5.0E–07 per mrem)
- nonfatal cancers (1.0E–07 per mrem)
- hereditary effects (1.3E–07 per mrem)

It should be noted that all radiological risk factors are based on observed and documented health effects to actual people who have received high doses (more than 10,000 mrem) of radiation, such as the Japanese atomic bomb survivors. Radiological risks at low doses (less than 10,000 mrem) are theoretical and are estimated by extrapolating the observed health effects at high doses to the low-dose region by using a linear, no-threshold model. However, cancer and other health effects have not been observed consistently at low radiation doses because the health risks either do not exist or are so low that they are undetectable by current scientific methods.

Exposure Duration According to EPA guidance, the upper bound value of 30 years can be used for exposure duration when calculating reasonable maximum residential exposures. This assessment compares the potential risks of exposure durations of 1 year, 30 years, and 50 years. The 30-year and 50-year exposure duration risks are simply 30 times and 50 times the 1-year exposure duration risk, respectively.

Risk Comparisons The maximum potential radiation doses and lifetime risks from the consumption of SRS creek mouth fish for 1-year, 30-year, and 50-year exposure durations are shown in table 7–6 and are compared to the radiation risks associated with the DOE Order 5400.5 all-pathway dose standard of 100 mrem (1.0 mSv) per year.

For each year, the maximum recreational fisherman dose was caused by the consumption of bass collected at the mouth of Steel Creek. More than 90 percent of the doses are attributable to cesium-137.

Figure 7–7 shows an 8-year history of the annual potential radiation doses from consumption of Savannah River fish. No apparent trends can be discerned from these data. This is because there is large variability in the annual cesium-137 concentrations measured in fish from the same location due to differences in

- the size of the fish collected each year
- their mobility and location within the stream mouth from which they are collected
- the time of year they are collected.

Also, it should be noted that most of the cesium-137 that exists in SRS stream watersheds is legacy contamination left from relatively large releases that occurred during the early years of operations at SRS (1954–1963) and is not from current direct operational releases [Carlton et al., 1994]. Therefore, there is large annual variability in the amount of cesium-137 available in the water and sediments at the site stream mouths; this is caused by annual changes in stream flow rates (turbulence) and water chemistry.

As indicated in table 7–6, the 50-year maximum potential lifetime risks from consumption of SRS creek mouth fish range between 2.2E–05 and 6.2E–05, which are below the 50-year risk associated with the 100-mrem-per-year dose standard.

According to EPA practice, if a potential risk is calculated to be less than 1.0E–06 (i.e., one additional case of cancer over what would be expected in a group of 1,000,000 people), then the risk is considered minimal and the corresponding contaminant concentrations are considered negligible. If a calculated risk is more than 1.0E–04 (one additional case of cancer in a population of 10,000), then some form of corrective action or remediation usually is required. However, if a calculated risk falls

Table 7–6
Potential Lifetime Risks from the Consumption of Savannah River Fish Compared to Dose Standards (1993–2000)

	Committed Dose (mrem)	ICRP–60 Risk Method	EPA/CERCLA Risk Method
2000 Savannah River Fish			
1-Year Exposure	0.64	4.7E–07	3.9E–07
30-Year Exposure	19	1.4E–05	1.2E–05
50-Year Exposure	32	2.3E–05	2.0E–05
1999 Savannah River Fish			
1-Year Exposure	0.61	4.5E–07	3.9E–07
30-Year Exposure	18	1.3E–05	1.2E–05
50-Year Exposure	31	2.2E–05	2.0E–05
1998 Savannah River Fish			
1-Year Exposure	1.6	1.2E–06	1.0E–06
30-Year Exposure	48	3.5E–05	3.0E–05
50-Year Exposure	80	5.8E–05	5.0E–05
1997 Savannah River Fish			
1-Year Exposure	0.65	4.8E–07	4.1E–07
30-Year Exposure	20	1.4E–05	1.2E–05
50-Year Exposure	33	2.4E–05	2.1E–05
1996 Savannah River Fish			
1-Year Exposure	1.7	1.2E–06	1.1E–06
30-Year Exposure	51	3.7E–05	3.3E–05
50-Year Exposure	85	6.2E–05	5.5E–05
1995 Savannah River Fish			
1-Year Exposure	1.2	8.8E–07	7.4E–07
30-Year Exposure	36	2.6E–05	2.2E–05
50-Year Exposure	60	4.4E–05	3.7E–05
1994 Savannah River Fish			
1-Year Exposure	1.3	9.5E–07	8.2E–07
30-Year Exposure	39	2.8E–05	2.5E–05
50-Year Exposure	65	4.7E–05	4.1E–05
1993 Savannah River Fish			
1-Year Exposure	1.3	9.5E–07	7.9E–07
30-Year Exposure	39	2.8E–05	2.4E–05
50-Year Exposure	65	4.7E–05	4.0E–05
Dose Standard			
100-mrem/year All Pathway			
1-Year Exposure	100	7.3E–05	6.3E–05
30-Year Exposure	3,000	2.2E–03	1.9E–03
50-Year Exposure	5,000	3.7E–03	3.2E–03

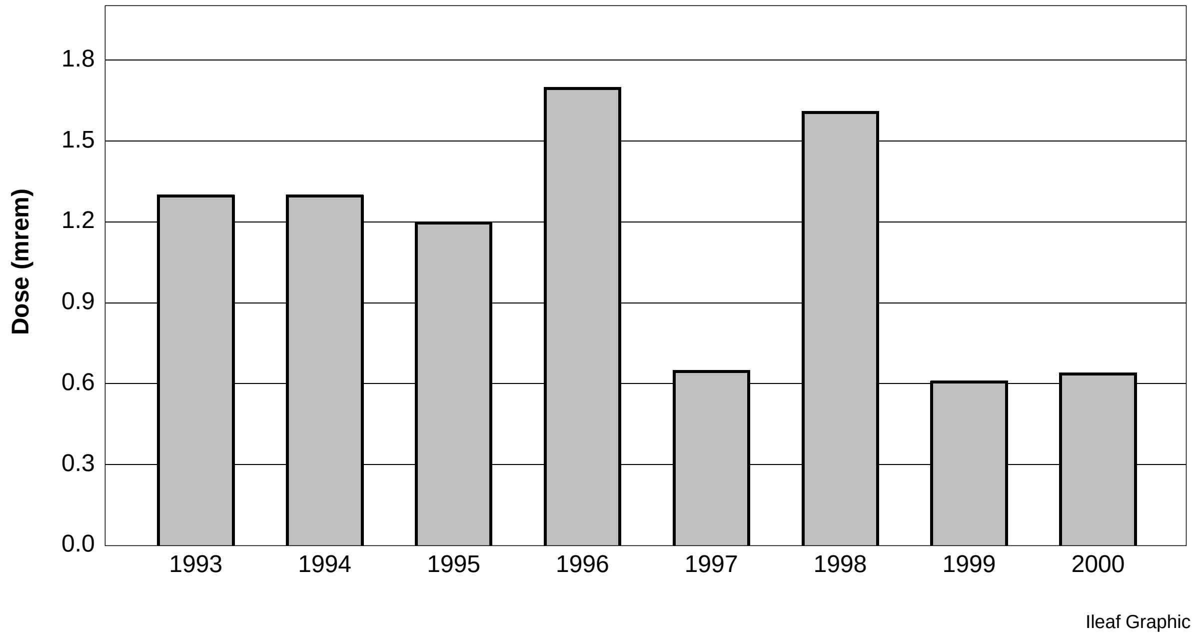


Figure 7–7 Annual Potential Radiation Doses from Consumption of Savannah River Fish, 1993–2000

between 1.0E–04 and 1.0E–06, which is the case with the maximum potential lifetime risks from the consumption of Savannah River fish, then the risks are considered acceptable if they are kept as low as reasonably achievable (ALARA).

At SRS, the following programs are in place to ensure that the potential risk from site radioactive liquid effluents (and, therefore, from consumption of Savannah River fish) are kept ALARA:

- radiological liquid effluent monitoring program (chapter 5)
- radiological environmental surveillance program (chapter 6)
- environmental ALARA program [SRS EM Program, 1999]

Dose to 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 per day (0.01 Gy per day) from exposure to radioactive material in liquid effluents released to natural waterways.

Hypothetical doses to various aquatic biota (fish, shellfish, algae, raccoon, and duck) in SRS streams are calculated annually to demonstrate compliance with this 1-rad-per-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 site's Environmental Monitoring Section (table 44, *SRS Environmental Data for 2000*).

The CRITR computer code [Soldat et al., 1974], incorporated as part of the LADTAPII code, calculates internal and external doses 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 currently 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 (effective radius) of the biota and on effective energies provided for each radionuclide for each radius. Because of their size and eating habits, ducks usually are the aquatic biota that receive the largest dose.

In 2000, the maximum dose to aquatic biota was estimated at 0.024 rad per day (0.00024 Gy per day), which potentially occurred in ducks inhabiting Four Mile Creek. This is 2.4 percent of the 1-rad-per-day DOE dose limit.

In future environmental reports, the potential dose to aquatic as well as terrestrial animals will be calculated following the guidance and methods developed by DOE's Biota Dose Assessment Committee.

Chapter 8
Nonradiological Effluent Monitoring

Carl Cook, Larry Eldridge,
and Chuck Hayes
Environmental Protection Department

To Read About . . . See Page . . .

2000 Highlights

- At SRS, there are 199 permitted/exempted nonradiological air emission sources, 137 of which were in operation to some capacity in 2000. Thirty-six of the SRS permitted sources are permitted to release toxic air pollutants; 21 of these were operated during the year.
- SRS conducts no onsite monitoring for ambient air quality; however, the site is required to show compliance with various air quality standards. This is accomplished by using air dispersion modeling techniques. Modeling analysis for new sources permitted at SRS in 2000 showed that the site was in compliance with all applicable ambient air quality standards.
- SRS monitors nonradioactive releases to surface water through NPDES. The site discharged water into site streams and the Savannah River under three NPDES permits in 2000.
- Thirty of the site's 33 permitted outfalls discharged; no flow was recorded at the other three. Results from 18 of the 5,486 discharge-sample analyses exceeded limits because of process upsets, enabling the site to achieve a 99.7-percent compliance rate. DOE has mandated a 98-percent compliance rate.

NONRADIOACTIVE air emissions originating at Savannah River Site (SRS) facilities are monitored at their points of discharge by direct measurement, sample extraction and measurement, or process knowledge. Air monitoring is used to determine whether all emissions and ambient concentrations are within applicable regulatory standards.

Nonradiological liquid effluent monitoring encompasses sampling and analysis and is performed by the Environmental Protection Department's Environmental Monitoring Section (EMS) and the Savannah River Technology Center.

A complete description of EMS sampling and analytical procedures used for nonradiological monitoring can be found in sections 1101–1111 (SRS EM Program) of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1. A summary of data results is presented in this chapter; more complete data can be found in *SRS Environmental Data for 2000* (WSRC–TR–2000–00329).

Airborne Emissions

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 of air emissions is permitted or exempted by SCDHEC, with specific limitations identified. The bases for the limitations are outlined in various South Carolina and federal air pollution control regulations and standards. Many of the applicable standards are source dependent, i.e., applicable to certain types of industry, processes, or equipment. However, some standards govern all sources for criteria and toxic air pollutants and ambient air quality. Air pollution control regulations and standards applicable to SRS sources are discussed briefly in appendix A, "Applicable Guidelines, Standards, and Regulations." The SCDHEC air standards for toxic air pollutants are listed in appendix C, "Standard No. 8 Toxic Air Pollutants."

At SRS, there are 199 permitted/exempted nonradiological air emission sources, 137 of which were in operation in some capacity during 2000. The remaining 62 sources either were being maintained in a "cold standby" status or were under construction.

Description of Monitoring Program

Major nonradiological emissions of concern from stacks at SRS facilities include sulfur dioxide, carbon monoxide, oxides of nitrogen, particulate matter smaller than 10 microns, volatile organic compounds, and toxic air pollutants. Facilities that have such emissions include diesel engine-powered equipment, package No. 2 fuel oil steam generators, powerhouse coal-fired boilers, the Defense Waste Processing Facility, the in-tank precipitation process, groundwater air strippers, and various other process facilities. Emissions from SRS sources are determined during an annual emissions inventory from calculations using source operating parameters such as fuel oil consumption rates, total hours of operation, and the emission factors provided in the U.S. Environmental Protection Agency (EPA) "Compilation of Air Pollution Emission Factors," AP–42. The calculation for boiler sulfur dioxide emissions also uses the average sulfur content of the coal and assumes 100-percent liberation of sulfur and 100-percent conversion to sulfur dioxide. Most of the processes at SRS are unique sources requiring nonstandard, complex calculations that use process chemical or material throughputs, hours of operation, chemical properties, etc., to determine actual emissions. In addition to the annual emissions inventory, compliance with various standards is determined in several ways, as follows:

At the SRS powerhouses, stack compliance tests are performed every 2 years for each boiler by airborne emission 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
- laboratory analysis of coal for sulfur content, ash content, moisture content, and British Thermal Unit (BTU) output

Sulfur content and BTU output are used to calculate sulfur dioxide emissions. SCDHEC also conducts visible-emissions observations during the tests to verify compliance with opacity standards. The day-to-day control of particulate matter smaller than 10 microns is demonstrated by opacity meters in all SRS powerhouse stacks.

For the package steam generating boilers in K-Area and for two portable units, compliance with sulfur dioxide standards is determined by analysis of the fuel oil purchased from the offsite vendor. The percent of sulfur in the fuel oil must be below 0.5 and is reported to SCDHEC each quarter. Compliance with particulate emission standards initially was demonstrated 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. The inspections include a review of operating parameters; the operating hours recorded in logbooks; an examination of continuous-emission monitors, where required for process or boiler stacks; and a visible-emissions observation for opacity. For diesel-powered equipment, the hours of operation for the previous calendar year are reviewed; they must not exceed the permitted number of hours. In August 2000, SCDHEC revised permits for portable diesel equipment to require the use of annual fuel oil consumption as the basis for determining permit compliance. The same revision was approved for stationary diesel equipment, but it will not be implemented until January 2001.

For some sources of SRS toxic air pollutants, source compliance is determined by stack testing for the permitted pollutants. SRS has several soil vapor extraction systems and two air strippers on which catalytic oxidation units were installed as pollution control devices. The construction permits for the systems required stack testing initially, with subsequent testing requirements to be specified when the operating permits were issued. However, the construction permits for all the existing systems have been modified to remove the catalytic oxidation units, thus eliminating the stack testing requirement. The Consolidated Incineration Facility (CIF) also must be tested once every 3 years for both toxic and criteria air pollutants.

Compliance by all toxic air pollutant and criteria pollutant sources also is determined by using EPA-approved air dispersion models. Air dispersion modeling is extremely conservative unless refined models are used. The Industrial Source Complex Version No. 3 model was used to predict maximum ground-level concentrations occurring at or beyond the site boundary for new sources permitted in 2000.

Monitoring Results

As noted earlier, emissions are calculated each year as part of an annual emissions inventory. In 2000, operating data were compiled and emissions calculated for 1999 operations for all site air emission sources (table 45, *SRS Environmental Data for 2000*). Because this process, which begins in January, requires up to 6 months to complete, this report will provide a comprehensive examination of total 1999 emissions, with only limited discussion of available

Table 8–1
SRS Power Plant Boiler Capacities

Location	Number of Boilers	Capacity (BTU/hr)
A-Area	2	71.7E+06
H-Area	3	71.1E+06

2000 monitoring results. It is known from compliance inspections, however, that the site received no notices of violation in 2000 and continued to maintain 100-percent compliance with all permitted emission rates and special conditions. Actual 2000 emissions will be compiled and reported in depth in the *SRS Environmental Report for 2001*.

Two power plants with five coal-fired boilers are operated by Westinghouse Savannah River Company (WSRC) at SRS. These boilers are used to generate steam, which is used for facility heating systems and, where required, as process steam. The location, number of boilers, and capacity of each boiler for these plants are listed in table 8–1. The A-Area and H-Area boilers are overfeed stoker fed and use coal as their only fuel. Both of the A-Area boilers were stack tested in 2000 and determined to be in compliance, results of the test appear in table 8–2. The H-Area No. 1 and No. 3 boilers had been scheduled to be stack tested in 2000 but instead were placed on cold standby. All three H-Area boilers (No. 2 already was on cold standby) will be tested upon being restarted.

SRS also has four package steam generating boilers fired by No. 2 fuel oil. The steam from these boilers is used primarily to heat buildings during cold weather, but also for process steam. The location, number of boilers, and capacity of each boiler are

Table 8–2
Boiler Stack Test Results (A-Area)

Boiler	Pollutant	Emission Rates	
		lb/10^6 BTU	lb/hr
A #1	Particulates	0.28	20.54
	Sulfur dioxide	1.33	NC[a]
A #2	Particulates	0.20	16.95
	Sulfur dioxide	1.31	NC[a]

a Not calculated

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
Portable	2	17.0E+06

shown in table 8–3. During 2000, only the 76.8- and 38.0-million BTU/hr boilers were operated. The percent of sulfur in the fuel oil burned during the year was certified by the vendor to meet the requirements of the permit.

At SRS, 128 permitted and exempted 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 to 2,050 kilowatts for generators and 200 to 520 horsepower for air compressor and pump engines. During the 2000 compliance inspections, the hours of operation and opacity for all inspected diesel engines were found to be in compliance. Fuel oil consumption for the diesel engines operated in 1999 was 565,982 gallons. Total fuel consumption for 2000 will be included in the report for calendar year 2001.

Another significant source of criteria pollutant emissions at SRS is the burning of forestry areas across the site. The U.S. Department of Agriculture Forest Service–Savannah River (USFS–SR, formerly the Savannah River Natural Resource Management and Research Institute) periodically conducts controlled burning of vegetation and undergrowth as a means of preventing uncontrolled forest fires. During 1999, USFS–SR personnel burned 12,828 acres across the site.

Other sources of criteria pollutants at SRS are too numerous to discuss here by type. Table 8–4 provides the 1999 atmospheric emissions results for all SRS sources, as determined by the air emissions inventory conducted in 2000. All calculated emissions were within applicable SCDHEC standards and permit limitations during 1999.

Thirty-six of the SRS permitted sources are permitted for toxic air pollutants; 21 of these were operated during 2000. Several of the toxic air pollutant sources—specifically, the soil vapor extraction and air strippers with catalytic oxidation units—were required to be stack tested following startup to verify initial compliance with their respective permitted

Table 8–4
1999 Criteria Pollutant Air Emissions

Pollutant Name	Actual Emissions[a] (Tons/Year)
Sulfur dioxide (SO_X)	5.53E+02
Total suspended particulates	4.61E+02
PM_{10} (particulate matter 10 microns)	1.85E+02
Carbon monoxide	3.44E+03
Ozone (volatile organic compounds)	2.16E+02
Gaseous fluorides (as hydrogen fluoride)	1.15E–01
Nitrogen dioxide (NO_X)	3.87E+02
Lead	2.07E–01

a From all SRS sources (permitted and nonpermitted)

emission rates. Subsequent test requirements were to be specified in their respective operating permits when the permits were issued. In 2000, the catalytic oxidation control device for the last vapor extraction unit was removed, thus eliminating requirements that the stack testing be conducted. As discussed in the description of the monitoring program, the CIF must be stack tested every 3 years. This facility last was tested in April 1997 and was not due for testing again until April 2000. However, all CIF operations were suspended in 2000, and the facility was placed on cold standby. Stack testing thus was postponed until the resumption of operations.

Total toxic air pollutant emissions at SRS are determined annually in tons per year for each pollutant (table 45, *SRS Environmental Data for 2000*). It should be noted that some toxic air pollutants (e.g., benzene) regulated by SCDHEC also are, by nature, volatile organic compounds (VOCs). As such, the total for VOCs in table 8–4 includes toxic air pollutant emissions. It also should be noted that table 8–4 includes the emissions for some hazardous air pollutants that are regulated under the Clean Air Act but not by SCDHEC Standard No. 8. These pollutants are included because they are compounds of some Standard No. 8 pollutants.

Ambient Air Quality

Under existing regulations, SRS is not required to conduct onsite monitoring for ambient air quality; however, the site is required to show compliance with various air quality standards. To accomplish this, air dispersion modeling was conducted during 2000 for new emission sources or modified sources as part of the sources' construction permitting process. The modeling analysis showed that SRS air emission sources were in compliance with applicable regulations.

South Carolina and Georgia continue to monitor ambient air quality near SRS as part of the network associated with the Clean Air Act. Resulting data are available to the public through (1) the South Carolina Bureau of Air Quality and (2) the Georgia Department of Natural Resources, Environmental Protection Division, Air Protection Branch.

Liquid Discharges

Description of Monitoring Program

SRS monitors nonradioactive releases to surface waters through the National Pollutant Discharge Elimination System (NPDES), as mandated by the Clean Water Act. As required by EPA and SCDHEC, SRS has NPDES permits for discharges to the waters of the United States and South Carolina. These permits require that SRS test water discharged from the site for certain pollutants. Also mandated are specific sites to be monitored, parameters to be tested, and monitoring frequency—as well as analytical, reporting, and collection methods. Detailed requirements for each permitted discharge point—including parameters sampled for, permit limits for each parameter, sampling frequency, and method for collecting each sample—can be found in the individual permits, which are available to the public through SCDHEC's Freedom of Information office at (803) 734–5376.

In 2000, SRS discharged water into site streams and the Savannah River under three NPDES permits: one for industrial wastewater (SC0000175) and two for stormwater runoff—SCR00000 (industrial discharge) and SCR10000 (construction discharge). Permit SCG250162 required sampling only at outfall 001, which did not discharge during 2000. Because no additional discharges are anticipated from this outfall, SRS asked to be removed from coverage under the permit. SCDHEC approved the request in October. A fifth permit, ND0072125, is a "no discharge" water pollution control land application permit that regulates sludge application and related sampling at onsite sanitary wastewater treatment facilities.

Permit SC0000175 regulated 32 industrial wastewater outfalls in 2000 (figure 8–1). Permit SCR000000 requires a representative sampling of site stormwater discharges; the 2000 stormwater sampling program included 13 outfalls. Permit SCR100000 does not require sampling unless requested by SCDHEC to address specific discharge issues at a given construction site; SCDHEC did not request such sampling in 2000.

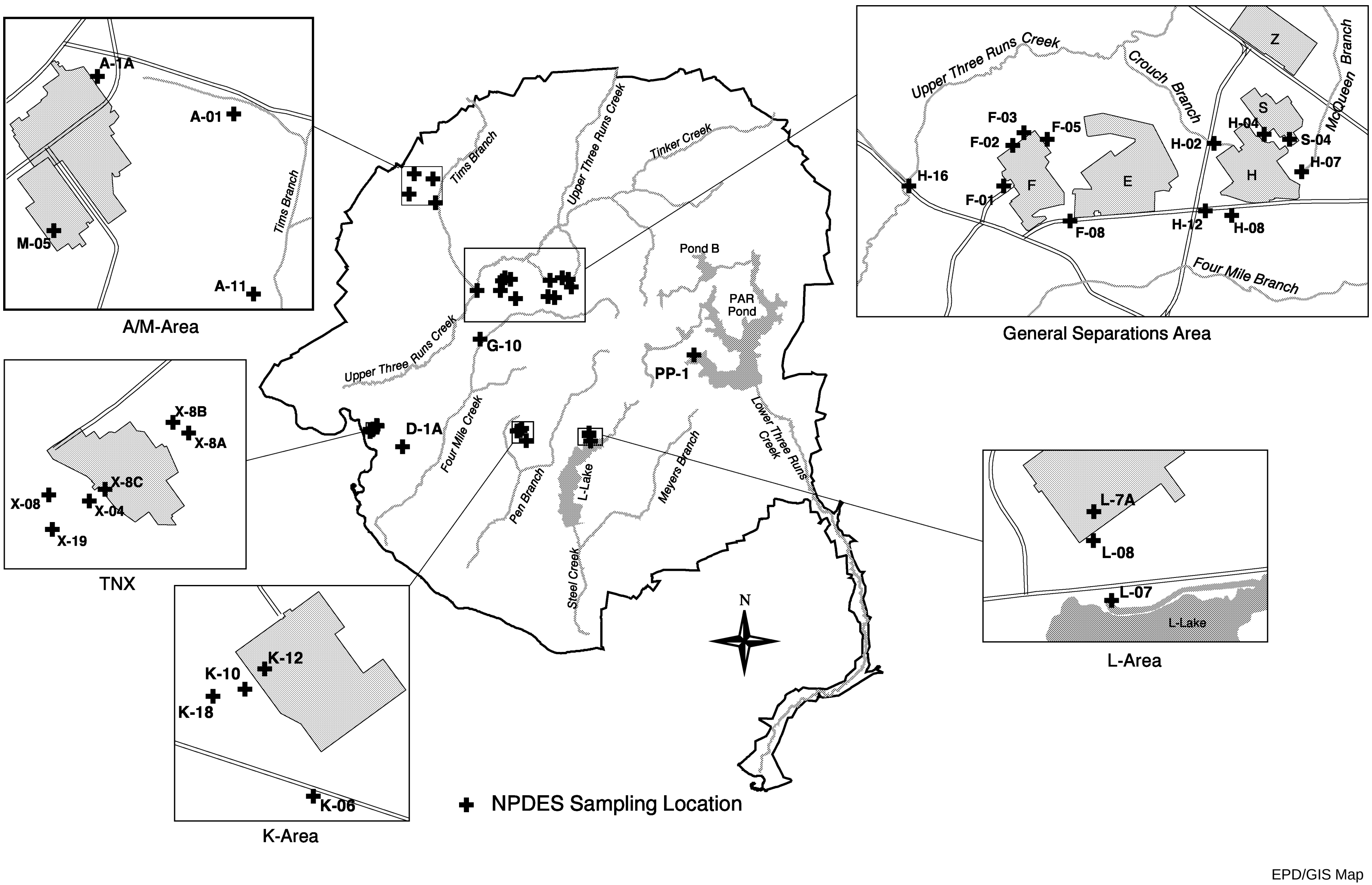


Figure 8–1 NPDES Sampling Locations

Thirty-two industrial wastewater outfalls were regulated at SRS under NPDES Permit SC0000175 during 2000.

NPDES samples are preserved in the field according to 40 CFR 136, the federal document that lists specific sample collection, preservation, and analytical methods acceptable for the type of pollutant to be analyzed. 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 according to procedures listed in 40 CFR 136 for the parameters required by the permit.

The effectiveness of the NPDES monitoring program is documented by a surveillance program involving chemical and biological evaluation of the waters to which effluents have been discharged. More monitoring information can be found in chapters 9, “Nonradiological Environmental Surveillance,” and 12, “Special Surveys and Projects.”

Monitoring Results

SRS reports analytical results to SCDHEC through a monthly discharge monitoring report, which includes an explanation concerning any analytical measurements outside permit limits and a summary of all analyses performed at each permitted outfall. Complete results from 2000 NPDES industrial discharges (permit SC0000175) can be found in tables 46 and 47, *SRS Environmental Data for 2000*.

Thirty of the 32 outfalls permitted by SC0000175 in 2000 discharged. Results from 18 of the 5,496 sample analyses performed during the year exceeded permit limits.

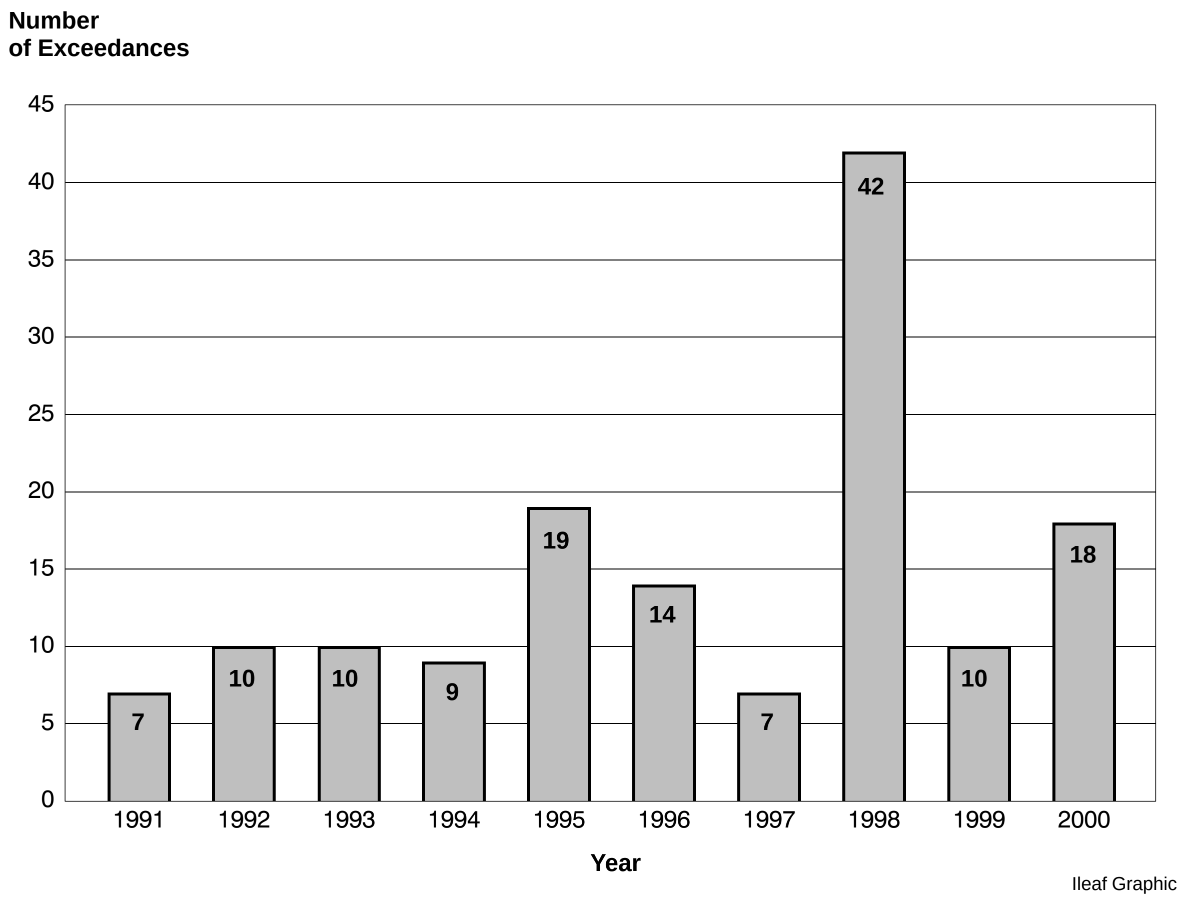
A list of 2000 NPDES exceedances appears in table 8–5. Figure 8–2 shows the NPDES exceedances at SRS from 1991 through 2000, along with the site’s compliance rate for each year. Complete results of 2000 industrial wastewater sample analyses can be found in table 46, *SRS Environmental Data for 2000*. SRS achieved a 99.7-percent compliance rate—higher than the DOE-mandated 98-percent rate.

The 2000 exceedance total of 18 represents an increase from the 10 exceedances of 1999. Chronic-toxicity failures at outfall A–11 accounted for 11 of the 18 exceedances. The remaining seven were attributable to process upsets, analytical errors, or unknown reasons. The chronic-toxicity problem, identified in 1998 and cited in a November 1998 notice of violation, has been a recurring issue. Toxicity identification evaluation analyses have been unable to determine the source of the toxicity. The toxicity is likely to be an artifact associated with the low-hardness condition of SRS waters and the condition’s effects on the non-native test organism *(Ceriodaphnia dubia*) mandated for use by the NPDES protocol (rather than due to a specific toxicant). The site is exploring this possibility through a series of chronic toxicity tests (i.e., tests of survivorship and reproduction during long-term exposure to SRS waters, as well as to toxicants) using a native test species (*Daphnia ambigua*). Preliminary data suggest that *Daphnia ambigua* may be a more appropriate test organism because of its lack of sensitivity to the low-hardness conditions of SRS waters.

A chronic toxicity problem at outfall A–01, identified in 1998 and attributed to elevated copper levels in the effluent (caused by multiple sources throughout the A–01 drainage area), continued throughout 2000. An SCDHEC consent order issued in 1999 mandates that SRS comply with permit SC0000175 requirements by October 2001. Artificial wetlands have been constructed to remove metals from the A–01 discharge. Also, the ongoing chronic toxicity tests using *Daphnia ambigua* may add valuable perspective with regard to the validity and degree of the A–01 toxicity issue. A summary of toxicity results from 2000 can be found in table 47, *SRS Environmental Data for 2000*.

A total of 513 analyses were performed during 2000 on stormwater discharge samples. SCDHEC has not mandated permit limits for stormwater outfalls. Complete results of 2000 NPDES stormwater sample analyses can be found in table 48, *SRS Environmental Data for 2000*.

A total of 49 analyses were performed during 2000 on sanitary sludge samples. All results were within permit specifications. Results from all the land application analyses can be found in table 49, *SRS Environmental Data for 2000.*



Year	*Number of Analyses*	*Compliance Rate*
1991	8,329	99.9%
1992	7,729	99.9%
1993	8,000	99.9%
1994	7,568	99.9%
1995	7,515	99.8%
1996	5,737	99.8%
1997	5,758	99.9%
1998	5,790	99.3%
1999	5,778	99.8%
2000	5,496	99.7%

Figure 8–2 History of NPDES Exceedances at SRS, and Site's Compliance Rate, 1991–2000

The chart and table provide historical information about NPDES exceedances from SRS liquid discharges to South Carolina waters, including the number of exceedances—and the site's compliance rate—for each year from 1991 to 2000.To determine the compliance rate, the number of analyses not exceeding limits for a given year is divided by the total number of analyses. For example, 5,496 analyses were performed in 2000, with 18 exceedances. To calculate the compliance rate for that year, divide 5,478 (5,496 minus 18) by 5,496 for a quotient of .9967—or 99.7 percent.

Table 8–5
2000 Exceedances of SCDHEC-Issued NPDES Permit Liquid Discharge Limits at SRS

Department/ Division	Outfall	Date	Parameter Exceeded	Result	Possible Cause	Corrective Action
ER	A–11	Jan. 10	C-TOX	Fail	Unknown	Under Investigation
SWD	H–16	Jan. 17	BOD	43.2 mg/L	Unknown	Under investigation
SUD	K–06	Jan. 20	pH	8.82 SU	High-pH boiler discharge	Discharge coordinated with cooling water
ER	A–11	Feb. 7	C-TOX	Fail	Unknown	Under investigation
ER	A–11	March 6	C-TOX	Fail	Unknown	Under Investigation
ER	A–11	April 10	C-TOX	Fail	Unknown	Under Investigation
SUD	D–1A	May 11	BOD	>13.0 mg/L	Analytical error	Data review initiated prior to end of month
ER	A–11	May 15	C-TOX	Fail	Unknown	Under investigation
ER	A–11	June 12	C-TOX	Fail	Unknown	Under investigation
ER	A–11	July 17	C-TOX	Fail	Unknown	Under investigation
TSD	X–08	Aug. 3	pH	5.80 SU	Unknown	Further investiga-tion revealed no pH problems
ER	A–11	Aug. 14	C-TOX	Fail	Unknown	Under investigation
TSD	A–01	Oct. 16	TSS	79 mg/L	Construction activity	Under investigation
TSD	A–01	Oct. 17	TSS	78 mg/L	Construction activity	Under investigation
ER	A–11	Oct. 18	C-TOX	Fail	Unknown	Under investigation
TSD	A–01	Oct. 25	TSS	78 mg/L	Construction activity	Under investigation
ER	A–11	Nov. 13	C-TOX	Fail	Unknown	Under investigation
ER	A–11	Dec. 6	C-TOX	Fail	Unknown	Under investigation

Key: BOD – Biochemical oxygen demand
C-TOX – Chronic toxicity
SU – Standard units
TSS – Total suspended solids

Chapter 9

Nonradiological Environmental Surveillance

Bill Littrell and Phillip Miller
Environmental Protection Department

Robert Turner
Engineering Services Department

Robin Davis
Academy of Natural Sciences of Philadelphia

To Read About . . . See Page . . .

2000 Highlights

- Analyses of the nonradioactive surveillance data generally indicated that SRS discharges are not significantly affecting the water quality of the streams or the river.
- All samples collected from SRS drinking water systems were in compliance with SCDHEC and EPA water quality limits.
- No pesticides or herbicides were detected in surface water samples. In addition, no pesticides or herbicides were found in sediment samples to be above the quantitation limits. All analyses of pesticides/herbicides were below the detection limits of EPA analytical procedures used.
- Overall individual results of all samples of fish (both on site and off site) indicated that bass contained the highest levels of mercury.
- Results of the 2000 river survey conducted by the Academy of Natural Sciences of Philadelphia were not complete by the end of the year, but results of the 1999 study (which are reported in this chapter) do not provide evidence of an SRS impact on biological communities in the Savannah River.

NONRADIOACTIVE environmental surveillance at the Savannah River Site (SRS) involves the sampling and analysis of surface water (six onsite streams and the Savannah River), drinking water, sediment, groundwater, and fish. Surface water, drinking water, sediment, and fish surveillance programs are discussed in this chapter. However, a description of the surveillance program and 2000 results for groundwater can be found in chapter 10, “Groundwater.”

The Environmental Protection Department’s Environmental Monitoring Section (EMS) and the Savannah River Technology Center (SRTC) perform nonradiological surveillance activities. 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). In addition, the Academy of Natural Sciences of Philadelphia (ANSP) conducts environmental surveys on the Savannah River through a program that began in 1951. A discussion of these surveys and latest results begins on page 141.

A complete description of the EMS sample collection and analytical procedures used for nonradiological surveillance can be found in section 1105 of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1 (SRS EM Program). A summary of analytical results is presented in this chapter; however, more complete data can be found in *SRS Environmental Data for 2000* (WSRC–TR–2000–00328). Information on the rationale for the nonradiological environmental surveillance program can be found in chapter 3, “Environmental Program Information.”

In 2000, approximately 6,300 nonradiological analyses for specific chemicals and metals were performed on about 1,200 samples, not including groundwater.

SRS currently does not conduct onsite surveillance for ambient air quality. However, to ensure compliance with SCDHEC air quality regulations and standards, SRTC conducted air dispersion modeling for all site sources of criteria pollutants and toxic air pollutants in 1993. This modeling indicated that all SRS sources were in compliance with air quality regulations and standards. Since that time, additional modeling conducted for new sources of criteria pollutants and toxic air pollutants has demonstrated continued compliance by the site with these regulations and standards. The states of South Carolina and Georgia continue to monitor ambient air quality near the site as part of a network associated with the federal Clean Air Act. (See chapter 8 for more information about criteria pollutants and toxic air pollutants.)

Surface Water

SRS streams and the Savannah River are classified as "Freshwaters" by SCDHEC. Freshwaters are defined as surface water suitable for

- primary—and secondary—contact recreation and as a drinking water source after conventional treatment in accordance with SCDHEC requirements
- fishing and survival and propagation of a balanced indigenous aquatic community of fauna and flora
- industrial and agricultural uses

Appendix A, "Applicable Guidelines, Standards, and Regulations," provides some of the specific guides used in water quality surveillance, but because some of these guides are not quantifiable, they are not tracked (i.e., amount of garbage found).

Description of Surveillance Program

SRS stream and Savannah River nonradiological surveillance is conducted for any evident degradation that could be attributed to the water discharges regulated by the site National Pollutant Discharge Elimination System (NPDES) permits and materials that may be released inadvertently from sources other than routine release points.

In addition, nonradiological surveillance is conducted to compare the SRS contribution of pollutants with background levels of chemicals from natural sources and from contaminants produced by municipal sewage plants, medical facilities, and other upriver industrial facilities.

Each SRS stream receives varying amounts of treated wastewater and rainwater runoff from site facilities. Stream locations are sampled for water quality at monthly and quarterly frequencies by the conventional grab-collection technique. Each grab sample shows the water quality at the time of sampling only.

River sampling sites are located upriver of, adjacent to, and downriver of the site. In the surveillance program, site streams and the Savannah River are sampled monthly for various physical and chemical properties. Surface water sampling locations are shown in figure 9–1.

To monitor the quality of water coming onto and leaving the site, field measurements for conductivity, dissolved oxygen, pH, and temperature are taken monthly and laboratory analyses are conducted for other water quality parameters, such as metals, pesticides/herbicides (quarterly), and other physical and chemical properties. Comparison of the results from upstream and downstream locations (locations that are below process areas or at points where the water leaves the site) indicates any impact the site may have had on the water.

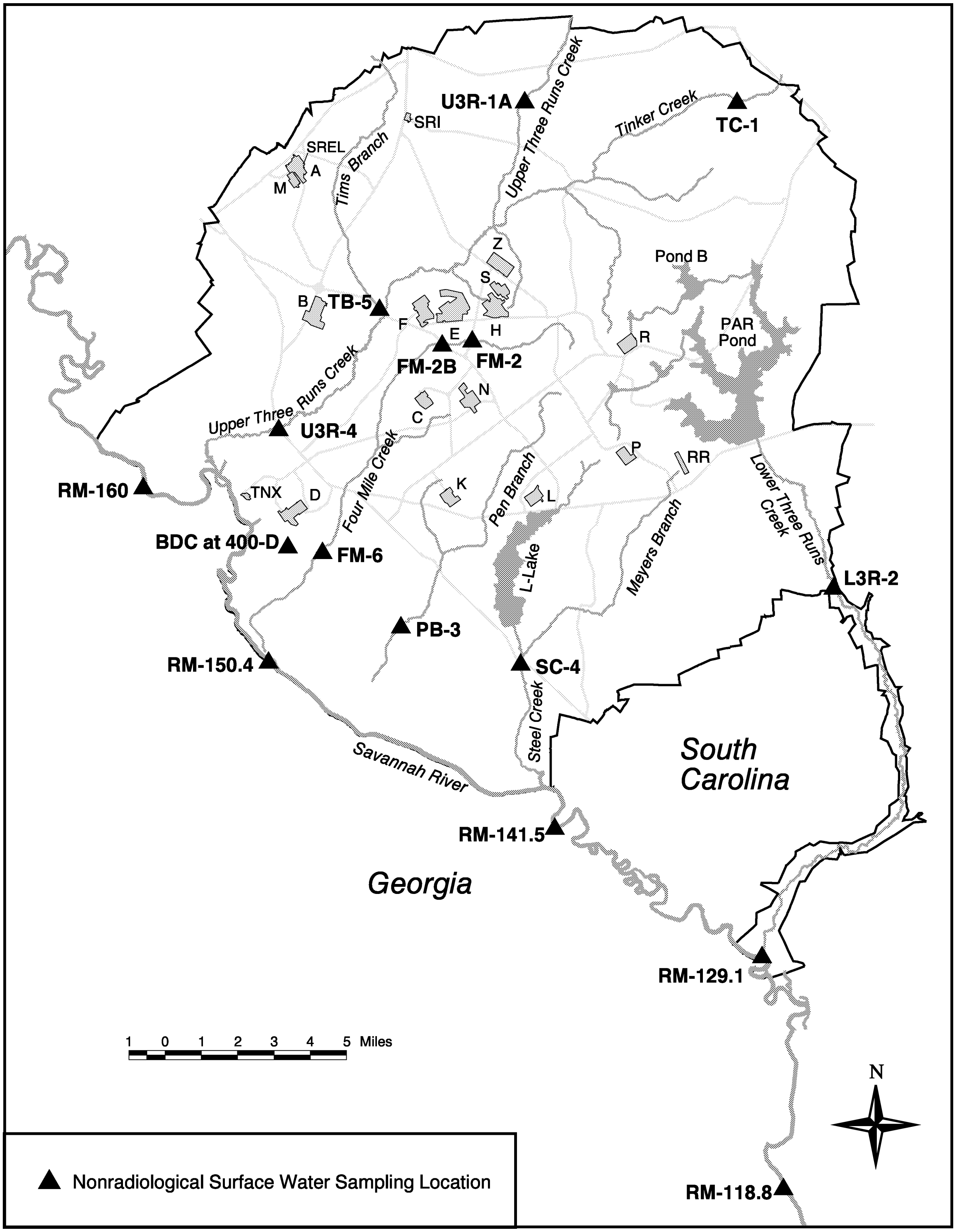
The natural chemical and physical parameters measured monthly on each stream and in the river vary to some extent throughout the year. This natural variation can be trended on a month-to-month basis. When results diverge greatly from the historical norm, an abnormal discharge event or occurrence in the environment may be indicated. An investigation is held to determine if a release has occurred.

Surveillance Results

Results can be found in table 50, *SRS Environmental Data for 2000*.

Comparison of the upstream and downstream locations where available (Upper Three Runs) and month-to-month trends for each of these stations indicated normal trends for a southern pine forest stream. The upstream pH varied within a range of 4.8 to 6.5 at Upper Three Runs–1A and between 5.8 and 7.0 at Tinker Creek–1. Conductivity ranged from a low of 15 µhmos/cm at the Upper Three Runs–1A location to a high of 54 µhmos/cm at Tinker Creek–1. The downstream station at Upper Three Runs–4 had a pH range of 5 to 7 and a conductivity range of 20 to 32 µhmos/cm.

Nitrate levels for most river and stream locations usually ranged below 0.50 mg/L. Four Mile–6 had the highest nitrate concentration of all the streams at 1.0 mg/L; concentrations ranged downward to below detection. This was due to discharges into Four Mile Creek from the waste treatment facility above the sampling location.



EPD/GIS Map

Figure 9–1 Nonradiological Surface Water Sampling Locations

Surface water samples are collected from five Savannah River and eleven SRS stream locations and are analyzed for various chemical and physical properties.

Average phosphate levels were typically higher in the Savannah River than in onsite streams. River levels ranged from an average of 0.106 mg/L at River Mile 160 to 0.159 mg/L at River Mile 150.4. The highest average on site was 0.1147 mg/L at Four Mile–6. Lower Three Runs–2 was second, with approximately the same average.

With the exception of the Lower Three Runs–2 location, total suspended solids averaged lower on site than in the river. Lower Three Runs–2 had high total suspended solids during July and August, which raised the location's average to 18.9 mg/L. Excluding Lower Three Runs–2, onsite total suspended solids averages ranged from a low average of 4 mg/L at Upper Three Runs–1A to a high average of 7.9 mg/L at Four Mile–2. In the river, the low average was at River Mile 160 (5.0 mg/L), and the high average was at River Mile 129.1 (11.1 mg/L).

Hardness in the Savannah River ranged from a low of 11 mg/L at River Mile 150.4 to a high of 36 mg/L at River Mile 160. On site, the low was below detection at two locations for the entire year (Tims Branch–5 and Upper Three Runs–1A), and the high was 44 mg/L at Lower Three Runs–2.

Aluminum, cadmium, chromium, copper, iron, manganese, and zinc were seen in surface waters at all river and stream locations. More positive results for several of the metals were found throughout the year than in the past. No mercury was seen above the quantitation limit in the Savannah River or in onsite streams. Copper was found several times at various locations, both upstream and throughout the site. All positive results were around the quantitation limit.

No pesticides or herbicides were detected during 2000.

Analyses of the data generally indicated that SRS discharges are not significantly affecting the water quality of the streams or the river.

Drinking Water

Most of the drinking water at SRS is supplied by three systems that have treatment plants in A-Area, D-Area, and K-Area. The site also has 15 small drinking water facilities at remote security barricades, field laboratories, and field offices that serve populations of fewer than 25 persons (figure 9–2).

Well water from the McBean, Congaree, Black Creek, and Middendorf aquifers is utilized for the 18 drinking water systems. Many of these well water supplies require treatment to ensure that SCDHEC and U.S. Environmental Protection Agency (EPA) drinking water quality standards are maintained. Treatment processes include aeration to remove dissolved gases; filtration to remove iron; and addition of potable water treatment chemicals to adjust pH, prevent piping corrosion, and prevent bacterial growth.

Description of Surveillance Program

SRS drinking water supplies are tested routinely by site personnel and by SCDHEC to ensure compliance with SCDHEC and EPA drinking water standards (the drinking water standards can be found in appendix B) and monitoring requirements. This testing includes

- daily testing to monitor concentration of any potable water treatment chemicals added
- monthly or quarterly testing to confirm that bacteria are not present
- periodic testing for metals, organic and inorganic chemicals, and radionuclides

Surveillance Results

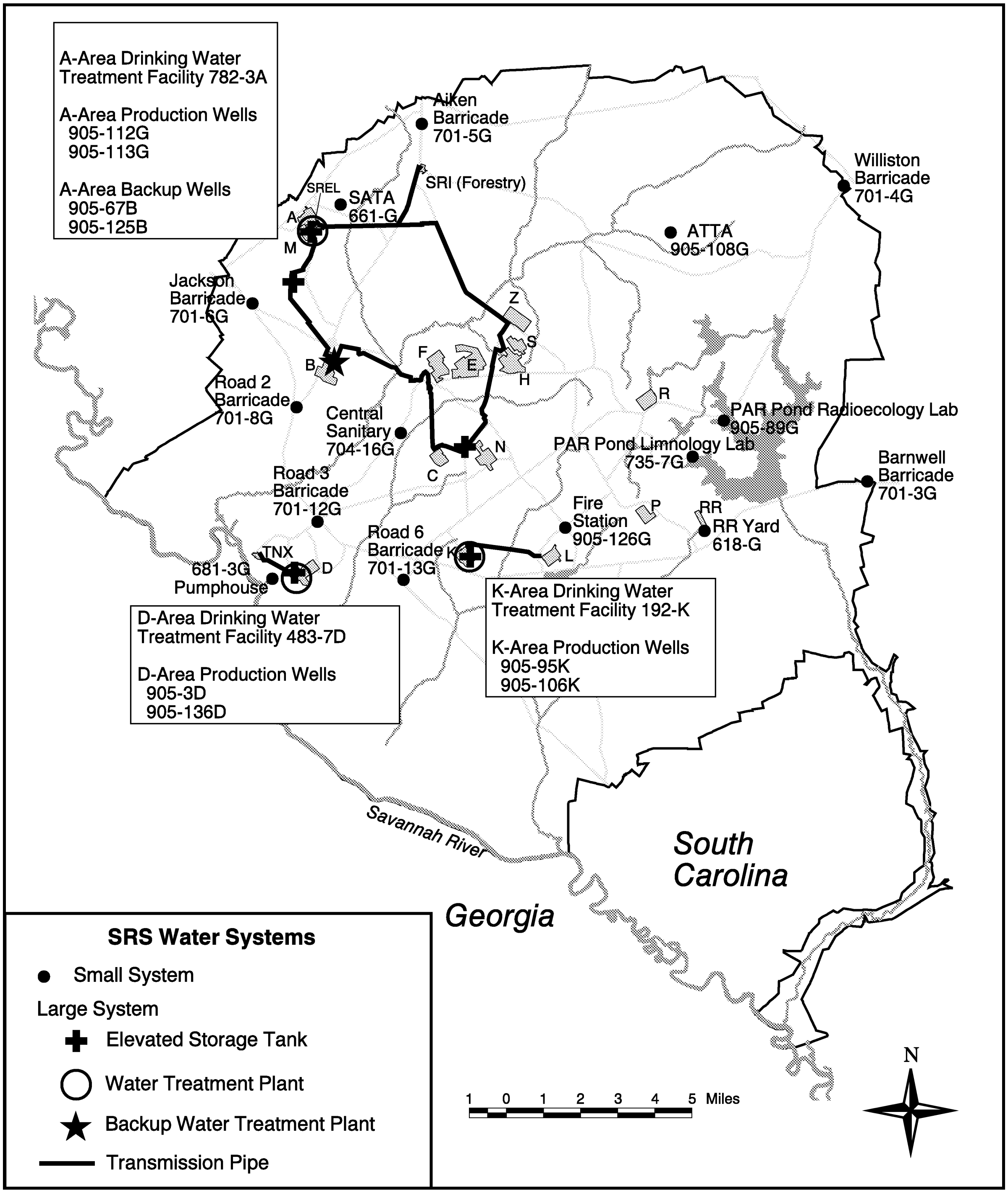
All samples collected from SRS drinking water systems during 2000 were in compliance with SCDHEC and EPA water quality limits (maximum contaminant levels).

Sediment

EMS's nonradiological sediment surveillance program provides a method of determining the deposition, movement, and accumulation of nonradiological contaminants in stream systems.

Description of Surveillance Program

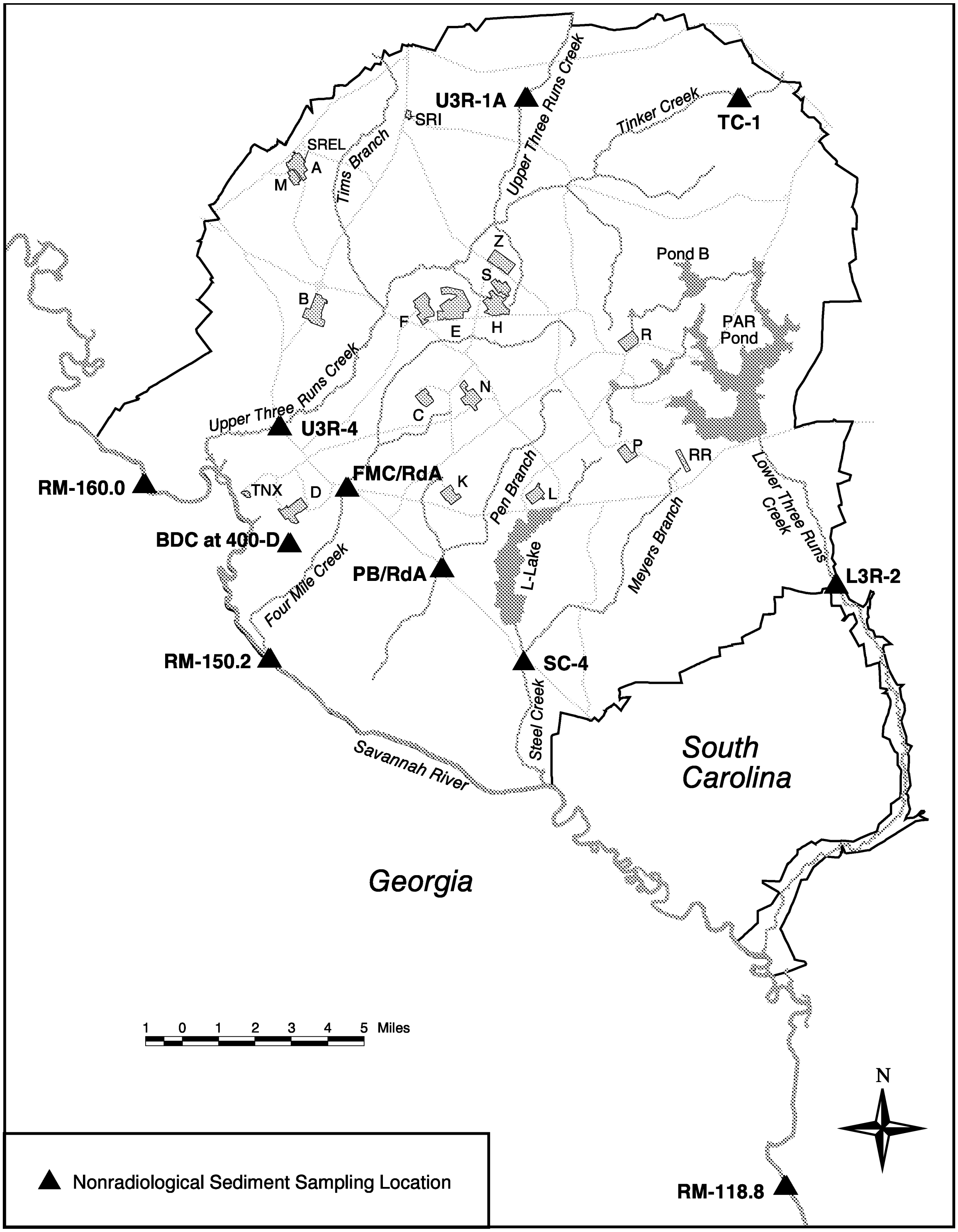
The nonradiological sediment program consists of the collection of sediment samples at eight onsite stream locations and three Savannah River locations (figure 9–3). Collection is made by either a Ponar sediment sampler or an Emery pipe dredge sampler. The samples are analyzed for various inorganic contaminants (metals) and pesticides/herbicides by the Toxicity Characteristic Leaching Procedure (TCLP). This method analyzes for the soluble constituents in sediment. The program is designed to check for the existence and possible buildup of the inorganic contaminants as well as for pesticides/herbicides.



EPD/GIS Map

Figure 9–2 Drinking Water Systems

Most of the drinking water at SRS is supplied by three systems. The site also has 15 small drinking water facilities that serve populations of fewer than 25 persons. The three larger systems are depicted by transmission pipes, elevated storage tanks, water treatment plants, and a backup water treatment plant.



EPD/GIS Map

Figure 9–3 Nonradiological Sediment Sampling Locations

Sediment samples are collected at eight onsite stream locations and three Savannah River locations. The samples are analyzed for various inorganic contaminants (metals) and pesticides/herbicides.

Surveillance Results

Sediment results can be found in table 51, *SRS Environmental Data for 2000*.

In 2000, as in the previous four years, no pesticides or herbicides were found to be above the quantitation limits in sediment samples. All pesticide/herbicide results were below the detection limits of the EPA analytical procedures used.

Barium, chromium, iron, manganese, and zinc were seen in sediment at one or more river and/or stream locations. Levels for these metals were consistent with those seen in soil samples. From year to year, most metals vary from nondetectable levels to very low levels.

In 2000, copper was not detected at any location. For years, it had ranged as high as 0.103 mg/L at Tinker Creek–1 (control location) to below the lower limit of detection (LLD) at several locations as well as Tinker Creek–1.

No mercury was detected in 2000 at any of the location sites. In 1999, Upper Three Runs–4 showed 0.0001 mg/L of mercury, which is at the detection level. The 1998 level at Tinker Creek–1 was slightly above detection. No mercury was detected at any site in 1996 and 1997. Note that the mercury issue at SRS currently is being reevaluated using the new EPA 1631 method, which has a much lower level of detection (0.006 ng/L) than that of the method used previously in the monitoring program.

Cyanide was seen at one location, 400–D (0.46 mg/Kg). No significant trends were observed for metals in the Savannah River or on site.

Fish

Description of Surveillance Program

EMS analyzes the flesh of fish caught from onsite streams and ponds and from the Savannah River to determine concentrations of mercury in the fish [SRS EM Program, 1999]. The freshwater fish analyzed (bass, bream, and catfish) represent the most common edible species of fish in the Central Savannah River Area (CSRA), an 18-county area in Georgia and South Carolina that surrounds Augusta, Georgia, and includes SRS. Saltwater fish analyzed in 2000 included mullet, redfish, and sea trout. (Sampling locations for fish are depicted in a map on page 96 in chapter 6, "Radiological Environmental Surveillance.")

Surveillance Results

In 2000, 172 fish were caught from SRS streams and ponds and the Savannah River and analyzed for mercury (table 52, *SRS Environmental Data for 2000*). Because of low water, no fish were caught from the Pen Branch–3, Four Mile Creek–6, Steel Creek–4, Upper Three Runs–4, and Beaver Dam Creek locations.

The mercury concentrations in fish analyzed from onsite waters ranged from a high of 1.817 µg/g in a bass from PAR Pond to a low of 0.094 in a bream in L-Lake. Mercury concentrations in offsite fish ranged from a high of 1.629 µg/g in a bass from the Highway 301 Bridge area to values of 0.016 in mullet downstream of the Highway 17 Bridge area. The quantitation limit for mercury in fish flesh is 0.008 µg/g.

Overall individual results of all samples indicated that bass contained the highest levels of mercury. After bass, the order of fish with the next highest levels of mercury was mixed, depending on location.

Table 3–57 in the EPA publication mentioned in the sidebar on page 142 indicates that the recommended monthly consumption limit for fish collected at the highest offsite location for 2000 (Highway 301 Bridge area) would be between one and two 8-ounce servings per month.

Academy of Natural Sciences of Philadelphia River Quality Surveys

Description of Surveys

The Patrick Center for Environmental Research of ANSP conducts biological and water quality surveys of the Savannah River. These surveys, which have been conducted by ANSP since 1951, are designed to assess potential effects of SRS contaminants and warm water discharges on the general health of the river and its tributaries. This is accomplished by looking for

- patterns of biological disturbance that are geographically associated with the site
- patterns of change over seasons or years that indicate improving or deteriorating conditions

Multiple levels of the aquatic food web are studied because (1) no single group is the best indicator of all aspects of ecosystem health and (2) there is a broad consensus that maintaining the integrity of the entire system is important. Studies are timed to coincide with periods of the year that are most

Perspective on Mercury

Mercury in the environment can come from natural sources, such as volcanoes and venting of the earth's crust. Testing by EPA during 2000 determined that 99 percent of the mercury in the Savannah River comes from atmospheric deposition [EPA, 2001]. Mercury also can come from manmade sources and processes, such as fungicides and fossil fuel combustion byproducts 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 offsite sources, such as Savannah River water [Davis et al., 1989]. Savannah River water is pumped onto the site to support fire protection efforts and the sanitary waste treatment plant and to maintain L-Lake's water level. The water subsequently is released into site streams and lakes.

The naturally occurring metal cycles between land, water, and air. As mercury enters streams and rivers through rainfall, runoff, and discharges, it is converted to the chemical compound methylmercury by bacterial and other processes. As part of the natural cycling, some methylmercury is absorbed by plants and animals into their tissues. Fish absorb methylmercury from food they ingest and from water as it passes over their gills; the methylmercury then is bound in their tissues. Consumption by people of fish containing methylmercury then completes the mercury pathway to humans. The amount of fish that can be eaten safely varies with (1) the concentration of methylmercury, (2) the amount consumed, and (3) the frequency of consumption. These factors are the basis of calculations performed during "risk analysis," a method to determine how much fish can be consumed safely.

State and federal regulatory agencies calculate the health risk associated with the consumption of fish, then recommend consumption guidelines based on that risk. Adherence to these guidelines can effectively control one's exposure to methylmercury. A list of fish advisories and/or recommended consumption limits can be obtained from state environmental agencies. EPA criteria taken from "Guidance For Assessing Chemical Contaminant Data For Use In Fish Advisories, Volume II Risk Assessment And Fish Consumption Limits" (EPA 823–B–94–004, June 1994), gives the monthly consumption limits for chronic systemic health endpoint for the general population.

stressful to the aquatic biota (e.g., low flows, elevated temperatures) and when pollution-sensitive taxa are more abundant. A limited amount of more frequent monitoring over the course of the year to flag potential perturbations that may occur outside the once or twice yearly studies is conducted.

The 1999 and 2000 surveys examined algae, insects (primarily) and other macroinvertebrates, and fish yearly or twice yearly. Diatoms, a type of algae, were examined monthly using artificial substrates.

The study design employed in the ANSP Savannah River surveys formerly included six sampling stations (figure 9–4). Use of station 3 was discontinued in 1997, and use of station 2A was discontinued in 2000. The current design includes four sampling stations—three exposed to SRS influence and one unexposed reference station upriver (station 1).

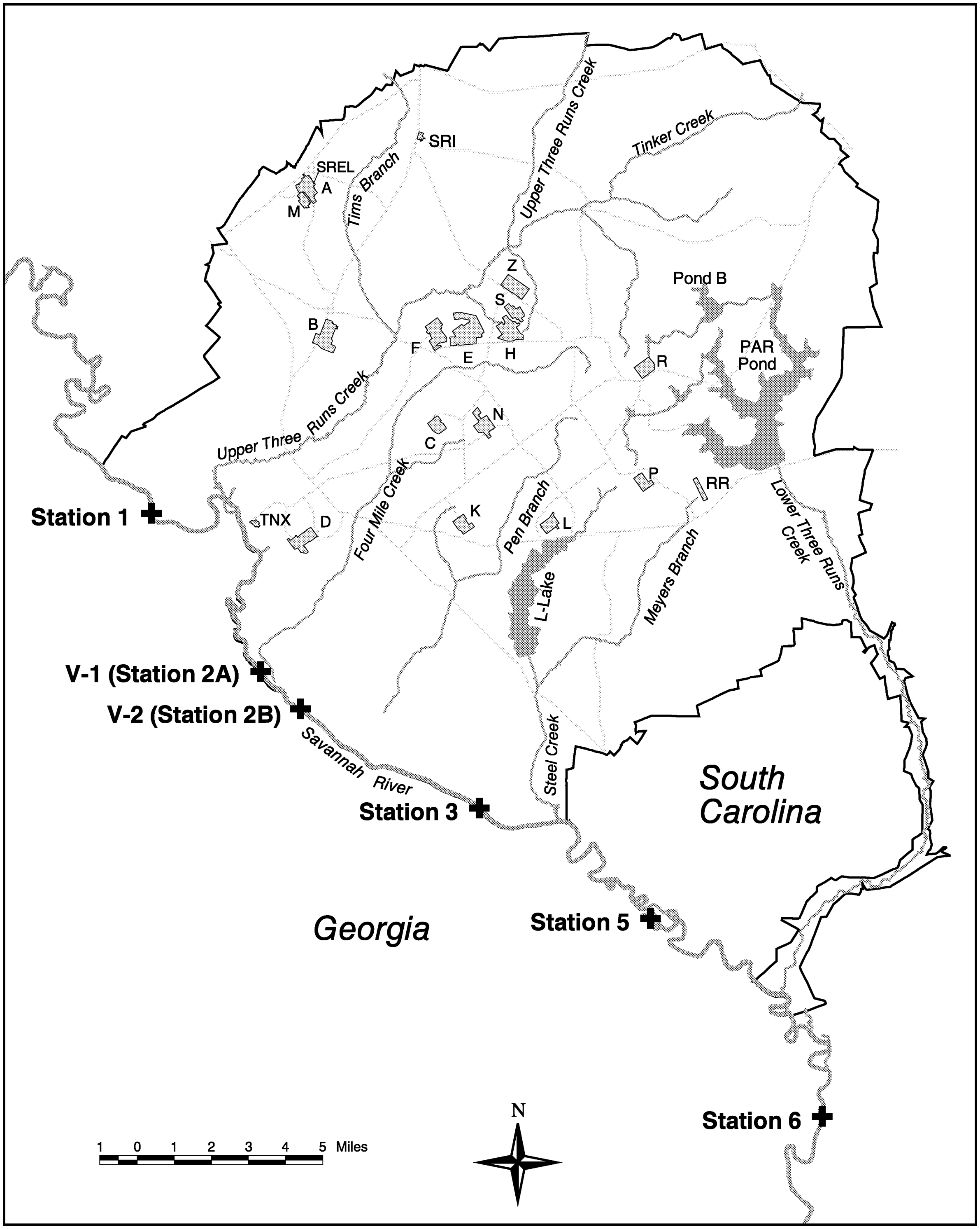
Multiple exposed stations are preferred because of the complex pattern of inputs along the river by SRS and other sources. Potential impacts are assessed by determining whether differences exist between the exposed and reference stations that are either greater or of a different character than would be expected if they were due merely to chance or natural differences among sampling sites.

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 may be implicated. If, however, the pattern is seen at the reference station, the impact must be due to sources upstream from the study area.

Other types of evidence for impact at a station include

- ecological community measures (i.e., species richness, dominance, abundance per unit of effort or area)
- community stress measures (e.g., presence and numbers of pollution-accommodating and pollution-sensitive species, pollution tolerances)
- functional feeding groups (dominance by certain groups in the food chain)

These patterns arise because pollution tends to reduce populations of a majority of species, while a



EPD/GIS Map

Figure 9–4 Academy Survey Sampling Sites

The Academy of Natural Sciences of Philadelphia has established specific sampling locations for surveys of the Savannah River—some exposed to SRS and other influences (stations 2A to 6) and one unexposed reference station (station 1). Sampling at station 3 was discontinued in 1997, and sampling at station 2A was discontinued in 2000.

ANSP Glossary

areal	of, relating to, or involving an area
assemblage	a group of organisms sharing a common habitat
biota	the animal and plant life of an area
dominance	the numerical abundance of one kind of individual in an area under consideration
fauna	the animals or animal life in an area under consideration
habitat	the specific place where a particular plant or animal lives, usually referring to one small part of the environment
nutrient loading	the amounts of nitrogen and phosphorus added to an aquatic system over time
perturbations	disturbances or variations (of water quality) from what is usual or expected
Shannon-Wiener Index	an index of species diversity; its minimum value occurs if all individuals belong to the same species and its maximum value if each individual belongs to a different species
species abundance	the number of individuals of one kind in an area under consideration
species density	the number of individuals of one kind per unit area
species diversity	measure of the number of different kinds of individuals (richness) and their abundances (evenness) in an area under consideration; low diversity refers to few species or unequal abundances, high diversity to many species or equal abundances
species evenness	the degree to which different kinds of individuals have similar abundances in an area under consideration
species richness	the number of different kinds of individuals in an area under consideration

few are able to thrive and dominate under 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 misleading if each station is characterized by only a single sample. For this reason, the ANSP 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 chance or natural variability.

The ANSP surveys also address variation over time (temporal variation). Important components of temporal variation include seasonal trends, multiyear trends, and trendless variability. All these components can be assessed using the unique data set generated by ANSP's long-term monitoring program in the Savannah River. Regular sampling with standardized collection techniques has continued largely unmodified since the early 1950s, making this one of the most comprehensive ecological data sets available for any of the world's rivers.

Such long-term records of biological change are valuable for several reasons. Because they allow the normal degree of year-to-year variability at a site to be measured or quantified, one can observe changes from one survey to the next and determine whether they fall within the normal range, much as one would use a control chart. Figure 9–5, for example, gives the number of diatom species at station 5 for 1999 superimposed on the long-term (1978–1999) average results for the same period. Changes that are outside this range provide evidence of altered conditions at the study site.

These data sets also are useful in distinguishing between potential impacts of SRS and variation caused by other factors. In particular, part of the biological variation observed over time is caused by documented changes in river flow, wastewater treatment methods, dredging activities, and so on.

Correlations between the known history of such changes on the one hand, and components of variation in long-term data sets on the other, provide evidence that these components were not caused by SRS activities.

Finally, long-term data sets can provide compelling evidence for multiyear trends of improvement or deterioration in ecosystem health. For example, analyses of some of ANSP's long-term data suggest a relatively steady increase in the number of different kinds of aquatic insects living in the river. Because aquatic insect species 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 river.

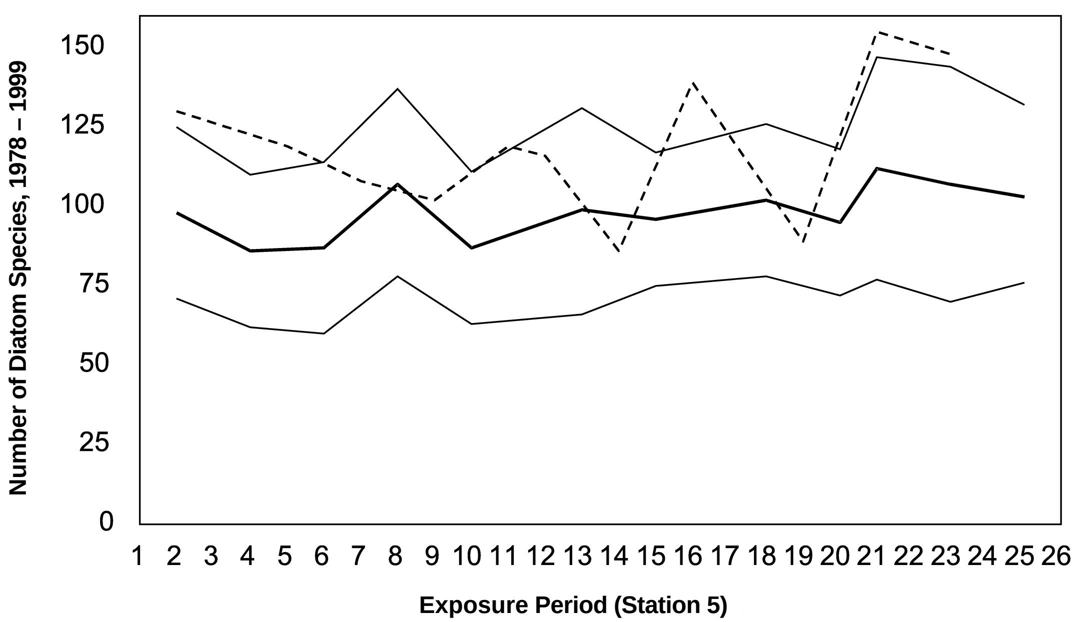
Survey Results

All components of the 1999 study are complete, and analyses of samples from the 2000 study are currently under way. Final results of the 1999 study are presented here, along with an interpretation of their place in assessing temporal trends in water quality. Progress to date for each component of the 2000 study is also reported.

Diatometer Monitoring

Periphyton are an assemblage of simple plants (e.g., algae) that grow attached to rocks and other submerged surfaces in the river. Diatoms, a type of microscopic algae, are particularly useful as indicators of water quality. In the diatometer monitoring program, diatoms are collected using a device called the Catherwood Diatometer, which floats glass slides near the surface of the water for two-week periods (called exposure periods). Diatoms attach and grow on these slides and can then be scraped off and examined in the laboratory to assess potential effects of SRS operations.

In 1999 and 2000, diatometers were deployed on a monthly basis from locations above SRS (reference station 1), above and below the discharge of Vogtle Electric Generating Plant (stations 2A and 2B; deployments at station 2A were discontinued in 2000), below Steel Creek (station 5), and below Lower Three Runs (station 6). Samples were analyzed to determine the number and types of diatom species at all stations except station 2A (samples collected in 1999 from station 2A were archived for future reference). More detailed analyses were performed on slides from one



ANSP Graphic (modified)

Figure 9–5 Diatom Species

The graph depicts the number of diatom species in diatometers at station 5, showing the 1999 values (dotted line) superimposed on the mean plus or minus 1 standard deviation (solid lines) for the period 1978 – 1999. Exposure periods represent 26 two-week intervals during which diatometers were deployed in the Savannah River.

exposure period in both April and October. (Analyses of the August through December 2000 samples are incomplete at this time.) Water quality was assessed by comparing the diatom assemblages from the different sampling periods and locations—based on diatom assemblage measures (called parameters) of species richness (number of species) and evenness (the degree of similarity among species abundances)—as well as the relative abundances and ecological tolerances (ability to tolerate pollution) of the common species.

1999 Results Results of the 1999 diatometer study do not indicate a negative SRS impact. No statistically significant among–station variation was detected for either species richness or evenness during 1999 studies. Species richness values were near the long–term average at the reference station (station 1) and above average at the downstream stations (stations 5 and 6). Conversely, percent dominance values were lower than the established average, especially at the reference station. A trend of lower species richness and higher percent dominance at the SRS stations compared to the reference station was noted for the exposure periods from October through December 1999, similar to a trend that had been observed in 1998. Ecological tolerances of the dominant diatom species were similar at all stations, with most dominants being characteristic of alkaline waters with moderate to high nutrient concentrations.

2000 Survey Preliminary results of the 2000 analyses (January through July) indicate lower diatom assemblage diversity when compared with previous study years. The number of diatom species was less than the established average, especially from May through July and at station 6. In fact, the number of diatom species was unusually low (less than 50) at station 6 from March through July. Though percent dominance was generally lower than the long-term averages, it exceeded 90 percent frequently at station 6 for the exposures from March through July. The lowered assemblage diversity (lower numbers of diatom species and higher percent dominance) at station 6 from March through July is reminiscent of the situation below Lower Three Runs that was observed from the mid 1980s until the mid 1990s (1985 through 1996).

Algae and Aquatic Macrophyte Studies

The 1999 and 2000 comprehensive algal and aquatic macrophyte studies were carried out on the Savannah River at four stations, one upstream (station 1) and three downstream (stations 2B, 5, and 6) from possible influence from SRS. Station and year comparisons were based on

- the number of species in major taxonomic groups
- known pollution tolerances of individual species
- relative abundances of individual species

Figure 9–6 gives the number of algal taxa at three stations during surveys conducted on the Savannah River from 1955 through 1999.

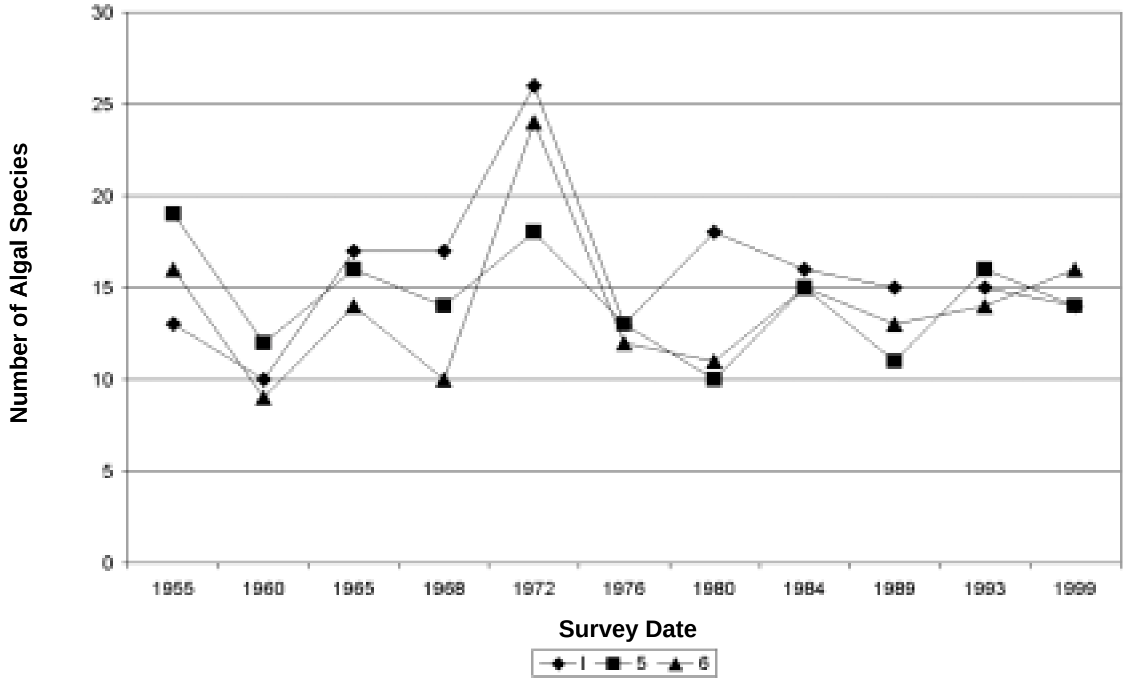
1999 Results The results of the September algal and aquatic macrophyte survey show no evidence that the operations of SRS were having a detrimental effect on the water quality of the Savannah River. As has been true since 1990 (inclusive), no significant beds of submerged aquatic vegetation were observed. Species richness and composition of both algae and macrophytes were similar to those of previous studies, and all the diatom collections examined were in good condition.

2000 Survey The 2000 comprehensive algal studies were carried out on the Savannah River at the same reference and exposed stations as the 1999 study. Although sample analysis is incomplete at this time, field observations did not indicate any obvious changes since 1999.

Noninsect Macroinvertebrate Studies

Qualitative samples of noninsect macroinvertebrates were collected at stations 1, 2B, 5, and 6 during 1999 and 2000. All specimens were identified to the lowest practical taxonomic level.

1999 Results The results of the 1999 survey (table 9–1) reveal that the principal groups of noninsect macroinvertebrates in the Savannah River in the vicinity of SRS are broadly similar in composition to those found in the 1976-to-1998 period, with four major assemblages dominating. In 1999, these four groups, collected at stations 1, 2B, 5, and 6, consisted of the bivalves [15 species—mussels (13) and clams (2)], snails (6), crustaceans (5), and leeches (3). These same four groups dominated the noninsect macroinvertebrate fauna of the previous seven studies (1998, 1997, 1993, 1989, 1984, 1980, and 1976). Only in 1972 was an additional group (mites) a major component of the river's fauna. It is in these larger groups that major changes in fauna among the years can be observed. The remaining smaller groups are either widely collected, spotty in distribution, rarely collected or represent taxa whose collection and/or taxonomic effort have been beyond the scope of the study.



ANSP Graphic (Modified)

Figure 9–6 Algal Taxa

The graph depicts the number of algal taxa at stations 1, 5, and 6 during spring surveys conducted on the Savannah River from 1955–1999.

The number of mussel species (13) recorded from hand collections in 1999 falls within the typical range of the 10 to 15 species collected during the August to October 1972 through 1998 period. The number of clam species collected in 1999 (2) is lower than during the 1972 through 1998 surveys, when 4 to 7 (mean 4.9) taxa were collected. The number of snail taxa collected during the 1972 through 1998 surveys varied from 6 to 11, with an average of 8.1 species. The species totals from 1999 (6) represent the low end of the range of species collected among these years. The number of

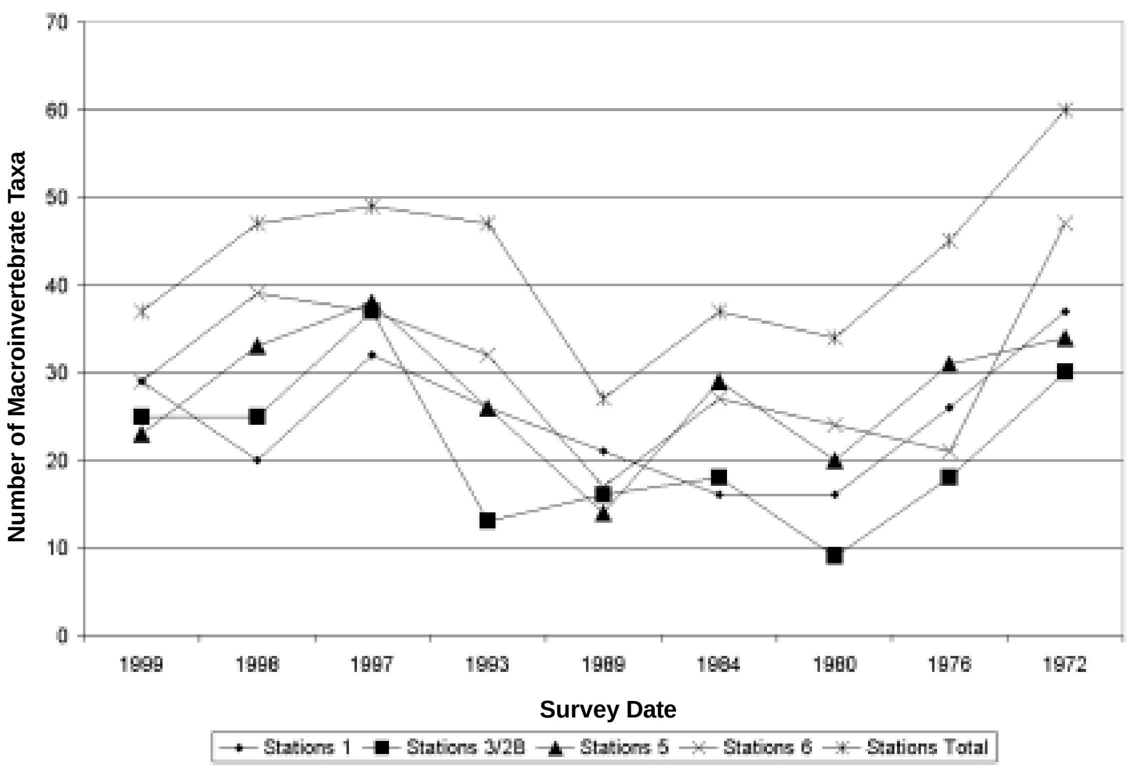
Table 9–1 Numbers of Macroinvertebrate Taxa in the Dominant Classes Collected by Hand from the Savannah River at Stations 1, 2B (1993–1999), 5, and 6 in August to October

Year	Leeches	Snails	Clams/Mussels Bivalves	Crustaceans	Mites
1999	3	6	2/13	5	2
1998	4	7	7/13	7	1
1997	6	10	6/14	5	2
1993	4	8	5/13	6	2
1989	2(1)	7	4(1)/2	4	1
1984	2(1)	6(1)	3(1)/10	5	0
1980	2	7	5/10	5	1
1976	6	8	4/14	4(1)	2
1972	10	11	5/15	5	7

Note: Species totals for 1993–1999 include mussel surveys. [Numbers in parentheses (1976 through 1989) represent additional species from Station 3, e.g., 6(1) = 7 species at Stations 1, 3, 5, and 6 to permit four station comparisons 1972 through 1999.]

crustacean taxa in 1999 (5 species) represents the modal number of crustaceans collected at four Savannah River stations. This number is within the 5 to 7 range of previous studies (average of 5.3 species). The three species of leeches taken in 1999 are within the 1976 through 1998 range of 3 to 6 taxa and slightly lower than the 4.8 mean. As a result of storm events and an impending hurricane during the September survey, stations 2B and 5 were collected the same day (typically a day is spent surveying each station) under rising water levels, and station 6 was surveyed under high water conditions. Stations 5 and 6 typically support the highest number of species in this region of the Savannah River. The slightly lower species totals for most groups probably reflect field effort and limited access to habitats due to water levels.

The total number of species collected during the 1972 through 1998 surveys has varied from a low of 34 (1980) to a high of 60 (1972) (mean 42.6). The 1999 total is slightly less than the average and lower than the totals of recent studies (47 to 49 in 1993 through 1998), although they are certainly within the range observed in previous studies (figure 9–7). Differences among the recent studies are due to slightly fewer species of leeches, snails, crustaceans and clam taxa in 1999. Higher numbers of species were collected in 1972 and were correlated with the dense stands of submerged aquatic plants. With the exception of the mussels, most members of the remaining groups are typically abundant in areas associated with these dense stands, and their species richness and/or abundance reflects the areal extent of these growths. Since 1990, the weed beds have been lacking from the study areas, and population densities of many species have declined (e.g., snails and sphaeriid clams). The reasons for the close similarity in the faunas among most of the groups despite recent changes in vegetation reveal that, although species density was reduced by the lack of vegetation (1993, 1997, 1998, and 1999), small numbers of most of these taxa can be found in other habitats if a sufficient effort is expended. The



ANSP Graphic (modified)

Figure 9–7 Macroinvertebrate Taxa

The graphic depicts numbers of macroinvertebrate taxa collected by hand from the Savannah River at stations 1, 2B (1993, 1997–1999), 3 (1989–1972), 5, and 6 in August to October 1972, 1976, 1980, 1984, 1989, 1993, 1997, 1998, and 1999**.** Numbers for 1997–1999 include the mussel studies.

differences between the 1989 to 1976 and 1972 surveys reflect their variation in density of vegetation. Two areas of strongest differences since the 1972 survey can be found in a comparison of the leech and mite species richness. The decline in numbers may be a reflection of the areal extent of the vegetation.

Although the results of the 1999 study may show fewer taxa than recent studies (1993, 1997 and 1998), these numbers fall within the range of results from the 1972 (the year of highest species diversity) through 1998 surveys. One value of long–term data sets is the ability to identify occasional anomalous (unusual or abnormal) results (e.g., species totals within taxonomic groups, stations, or summed across all taxa) in a specific year or to place the data into the context of past or emerging trends. Inasmuch as species diversity within most of the major groups and totals for this faunal assemblage fall within the historical ranges, the 1999 results most likely represent, in the near-term trends, a data set that reflects effort due to weather and field conditions at the time of sampling. The results do not indicate an impact on the noninsect macroinvertebrate biota of the Savannah River by SRS in 1999. The 2000 study will help confirm the status and position of the 1999 results. Recent (1999) and long-term trends (27 years, 1972 through 1999) reveal no impact on the noninsect macroinvertebrate biota of the Savannah River by SRS.

2000 Survey An examination of field notes from the September 2000 Savannah River study of the noninsect macroinvertebrate fauna indicates a species diversity that will probably be similar among the four study stations and that still supports populations of mussels. Analyses of these samples will be undertaken in 2001.

Insect Studies

Quantitative and qualitative samples of aquatic insects were collected at stations 1, 2B, 5, and 6 during 1999 and 2000. The quantitative samples were collected using floating artificial substrates, (insect “traps”) that allow insect colonization of the same amount of substrate at different stations. These standardized artificial substrates permit replicate samples at each station and rigorous statistical comparisons. All specimens were identified to the lowest practical taxonomic level (figure 9–8).

Station and season comparisons were based both on visual inspection of the data from the qualitative collections and on statistical analysis (Analysis of Variance) of quantitative estimates of population densities and selected indexes commonly used in pollution monitoring. These indexes include

- total species richness
- richness of selected groups of pollution-sensitive (Ephemeroptera, Plecoptera, Trichoptera) and pollution-tolerant (Chironomidae) taxa
- species diversity (Shannon–Wiener index)
- dominance (percent Chironomidae, percent Dominance–1 taxon, percent Dominance–5 taxa)
- indexes of the overall degree of pollution tolerance (Hilsenhoff Biotic Index, North Carolina Biotic Index)

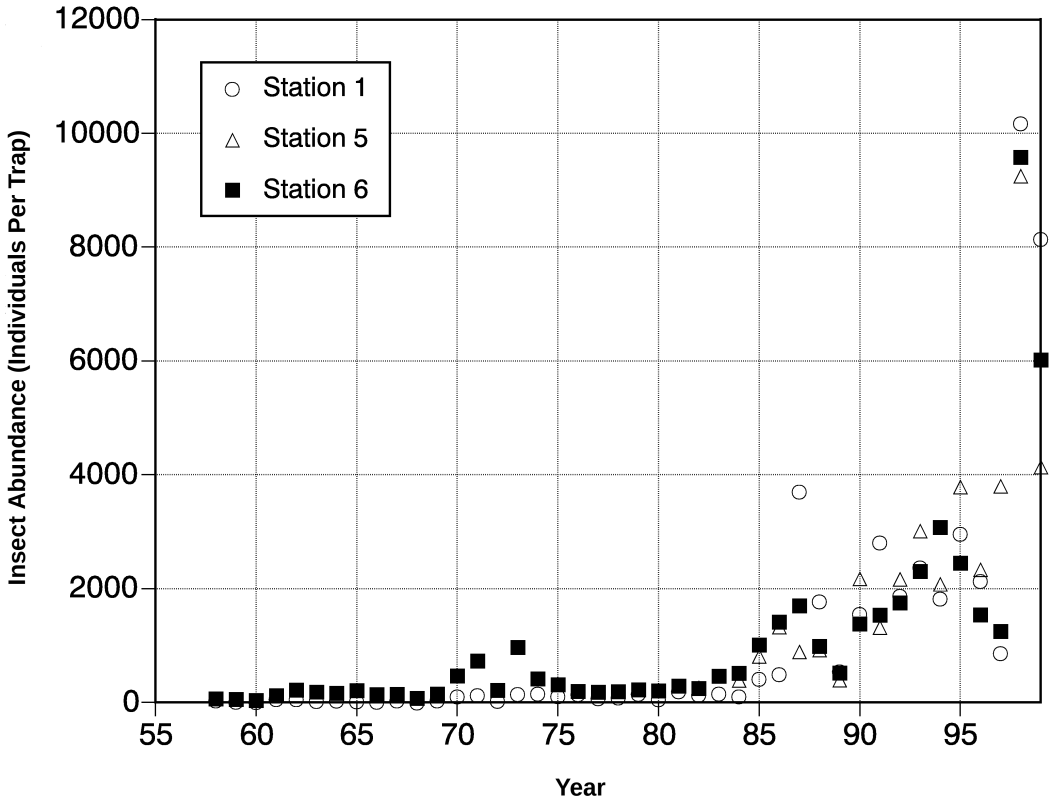
1999 Results Analyses of the quantitative and qualitative samples found that the 1999 aquatic insect fauna at all four stations consisted of a wide variety of species (84 and 180 species in the quantitative and qualitative samples, respectively), including many pollution-sensitive species. A few differences among stations and seasons were observed, but none of these differences suggest an SRS impact. Overall, the results of the 1999 aquatic insect study suggest that differences observed among stations and seasons reflect natural spatial and temporal variation that is characteristic of all streams and rivers. The 1999 results provide no evidence of a negative SRS impact on the aquatic insect assemblage.

2000 Survey Aquatic insect samples were collected in 2000 during May and September. Laboratory analysis of these samples is scheduled to be completed in 2001.

Fish Studies

Fish were sampled at stations 1, 2B, 5, and 6 in 1999 and 2000. The main collecting techniques were seining, boat electroshocking in the main channel, and walk-along electroshocking in backwaters. (Electroshocking is a technique in which an electric current is passed through the water, temporarily stunning fish and allowing them to be identified and released or kept for further analysis). Some small fish (mainly catfish) were also collected with dip nets and traps, most as part of macroinvertebrate and insect study elements. Specimens were identified to species. Species richness (number of species), species diversity (Shannon–Wiener index), and densities of individual species were estimated for each quantitative seine sample.

1999 Results The 1999 survey provided an evaluation of the fish assemblages on the Savannah



ANSP Graphic (modified)

Figure 9–8 Insect Abundance

The graph depicts the total insect abundance (annual mean number of individuals per trap) at Savannah River stations 1, 5, and 6. Annual means summarize four sampling seasons for 1958–1995 and two sampling seasons for 1996–1999. Samples from 1998 and1999 were washed through a 0.5-mm mesh sieve (a modern standard) rather than the 1.8- x 1.4-mm mesh screen that was used earlier. This change presumably contributed to the high densities observed in those years. The impact of this methodological change on the historical data set is currently being explored.

River using the same collection techniques at the same stations as the 1997 and 1998 surveys. Previous ANSP surveys provide extensive historical data at these stations prior to 1997, but with some differences in sampling techniques and effort.

A total of 5,623 individuals of 51 species of fish were captured in the 1999 ANSP Savannah River survey. Five species made up 77 percent of the total catch: spottail shiner (*Notropis hudsonius*), whitefin shiner (*Cyprinella nivea*), bluegill (*Lepomis macrochirus*), brook silverside (*Labidesthes sicculus*) and bannerfin shiner (*C. leedsi*). The species collected are typical of those recorded in recent surveys. Uncommon species collected include an Atlantic needlefish (*Strongylura marina*) at station 6, bluehead chub (*Nocomis leptocephalus*) at stations 1 and 2B, and a northern hog sucker (*Hypentelium nigricans*) at station 2B.

A total of 1,479 individuals of 36 species were caught in the backwater samples, with more species at station 6 (29) than at stations 1 and 5 (18 and 19, respectively). A variety of sunfishes was caught at each station. Spottail shiner and Eastern mosquitofish (*Gambusia holbrooki*) were also widespread.

Estimates of species densities varied greatly among sites. Very low densities were found in the most isolated site, the floodplain pool at station 1, while high densities were found in sites on the edge of the channel, such as the edge sample at station 1 and the two samples from Ring Jaw Cove in station 6. The highest density was recorded in the upper Ring Jaw site; density estimates were poor for this site, and true densities may have been even higher. Species dominance varied greatly among sites, with some species abundant in a few sites.

A total of 2,492 individuals of 24 species were collected in the seine samples. Minnows (the spottail shiner and/or the whitefin shiner) were the most abundant species in the samples. Mosquitofish, sunfish (*Lepomis* sp.) and hogchoker (*Trinectes maculatus*) were widespread, though not collected in abundance. Two species of darters, the tessellated darter (*Etheostoma olmstedi*) and the blackbanded darter (*Percina nigrofasciata*) were relatively frequent at stations 1 and 2B, but were absent or rare at stations 5 and 6. Statistical comparisons of abundance of the seven most common taxa (spottail shiner, whitefin shiner, *Cyprinella* species, Eastern mosquitofish, Eastern silvery minnow, blackbanded darter, and tessellated darter) and of species richness and Shannon-Weiner diversity showed a significant station difference only for the tessellated darter, which was more abundant at station 2B than that at the other stations. Abundance of a few species showed significant relationships with habitat variables. (Observed species abundance-habitat relationships will depend on the scale at which such relationships are analyzed. For example, fish sampling in the Savannah River certainly demonstrates differences of occurrence of species among beaches, backwater sites, snag habitats, etc. The seine samples were taken across a restricted range of microhabitat variation, and there was little observed correlation between fish occurrence and microhabitat differences within these beach habitats.)

A total of 1,595 individuals of 36 species were caught by boat electroshocking. Several species were recorded mainly in the boat electroshocking samples, including American shad (*Alosa sapidissima*), American eel (*Anguilla rostrata*), bowfin (*Amia calva*), silver redhorse (*Moxostoma anisurum*), striped mullet (*Mugil cephalus*) and yellow perch (*Perca flavescens*). Several species of minnows, including the spottail shiner, whitefin shiner, bannerfin shiner, coastal shiner (*Notropis petersoni*), and rosyface minnow (*Notropis rubescens*) were the most abundant species, while brook silversides (*Labidesthes sicculus*) and several species of sunfish were also frequent. More species were caught at stations 5 and 6 (26 and 25) than at stations 1 and 2B (22 and 23), although the average number of species per sample was similar among stations (range: 12.7–14.3). Species composition was similar across stations, and catch varied among individual samples.

The patterns of species occurrence, richness, diversity, and abundance did not show spatial differences that could be related to SRS operations. There was typically much variation in fish communities among sample sites, particularly for the more complex habitats sampled by electroshocking in the backwaters and main channels. Comparing the results of the 1997–1999 surveys shows no consistent trends in the species abundance, although there are among-year variations in abundance of some species.

2000 Survey In the summer, water levels had fallen to extremely low levels. At the time of the fish survey in September, water levels had risen, but were still at low levels relative to past surveys. Because of the importance of various off-main-channel habitats to fish (including oxbow lakes, overflow channels, and ponds on the floodplain), these water level fluctuations are expected to have significant effects on the fish communities. One of the standard fish sampling sites (a pond behind the levee at station 1) was dry. Other sites, which have more permanent connection to the main river, had water, but would have been shallow or dry at summer water levels. Grasses had grown on exposed banks during the summer. These were partially flooded at the higher fall water levels, and these emergent grasses provided cover for fish. Little aquatic macrophytes were observed in the river channel. This is consistent with the last several surveys, but contrasts with high densities of macrophytes in some earlier surveys (e.g., the late 1980s).

Samples from the survey will be processed in 2001. Therefore, conclusions presented here depend primarily on observations made during the field. In addition, fish collected and released in the field were tabulated.

Twenty-eight species were captured and released in the field. These are primarily larger fish (gars, bowfin, gizzard shad, pickerels, larger catfish individuals, suckers, sunfish, and bass). A large number of minnows were also caught, comprising a variety of species.

In general, collections indicated the occurrence of typical fish fauna of the river. The boat-electroshocking samples collected a large number of sunfish and minnows, and these samples will provide a good record of fish using channel edge habitats. Compared to previous surveys, a relatively large number of largemouth bass and American eels were collected, but quantitative comparisons will require full analysis of the data. The bluegill appeared to be the most common species of sunfish caught in the boat electroshocking samples; redbreast sunfish were also common. A number of other species of sunfish (dollar, redear, spotted, pumpkinseed, and warmouth) were caught in smaller numbers; these may be more common in backwater sites. Yellow perch and striped mullet were caught; these are relatively uncommon in the ANSP surveys.

Compared to past surveys, fewer fish seem to have been caught in the backwater samples at stations 1 and 5. This may be due to the low summer water levels. The backwater sample in Ring Jaw Cove at station 6 seemed typical; the cove is deeper and has more permanent water than other backwater sites and may retain fish better during low water. Some of the typical backwater species (redfin and chain pickerels, pirateperch, flier, and blue-spotted sunfish) were collected; more species are probably represented in the preserved samples that have not yet been analyzed.

Conclusions

Assessments of the various biological groups in the 1999 river quality survey (diatoms, other attached algae, rooted aquatic plants, insects, noninsect macroinvertebrates, and fish) were consistent with one another and demonstrated similar communities at exposed and references stations. Several species showed station differences that were related to differences in habitat availability rather than SRS influence. Statistical comparisons of community attributes at the various sampling stations detected few significant differences, and there were no patterns that would indicate a negative impact of SRS. Thus, results of the 1999 study do not provide evidence of an SRS impact on biological communities in the Savannah River.

Results of the 2000 river quality survey are not complete at this time. However, field notes and preliminary analyses of samples do not reveal any obvious differences between communities at exposed and reference stations.

Chapter 10

Groundwater

Maggie Nettles and Jen Williams
ExR, Inc.

Bob Hiergesell
Environmental Sciences and Technology

To Read About . . . See Page . . .

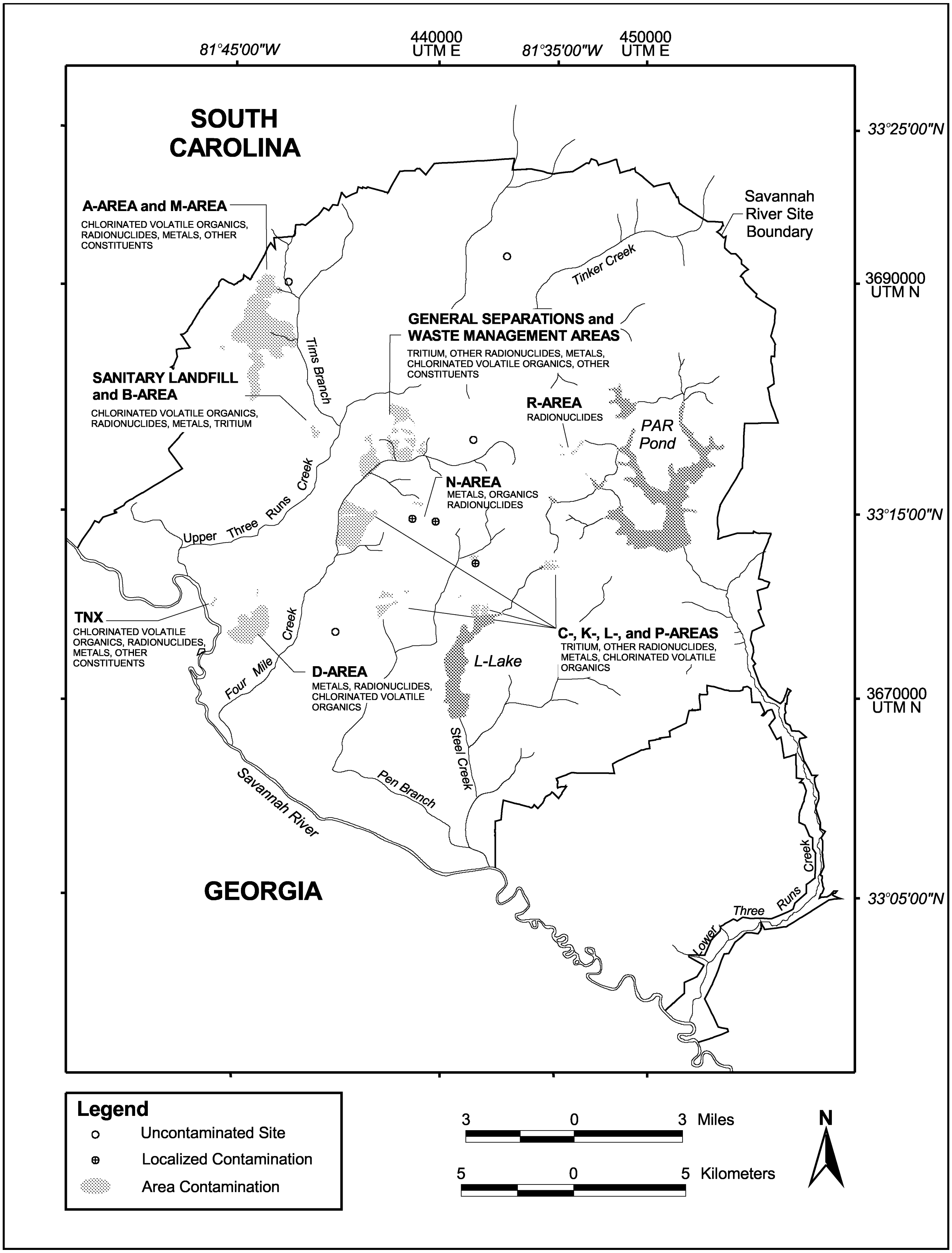
2000 Highlights

- Most analytical results from groundwater monitoring were similar to those of recent years. In A-Area and M-Area, trichloroethylene and tetrachloroethylene continued as the most widespread contaminants and appear to be moving to the southwest. However, ongoing remediation efforts are slowing the spread of contamination (primarily organics and metals) and reducing the impact of past operations in those areas on the groundwater.
- In the reactor areas (K-Area, L-Area, P-Area, R-Area, and C-Area), tritium continues as the most widespread radioactive contaminant, and trichloroethylene contamination is the most prevalent organic contaminant in the groundwater. Volatile organics showed up less often than in preceding years. R-Area showed contamination with other radionuclides, especially nonvolatile beta and strontium-90. However, ongoing remediation efforts—such as soil vapor extraction/air sparging, stabilization, excavation, and the placement of covers over the source units—are slowing the spread of contamination and reducing the impact to the groundwater.
- D-Area shows continued contamination associated with activities at the coal-fired power plant and related facilities and with volatile organics and metals near the oil disposal basin. The contaminant plume in the TNX area comprises volatile organics (especially trichloroethylene and tetrachloroethylene), metals, radionuclides, and other constituents near disposal sites, according to tests from preceding years; however, tests during the first three quarters of 2000 showed primarily volatile organics and radionuclides.
- In the general separations and waste management areas (E-Area, F-Area, and H-Area), the groundwater contamination includes tritium as the primary contaminant, volatile organics (especially trichloroethylene and tetrachloroethylene), radionuclides, metals, and other constituents. F-Area had high concentrations of gross alpha and nonvolatile beta as well as tritium. H-Area tested high in tritium and also in nonvolatile beta. Sampling from previous years shows that volatile organics, metals, and radionuclides are present in N-Area. Stabilization and closure programs are ongoing in these areas. In Z-Area, tritium was detected in one well. S-Area shows evidence of groundwater contamination comprised primarily of tritium in the vicinity of the vitrification building.
- Volatile organics (especially trichloroethylene and vinyl chloride), are the most widespread contaminants in the groundwater near the sanitary landfill. Metals, tritium, and other radionuclides also are present.

THIS chapter summarizes the groundwater monitoring results for 1,180 wells in 77 locations (figure 10–1) within designated areas at the Savannah River Site (SRS), with emphasis on results exceeding the Safe Drinking Water Act primary drinking water standards (DWS). Most constituents are compared to the final federal primary DWS. In some cases, comparison is to the proposed primary DWS or to the interim final primary DWS. (See appendix A, “Applicable Guidelines, Standards, and Regulations,” for additional information about applicable monitoring standards, and appendix B, “Drinking Water Standards,” for the DWS.) Other constituents of interest also are discussed in the text of this chapter.

Detailed groundwater monitoring results are presented in the following public documents: *The Savannah River Site’s Groundwater Monitoring Program, First Quarter 2000* (ESH–EMS–2000–405); *The Savannah River Site’s Groundwater Monitoring Program, Second Quarter 2000* (ESH–EMS–2000–406); *The Savannah River Site’s Groundwater Monitoring Program, Third Quarter 2000* (ESH–EMS–2000–407); and *The Savannah River Site’s Groundwater Monitoring Program, Fourth Quarter 2000* (ESH–EMS–2000–408). Full results for each well sampled during a quarter are presented alphabetically in the quarterly reports.

Another public document, the *Environmental Protection Department’s Well Inventory* (ESH–EMS–2000–470), contains detailed maps of the wells at each monitored location.



SRTC/ER Map

Figure 10–1 Facilities Monitored by the SRS Monitoring Well Network, Including Areas Having Constituents Exceeding Drinking Water Standards in 2000

Key for Figure 10–1

A-Area/M-Area

- A-Area/M-Area Recovery Well Network
- A-Area Background Well Near Firing Range
- A-Area Burning/Rubble Pits/A-Area Ash Pile
- A-Area Coal Pile Runoff Containment Basin
- A-Area Metals Burning Pit
- M-Area Hazardous Waste Management Facility & M-Area Plume Definition
- Metallurgical Laboratory Seepage Basin
- Miscellaneous Chemical Basin
- Motor Shop Oil Basin
- Savannah River Laboratory Seepage Basins
- Silverton Road Waste Site

General Separations/Waste Management (E-Area, F-Area, H-Area, S-Area, & Z-Area)

- Burial Grounds Perimeter
- Burma Road Rubble Pit
- E-Area Vaults near the Burial Grounds
- F-Area Ash Basin
- F-Area Burning/Rubble Pits
- F-Area Canyon Building/A-Line Uranium Recovery Facility
- F-Area Coal Pile Runoff Containment Basin
- F-Area Effluent Treatment Cooling Water Basin
- F-Area Retention Basins
- F-Area Sanitary Sludge L& Application Site
- F-Area Seepage Basins/Inactive Process Sewer Line
- F-Area Seepage Basins Remediation Extraction Wells/ Tank
- F-Area Seepage Basins Remediation Injection Wells/ Tank
- F-Area Tank Farm
- H-Area Auxiliary Pump Pit
- H-Area Canyon Building
- H-Area Coal Pile Runoff Containment Basin
- H-Area Effluent Treatment Cooling Water Basin
- H-Area Retention Basins
- H-Area Seepage Basins/Inactive Process Sewer Line
- H-Area Seepage Basins Remediation Extraction Wells & Tank
- H-Area Seepage Basins Remediation Injection Wells & Tank
- H-Area Tank Farm/Tank Farm Groundwater Operable Unit
- Hazardous Waste/Mixed Waste Disposal Facility
- HP-52 Outfall/Warner's Pond Area
- Old Burial Ground
- Old F-Area Seepage Basin
- Old H-Area Retention Basin
- S-Area Defense Waste Processing Facility
- S-Area Low-Point Pump Pit
- S-Area Vitrification Building
- Waste Solidification/Disposal Facility
- Wells Between the F-Area Canyon Building & the Naval Fuel Material Facility
- Z-Area Low-Point Drain Tank
- Z-Area Saltstone Facility Background Wells

C-Area

- C-Area Burning/Rubble Pit
- C-Area Coal Pile Runoff Containment Basin
- C-Area Disassembly Basin
- C-Area Reactor Seepage Basins
- Injection Wells of the C-Area Reactor

K-Area

- K-Area Ash Basin
- K-Area Bingham Pump Outage Pit
- K-Area Burning/Rubble Pit
- K-Area Coal Pile Runoff Containment Basin
- K-Area Disassembly Basin
- K-Area Reactor Seepage Basin
- K-Area Retention Basin
- K-Area Tritium Sump

L-Area

- Chemicals, Metals, & Pesticides Pits
- L-Area Acid/Caustic Basin/L-Area Oil & Chemical Basin
- L-Area Bingham Pump Outage Pits
- L-Area Burning/Rubble Pit
- L-Area Disassembly Basin
- L-Area Reactor Seepage Basin
- L-Area Research Wells

P-Area

- P-Area Bingham Pump Outage Pit
- P-Area Burning/Rubble Pit
- P-Area Coal Pile Runoff Containment Basin
- P-Area Disassembly Basin
- P-Area Reactor Seepage Basins

R-Area

- R-Area Acid/Caustic Basin
- R-Area Bingham Pump Outage Pit
- R-Area Burning/Rubble Pits
- R-Area Coal Pile
- R-Area Disassembly Basin
- R-Area Reactor Seepage Basins

Sanitary Landfill & B-Area

- B-Area Microbiology Wells
- Sanitary Landfill/Interim Sanitary Landfill

Central Shops (N-Area)

- Ford Building Seepage Basin
- Hazardous Waste Storage Facility
- Hydrofluoric Acid Spill
- N-Area Diesel Spill
- N-Area Burning/Rubble Pits
- N-Area (Central Shops) Sludge Lagoon
- N-Area Fire Department Training Facility

D-Area & TNX

- D-Area Burning/Rubble Pits
- D-Area Oil Seepage Basin
- D-Area Coal Pile, Coal Pile Runoff Containment Basin, & Ash Basins
- New/Old TNX Seepage Basins
- Road A Chemical Basin (Baxley Road)
- TNX-Area Assessment Wells
- TNX-Area Background Wells
- TNX-Area Points along Seepline
- TNX-Area Operable Unit Wells
- TNX-Area Floodplain Wells
- TNX-Area Recovery Wells
- TNX Burying Ground
- TNX Intrinsic Remediation Piezometers
- TNX Permeable Wall Demonstration Well Installation

Other Sites

- Accelerator for Production of Tritium Area
- SREL Flowing Springs Site

Groundwater at SRS

SRS is underlain by sediment of the Atlantic Coastal Plain. The Atlantic Coastal Plain consists of a southeast-dipping wedge of unconsolidated sediment that extends from its contact with the Piedmont Province at the Fall Line to the edge of the continental shelf. The sediment ranges from Late Cretaceous to Miocene in age and comprises layers of sand, muddy sand, and clay with subordinate calcareous sediments. It rests on crystalline and sedimentary basement rock.

The hydrostratigraphy of SRS has been subject to several classifications. The hydrostratigraphic classification established in Aadland et al., 1995, and in Smits et al., 1996, is widely used at SRS and is regarded as the current SRS standard. This system is consistent with the one used by the U.S. Geological Survey (USGS) in regional studies that include the area surrounding SRS [Clarke and West, 1997]. Figure 10–2 is a chart that indicates the relative position of hydrostratigraphic units and relates hydrostratigraphic units to corresponding lithologic units at SRS and to the geologic time scale. This chart was modified from Aadland et al., 1995, and Fallaw and Price, 1995.

The hydrostratigraphic units of primary interest beneath SRS are part of the Southeastern Coastal Plain Hydrogeologic Province. Within this sequence of aquifers and confining units are two principal sub–categories, the overlying Floridan Aquifer System and the underlying Dublin-Midville Aquifer System. These systems are separated from one another by the Meyers Branch Confining System. In turn, each of the systems is subdivided into two aquifers, which are separated by a confining unit.

In the central to southern portion of SRS, the Floridan Aquifer System is divided into the overlying Upper Three Runs Aquifer and the underlying Gordon Aquifer, which are separated by the Gordon Confining Unit. North of Upper Three Runs Creek, these units are collectively referred to as the Steed Pond Aquifer, in which the Upper Three Runs Aquifer is called the M-Area Aquifer zone, the Gordon Aquifer is referred to as the Lost Lake Aquifer zone, and the aquitard that separates them is referred to as the Green Clay confining zone [Aadland et al., 1995]. The Upper Three Runs Aquifer/Steed Pond Aquifer is the hydrostratigraphic unit within which the water table usually occurs at SRS; hence, it is informally referred to as the “water table” aquifer.

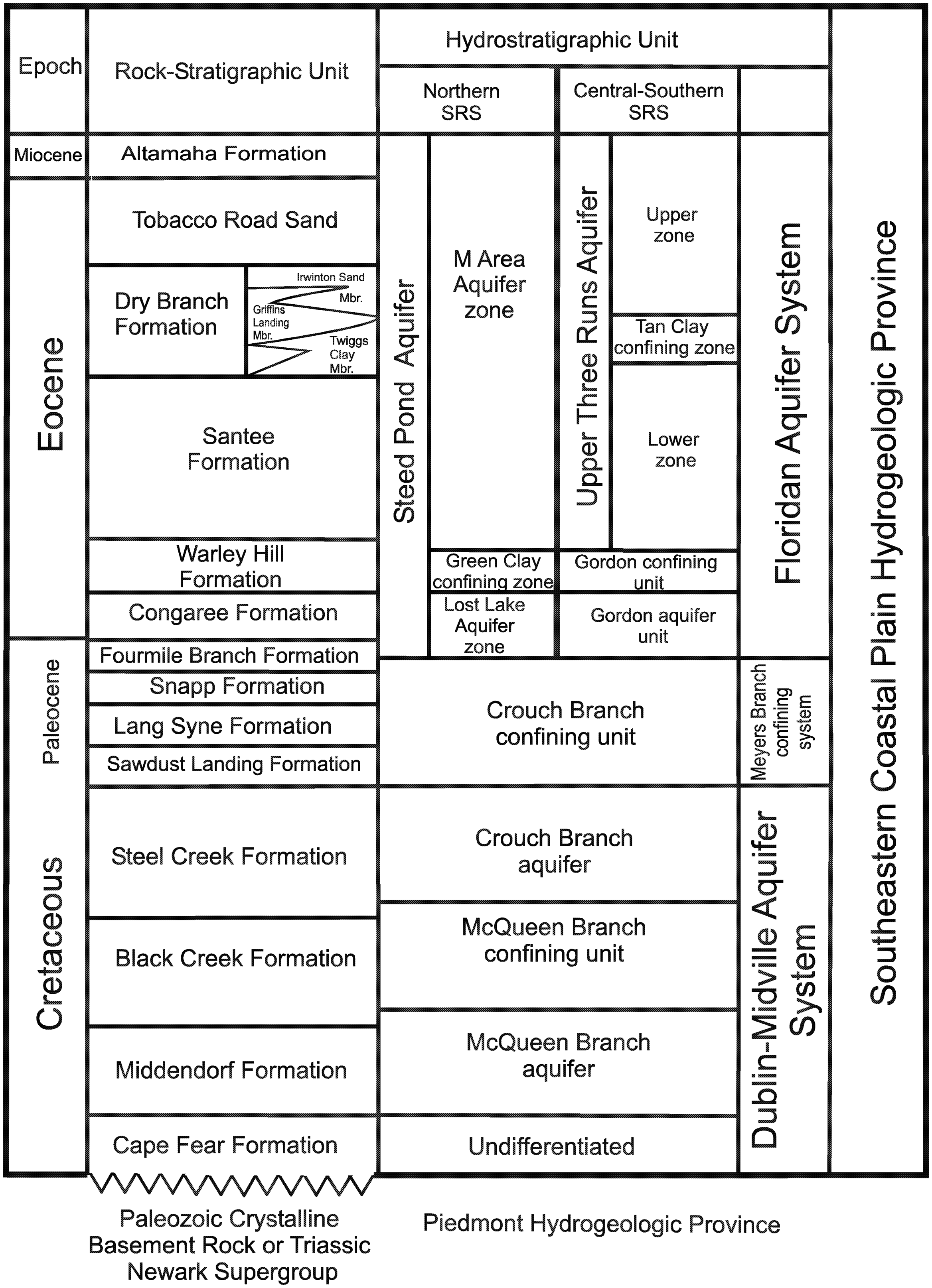
The Dublin-Midville Aquifer System is divided into the overlying Crouch Branch Aquifer and the underlying McQueen Branch Aquifer, which are separated by the McQueen Branch Confining Unit. The Crouch Branch Aquifer and McQueen Branch Aquifer are names that originated at SRS [Aadland et al., 1995]. These units are equivalent to the Dublin Aquifer and the Midville Aquifer, which are names originating with the USGS [Clarke and West, 1997].

Figure 10–3 is a three-dimensional block diagram of the hydrogeologic units at SRS and the generalized groundwater flow patterns within those units. These units are from shallowest to deepest: the Upper Three Runs/Steed Pond Aquifer (or water table aquifer), the Gordon/Lost Lake Aquifer, the Crouch Branch Aquifer, and the McQueen Branch Aquifer.

Groundwater recharge is a result of the infiltration of precipitation at the land surface; the precipitation moves vertically downward through the unsaturated zone to the water table. Upon entering the saturated zone at the water table, water moves predominantly in a horizontal direction toward local discharge zones along the headwaters and midsections of streams, while some of the water moves into successively deeper aquifers. The water lost to successively deeper aquifers also migrates laterally within those units toward the more distant regional discharge zones. These typically are located along the major streams and rivers in the area, such as the Savannah River. Groundwater movement within these units is extremely slow when compared to surface water flow rates. Groundwater velocities also are quite different between aquitards and aquifers, ranging at SRS from several inches to several feet per year in aquitards and from tens to hundreds of feet per year in aquifers.

Figure 10–4 illustrates the water table configuration at SRS for second quarter 2000; the contours were initially taken from the SRS long-term mean water table configuration [Hiergesell, 1998]. Water level measurements obtained in second quarter 2000 then were posted on this map and contours then were adjusted to be consistent with time-specific measurements. Horizontal groundwater movement in the water table aquifer is in a direction that is perpendicular to the contours, proceeding from areas of higher fluid potential (recharge areas) to areas of lower fluid potential, where it discharges along the reaches of perennial streams at SRS.

The potentiometric level contours for the Gordon/Lost Lake Aquifer, Crouch Branch Aquifer, and McQueen Branch Aquifer are illustrated in figures 10–5, 10–6, and 10–7, respectively. These contours are based on water level measurements obtained from SRS regional cluster wells in second



Modified from Aadland et al, 1995, and Fallaw and Price, 1995

Figure 10–2 Hydrostratigraphic Units at SRS

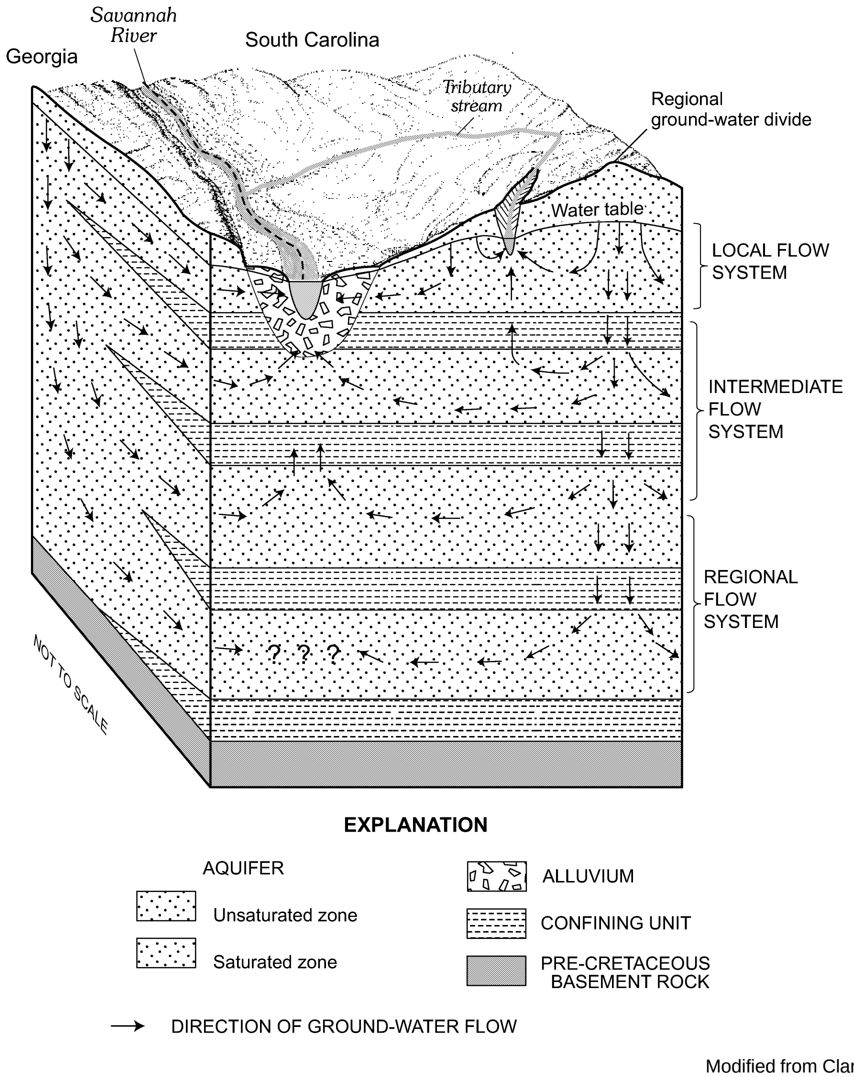


Figure 10–3 Groundwater at SRS

quarter 2000; however, additional water level measurements obtained from monitoring wells also were used to construct the Gordon/Lost Lake Aquifer contours in A-Area, M-Area, and the general separations area of SRS. As with the water table, horizontal groundwater movement is in a direction perpendicular to the contours and proceeds from areas of higher fluid potential to areas of lower fluid potential.

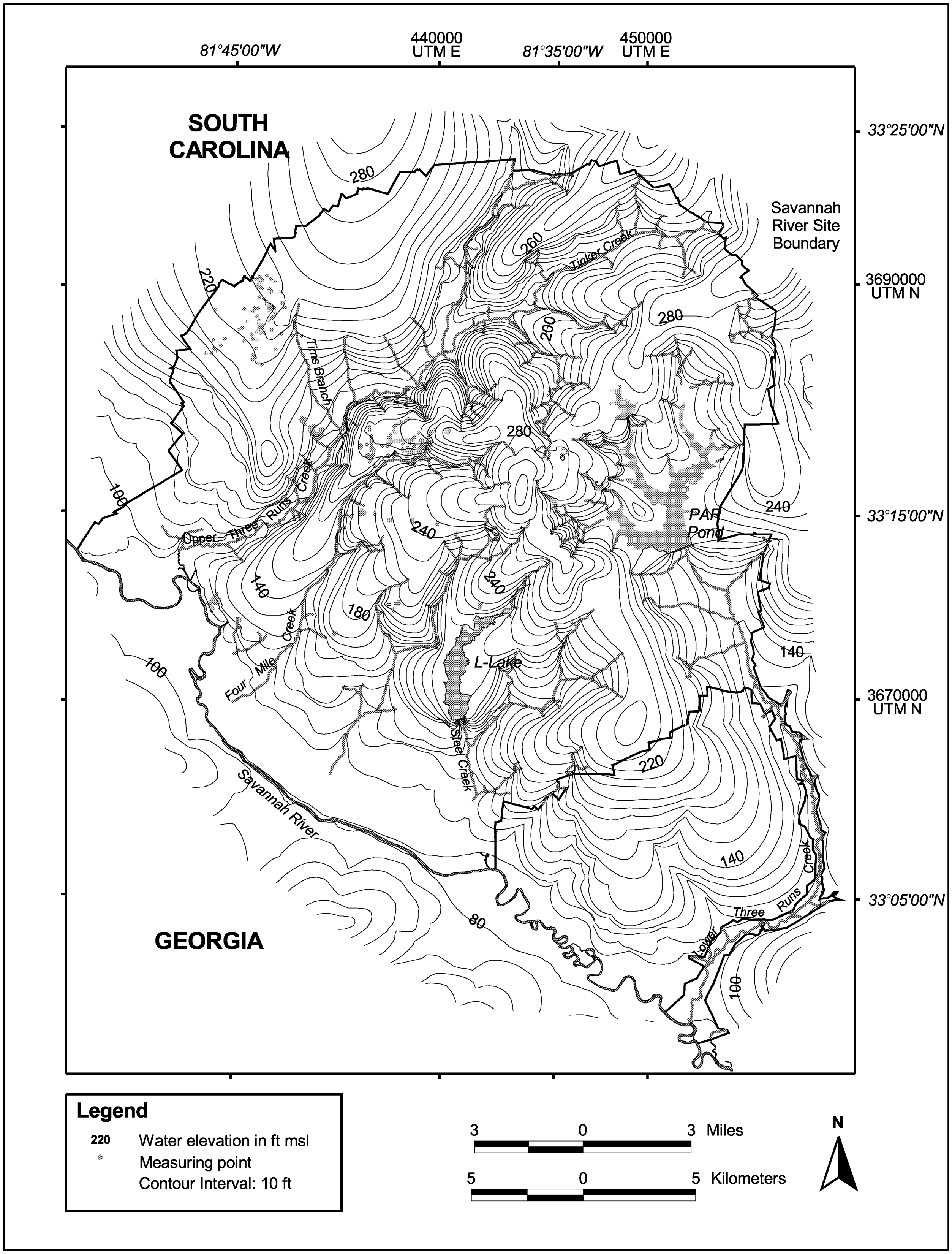
Monitoring wells are used extensively at SRS to assess the effect of site activities on groundwater quality. Most of the wells monitor the upper groundwater zone, although wells in lower zones are present at the sites with the larger groundwater contamination plumes. Groundwater in areas indicated on figure 10–1 contains one or more constituents at or above the levels of the DWS of the U.S. Environmental Protection Agency (EPA).

Description of the Groundwater 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

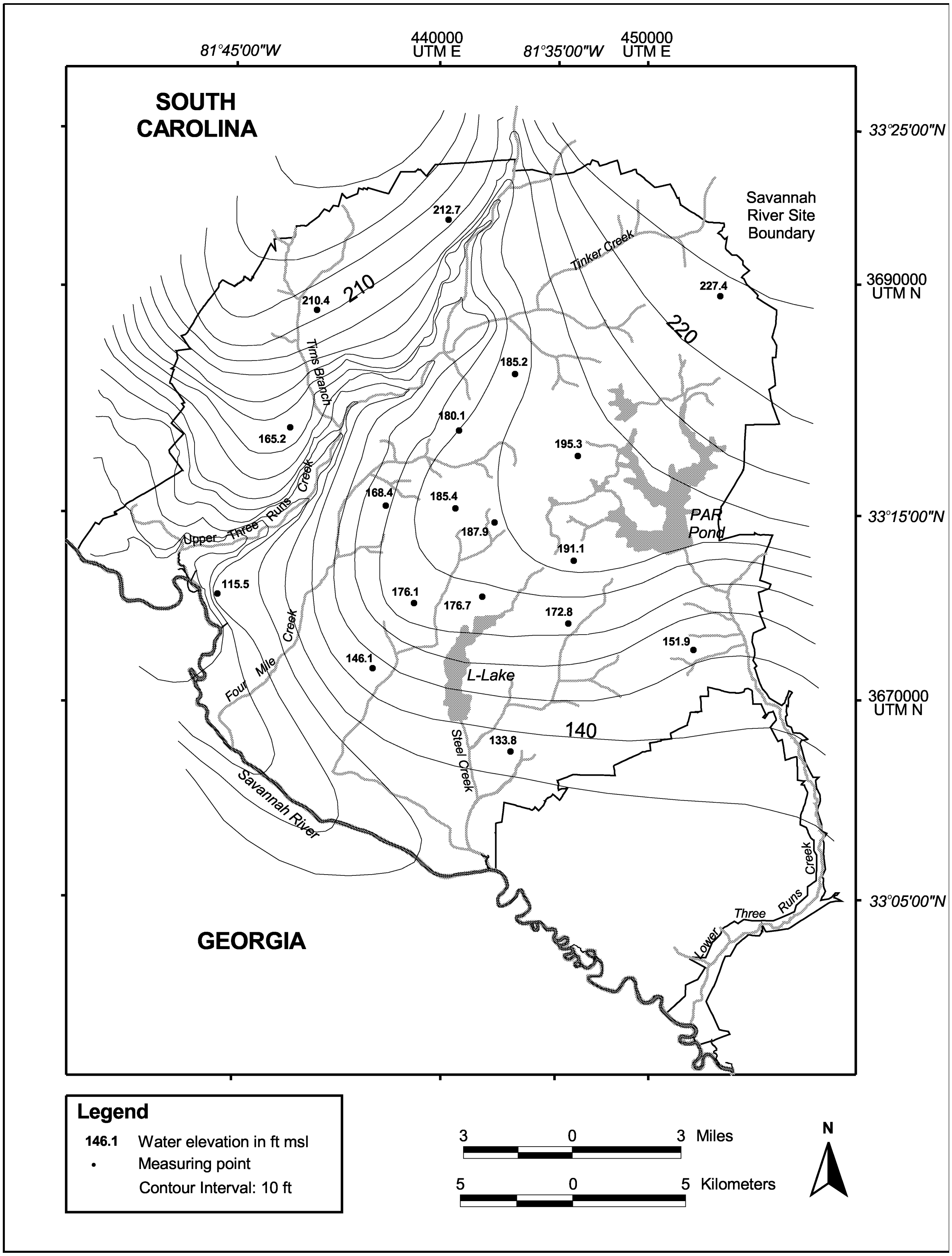
- assist SRS in complying with environmental regulations and U.S. Department of Energy (DOE) directives
- provide data to identify and monitor constituents in the groundwater
- permit characterization of new facility locations to ensure that they are suitable for the intended facilities
- support basic and applied research projects

The groundwater monitoring program at SRS is conducted by the Environmental Geochemistry



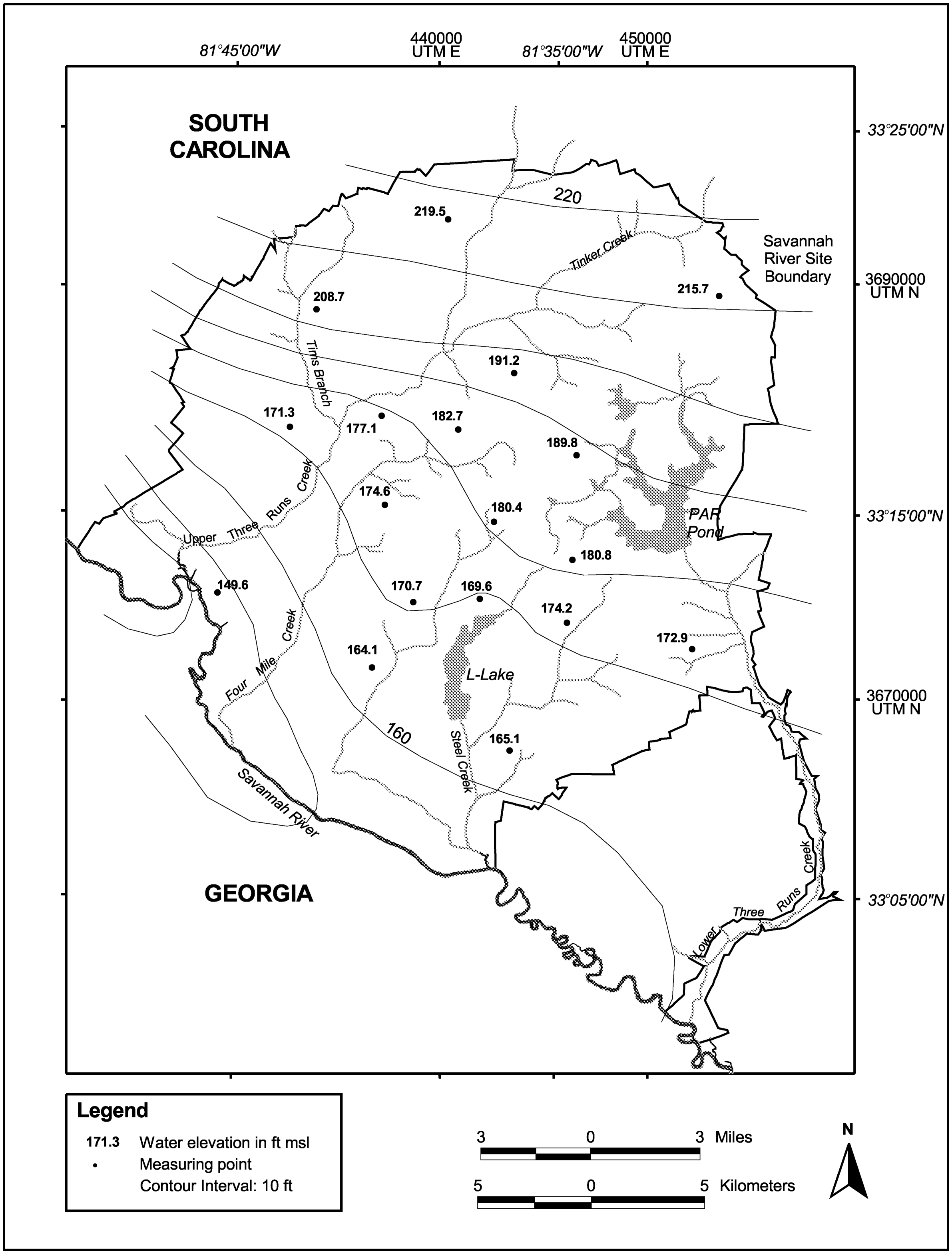
SRTC/EST Map

Figure 10–4 Water Table Contours at SRS During the Second Quarter of 2000



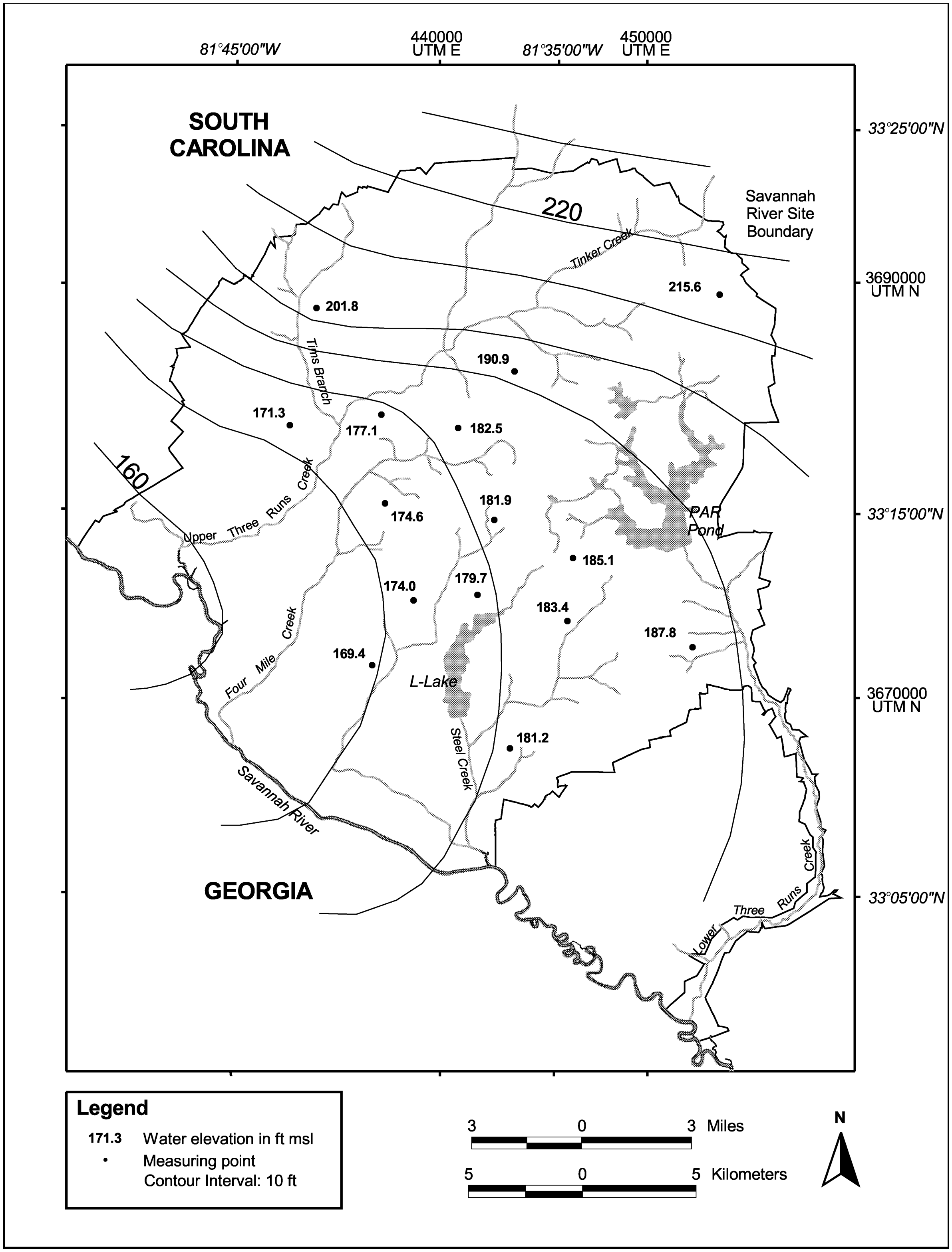
SRTC/EST Map

Figure 10–5 Potentiometric Surface of the Gordon Aquifer at SRS During the Second Quarter of 2000



SRTC/EST Map

Figure 10–6 Potentiometric Surface of the Crouch Branch Aquifer at SRS During the Second Quarter of 2000



SRTC/EST Map

Figure 10–7 Potentiometric Surface of the McQueen Branch Aquifer at SRS During the Second Quarter of 2000

Group (EGG) of the Environmental Protection Department/Environmental Monitoring Section (EPD/EMS) of Westinghouse Savannah River Company (WSRC). To assist other departments in meeting their responsibilities, EGG provides the services for installing monitoring wells, collecting and analyzing samples, and reporting results.

The *WSRC Environmental Compliance Manual* (WSRC–3Q1) provides details about the following aspects of the groundwater monitoring program:

- well siting, construction, maintenance, and abandonment
- sample planning
- sample collection and field measurements
- analysis
- data management
- related publications, files, and databases

The next four sections of this chapter present overviews of several of these topics, along with information specific to 2000.

Sample Scheduling and Collection

EMS schedules groundwater sampling either in response to specific requests from SRS personnel or as part of its ongoing groundwater monitoring program. These groundwater samples provide data for reports required by federal and state regulations and for internal reports and research projects. The groundwater monitoring program schedules wells to be sampled at intervals ranging from quarterly to triennially.

- Groundwater from new wells added to the program is analyzed for environmental-screening constituents (table 10–1) for 4 consecutive quarters for only the wells identified in the *Savannah River Site Screening Program Wells* (ESH–EMS–99–0539).
- Environmental-screening analyses are conducted once every 3 years for only the wells identified in the *Savannah River Site Screening Program Wells* (ESH–EMS–99–0539).
- If their environmental-screening constituent concentrations are above certain limits, wells identified in the *Savannah River Site Screening Program Wells* (ESH–EMS–99–0539) are sampled annually.

Personnel outside EMS may request sample collection as often as weekly. In addition to environmental-screening constituents, constituents that may be analyzed by request include suites of herbicides, pesticides, additional metals, volatile organics, and others. Radioactive constituents that may be analyzed by request include gamma emitters, iodine-129, strontium-90, radium-228, uranium isotopes, and other alpha and beta emitters.

Table 10–1 Environmental-Screening Constituents

Aluminum
Arsenic
Barium
Boron
Cadmium
Calcium
Chloride
Chromium
Fluoride
Gross alpha
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Nitrate-nitrite as nitrogen
Nonvolatile beta
Potassium
Selenium
Silica
Silver
Sodium
Sulfate
Total dissolved solids
Total organic carbon
Total organic halogens
Total phosphates (as P)
Tritium

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; this equipment 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 guidelines. EPA-recommended preservatives and sample-handling techniques are used during sample storage and transportation to both onsite and offsite analytical laboratories. Potentially radioactive samples are screened for total activity (alpha and beta emitters) prior to shipment to determine appropriate packaging and labeling requirements.

Deviations (caused by dry wells, inoperative pumps, etc.) from scheduled sampling and analysis for 2000 are enumerated in the SRS quarterly groundwater monitoring reports cited previously in this chapter.

In 2000, 24,806 radiological analyses and 125,924 nonradiological analyses were performed on groundwater samples collected from 1,180 monitoring wells.

Analytical Procedures

In 2000, General Engineering Laboratories of Charleston, South Carolina; Recra LabNet Philadelphia of Lionville, Pennsylvania; and EMAX Laboratories, Inc., of Torrance, California, performed most of the groundwater analyses. In addition, the General Engineering Mobile Laboratory performed onsite analyses of volatile organics and semivolatile organics and metals. MicroSeeps of Pittsburgh, Pennsylvania, performed natural attenuation analyses. The contracted laboratories are certified by SCDHEC to perform specified analyses.

The EMS laboratory at SRS screened potentially radioactive samples for total activity prior to shipment. General Engineering Laboratories performed radiological analyses, and Thermo NUtech of Oak Ridge, Tennessee, subcontracted radiological analyses from Recra LabNet Philadelphia.

Full lists of constituents analyzed, analytical methods used, and the laboratories' estimated quantitation limits are given in the SRS quarterly groundwater reports referenced earlier.

Evaluation of Groundwater Data

EMS receives analytical results and field measurements as reports and as ASCII files that are loaded into databases at SRS. Logbooks track receipt and transfer of data to the Geochemical Information Management System (GIMS) database, and computer programs present the 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 were completed by 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 verified by the laboratory and list groundwater samples associated with blanks having elevated results. These reports also present the results of intralaboratory and interlaboratory quality assurance comparisons (chapter 11, "Quality Assurance").

Changes to the Groundwater Monitoring Program during 2000

Well Abandonments and Additions; Changes to the Sampling Schedule

During 2000, seven wells were abandoned. Two wells were abandoned in the Chemical, Metals, Pesticides Pits and four were abandoned in the K-Area Reactor Seepage Basin due to construction activities. One well was abandoned in the Old TNX-Area Seepage Basin due to access problems.

The following 180 wells were scheduled to be monitored for the first time in 2000:

- Eleven new wells installed in the D-Area Oil Seepage Basin in conjunction with a Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) project.
- Sixteen new wells monitored in compliance with the Groundwater Effectiveness Monitoring Strategy for the Proposed Southern Sector Phase I Groundwater Corrective Action.
- Four new wells installed in compliance with the RFI/RI work plan for the Road A Chemical Basin.
- Fifty-three new wells installed at the C-Area Burning/Rubble Pit. Of these wells, 17 were installed in compliance with the Effectiveness Monitoring Plan; nine were installed in conjunction with the RFI/RI work plan characterization; and 27 were installed for natural attenuation characterization.
- Eleven new wells installed to monitor extracted groundwater prior to treatment and evaluate overall effectiveness of the corrective action in the F-Area Seepage Basins.

- Nine new wells installed to monitor extracted groundwater prior to treatment and evaluate overall effectiveness of the corrective action in the H-Area Seepage Basins.
- Eight new wells installed in the Chemicals, Metals, and Pesticides Pits to support RFI/RI groundwater characterization.
- One new well installed in compliance with the TNX Effectiveness Monitoring Strategy Addendum.
- Seven new wells installed in the Old F-Area Seepage Basin to establish baseline data at the end of construction activities in accordance with mixing zone application and post construction support.
- Two new wells installed in the F-Area Seepage Basins to complement the sewer line sampling required by the 1995 RCRA Part B Permit.
- Three new wells installed in the H-Area Seepage Basins to complement the sewer line sampling required by the 1995 RCRA Part B Permit.
- Two new recovery wells in the A/M-Area Recovery Well Network, monitored in compliance with the 1995 RCRA Part B Permit.
- Fifty-three new assessment wells installed in the Old Radioactive Waste Burial Ground in compliance with the Mixed Waste Management Facility (MWMF) RCRA Part B Permit.

Groundwater Monitoring Results at SRS

This section summarizes groundwater monitoring results during 2000 for each of the following areas at SRS:

- A-Area and M-Area
- C-Area
- D-Area and TNX
- General separations and waste management areas (E-Area, F-Area, H-Area, S-Area, and Z-Area)
- K-Area
- L-Area and chemicals, metals, and pesticides (CMP) pits
- N-Area
- P-Area
- R-Area
- Sanitary Landfill and B-Area

Groundwater monitoring results for each area in the above list are (1) illustrated with a figure showing the extent of contamination for selected contaminants, (2) described in the text, and (3) summarized with a table.

A figure (from each area) shows facilities of interest at or near the site and illustrates areas of notable contamination above DWS. The figures do not specify every contaminant identified through groundwater monitoring, but they illustrate contamination above DWS. The degree of uncertainty in the shape and extent of individual contaminant plumes illustrated in the maps for each SRS operations area varies depending on the abundance/paucity of control points (well and direct-push data) and the inherent complexity of the aquifer system at individual waste sites.

Each figure is accompanied by a brief description of the sites and facilities of interest in the area, an explanation of groundwater flow, and the nature of contamination in the area. Note that the figures display the estimated extent of contamination determined from previous as well as current years' results, and from additional data. Also, the plumes in the figures are maximum representations of all the contamination from all the aquifer zones and are continuously revised as a work in progress. They were revised using fourth quarter 2000 data, which were not available in the appropriate format for the extent-of-contamination tables.

In addition, the extent-of-contamination tables include data for four quarters for 1998 and 1999; data for 2000 are for the first three quarters because fourth-quarter data were not available in the appropriate format.

The description of contamination at each area concludes with a table that summarizes the following:

- major groups of constituents
- percent of wells sampled (for 1998 through 2000) that contained constituents above drinking water standards
- number of wells sampled (for 1998 through 2000) for each constituent group
- sources of contamination

Substantial areas of contamination identified in the tables are illustrated in more detail, in some cases, in the accompanying figures. For example, a table may identify volatile organics contamination, and the figure may show that most of that contamination is trichloroethylene.

Groundwater Contamination at A-Area and M-Area

Location and Facilities

The administration and manufacturing areas, A-Area and M-Area, are located in the northwest portion of SRS. A-Area houses administrative and research facilities, including the Savannah River Technology Center (SRTC). M-Area was used for production of nuclear fuels, targets, and other reactor components.

A-Area and M-Area include the following facilities and sites associated with the groundwater monitoring program:

- A-Area ash pile
- A-Area burning/rubble pits
- A-Area coal pile runoff containment basin
- A-Area metals burning pit
- M-Area Hazardous Waste Management Facility (HWMF)
- M-Area settling basin
- Metallurgical Laboratory seepage basin
- Miscellaneous chemical basin
- Motor Shop oil basin
- Savannah River Laboratory (SRL) seepage basins
- Silverton Road waste site

Nature of Contamination

Surface drainage in A-Area and M-Area is toward Tims Branch, approximately to the east, and toward valleys to the northwest and southwest that lead to the Savannah River. The water table in this vicinity slopes to the southeast, south, and southwest toward Tims Branch and other discharge points. Most of the water of the upper saturated zone migrates downward into lower water-bearing zones.

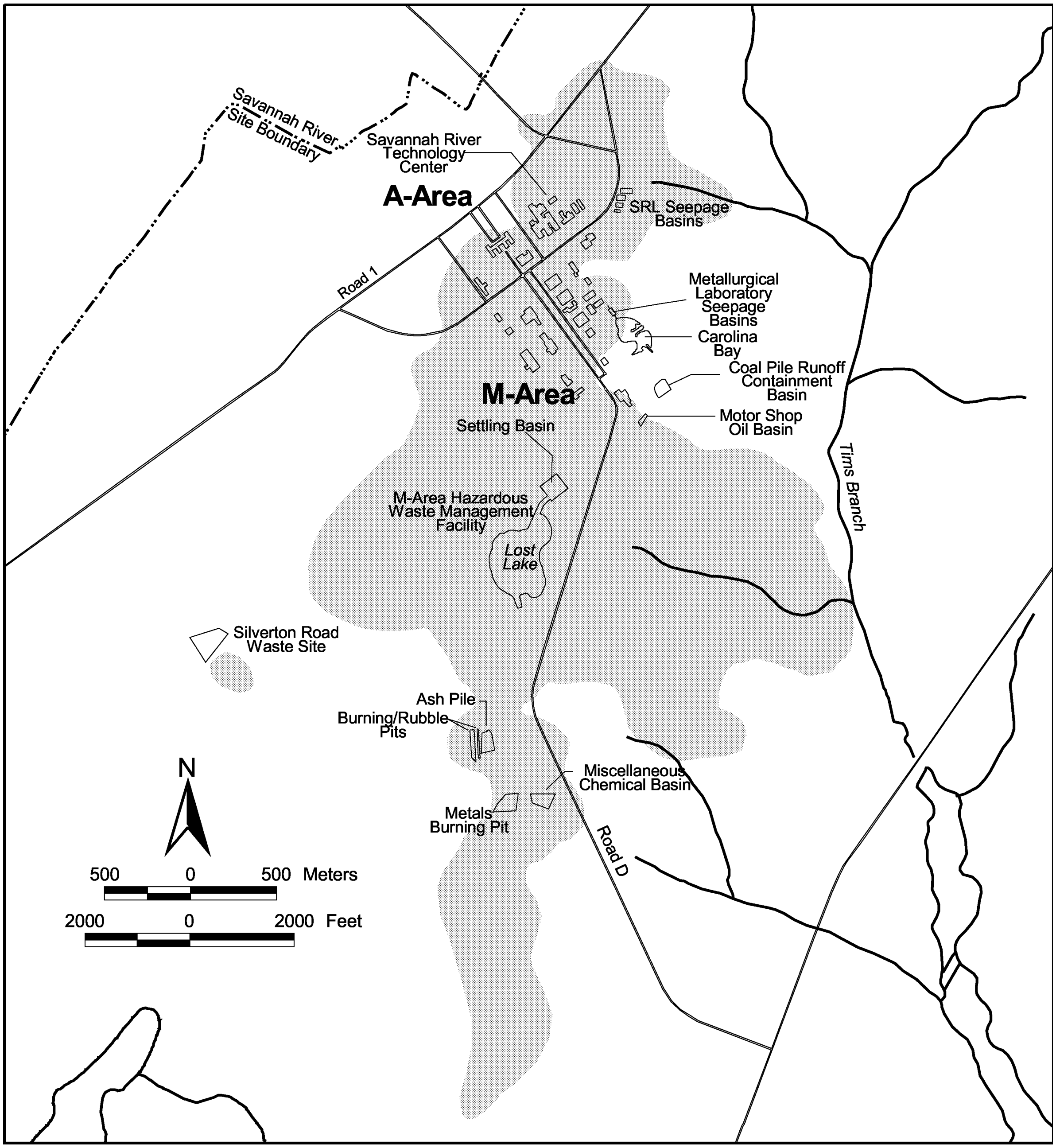
Figure 10–8 shows the extent of contamination and the location of contaminants of primary concern at A-Area and M-Area. There is a large groundwater contamination plume under and downgradient of A-Area and M-Area. Volatile organic constituents—the primary contaminants—are found throughout the area and account for the largest percentage of contaminated wells. Trichloroethylene, tetrachloroethylene, and other volatile organic compounds were used as degreasers during manufacturing and research. After use, organic wastes, metals, and other contaminants were placed into unlined basins, from which they slowly seeped into the groundwater. Contaminants also entered the groundwater as the result of spills or leaking pipes.

The highest concentrations of volatile organics and metals generally are found beneath seepage and settling basins in central and southern portions of the area. The entire contaminant plume covers approximately 5.5 square miles and is approximately one-third mile from the SRS boundary.

Because of the chemical nature of trichloroethylene and tetrachloroethylene and the groundwater conditions in the upper aquifer zone, the contaminant movement generally is downward into deeper aquifers. Once in the deeper aquifers, these contaminants may be moved horizontally by faster groundwater flow rates. Contamination has been documented in the Steed Pond, Crouch Branch, and McQueen Branch aquifers.

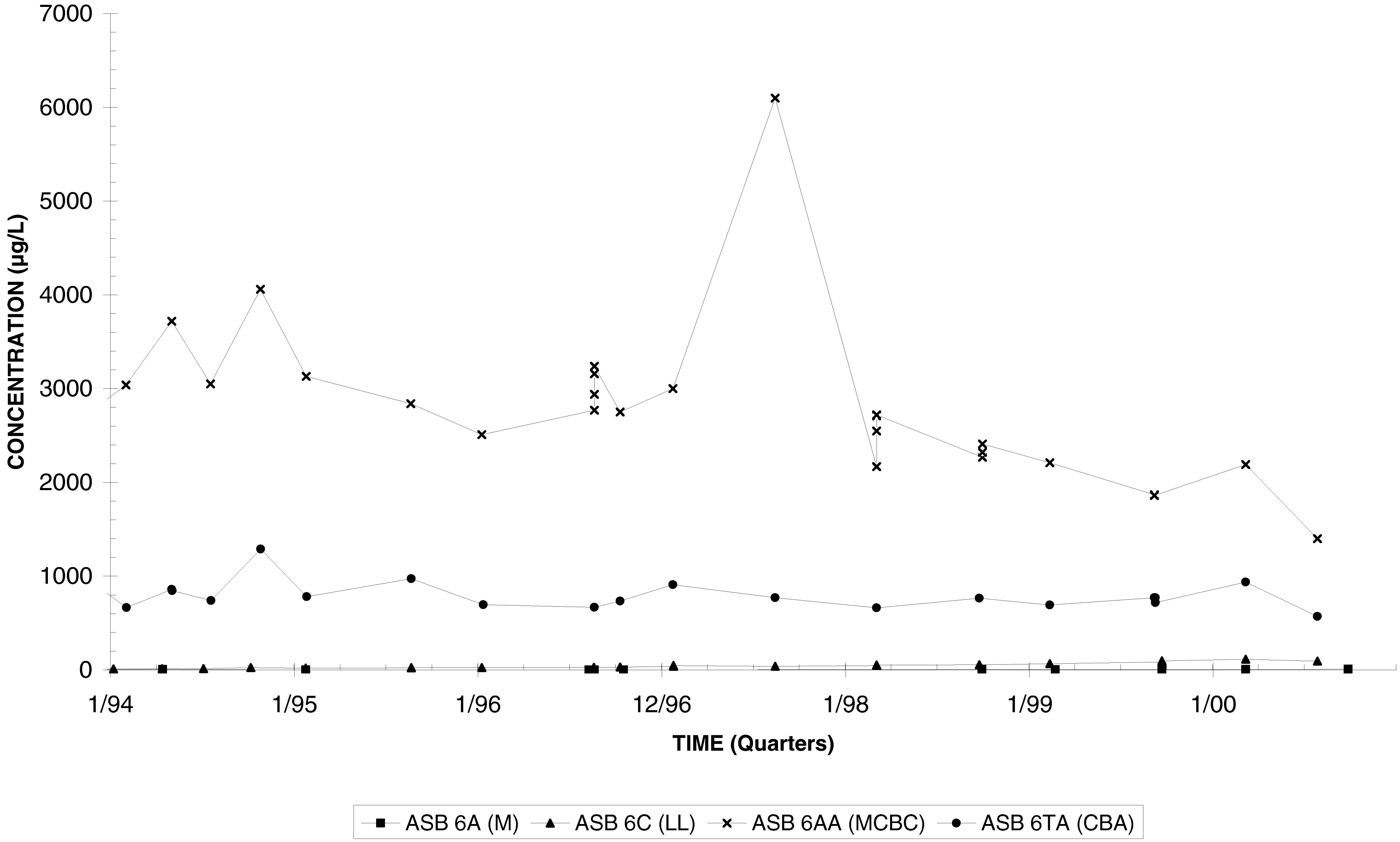
The ASB 6 well cluster monitors the contaminant plume just west of the Savannah River Laboratory seepage basins. Figure 10–9 illustrates the concentration of trichloroethylene in these wells since January 1994 and demonstrates the trend for that contaminant to move to lower aquifer zones. Wells ASB 6A and ASB 6C, which monitor the uppermost aquifer zones, exhibit trichloroethylene levels near the detection limit. The trichloroethylene concentration is highest in well ASB 6AA, which is screened in the next lower zone. Well ASB 8C shows the highest concentration of trichloroethylene in the ASB cluster.

Trending data for trichloroethylene and tetrachloroethylene contamination in A-Area and M-Area indicate that all wells on the southern extent of the central portion of the areas show an upward trend for concentrations. Table 10–2 illustrates this movement of trichloroethylene toward the southeast in selected M-Area wells. All the wells included on this table are located west and south of central M-Area facilities, in the vicinity of the M-Area settling basin and generally north of Lost Lake. Of all M-Area wells, well MSB 11C tested highest for trichloroethylene in 2000 while continuing to follow the downward trend of past years. During the first quarter of 2000, data for well MSB 23B showed increasing levels of trichloroethylene, testing nearly as high as well MSB 11C; well MSB 12B also tested higher in 2000 than in 1999. Wells MSB 11C, 14A, 15A, 16A, 23B, and 25A, which are the most northern and eastern wells on the table, show decreasing or relatively unchanging levels of trichloroethylene between 1996 and 2000. Wells MSB 2B, 2C, 3C, and 17B, which are further south and west, display increasing trichloroethylene levels during the same 5-year period. Well MSB 2C also



SRTC/ER Map

Figure 10–8 Extent of Volatile Organic Contamination of the Groundwater Beneath A-Area and M-Area in 2000 and Location of Noteworthy Sources Responsible for Groundwater Contamination Exceeding Drinking Water Standards



: M=M Area; LL=Lower Lost Lake; MCBC=Middle Sand; CBA=Crouch Branch

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Figure 10–9 Trichloroethylene Concentrations in Well Cluster ASB 6

shows a high concentration of tetrachloroethylene, as does well MSB 31C in the Motor Shop Oil Basin.

Table 10–3 summarizes 1998–2000 groundwater monitoring results for A-Area and M-Area.

Remediation

Ongoing remediation efforts have substantially altered the groundwater and contaminant flow patterns in the upper, middle, and lower aquifer zones beneath A-Area and M-Area. These efforts include capping the basins and extracting and processing volatile organics from the groundwater. Remediation efforts also include pumping contaminated air to six soil vacuum-extraction units, where the volatile organic compounds are destroyed. While ongoing remediation never will clean up contaminated groundwater zones completely, it can slow the spread of contamination and minimize the impact to the environment.

Table 10–2 Trichloroethylene Concentrations (in µg/L) in Selected M-Area Wells, 1996–2000

Well	1996	1997	1998	1999	2000
MSB 1B	459	970	1,240	1,700	1,630
MSB 2B	4,880	6,900	8,970	10,900	13,000
MSB 2C	22,200	41,000	25,500	44,500	25,000
MSB 3C	10,300	11,000	18,700	23,400	17,300
MSB 4C	8,930	19,000	10,600	11,300	16,900
MSB 11C	105,000	73,000	44,700	42,900	40,300
MSB 12B	16,500	19,000	23,800	15,600	13,300
MSB 14A	3,240	2,700	4,240	8,530	NA
MSB 15A	7,080	8,000	8,310	7,990	7,800
MSB 16A	13,100	13,000	9,890	10,600	8,190
MSB 17B	5,140	7,100	7,140	11,200	7,740
MSB 23B	21,400	27,000	30,100	23,600	33,100
MSB 25A	1,350	1,200	1,140	1,290	740
MSB 38C	3,620	4,000	6,880	18,700	6,500

Notes: NA = not analyzed.

All data are from third quarter of the respective years, with the following exceptions: during 1997, data for wells MSB 2C and 11C are from first quarter; during 1999, data from wells MSB 3C, 11C, 12B, and 38C are from first quarter; during 1999, data for well MSB 11C are from first quarter; and during 2000, data for well MSB 23B are for first quarter.

The federal primary DWS for trichloroethylene is 5 µg/L.

Table 10–3 Constituent Groups Above Drinking Water Standards at A-Area and M-Area, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	0%	0%	7%	14	13	14	Met lab seepage basin
Metals	14%	4%	11%	279	291	89	HWMF, motor shop oil basin, metals burning pit, miscellaneous chemical pit, Met lab seepage basin, SRL seepage basins
Organics	59%	54%	55%	299	303	275	Burning/rubble pits, HWMF, metals burning pit, miscellaneous chemical pit, Met lab seepage basin, motor oil shop basin, SRL seepage basins
Pesticides/PCBs	0%	0%	0%	70	87	82	None (no contamination)
Tritium	0%	0%	—	3	20	—	
Other radionuclides	10%	5%	5%	261	267	81	HWMF, Met lab seepage basin, motor shop oil basin
Other constituents (sulfate and nitrate-nitrite as nitrogen)	5%	5%	9%	267	295	148	HWMF, SRL seepage basins

Note: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

Tritium was not sampled at A-Area and M-Area during 2000.

Groundwater Contamination at C-Area

Location and Facilities

C-Area, which is in the west-central part of SRS, contains the C-Area reactor. The C-Area reactor achieved criticality in March 1955 and was shut down in 1985 for maintenance. It was placed on cold standby in 1987, followed by cold shutdown.

C-Area includes the following facilities associated with the groundwater monitoring program:

- C-Area burning/rubble pit
- C-Area coal pile runoff containment basin
- C-Area disassembly basin
- C-Area discharge canal
- C-Area reactor
- C-Area reactor seepage basins
- C-Area retention basin

Nature of Contamination

Groundwater flow beneath C-Area tends to be toward incised creeks near the area. Horizontal flow generally is west toward Four Mile Creek (also known as Fourmile Branch), and surface drainage is predominantly west toward a tributary of Four Mile Creek. Shallow groundwater flow is also toward Castor Creek (southwest of the C-Reactor Area).

During routine reactor operations, radioactive levels of tritium increased in the disassembly basins that held activated target rods. Periodically, the water from these basins was purged to limit worker exposure. During different time periods, the water was discharged to the reactor seepage basins or to surface streams. Tritium also escaped from the disassembly basins.

Trichloroethylene contamination also is present in the groundwater at C-Area. The C-Area burning/rubble pit is one source of this contamination. However, soil vapor extraction/air sparging wells in this area are operating to reduce the source and lower the impact to groundwater.

Figure 10–10 shows the extent of contamination and the location of contaminants of primary concern at C-Area. Consistent with results from previous years, trichloroethylene and tritium are the most widespread contaminants of concern. Contamination is restricted to the Upper Three Runs aquifer. Monitoring results from 2000 are consistent with those of previous years.

Table 10–4 summarizes C-Area’s 1998–2000 groundwater monitoring results.

Table 10–4 Constituent Groups Above Drinking Water Standards at C-Area, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	—	—	—	—	—	—	
Metals	0%	21%	50%	5	19	4	Disassembly basin, reactor seepage basins
Organics	33%	27%	67%	6	30	6	Burning/rubble pit, reactor seepage basins, reactor building
Pesticides/PCBs	0%	0%	—	4	6	—	
Tritium	22%	56%	50%	9	18	4	Burning/rubble pit, disassembly basin, reactor seepage basins
Other radionuclides	40%	0%	0%	5	9	1	None (no contamination)
Other constituents (sulfate and nitrate-nitrite as nitrogen)	0%	0%	—	6	11	—	

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

Dioxins/furans were not sampled at C-Area during 1998, 1999, and 2000. Pesticides/PCBs were not sampled at C-Area during 2000. Other constituents (sulfate and nitrate-nitrite as nitrogen) were not sampled at C-Area during 2000.

Groundwater Contamination at D-Area and TNX

Location and Facilities

D-Area, located in the southwest part of SRS, includes a large coal-fired power plant and the inactive heavy-water facilities.

D-Area includes the following facilities associated with the groundwater monitoring program:

- D-Area burning/rubble pits
- D-Area coal pile, coal pile runoff containment basin, and ash basins
- D-Area oil disposal basin
- Road A chemical basin (Baxley Road)

TNX, also located in the southwest part of SRS—and operated by SRTC—tests equipment prior to installation and develops new designs. The nearest SRS boundary is the Savannah River, approximately one-quarter mile to the west.

Facilities in TNX include the following:

- New TNX seepage basin
- Old TNX seepage basin
- TNX burying ground

Nature of Contamination

The water table aquifer in D-Area discharges to the Savannah River and to a nearby swamp along Beaver Dam Creek. The water table aquifer surface in the vicinity of the coal pile runoff containment basin in D-Area is very close to the ground surface and drains to Beaver Dam Creek, which flows into the Savannah River Swamp.

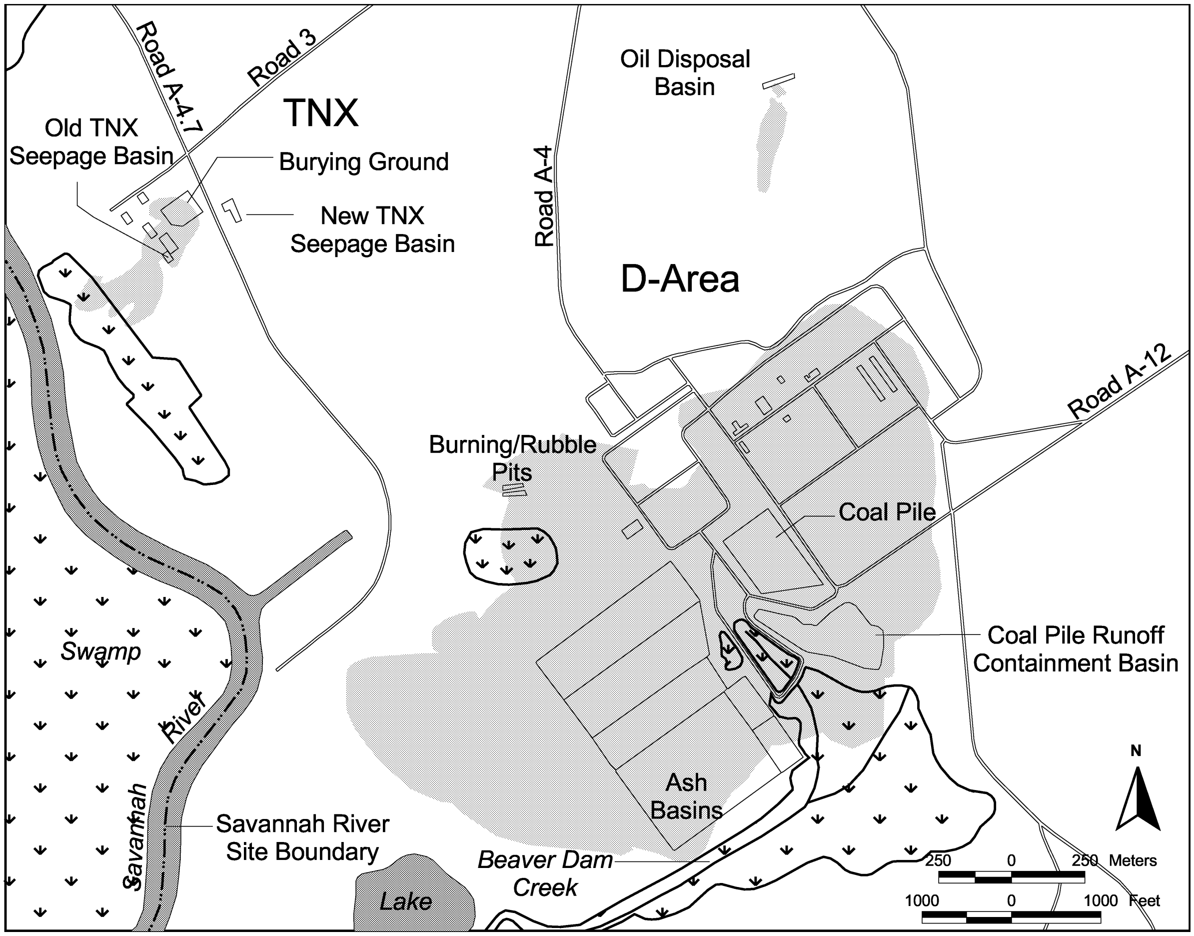
Figure 10–11 shows the extent of contamination and the location of contaminants of primary concern at D-Area and TNX. Contamination is restricted to the Upper Three Runs aquifer. In D-Area, there is substantial contamination of the groundwater near the coal pile,coal pile runoff containment basin, and ash basins. The most widespread contaminant at D-Area and TNX is trichloroethylene. No wells in those areas tested high during the first three quarters of 2000 for tritium or metals, a change from preceding years. The water also is characterized by high conductivity and low pH. solids. Elevated levels of alpha-emitting radionuclides are found as well. The contamination is consistent with the leaching of coal and coal ash.

A separate, smaller plume of contaminated groundwater is present near the D-Area oil disposal basin. Volatile organics (especially trichloroethylene) and lead have been detected above DWS.

The water table aquifer in TNX discharges to the Savannah River and the nearby Savannah River Swamp.

There is a plume of contaminated groundwater underneath much of TNX and downgradient into the Savannah River Swamp. Volatile organic compounds (especially trichloroethylene) are the most widely distributed contaminants. Metals also are present near the known disposal sites. The highest levels of trichloroethylene are found northwest and southeast of the TNX burying ground, although a plume appears to be moving to the southwest of the TNX outfall delta toward the Savannah River and/or the X–08 outfall ditch. Table 10–5 summarizes trichloroethylene concentrations in selected TNX wells between 1996 and 2000. These wells are located in and around the TNX burying ground and the old TNX seepage basin. Trichloroethylene levels in seven wells exceed standards; however, all but one well, TBG–1, have lower concentrations than during the previous year.

Table 10–6 summarizes 1998–2000 groundwater monitoring results for D-Area and TNX.



SRTC/ER Map

Figure 10–11 Extent of Volatile Organic Contamination of the Groundwater Beneath D-Area and TNX in 2000 and Location of Noteworthy Sources Responsible for Groundwater Contamination Exceeding Drinking Water Standards

Table 10–5 Trichloroethylene Concentrations (in µg/L) in Selected TNX Wells, 1996–2000

Well	1996	1997	1998	1999	2000
TBG 1	10.3	12.6	8.16	61.0	270
TBG 3	360	217	875	310	31.0
TBG 4	561	263	687	500	30.0
TBG 5	1,400	1,410	1,710	1,600	1,100
TBG 6	1,780	62.3	465	3,000	27.0
XSB 1D	289	9.23	282	260	220
XSB 2D	106	74.0	15.2	18.0	4.10
XSB 3A	388	34.9	12.3	33.0	4.30
XSB 4D	21.8	3.18	288	45.0	1.70
XSB 5A	12.6	48.9	34.5	18.0	14.2

Notes: NA = not analyzed.

All data are from fourth quarter for 1996 and 1997; from third quarter for 1998, except for wells TBG 5 and XSB 5A, which are from first quarter, and wells XSB 1D and 4D, which are from second quarter; from second quarter for 1999, except for wells XSB 1D, 3A, and 5A, which are from third quarter, and well TBG 1, which are from fourth quarter; and from third quarter for 2000, except for well XSB 5A, which are from second quarter 2000. Well XSB 5A has been replaced by XSB 6; the trichloroethylene result for XSB 6 is 4.7 µg/L for third quarter 2000.

The federal primary DWS for trichloroethylene is 5 µg/L.

Table 10–6 Constituent Groups Above Drinking Water Standards at D-Area and TNX, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	0%	0%	—	30	1	—	
Metals	15%	6%	0%	67	78	24	None (no contamination)
Organics	52%	47%	43%	44	141	42	Burning rubble pit, coal facilities, oil disposal basin, old TNX seepage basin, TNX burying ground
Pesticides/PCBs	0%	0%	0%	55	7	15	None (no contamination)
Tritium	0%	13%	0%	7	32	24	None (no contamination)
Other radionuclides	21%	13%	17%	38	72	71	Coal facilities, TNX burying ground
Other constituents (sulfate and nitrate-nitrite as nitrogen)	23%	16%	0	37	73	6	None (no contamination)

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

Dioxins/furans were not sampled at D-Area and TNX-Area during 2000.

Groundwater Contamination at the General Separations and Waste Management Areas

Location and Facilities

The separations and waste management areas, which include E-Area, F-Area, H-Area, S-Area, and Z-Area, are located in the central part of SRS. Reactor-produced materials are processed in the chemical separations plants in F-Area and H-Area, where uranium, plutonium-238, and plutonium-239 are separated from each other and from fission products. These areas also have facilities for purification and packaging of tritium and for storage of fission wastes.

The separations and waste management areas include the following facilities associated with the groundwater monitoring program:

E-Area

- Burial Grounds perimeter
- E-Area Vaults near the Burial Ground
- Hazardous Waste/Mixed Waste Disposal Facility
- Old Burial Ground
- Radioactive Waste Burial Ground (also known as Solid Waste Disposal Facility)

F-Area

- F-Area acid/caustic basin
- F-Area Burma Road rubble pit
- F-Area burning/rubble pits
- F-Area canyon building and A-Line Uranium Recovery Facility
- F-Area coal pile runoff containment basin and ash basins
- F-Area effluent treatment cooling water basin
- F-Area sanitary sludge land application site
- F-Area seepage basins and inactive process sewer line
- F-Area tank farm
- New F-Area retention basin
- Old F-Area retention basin
- Old F-Area seepage basin

H-Area

- H-Area acid/caustic basin
- H-Area auxiliary pump pit
- H-Area canyon building
- H-Area coal pile runoff containment basin and ash basin
- H-Area effluent treatment cooling water basin
- H-Area sanitary sludge land application site
- H-Area retention basin
- H-Area seepage basins and inactive process sewer line
- H-Area tank farm
- New H-Area retention basin
- Old H-Area retention basin

S-Area

- S-Area auxiliary pump pit
- S-Area Defense Waste Processing Facility
- S-Area low-point pump pit
- S-Area Vitrification Building

Z-Area

- Waste Solidification and Disposal Facility
- Z-Area low-point drain tank
- Z-Area Saltstone Disposal Facility

Nature of Contamination

Surface drainage in these areas of SRS is to Four Mile Creek to the south and Upper Three Runs Creek and its tributaries to the north and west.

E-Area, F-Area, and H-Area are located on the groundwater divide between Four Mile Creek and Upper Three Runs Creek. Near-surface groundwater in the southern portions of these areas discharges to Four Mile Creek and its tributaries. Near-surface groundwater in the northern portions of these areas discharges to Upper Three Runs Creek and its tributaries to the north.

S-Area and Z-Area are located on the groundwater divide between Upper Three Runs Creek and its tributaries to the west.

Figure 10–12 shows the extent of contamination and the locations of contaminants of primary concern in the general separations area. The facilities at E-Area, F-Area, and H-Area have been sources of substantial groundwater pollution. In the past, the seepage and retention basins in F-Area and H-Area have been used to dispose of liquids containing radionuclides, metals, organics, and nitrates. Radioactive liquids have leaked into the groundwater below the tank farms. Tritium and metals have leached from materials buried in E-Area. Several stabilization and closure programs have been implemented to reduce the impact of the sources of groundwater contamination. In Z-Area during 2000, tritium was found in only one well. In the F–Area Seepage Basins, tritium tested highest at wells FSB 87C and 95CR, while gross alpha tested highest in wells FSB 77, FSB 78, and FSB 95CR. Wells FSB 78C and 87D tested high for nonvolatile beta.

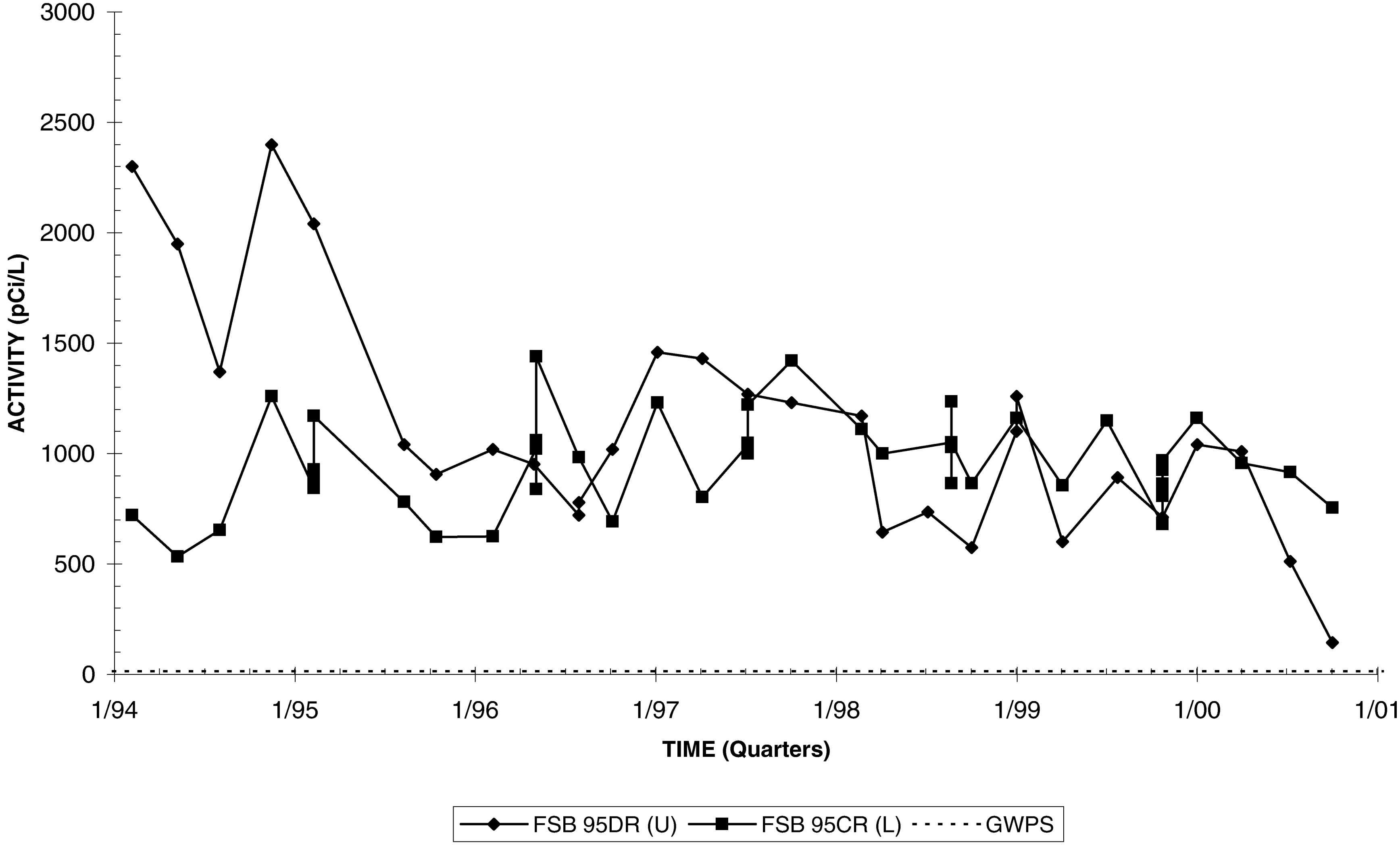
In the H–Area Seepage Basins, tritium tested high in wells HSB 105C, 107C, HSB 112C, HSB 112E, and HSB 127D, while nonvolatile beta and radium–226 tested high in well HSB 114D and nonvolatile beta high in well HSB 116D.

Many groundwater contamination plumes overlap in the area. Plumes from the Old Burial Ground and the F-Area and H-Area seepage basins discharge tritium, radionuclides, metals, and nitrates into Four Mile Creek. Table 10–7 summarizes tritium concentrations in wells to the west and south of the Old Burial Ground and demonstrates stable concentrations of the contaminant over time. The highest tritium concentrations generally are found in wells to the south of the central portion of the Old Burial Ground, near the intersection of Roads E and E–0.2, screened in the water table and next lower (Lower Upper Three Runs) aquifers. Contamination in the general separations area has been documented in the Upper Three Runs and Gordon aquifers.

An extensive tritium plume is migrating north from the Solid Waste Disposal Facility. Other plumes are under the buildings, tank farms, and other waste disposal areas.

The F-Area Hazardous Waste Management Facility well network monitors three distinct hydrostratigraphic units in the uppermost aquifer beneath the facility (two zones of the Upper Three Runs and Gordon aquifers). Groundwater flows in water table and Lower Upper Three Runs aquifer zones generally are south or southwest toward Four Mile Creek. Figure 10–13 illustrates the concentration of gross alpha in well cluster FSB 95 since June 1994. For this cluster during 2000, the gross alpha concentration is highest in well FSB 95CR, which also tested high for tritium. Well FSB 78 tested nearly as high for gross alpha in 2000, as did well FSB 77. Well FSB 79C tested high for iodine-129, well FSB 87D high for nonvolatile beta. Well FSB 91D tested high for americium-241 and curium-243/244; well FSB 97C had high results for americium-241.

Table 10–8 summarizes 1998–2000 groundwater monitoring results for the general separations and waste management areas.



U=Upper Aquifer Zone of the Upper Three Runs Aquifer; L=Lower Aquifer Zone of the Upper Three Runs Aquifer

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Figure 10–13 Gross Alpha Activities in Well Cluster FSB 95

Table 10–7 Tritium Concentrations (in μCi/mL) in Selected General Separations Area Wells, 1996–2000

Well	1996	1997	1998	1999	2000
BGO 29D	8.16E–06	8.40E–06	NA	NA	8.0E–06
BGO 30C	1.37E–03	8.58E–04	NA	NA	5.57E–04
BGO 30D	4.05E–03	1.94E–02	NA	1.45E–02	1.02E–02
BGO 31C	3.59E–03	4.34E–03	NA	6.68E–03	5.30E–03
BGO 31D	1.38E–05	3.65E–05	NA	5.25E–05	2.52E–04
BGO 32D	5.97E–06	NA	NA	7.23E–04	7.52E–04
BGO 33C	1.14E–02	1.21E–02	1.29E–02	1.45E–02	1.82E–02
BGO 33D	2.10E–05	2.42E–05	2.11E–05	2.33E–05	1.40E–05
BGO 34D	1.29E–05	1.55E–05	3.69E–05	2.71E–05	1.03E–05
BGO 35C	5.62E–05	5.12E–05	2.10E–04	4.80E–04	2.31E–04
BGO 35D	2.09E–05	6.72E–05	3.10E–05	6.93E–05	4.11E–05
BGO 36D	2.34E–05	2.32E–05	2.31E–05	2.19E–05	1.55E–05
BGO 37C	1.60E–01	2.10E–01	2.66E–01	1.70E–01	2.72E–02
BGO 37D	2.67E–05	2.71E–05	2.88E–05	2.65E–05	1.59E–05
BGO 46C	9.17E–04	1.33E–03	NA	4.30E–03	3.38E–03
BGO 46D	9.78E–03	3.88E–02	NA	NA	8.04E–03
BGO 47C	3.61E–04	3.65E–04	NA	3.80E–04	4.26E–04
BGO 47D	7.35E–04	5.20E–04	NA	2.50E–04	1.30E–04
BGO 48C	4.31E–03	2.78E–03	NA	3.86E–03	3.14E–03
BGO 48D	3.70E–02	3.78E–02	NA	NA	4.50E–05
BGO 50C	1.49E–04	1.77E–04	NA	6.98E–04	9.72E–04
BGO 50D	1.66E–03	6.88E–04	NA	9.71E–04	8.70E–04

Notes: NA = not analyzed. Well BGO 32D was not analyzed in 1997. Wells BGO 29D, 30C, 30D, 31C, 31D, 32D, 46C, 46D, 47C, 47D, 48C, 48D, 50C, and 50D were not analyzed in 1998. Wells BGO 29D, 30C, 46D, and 48D were not analyzed in 1999.

All data for 1996 and 1997 are from fourth quarter. Data for 1998 are from third quarter except for well BGO 33C, which is from second quarter. Data for 1999 are from fourth quarter except for wells BGO 33D, 35C, 35D, 36D, and 37D, which are from first quarter; and wells BGO 33C and 34D, which are from third quarter. Data for 2000 are from third quarter except for wells BGO 30C, 30D, 31C, 31D, and 32D, which are from second quarter, and wells BGO 29D, 46C, 46D, 47C, 47D, 48C, 48D, 50C, and 50D, which are from fourth quarter.

The federal final primary DWS for tritium is 2.0E–05 μCi/mL.

Table 10–8 Constituent Groups Above Drinking Water Standards at the General Separations and Waste Management Areas, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	**1999**	**2000**	**1998**	**1999**	**2000**	
Dioxins/furans	0%	0%	0%	26	26	14	None (no contamination)
Metals	17%	14%	21%	451	500	332	F-Area ash basins, F-Area seepage basins, MWMF
Organics	12%	12%	10%	470	498	322	Old burial grounds, old retention basin, H-Area seepage basin, MWMF
Pesticides/PCBs	0%	0%	8%	59	52	25	F-Area seepage basins
Tritium	51%	54%	63%	519	487	349	E-Area vaults, coal pile runoff contamination basin, old retention basin, new retention basin, F-Area seepage basins, H-Area seepage basins, tank farms, effluent treatment cooling water basin, Z-Area low-point drain tank, MWMF
Other radionuclides	40%	36%	46%	505	469	355	Old burial grounds, F-Area seepage basins, H-Area seepage basins, tank farms, effluent treatment cooling water basin, MWMF
Other constituents (sulfate and nitrate-nitrite as nitrogen)	20%	22%	35%	488	437	306	Old retention basin, H-Area seepage basin

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

years, shown gross-alpha contamination. This is a typical contaminant leached from coal and coal ash.

Table 10–9 summarizes 1998–2000 groundwater monitoring results for K-Area. Only tritium tested high during 2000.

Table 10–9 Constituent Groups Above Drinking Water Standards at K-Area, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	—	—	—	—	—	—	
Metals	0%	10%	0%	13	20	4	None (no contamination)
Organics	38%	23%	—	8	13	—	
Pesticides/PCBs	0%	—	—	6	—	—	
Tritium	60%	63%	100%	10	16	6	Reactor seepage basin, disassembly basin, and retention basin
Other radionuclides	17%	29%	0%	12	14	8	None (no contamination)
Other constituents (sulfate and nitrate-nitrite as nitrogen)	0%	0%	—	10	7	—	

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

Dioxins/furans were not sampled at K-Area during 1998, 1999, and 2000. Pesticides/PCBs were not sampled during 1999 and 2000. Organics were not sampled during 2000. Other constituents (sulfate and nitrate-nitrite as nitrogen) were not sampled at K-Area during 2000.

Groundwater Contamination at L-Area and the Chemicals, Metals, and Pesticides Pits

Location and Facilities

L-Area is in the south-central part of SRS and contains the L-Area reactor, which achieved criticality in 1954 and continued production until 1968, when it was placed in warm standby. It subsequently operated from 1985 until 1988, when it was shut down for maintenance. It was placed in warm standby in December 1991 to be put into operation as a backup to K-Reactor, if necessary, but since has been placed in cold shutdown.

L-Area includes the following facilities associated with the groundwater monitoring program:

- L-Area acid/caustic basin
- L-Area Bingham pump outage pits
- L-Area burning/rubble pits
- L-Area disassembly basin
- L-Area oil and chemical basin
- L-Area reactor
- L-Area reactor seepage basin

The CMP pits are near the head of Pen Branch. The pits were used from 1971 to 1979 to dispose of waste consisting of drummed oil, organic solvents, and small amounts of pesticides and metals. In 1984, the pits were excavated to form two trenches, backfilled, and capped. During excavation, most of the contaminated material was removed to the Hazardous Waste Storage Facility.

Nature of Contamination

Figure 10–15 shows the extent of contamination and the location of contaminants of primary concern at L-Area and the CMP pits. There is a plume of contaminated groundwater downgradient between the L-Area reactor buildings and L-Lake. Tritium is the most extensive contaminant, and results from current and previous years show that lead and tetrachloroethylene are present in low concentrations. Tritium activity in a monitoring well about 1,000 feet southwest of the reactor building has increased substantially since 1994. Tetrachloroethylene and nitrate are present near the disassembly basin and the oil and chemical basin. Contamination is restricted to the Upper Three Runs aquifer.

Several small tributaries of Steel Creek receive surface drainage from L-Area. The near-surface groundwater discharges to Steel Creek and Pen Branch. Surface drainage and shallow groundwater at the CMP pits flows radially toward Pen Branch and its tributaries.

A plume of groundwater beneath the CMP pits has in past years shown contamination with volatile organics, most notably trichloroethlyene and tetrachlorethylene.

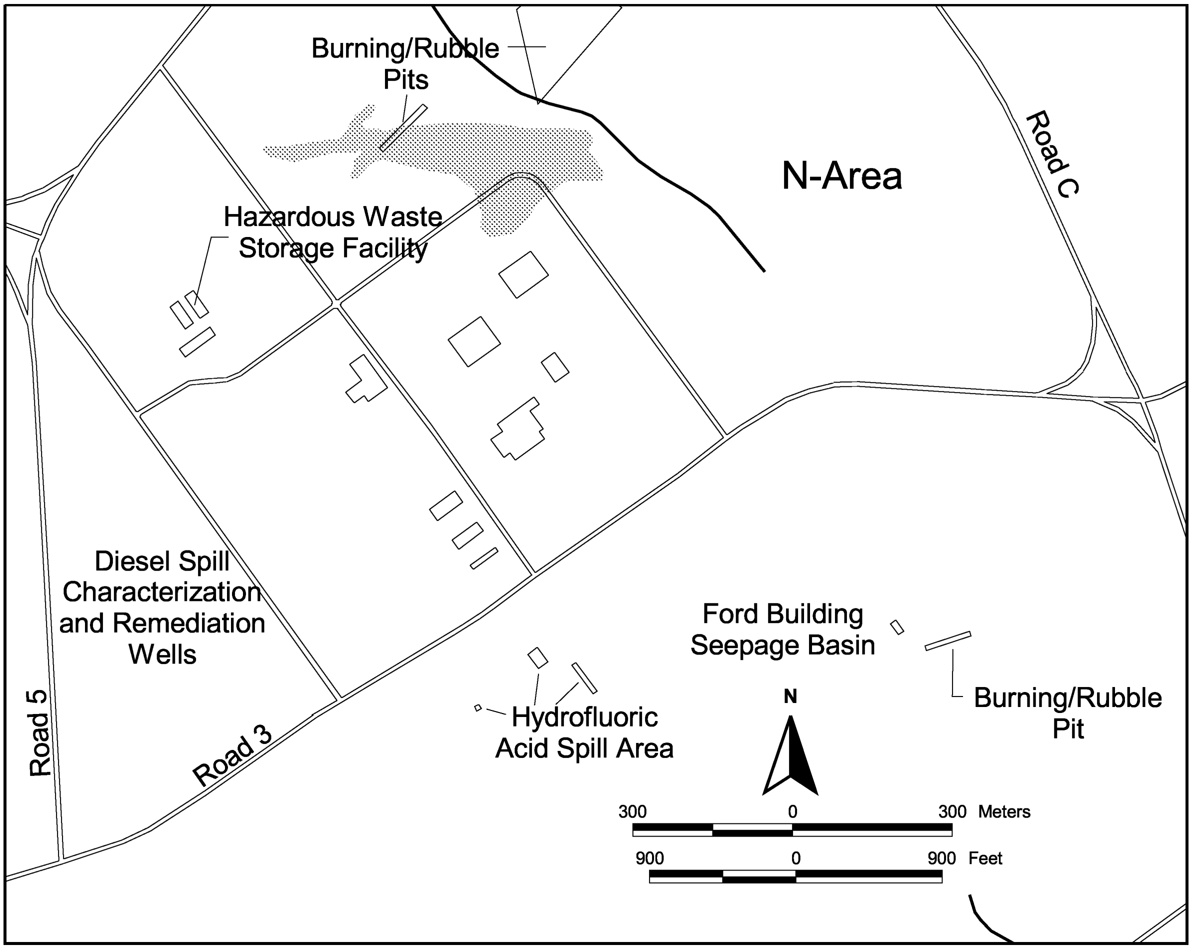
Table 10–10 summarizes 1998–2000 groundwater monitoring results for L-Area and the CMP pits. Tritium tested high in L-Area, and tetrachlorothylene and trichloroethylene tested high at the CMP pits in the first three quarters of 2000.

Table 10–10 Constituent Groups Above Drinking Water Standards at L-Area, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	—	—	—	—	—	—	
Metals	23%	5%	0%	13	19	5	None (no contamination)
Organics	8%	0%	10%	12	16	10	Burning/rubble pit, disassembly basin, oil and chemical basin
Pesticides/PCBs	0%	—	—	6	—	—	
Tritium	36%	50%	43%	14	10	14	Disassembly basin, oil and chemical basin, reactor seepage basin
Other radionuclides	0%	0%	0%	9	10	2	None (no contamination)
Other constituents (sulfate and nitrate-nitrite as nitrogen)	0%	0%	—	13	9	—	

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

Dioxins/furans were not sampled at L-Area and CMP Pits during 1998, 1999, and 2000. Pesticides/PCBs were not sampled at L-Area and CMP Pits during 1999 and 2000. Other constituents (sulfate and nitrate-nitrite as nitrogen) were not sampled during 2000.



SRTC/ER Map

Figure 10–16 Extent of Volatile Organic Contamination of the Groundwater Beneath N-Area in 2000 and Location of Noteworthy Sources Responsible for Groundwater Contamination Exceeding Drinking Water Standards

Groundwater Contamination at N-Area

Location and Facilities

N-Area, also called the Central Shops area, is located in the central part of SRS and provides supply, maintenance, and other support services for the site.

N-Area includes the following facilities associated with the groundwater monitoring program:

- Ford Building seepage basin
- Hazardous Waste Storage Facility
- Hydrofluoric acid spill
- N-Area burning/rubble pits
- N-Area (Central Shops) sludge lagoon
- N-Area diesel spill
- N-Area Fire Department Training Facility

Figure 10–16 shows the extent of contamination and the location of contaminants of primary concern in N-Area. Surface drainage in N-Area is to tributaries of Four Mile Creek to the north, west, and south and to tributaries of Pen Branch to the east. Four Mile Creek, Upper Three Runs Creek, and several other incised creeks are located between N-Area and the SRS boundary and are areas of groundwater discharge. Figure 10–1 shows the locations of these streams. Contamination is restricted to the Upper Three Runs aquifer.

Table 10–11 summarizes 1998–2000 groundwater monitoring results for N-Area. Monitoring well sampling in 2000 was performed outside the volatile organic plume identified in the vicinity of the burning/rubble pits from previous years' sampling; for this reason, there are no sources of contamination identified on table 10–11 for 2000.

Table 10–11 Constituent Groups Above Drinking Water Standards at N-Area, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	0%	—	—	16	—	—	
Metals	25%	0%	0%	24	12	3	None (no contamination)
Organics	17%	0%	—	24	12	—	
Pesticides/PCBs	0%	—	—	24	—	—	
Tritium	0%	0%	—	11	5	—	
Other radionuclides	9%	0%	—	11	6	—	
Other constituents (sulfate and nitrate-nitrite as nitrogen)	0%	0%	—	24	5	—	

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

Dioxins/furans and pesticides/PCBs were not sampled at N-Area during 1999.

contaminants of primary concern at P-Area. The largest plume of contaminated groundwater in P-Area historically has consisted of tritium contamination near the disassembly basin and the reactor seepage basins. Contamination is restricted to the Upper Three Runs aquifer.

Sampling from previous years also shows that lead is elevated in a few wells near the seepage basins. Sampling from previous years detected low levels of volatile organics, primarily trichloroethylene and/or tetrachloroethylene, in the groundwater northwest of the reactor, the retention basin, and near the burning/rubble pit.

Table 10–12 summarizes 1998–2000 groundwater monitoring results for P-Area. P-Area wells were not sampled during the first three quarters of 2000.

Table 10–12 Constituent Groups Above Drinking Water Standards at P-Area, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	—	—	—	—	—	—	
Metals	14%	10%	—	7	21	—	
Organics	25%	6%	—	4	28	—	
Pesticides/PCBs	0%	—%	—	4	—	—	
Tritium	0%	64%	—	7	14	—	
Other radionuclides	14%	21%	—	14	14	—	
Other constituents (sulfate and nitrate-nitrite as nitrogen)	0%	11%	—	11	9	—	

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

P-Area wells were not sampled during the first three quarters of 2000; fourth quarter 2000 data were not available at time of publication.

groundwater divide between Mill Creek and PAR Pond. The groundwater just north of R-Area naturally discharges to Mill Creek to the northwest and to the Joyce Branch of Pond A to the northeast. The groundwater from the southern part of R-Area naturally discharges to a tributary of Pond 4 south of R-Area.

Figure 10–18 shows the extent of contamination and the location of contaminants of primary concern at R-Area. Analyses during previous years indicate that there is a plume of volatile organics in the vicinity of the Bingham pump outage pits. Contamination is restricted to the Upper Three Runs aquifer.

Testing during the first three quarters of 2000, however, showed high readings only for radionuclides other than tritium, especially nonvolatile beta and strontium-90.

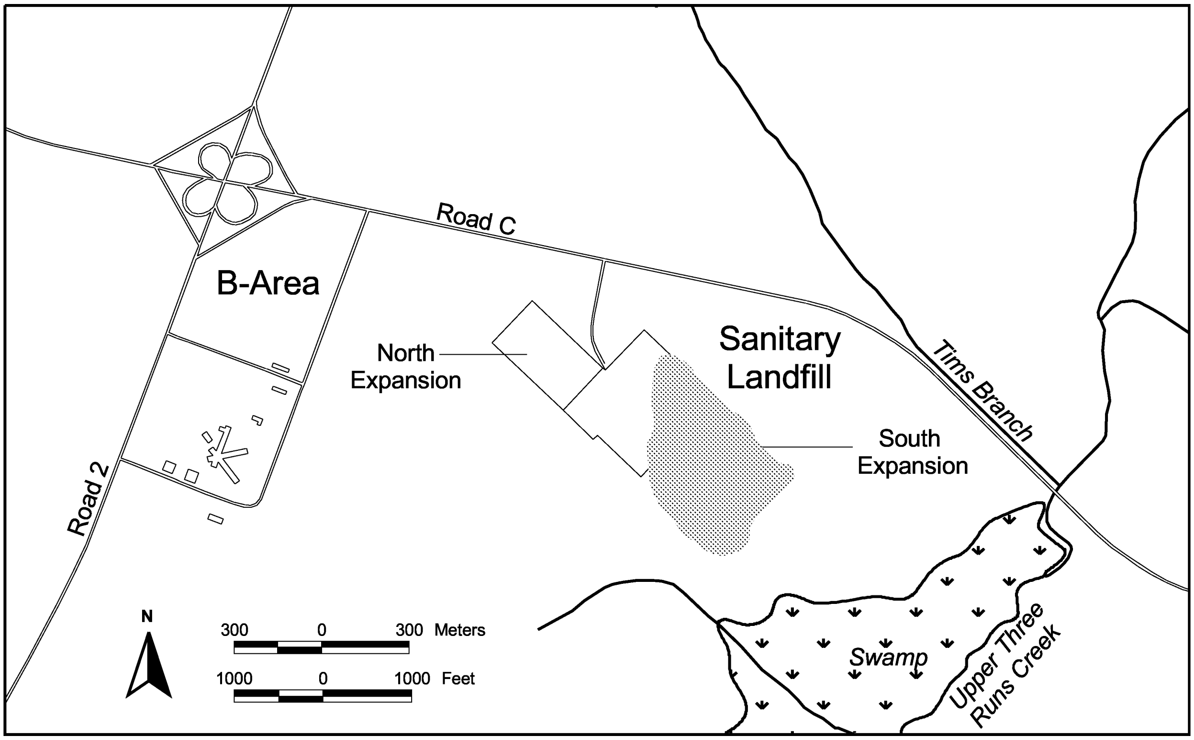
Table 10–13 summarizes 1998–2000 groundwater monitoring results for R-Area.

Table 10–13 Constituent Groups Above Drinking Water Standards at R-Area, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	—	—	—	—	—	—	
Metals	0%	20%	0%	7	20	4	None (no contamination)
Organics	0%	7%	—	7	15	—	
Pesticides/PCBs	0%	0%	0%	4	4	4	None (no contamination)
Tritium	0%	0%	0%	8	11	4	Disassembly basin, reactor seepage basins
Other radionuclides	14%	9%	14%	35	22	21	Disassembly basin, reactor seepage basins
Other constituents (sulfate and nitrate-nitrite as nitrogen)	0%	0%	—	10	13	—	

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

Dioxins/furans were not sampled at R-Area during 1998, 1999, and 2000. Organics were not sampled at R-Area during 2000. Other constituents (sulfate and nitrate-nitrite as nitrogen) were not sampled at R-Area during 2000.



SRTC/ER Map

Figure 10–19 Extent of Volatile Organic Contamination of the Groundwater Beneath the Sanitary Landfill and B-Area in 2000 and Location of Noteworthy Sources Responsible for Groundwater Contamination Exceeding Drinking Water Standards

Groundwater Contamination at the Sanitary Landfill and B-Area

Location and Facilities

The Sanitary Landfill is south of Road C, about midway down the slope from the Aiken Plateau to Upper Three Runs Creek. The landfill 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, carcasses, asbestos in bags, and sludge from SRS's wastewater treatment plant were placed in unlined trenches and covered daily with soil or a fabric substitute. The original section of the landfill and its southern expansion, with a total area of approximately 54 acres, have been filled. The portion of approximately 16 acres known as the northern expansion, or the interim sanitary landfill, ceased operations in November 1994.

Nature of Contamination

Surface drainage at the Sanitary Landfill is to the south-southeast, toward Upper Three Runs Creek. Horizontal groundwater flow is to the southeast, toward Upper Three Runs Creek.

Sanitary landfills are intended to receive only nonradioactive, nonhazardous waste. However, until October 1992, some hazardous wastes (specifically, solvent-laden rags and wipes used for cleaning, decontamination, and instrument calibration) were buried in portions of the original 32-acre landfill and its southern expansion.

Figure 10–19 shows the extent of contamination and the location of contaminants of primary concern at the Sanitary Landfill and near B-Area. There is a substantial plume of contaminated groundwater under and downgradient of the Sanitary Landfill. Volatile organic compounds (primarily trichloroethylene and vinyl chloride) are the most widespread contaminants, but metals, tritium, and other radionuclides also are present. Tritium was detected in one well and gross alpha in two.

Table 10–14 summarizes 1998–2000 groundwater monitoring results for the landfill and B-Area.

A biosparging system consisting of two horizontal wells (SLH–1 and SLH–2 on figure 10–19) began operation in August 1999. This remediation system involves the injection of

- methane and nutrient compounds to create conditions for *in situ* biodegradation of trichloroethylene at SLH–1
- air to stimulate biodegradation of vinyl chloride at SLH–2

Both wells are installed in the shallow aquifer zone beneath the landfill. The results of quarterly groundwater monitoring indicate that the biosparging treatment has significantly reduced volatile organic compound concentrations—especially of trichloroethylene—in the groundwater. Plans are under way to convert SLH–1 to air and nutrient injection to address vinyl chloride in the groundwater at this location.

Table 10–14 Constituent Groups Above Drinking Water Standards at the Sanitary Landfill and B-Area, 1998–2000

Constituent Groups	Percent of Wells With Results Above Standards			Number of Wells Sampled			Sources of Contamination
	1998	1999	2000	1998	1999	2000	
Dioxins/furans	—	—	—	—	—	—	
Metals	6%	6%	14%	51	50	50	Sanitary landfill
Organics	36%	35%	35%	50	49	49	Sanitary landfill
Pesticides/PCBs	0%	0%	0%	16	18	21	None (no contamination)
Tritium	6%	8%	2%	50	49	50	Sanitary landfill
Other radionuclides	3%	8%	13%	38	38	38	Sanitary landfill
Other constituents (sulfate and nitrate-nitrite as nitrogen)	0%	0%	0%	8	10	10	None (no contamination)

Notes: Drinking Water Standards refer to federal final primary DWS, proposed primary DWS, and interim final primary DWS.

Dioxins/furans were not sampled at Sanitary Landfill or B-Area during 1998, 1999, and 2000.

Chapter 11

Quality Assurance

Margaret Arnett, Chuck Hayes, Bob Henderson, Moheb Khalil, and Walt Kubilius
Environmental Protection Department

Jen Williams
ExR, Inc.

2000 Highlights

- In the blind sample program routinely conducted by EMS to assess the quality and reliability of pH field data, pH measurements were taken on 24 samples. All field pH measurements were within EPA's suggested acceptable control limit.
- Eleven blind samples were analyzed for tritium by the EMS laboratory. EMS performance demonstrated a high level of accuracy. All tritium data were within the control limits. The results of these blind samples were used to validate analytical work in the chemistry and counting laboratory.
- An automated capability was developed and initiated for the statistical evaluation of duplicate samples in the EMS laboratory. This process will eliminate manual data entry and thus reduce the possibility of human error.
- The EMS laboratory achieved an acceptability ratio of 90 percent during the first DOE QAP intercomparison study of the year and 95 percent during the second DOE QAP intercomparison study of the year. The results of the two studies reflect the accuracy and precision of the data produced by EMS. All laboratories that provide environmental measurements for DOE sites are required to participate in the QAP studies twice a year.
- In the interlaboratory comparison program for subcontracted laboratories (nonradiological liquid effluents), EMS sent two sets of blind standards to Shealy Environmental Services and two duplicate sets of standards to General Engineering Laboratories. Shealy reported acceptable results for 30 of 37 parameters, and General Engineering reported acceptable results for 33 of 37 parameters. Shealy and General Engineering reported acceptable results on additional samples for all missed parameters.
- The intralaboratory comparison program for subcontracted laboratories (nonradiological liquid effluents), compares performance within a laboratory by analyzing duplicate and blind samples throughout the year. Results during 2000 were considered to be excellent, with no indications of consistent problems in the laboratories (Shealy Environmental Services and the EMS laboratory).

THE Environmental Monitoring Section (EMS) of the Savannah River Site's (SRS) Environmental Protection Department (EPD) maintains a quality assurance (QA) program to continuously verify the integrity of data generated by its own environmental monitoring program and by its subcontracted laboratories.

Various definitions have been suggested for QA and quality control (QC). Frequently, the terms are used interchangeably. In the EMS program, QA consists of the system whereby the laboratory can assure clients and other outside entities, such as government agencies and accrediting bodies, that the laboratory is generating data of proven and known quality. QC refers to those operations undertaken in the laboratory to ensure that the data produced are generated within known probability limits of accuracy and precision.

Although QC represents the core activity in a QA program, the latter encompasses planned and systematic actions necessary to provide the evidence needed to assure that quality is achieved. The QA program has two basic goals:

- to create a management system that reduces the probability of error
- to detect and correct any errors that have occurred

Another QA component is quality assessment, which refers to the evaluation activities that provide assurance that the QC job is being done effectively.

Statistical Terms

mean measurement of central tendency, commonly called the average

mean relative difference measure of reproducibility of identical chemical analyses

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 known value; usually multiplied by 100 to be expressed as a percentage

Each aspect of the EMS environmental monitoring program, from sample collection to data reporting, must address QC and quality assessment standards defined in the *Savannah River Site Environmental Monitoring Section Quality Assurance Plan* (WSRC–3Q1–2, Volume 3, Section 8000).

This chapter summarizes the EMS QA/QC program. Guidelines and applicable standards for the program are referenced in appendix A, “Applicable Guidelines, Standards, and Regulations.”

Tables containing the 2000 QA/QC data can be found in *SRS Environmental Data for 2000* (WSRC–TR–2000–00329).

A more complete description of the QA/QC program can be found in chapter 1110, “Quality Assurance,” of the *Savannah River Site Environmental Monitoring Section Plans and Procedures* (WSRC–3Q1–2, Volume 1, Section 1100).

QA/QC for Environmental Monitoring Section Laboratories

General objectives of the QA/QC program include

- validity, traceability, and reproducibility of reported results
- comparability of results within databases
- representativeness of each sample to the population or condition being measured
- accuracy and precision

Training for Personnel

EMS personnel are responsible for understanding and complying with all requirements applicable to the activities with which they are involved. Consequently, appropriate training courses are provided to assist them in fulfilling their responsibilities. Courses include training on applicable QA procedures, Occupational Safety and Health Administration-mandated training, and General Employee Training. Regulations and procedures that govern the environmental monitoring program are emphasized.

EMS analysts begin with specific training determined by job assignment. The section’s technical work is based on its environmental procedures in sampling, radiochemistry, water quality, counting room, and data management and computer support.

Internal Quality Assurance Program

Specific QA checks and accepted practices are conducted by each EMS group, as described in the following paragraphs.

Field Sampling Group

Blind Sample Program EMS routinely conducts a blind sample program for field measurements of pH to assess the quality and reliability of field data measurements. Measurements of pH are taken in the field using the same equipment as is used for routine measurements.

During 2000, blind pH field measurements were taken for 24 samples (table 53, *SRS Environmental Data for 2000*). All field pH measurements were within the U.S. Environmental Protection Agency’s (EPA’s) suggested acceptable control limit of ± 0.4 pH units of the true (known) value.

Instrumentation Calibration EMS personnel also measure total residual chlorine, dissolved oxygen, and temperature in water samples; but because of the difficulties in providing field standards, these measurements are not suitable for a blind sample program. Therefore, quality control of these analyses relies instead on instrumentation calibration, per the section’s procedures.

Chemistry and Counting Laboratories

Laboratory performance is evaluated through instrument checks, control charts, and data analyses. Within the Environmental Chemistry and Analysis group, graphical control checks and numerical trending are conducted on technician and method performance, with reports generated for sample results that exceed 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 validity. The Environmental Chemistry and Analysis group prepares spike, blank, duplicate, and blind samples to check the performance of routine analyses. Spike samples and blank samples are used to calculate a recovery efficiency of an analytical method, to adjust for background radiation, and to evaluate counting equipment performance.

Blind Tritium Samples Blind tritium samples provide a continuous assessment of laboratory sample preparation and counting. The tritium activity is unknown to the technicians preparing the samples or the counting laboratory personnel. The blind samples are prepared from National Institute of Standards and Technology (NIST)-traceable material or standardized against NIST material. The results are added to control charts to identify trends. During 2000, 11 blind samples were analyzed for tritium (table 54, *SRS Environmental Data for 2000*). All tritium data were within the control limits. The results of these blind samples were used to validate analytical work in the chemistry and counting laboratories.

Laboratory Certification The EMS laboratory is certified by the South Carolina Department of Health and Environmental Control (SCDHEC) for the following analytes:

- under the Clean Water Act (CWA)—chemical oxygen demand, total suspended solids, and field pH, total residual chlorine, and temperature
- under the Resource Conservation and Recovery Act (RCRA)—50 volatile organic compounds (VOCs)

During 2000, the EMS laboratory's certification for 26 metal analytes under the CWA program and 27 metal analytes under the RCRA program was extended until June 2003 after review by the SCDHEC Office of Laboratory Certification.

Data Verification and Validation

Results received from the counting laboratory are electronically evaluated by the Environmental Monitoring Computer Automation Program (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. An acceptance range for each analysis, based on historical results, is calculated for all routine environmental samples. Sample results outside the acceptance range are submitted for individual review, which may result in repeating the analyses, recounting, recalculating, or resampling for verification.

Before data are reported, they must be reviewed and validated by qualified personnel. Electronic verification is performed on 100 percent of the data stored in EMS databases. Through this verification, data anomalies are removed or data are rejected if there is disagreement with EMS QA/QC policies. The validation methods and criteria are documented in *WSRC Quality Assurance Manual* (WSRC–1Q, section 21–1, "Quality Assurance Requirements for the Collection and Evaluation of Environmental Data") and in EMS environmental geology procedures. Quality control requirements for managing, evaluating, and publishing environmental monitoring data are defined in WSRC–3Q1–2, volume 3, section 8000 (procedure 8250, "Quality Control Program for Environmental Data Management and Publications").

In 2000, an automated capability was developed and initiated for the statistical evaluation of duplicate samples in the EMS laboratory. This process will eliminate manual data entry and thus reduce the

QA Terminology in the Laboratory

accuracy degree of agreement between a measurement and an accepted reference or true value

bias systematic (constant) underestimation or overestimation of the true value

spike sample sample to which a known amount of a substance has been added

precision measure of mutual agreement among individual measurements of the same property, under prescribed, similar conditions.

duplicate sample repeated but independent determinations on the same sample

blind sample (blind duplicate) mock sample of known constituent(s) or concentration(s); used as a control

blank samples clean samples analyzed to establish a baseline or background value used to adjust or correct results

control chart graphical chart of some measured parameter for a series of samples possibility of human error. Expectations include much more timely evaluations of duplicate measurements that will result in a significant quality assurance check regarding sample measurements.

External Quality Assurance Program

In 2000, the EMS laboratory participated in the U.S. Department of Energy (DOE) Quality Assurance Program (QAP), an interlaboratory comparison program that tracks performance accuracy and tests the quality of environmental data reported to DOE by its contractors.

Under this program, the DOE Environmental Measurements Laboratory (DOE/EML) sends samples to participating laboratories twice a year and compares the laboratories' results to program values. These comparisons verify the accuracy of EMS radiochemical analytical results. The quality control chemist maintains control charts to monitor trends and bias for each matrix (e.g., water, air filter, vegetation, soil) and analysis for various nuclides.

Reference samples for the QAP program—including soil/sediment, water, vegetation, and air filter samples—are prepared by DOE/EML and sent to the participating laboratories. Analytical results are reported to DOE/EML and are compared with the test results of other laboratories. DOE/EML evaluates the results and distributes a report to the participating laboratories. Results are rated as acceptable (A), acceptable with warning (W), and not acceptable (N). Control charts are maintained according to DOE/EML control limits. The following EMS analytical methods and instruments are tested in these studies:

- gamma emitters by gamma spectroscopy
- actinides by alpha spectroscopy
- strontium and gross alpha/beta by gas-flow proportional counters
- tritium by liquid scintillation

Work was completed in March on the 52nd set of QAP samples from a DOE/EML radiological intercomparison study. EMS analyzed 12 isotopes in air, 12 in soil, seven in vegetation, and 11 in water for a total of 42 results. Thirty-three of the results were rated "A," five were rated "W," and four were rated "N." A performance rating of 90 percent acceptable was achieved for this study. (This rating was calculated by dividing the "As" and the "Ws" by the total number of results.)

In QAP set 53, which was completed in September, EMS analyzed 12 isotopes in air, 13 in soil, seven in vegetation, and 11 in water for a total of 43 results. Thirty-four of the results were rated "A," seven were rated "W," and two were rated "N." A performance rating of 95 percent acceptable was achieved for this study. (This rating was calculated by dividing the "As" and the "Ws" by the total number of results.) EMS QA personnel consider 80 percent to be a minimum acceptance rate in this program.

The high bias (approximately 50 percent) in uranium in soil in the March study could be attributed to the soil matrix and the difficulty in analyzing a representative sample. The September results for uranium in soil were within acceptable limits.

The low bias (approximately 23 percent) in gamma analysis of vegetation in the March study was corrected by recalibrating the detector systems for this counting geometry. This was verified when the September study showed no bias for gamma analysis of vegetation.

The high bias (31 percent) in strontium-90 in vegetation in the September study was attributed to poor precision because of the difficulty in acquiring a representative sample.

An EMS investigation of the low bias (23 percent) in uranium-234 in water in the September study was inconclusive. Previous results (March) were within acceptable limits, and EMS control charts showed no long-term bias for uranium in water.

The QAP results for the two sets can be found in table 55, *SRS Environmental Data for 2000*. The table includes the DOE/EML control limits for nonacceptable results.

QA/QC for Subcontracted Laboratories

Subcontracted laboratories providing analytical services must have a documented QA/QC program and meet the quality requirements defined in WSRC–1Q. The subcontracted laboratories used during 2000 and the types of analyses performed are listed in table 11–1.

EMS personnel perform an annual evaluation of each subcontracted laboratory to ensure that the laboratories maintain technical competence and follow the 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 corrective actions, and preventive maintenance. EMS provides reports of the findings and recommendations to each laboratory and conducts followup evaluations as necessary.

Table 11–1
Subcontracted Laboratories for 2000

General Engineering Laboratories
(Charleston, S.C.)

- groundwater nonradiological analyses
- soil/sediment
- waste characterization

Recra LabNet Philadelphia
(Philadelphia, Pa.)

- groundwater nonradiological analyses
- soil/sediment
- waste characterization

ThermoNUtech
(Oak Ridge, Tenn.)

- groundwater radiological analyses
- soil/sediment radiological analyses
- waste characterization radiological analyses

EMAX Laboratories, Inc.
(Torrence, Calif.)

- groundwater nonradiological analyses

Microseeps, Inc.
(Pittsburgh, Pa.)

- groundwater nonradiological analyses
- soil gas
- soil/sediment
- site evaluation

Shealy Environmental Services
(Cayce, S.C.)

- NPDES analyses
- analyses for SRS streams and the Savannah River

RFI Mobile Laboratory
(Savannah River Site)

- groundwater radiological and nonradiological analyses
- soil radiological and nonradiological analyses

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 SCDHEC (discussed in appendix A, page 216). Effluent samples are analyzed by four laboratories—three onsite laboratories and one subcontract laboratory. Laboratories must be certified by SCDHEC for all analyses. The EMS laboratory performs analyses for temperature, pH, most total suspended solids, and total residual chlorine. The WSRC Site Utilities Division (SUD) Wastewater Laboratory performs analyses for pH, biological oxygen demand, and total suspended solids on sanitary facility wastewater samples. The WSRC TNX Effluent Treatment Facility performs analyses for temperature and pH. Shealy Environmental Services was the primary subcontractor for the NPDES program throughout 2000.

Interlaboratory Comparison Program

Interlaboratory comparison studies are used to compare the quality of results between laboratories performing the same analyses. All subcontracted laboratories analyzing NPDES samples must participate in the EPA Discharge Monitoring Report Laboratory Performance Evaluation program. Under this program, EPA sends to participating laboratories performance samples containing constituents normally found in industrial and municipal wastewaters.

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 known sample value, with stated acceptance limits and warning limits. Accepted variations from the known sample value depend on a variety of factors, including the precision of the analysis and the extent to which the results can be reproduced.

NPDES Discharge Monitoring Report protocols require SRS to assign a “0” value to all nondetect values for reporting purposes. To facilitate data evaluation and provide consistency, SRS assigns a value of “0” to all QA/QC nondetect analysis results.

The EMS laboratory sent two sets of blind standards to Shealy in 2000. The QA/QC control standards and acceptance limits were provided by Environmental Resource Associates (ERA). Two duplicate sets of standards were also sent to General Engineering Laboratories for comparative purposes. Shealy reported acceptable results for 30 of 37 parameters, and General Engineering reported acceptable results for 33 of 37 parameters (table 56, *SRS Environmental*

Data for 2000). Shealy's results were not acceptable for aluminum, ammonia (2), biochemical oxygen demand, oil and grease, and phenol (2). General Engineering's results were not acceptable for ammonia, oil and grease, total organic carbon, and zinc. Shealy and General Engineering reported acceptable results on additional samples for all missed parameters.

EMS subcontract laboratories are required to have a corrective action plan to investigate and correct problems encountered in their performance.

During 2000, Shealy participated in various InterlaB WatR™ Supply Water Pollution (WP) and Water Supply (WS) Performance Evaluation Programs. ERA administered these programs. The format for the WP statistical summary is based on EPA's national standards for water proficiency testing studies criteria. The format for the WS statistical summary is based on the Safe Drinking Water Act regulated acceptance limits. The statistical summaries are designed to show subcontract laboratories' performance against the national WP and WS studies formerly run by EPA. Performance results by Shealy and other participating EMS subcontract laboratories can be found in table 11–2. The proficiency rating is calculated as follows: acceptable parameters divided by total parameters analyzed, multiplied by 100.

EPA uses WP and WS results to certify laboratories for specific analyses. As part of the recertification process, EPA requires that subcontract laboratories investigate the outside-acceptance-limit results and implement corrective actions as appropriate.

Intralaboratory Comparison Program

SRS's intralaboratory program compares performance within a laboratory by analyzing duplicate and blind samples throughout the year. Shealy and the EMS laboratory analyzed 117

Table 11–2 Subcontract Laboratory Performance in ERA Water Pollution and Water Supply Studies

Laboratory	Water Pollution Studies (Percent Acceptable)		Water Supply Studies (Percent Acceptable)
EMAX	WP 61 (96%)[a]	WP 66 (95%)[b]	WS 48 (97%)[c]
Recra	WP 60 (94%)[d]	WP 66 (94%)[e]	WS 49 (96%)[f]
General Engineering	WP 65 (98%)[g]	WP 66 (100%)	WS 45 (94%)[h]
RFI Mobile Lab	WP 69 (99%)[i]		
Shealy	WP 65 (88%)[j]	WP 67 (82%)[k]	

a Results for mercury, fluoride, sodium, calcium, and magnesium were not acceptable. Results for chloride, potassium, total suspended solids, calcium hardness ($CaCO_3$), and total organic carbon were acceptable but near the acceptance limits.

b Results for fluoride, biological oxygen demand, chemical oxygen demand, and 2,4–dinitrotoluene were not acceptable. The result for total hardness ($CaCO_3$) was acceptable but near the acceptance limit.

c Results for fluoride and phosphate as P were not acceptable.

d Results for conductivity, total suspended solids, chemical oxygen demand, total organic carbon, total Kjeldahl nitrogen, total cyanide, and total residual chlorine were not acceptable. The result for total phenolics was acceptable but near the acceptance limit.

e Results for total suspended solids, biological oxygen demand, total phosphorus as P, benzene, 1,2 dichlorobenzene, 1,3 dichlorobenzene, 1,4 dichlorobenzene, and methylene chloride were not acceptable. Results for chemical biological oxygen demand, total cyanide, titanium, carbon tetrachloride, chloroform, toluene, 1,1,1–trichloroethane, and trichloroethylene were acceptable but near the acceptance limits.

f Results for dichlorodifluoromethane, 1,1,2,2–tetrachloroethane, and hexachlorocyclopentadiene were not acceptable.

g Results for total phosphorus as P, dieldrin, heptachlor epoxide, and diethylphthalate were not acceptable. Results for sodium, total phenolics, tetrachloroethylene, 4,4'–DDD, 4,4'–DDE, and 4,4'–DDT were acceptable but near the acceptance limits.

h Results for calcium hardness ($CaCO_3$), bromide, conductivity, nitrite as N, ortho–phosphate as P, total organic carbon, calcium, copper, manganese, benzo(a)pyrene, and 2,4–D were not acceptable.

i Results for benzo(b)fluoranthene and dimethylphthalate were not acceptable. Results for calcium and Aroclor 1260 were acceptable but near the acceptance limits.

j Results for iron and silver were not acceptable.

k Results for iron, phenol, and total organic carbon were not acceptable.

duplicate samples during 2000 (table 57, *SRS Environmental Data for 2000)*.

Shealy analyzed 83 duplicate samples for various parameters, and the EMS laboratory analyzed 34 duplicate samples for total suspended solids. Nondetectable results were reported for 68 of the 117 samples. Percent difference calculations showed that nine of the 83 samples analyzed by Shealy were outside the EMS internal QA/QC requirement (± 20 percent of the true value). Six of the exceptions were at or near the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability. Exceptions in this range generally are not considered a problem. Three exceedances—for copper, lead, and oil and grease—appeared to be related to analytical error at the subcontract laboratory, sample contamination, or improper sampling techniques.

The EMS laboratory was within the 20-percent acceptance range on 26 of 34 samples. Six of the exceptions were at or near the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability. Again, exceptions in this range generally are not considered a problem. The remaining two exceptions appeared to be related to analytical error in the laboratory, sample contamination, or improper sampling technique.

SRS submitted 64 blind samples to the Shealy and EMS laboratories, and 120 analyses were performed—87 by Shealy and 33 by EMS (table 58, *SRS Environmental Data for 2000)*. Nondetectable results were reported for 70 of the 120 analyses. Percent difference calculations showed that 10 total suspended solids analyses, nine performed by the EMS laboratory and one by Shealy, were outside the acceptance range (± 20 percent of the true value). Six of the total suspended solids exceptions were at or below the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability.

Of the 87 analyses that Shealy conducted, 76 were within the 20-percent acceptance range. Of the 11 analyses outside the acceptance range (± 20 percent of the true value), nine were at or near the detection limit. The remaining two exceptions—for aluminum and lead—appeared to be related to analytical error at the subcontract laboratory, sample contamination, or improper sampling technique.

Results for the duplicate and blind sampling programs were considered to be excellent, with no indications of consistent problems in the laboratories.

Nonradiological detection limits are provided in table 3, *SRS Environmental Data for 2000*.

Stream and River Water Quality

The water quality program requires quality checks of 10 percent of the samples to verify analytical results. Analyses are required to be performed by a certified laboratory. Duplicate grab samples from SRS streams and the Savannah River were analyzed by Shealy and the EMS laboratory in 2000. Shealy analyzed samples for hardness, herbicides, nitrate + nitrite, phosphorus, pesticides, and total organic carbon. EMS analyzed duplicate samples for chemical oxygen demand, metals, and total suspended solids. A total of 601 analyses were performed (table 59, *SRS Environmental Data for 2000*).

Twenty-six samples were outside the acceptance limit. For all of these results, the actual differences were small and the parameter concentrations low. Ten of the 26 analyses were at or near the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability. Exceptions in this range generally are not considered a problem. The remaining 16 analyses—one for iron, five for phosphorus, two for aluminum, two for hardness, two for manganese, one for nitrate + nitrite, two for total suspended solids, and one for total organic carbon—could be attributed to laboratory analytical error, sample contamination, or improper sampling technique.

Nonradiological detection limits are provided in table 3, *SRS Environmental Data for 2000*.

Groundwater

Groundwater analyses at SRS are performed by subcontracted laboratories. During 2000, EMAX Laboratories, Inc., the EMS laboratory, General Engineering Laboratories, MicroSeeps, Inc., and Recra LabNet Philadelphia were the primary subcontractors for nonradiological analyses. General Engineering and Thermo NUtech were the primary subcontractors for radiological analyses. In addition, RFI (RCRA Facility Investigation) Mobile Laboratory performed onsite analyses of volatile and semivolatile organics and metals.

SRS requires that subcontracted laboratories investigate the outside-acceptance-limit results and implement corrective actions as appropriate.

Internal QA

During 2000, approximately 5 percent of the samples collected (radiological and nonradiological) for the RCRA and the Comprehensive Environmental

Response, Compensation, and Liability Act (CERCLA) programs were submitted to the primary laboratory for analysis as blind duplicates and to a different laboratory as a QA check. The laboratories' results were evaluated on the basis of the percentage within an acceptable concentration range.

A statistical measure, the mean relative difference (MRD), is calculated to assess result reproducibility and laboratory performance. The laboratories also analyze approximately 10 percent of samples as intralaboratory QA checks. Interlaboratory comparisons were conducted between the following:

- EMAX/Recra LabNet Philadelphia
- General Engineering/Thermo NUtech
- General Engineering/Recra LabNet Philadelphia
- EMAX/RFI Mobile Laboratory
- Recra LabNet Philadelphia/RFI Mobile Laboratory
- RFI Mobile Laboratory/Thermo NUtech
- General Engineering/RFI Mobile Laboratory

Analytes outside or near acceptance limits do not appear to be systematic or to exhibit any identifiable trends. Full results for all QA/QC evaluations, including MRD calculations where appropriate, may be found in the following groundwater reports:

- *The Savannah River Site's Groundwater Monitoring Program, First Quarter 2000* (ESH–EMS–00–0405)
- *The Savannah River Site's Groundwater Monitoring Program, Second Quarter 2000* (ESH–EMS–00–0406)
- *The Savannah River Site's Groundwater Monitoring Program, Third Quarter 2000* (ESH–EMS–00–0407)
- *The Savannah River Site's Groundwater Monitoring Program, Fourth Quarter 2000* (ESH–EMS–00–0408)

External QA (Environmental Resource Associates Standards)

Water Pollution and Water Supply Studies During 2000, EMAX, Recra LabNet Philadelphia, General Engineering, and RFI Mobile laboratories participated in various WP and WS studies (WP and WS studies are described on page 202). Performance result summaries can be found in table 11–2.

Quarterly Assessments During 2000, EMS conducted quality assessments of the primary analytical laboratories to review their performance on certain analyses. Each laboratory received a set of certified environmental quality control standards from ERA, and its results were compared with the ERA-certified values and performance acceptance limits. The performance acceptance limits are listed as guidelines for acceptable analytical results, given the limitations of the EPA methods used to determine these parameters. The performance acceptance limits closely approximate the 95 percent confidence interval. Results from the laboratories (EMAX, EMS, General Engineering, RFI Mobile Laboratory, Microseeps, and Recra LabNet Philadelphia) are summarized in table 11–3.

Soil/Sediment

Environmental investigations of soils and sediments, primarily for RCRA/CERCLA units, are performed by subcontracted laboratories (General Engineering Laboratories, Recra LabNet Philadelphia, ThermoNUtech, and Microseeps—table 11–1, page 201).

EMS personnel validated and managed approximately 200,000 analytical records during 2000. Data are validated according to EPA standards for analytical data quality unless specified otherwise by site customers. Fifty projects were begun in 2000. Most projects, when completed, include a project summary report, which contains

- a project QA/QC summary
- a discussion of validation findings
- tables of validated and qualified data

Validation activities resulted in rejection of 1,093 analytical records analyzed in 2000, less than one percent of the reported data. Typical reasons for data rejection included spectral interference, low surrogate recovery, and low matrix spike recovery.

The EMS validation program is based on an EPA guidance document, *Data Quality Objectives Process for Superfund* (EPA–540–R–93–071). This document identifies QA issues to be addressed, but it does not formulate a procedure for how to evaluate these inputs, nor does it propose pass/fail criteria to apply to data and documents. Hence, the EMS validation program necessarily contains elements from—and is influenced by—several other sources, including

- *QA/QC Guidance for Removal Activities*, interim final guidance, EPA–540–G–90–004
- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review,* EPA–540/R–94/012

Table 11–3 Subcontract Laboratory Performance on ERA Standards

Laboratory	Percent Within Limits 1st Quarter 2000	2nd Quarter 2000	3rd Quarter 2000	4th Quarter 2000
EMAX	92.2[a]	94.9[b]	95.9[c]	95.9[d]
EMS			95.5[e]	95.5[f]
General Engineering	97.1[g]	90.2[h]	92.6[i]	100.0
RFI Mobile Lab	98.7[j]	89.6[k]	91.5[l]	96.9[m]
Microseeps		86.6[n]	93.3[o]	
Recra	93.3[p]	98[q]	94.5[r]	93.8[s]

a Results for phenols, 2-sec-butyl-4,6-dinotrophenol, bromide, alpha-chlordane, gamma-chlordane, 4,4'-DDD, 4,4'-DDE, and boron were not acceptable.

b Results for di-n-butyl phthalate, potassium, chloride, total phosphates (as P), and carbon tetrachloride were not acceptable.

c Results for diethylphthalate, bromide, total petroleum hydrocarbons, infrared, and turbidity were not acceptable.

d Results for dibromochloromethane, 2,4–dichlorophenoxyacetic acid, total petroleum hydrocarbons (infrared), and total phosphates (as P) were not acceptable.

e Results for strontium were not acceptable.

f The result for strontium was not acceptable.

g Results for potassium, chloride, and boron were not acceptable.

h Results for calcium, magnesium, potassium, 2,4-dichlorophenoxyacetic acid, alkalinity (as $CaCO_3$), 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and tetrachloroethylene not acceptable.

i Results for bromide, total petroleum hydrocarbons, infrared, toxaphene, bromoform, 1,2-dichlorobenzene , 1,4-dichlorobenzene, and 4-methyl-2-pentanone (MIBK) were not acceptable.

j Results for xylenes were not acceptable.

k Results for hexachloroethane were not acceptable.

l Results for bis(2-ethylhexyl) phthalate, chrysene, pyrene, and toxaphene, were not acceptable.

m Results for 1,3–dichlorobenzene and PCB 1242 were not acceptable.

n Results for 2-chlorophenol, di-n-butyl phthalate, pyrene, heptachlor epoxide, methoxychlor, toxaphene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene were not acceptable.

o Results for carbontetrachloride, endrin, and toluene were not acceptable.

p Results for 1,2-dichlorobenzene, 1,4-dichlorobenzene, cyanide, phenols, 2-sec-butyl-4,6-dinotrophenol, fluoride, and dieldrin were not acceptable.

q Results for cyanide and 2,4-dichlorophenoxyacetic acid were not acceptable.

r Results for bromide, fluoride, pH, and turbidity were not acceptable.

s Results for ammonia (as nitrogen), 2–sec–Butyl–4,6–dinotrophenol (Dinoseb), grease and oil, methoxychlor, toxaphene, and turbidity were not acceptable.

- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA–540/R–94/013
- T*est Methods for Evaluating Solid Waste*, EPA, November 1986, SW–846, Third Edition
- *Data Validation Procedures for Radiochemical Analysis*, WHC–SD–EN–SPP–001

Data management personnel in the soil/sediment program perform additional functions to ensure the quality of the data released by EMS. Two people enter the data for each entry to help eliminate errors, and all field, shipping, invoice, and analytical data are 100 percent verified.

Relative percent difference for the soil/sediment program is calculated for field duplicates and laboratory duplicates. A summary of this information is presented in each project report prepared by the Environmental Geochemistry Group of EMS.

Data Review

Several detailed data validation activities have been added to the QA program for groundwater and soil/sediment analyses procured from offsite commercial laboratories:

- laboratory data record reviews (since 1993)
- radiological data reviews (since 1996)
- metals interference reviews (since 1997)

The detailed data review is described in chapter 1110, “Quality Assurance,” of the *Savannah River Site Environmental Monitoring Section Plans and Procedures* (WSRC–3Q1–2, Volume 1, Section 1100).

In 2000, the major QA issues that were discovered and addressed in connection with these programs included

- false positives and false negatives in antimony and thallium due to poor instrument performance
- poor matrix spike recovery for antimony
- improperly performed manual peak integration for pesticides and polychlorinated biphenyl (PCBs)
- false positives of pesticides due to interference from PCBs
- instrument misidentification of pesticides

These findings illustrate that, although laboratory procedures are well defined, analytical data quality does benefit from technical scrutiny.

Conclusion

The QA/QC program reviews the performance of SRS organizations and its subcontractors to ensure that relevant quality control criteria are satisfied. Reviews include

- laboratory audits
- field audits of sampling activities
- examination of sample preservation techniques and sample shipping process
- interlaboratory comparisons
- evaluation of analytical results of blanks, standards, and duplicates

Review of SRS subcontractor laboratories indicated that all met or exceeded the performance target criteria. Review of SRS’s environmental sampling and analytical programs indicated that most data met applicable quality standards. Any deviations encountered were addressed by appropriate corrective action plans.

Quality assurance goals for the coming year include the following:

- Monitor closely the acceptance criteria for samples analysis within EMS and its subcontract laboratories.
- Implement a plan to minimize the impact on the quality of sample analysis during EMS’s move to a new laboratory facility.
- Identify ways—using feedback from employees and data users—to improve the assessment process of the environmental monitoring program.

Chapter 12

Special Surveys and Projects

Pete Fledderman
Environmental Protection Department

Eric Nelson
Environmental Sciences and Technology Department

To Read About . . . See Page . . .

2000 Highlights

- The latest comprehensive survey of the Savannah River Swamp was conducted to determine the levels and distribution of radionuclides within the swamp. Some changes in the spatial distribution of activity were observed; however, the survey indicated that activity has not migrated out of the identified contaminated area.
- Studies on reforestation of the Pen Branch corridor and delta have been completed. Both natural succession and planting have led to the successful reforestation of this wetland system.

IN addition to routine sampling and special sampling during nonroutine environmental releases, special sampling for radiological and nonradiological surveys is conducted on and off site by personnel from the Savannah River Site (SRS) Environmental Protection Department's Environmental Monitoring Section (EMS) and from other groups, such as the Savannah River Technology Center (SRTC).

Both short- and long-term radiological and nonradiological surveys are used to monitor the effects of SRS effluents on the site's environment and in its immediate vicinity.

All conclusions discussed in this chapter are based on samples and analyses that have been completed. Because of sampling and/or analytical difficulties, some sample analyses may be missing. These analyses typically are small in number and represent only a very small fraction of the total number of samples. Their exclusion does not affect the results drawn from the data set.

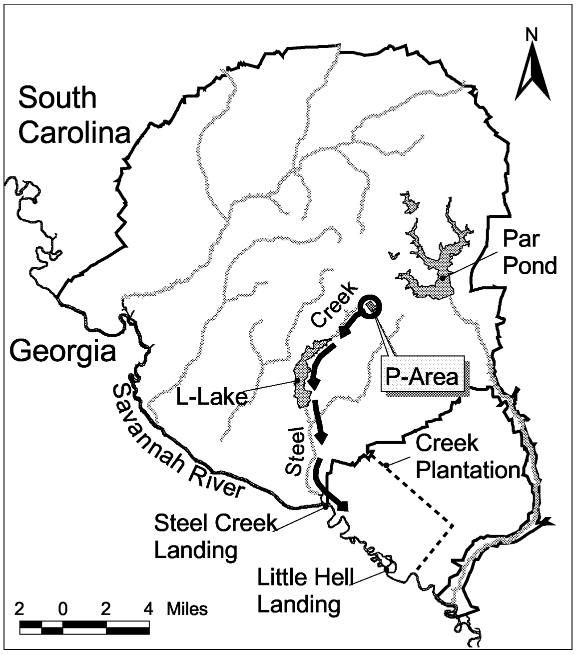
Savannah River Swamp Surveys

Introduction

The Creek Plantation, a privately owned land area located along the Savannah River, borders the southeast portion of SRS. The land is primarily undeveloped and agricultural; it is used in equestrian-related operations and is a recreational hunt club. A portion of Creek Plantation along the Savannah River is a low-lying swamp known as the Savannah River Swamp, which is uninhabited and not easily accessible.

In the 1960s, an area of the Savannah River Swamp on Creek Plantation—specifically, the area between Steel Creek Landing and Little Hell Landing—was contaminated by SRS operations (figure 12–1). Failed experimental fuel elements leaked activity into the P-Area storage basin, whose water occasionally was discharged to Steel Creek. During high river levels, water from Steel Creek flowed along the lowlands comprising the swamp, resulting in the deposition of radioactive material. This water eventually discharged to the Savannah River at Little Hell Landing, contaminating a portion of the Savannah River Swamp. SRS studies estimated that a total of approximately 25 Ci of cesium-137 and 1 Ci of cobalt-60 were deposited in the swamp.

In 1974, a series of 10 sampling trails was established through the swamp, ranging in length from 240 to 3,200 feet (figure 12–2). Fifty-two monitoring locations were designated on the trails to allow for continued monitoring at a consistent set of locations. Comprehensive and cursory surveys of the swamp have been conducted periodically since 1974. These surveys measure radioactivity levels to determine changes in the amount and/or distribution of radioactivity in the swamp. A comprehensive survey was conducted in 2000.



SRTC Map

Figure 12–1 Swamp Contamination

Radioactivity released from SRS operations contaminated the Savannah River Swamp between Steel Creek and Little Hell Landing during the 1960s. Approximately 25 Ci of cesium-137 and 1 Ci of cobalt-60 were released from the P-Area storage basin to Steel Creek and migrated downstream to a part of the Savannah River Swamp that extends beyond the SRS boundary.

Details – 2000 Survey

The 2000 survey was conducted from early January through late April. Because of adverse field conditions, not all scheduled samples could be obtained. High water levels in January prevented the collection of samples at four locations, while the lack of green grass-type vegetation throughout the survey period prevented the collection of vegetation samples at an additional 38 locations.

Analytical Results

Analytical results are presented in *SRS Environmental Data for 2000* (WSRC–TR–2000–00329). With one exception (a sample discarded accidentally prior to completion), all samples were successfully analyzed. As anticipated, based on source term information and historical survey results, cesium-137 was the primary radionuclide detected. Also, cobalt-60 and/or total strontium was present at low concentrations in some samples.

Cesium-137 was detected in 67 of the 71 soil samples and seven of the 11 vegetation samples (tables 60 and 61, *SRS Environmental Data for 2000*). Cesium-137 concentrations varied from below the detection limit to 102 pCi/g in soil, and from below the detection limit to 4.4 pCi/g in vegetation. These concentrations are consistent with historical results. In general, higher levels of cesium-137 in soil were observed in the trails closer to the SRS boundary, although somewhat elevated levels in soil were observed as far away as approximately four miles (trail 9).

All vegetation samples with detectable activity were collected from trails 1 and 2. The samples with higher concentrations were located in the interior portions of each trail; this was expected based on the initial deposition mechanism (the highest concentrations were deposited in low-lying areas away from the river in which contaminated water stood) and on earlier survey results. As observed in previous surveys, the vertical distribution profile in soil—that is, the variation of contaminant concentration with depth in a soil column—is not as pronounced in the swamp, where significant scouring and/or deposition is possible, as it is in areas of undisturbed soil. These results indicate some movement (mobilization, movement and/or redeposition) of contamination in the swamp. No elevated cesium-137 levels were observed in samples from trail 10, indicating that the area of contamination has not spread beyond the current survey area boundary.

Cobalt-60 was detected in only seven of the 71 soil samples and in none of the vegetation samples. The cobalt-60 concentrations in soil varied from nondetectable to 0.3 pCi/g. These concentrations are consistent with historical survey results. Although no definite spatial distribution was observed, the sites with detectable cobalt-60 concentrations generally were at locations showing relatively high cesium-137 concentrations. As with the distribution of cesium-137 activity, this trend was expected based on the initial deposition mechanism and on previous survey results.

Total strontium was detected in five of the 29 soil samples selected for analysis; no vegetation samples were analyzed for total strontium because none were available at the locations identified for strontium analysis.

Although slightly increased, the strontium levels in soil generally were consistent with historical survey results. Changes in the analytical method used may be partly responsible for the increase. Although the samples showing detectable activity were core segments, no apparent spatial distribution or

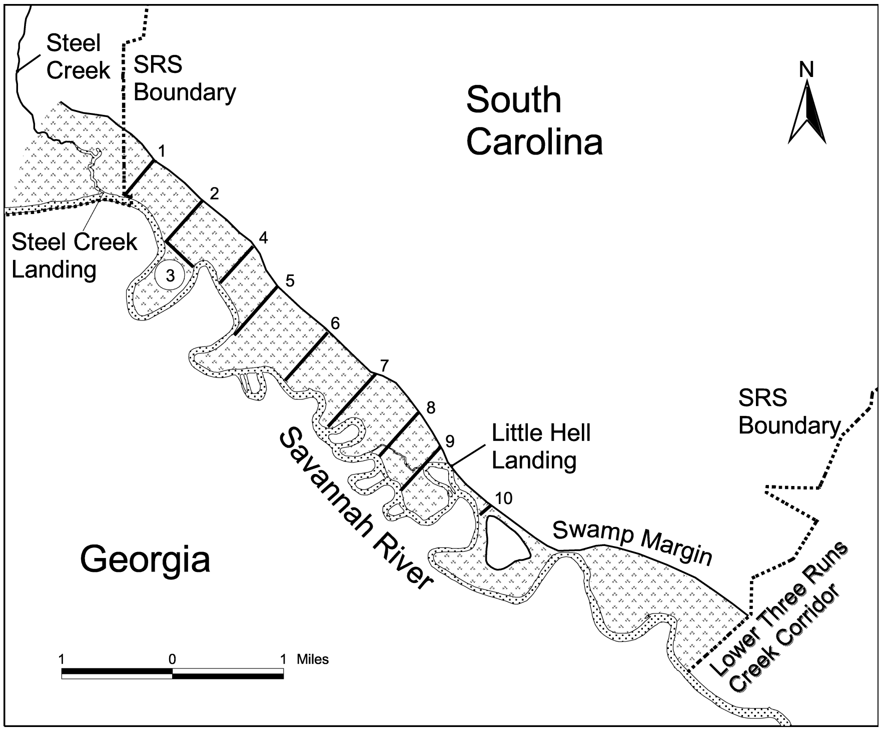


Figure 12–2 Savannah River Swamp Sampling Trails
Ten sampling trails were established in the Savannah River Swamp in 1974 so that surveys could be conducted on the movement of contamination from SRS operations.

SRTC Map

correlation with cesium-137 concentrations was observed.

Thermoluminescent dosimeter (TLD) sets were placed at 50 of the 54 monitoring sites to determine ambient gamma exposure rates. Forty-eight of the 50 sets were able to be retrieved from the swamp; the exposure time varied from 56 to 98 days. The gamma exposure rate ranged from 0.26 to 0.81 mrem/day (table 62, *SRS Environmental Data for 2000*), which is consistent with the range observed in the 1993 survey—the most recent in which exposure rates were determined.

The highest exposure rates were measured on trails 4 and 5. In general, areas of higher exposure rates showed elevated cesium-137 concentrations; however, the locations of highest exposure rates do not directly correspond with the locations that have the highest cesium-137 activity. This is not unexpected, since each measured cesium-137 level is the concentration at a single point, while the TLD has a "field of view," which integrates exposure over an entire area.

Conclusion

Results of the 2000 survey of the Savannah River Swamp generally were consistent with those observed in previous surveys. Over time, some changes in the spatial distribution of activity throughout the swamp have been observed, which means that some localized movement of activity may be occurring. However, there has been little change in the results from the downstream location (trail 10), which indicates that activity is not migrating out of the identified contaminated area.

Mitigation Action Plan for Pen Branch Reforestation

The final Environmental Impact Statement for the continued operation of K-Reactor, L-Reactor, and P-Reactor at SRS predicted several unavoidable impacts to the site's wetlands. This resulted in the development of a Mitigation Action Plan (MAP) that documented the U.S. Department of Energy (DOE) approach to mitigating these impacts [DOE, 1990]. Permanent closure of these reactors mandated reevaluation of the mitigation strategies identified in the 1991 MAP and its 1992 update. The section on "Mitigation for Wetlands Adversely Impacted by Operations" in the original MAP is the only remaining active program element. All parties involved with the reporting process agreed that the *SRS Environmental Report* would be used as the document to report annual progress on the reforestation portion of the commitment.

A complete history of the regulatory commitment for the reforestation can be found in the MAP 1992 update [DOE, 1992]. Since that time, the change in

Al Mamatey Photo (00J04340001)

Environmental Monitoring Section sampling technicians exchange thermoluminescent dosimeters (TLDs) during the comprehensive survey conducted at the Savannah River Swamp in early 2000. The TLDs, which measure ambient gamma exposure rates, are used with samples of soil and vegetation to determine levels and distribution of radioactive materials.

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 details of the reforestation effort. The following paragraphs describe 2000 reforestation mitigation actions.

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). K-Reactor thermal discharges were determined by a 1992 survey to have caused canopy loss or vegetation damage to 583 acres in the corridor and swamp areas. The survey, which used aerial photography and aircraft-acquired multispectral data, showed less damage than anticipated [Blohm, 1995]. The final Environmental Impact Statement had estimated that 670 acres would be impacted [DOE, 1990].

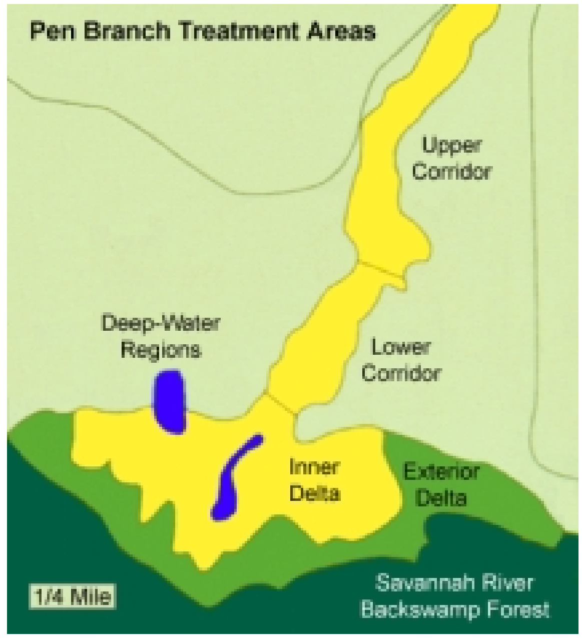
During 1995, an extensive survey of natural regeneration of forest species was conducted around the outer perimeter of the delta region of Pen Branch. Results of that survey indicated that approximately 100 acres of the exterior delta had sufficient bald cypress seedlings and saplings to consider the area reforested. Stocking tallies taken in 1997 quantified these high densities and the vigor of this natural regeneration. Naturally regenerating areas closer to the terrace areas were heavily stocked with maple, sweetgum, water tupelo, green ash, and bald cypress—and averaged more than 319 seedlings per acre. Areas of natural regeneration in the deeper swamp, stocked primarily with water tupelo and bald cypress, averaged more than 1,087 seedlings per acre. These areas are included in a Geographic Information System layer for mapping of the Pen Branch area. All areas of the Pen Branch corridor above Risher Pond Road (A–13.2) also are considered to have been reforested by natural regeneration to a bottomland hardwood forest type.

Reforestation of the Pen Branch Corridor and Delta by Planting

The Pen Branch corridor and delta are being reforested by planting with indigenous wetland species. Seeds were collected from individual trees at SRS and in the Upper Coastal Plain during 1992–1993 to ensure appropriate genetic material for use in the project. The seeds were planted and grown at a State of Georgia nursery during 1993–1995 for use in the Pen Branch seedling planting program. These seedlings—of species appropriate to the area being reforested—subsequently were transplanted to the Pen Branch wetland areas. The reforested areas will be managed until successful reforestation has been achieved. This is the preferred method of mitigation for the Pen Branch corridor and delta because of the brief restoration time allowed by DOE.

The initial and secondary seedling plantings of the entire corridor and delta areas (figure 12–3) have been completed in those locations in which it was determined that intervention would be required for successful mitigation. This intervention consisted of planting approximately 31 acres of the lower corridor with a mixture of flood-tolerant hardwood species and cypress seedlings in 1993. Forty-seven acres of the upper corridor were replanted with a mixture of bottomland hardwood seedlings in 1994. Species planted included water and pignut hickory, sycamore, green ash, swamp and water tupelo, black gum, persimmon, cherrybark and water oak, bald cypress, and swamp chestnut oak. In 1995, the upper corridor section was replanted with seedlings because of the mortality that resulted from feral hog predation on the original planted seedlings. Also in 1995, the inner delta area was planted for the first time with bald cypress, water tupelo, and—on drier ridges—green ash seedlings; approximately 90 acres were planted at densities of 425 seedlings per acre. Approximately 85,000 seedlings were planted during the 3 years of planting (1993–1995) in the corridor and delta areas. An establishment report detailing all activities associated with the reforestation was issued in 1996 and serves as the operational guidebook describing the silvicultural activities that have been used to accomplish the mitigation to this point [Dulohery et al., 1996].

A regeneration survey was conducted in 1997 to establish the current stocking levels of desirable species in the different areas of the Pen Branch corridor and delta regions. Results of the survey indicated that appropriate species were present at densities of 160 trees per acre in the corridor and 200 trees per acre in the inner delta. Some mortality will continue to occur over time, but the number of seedlings available in planted areas is considerably above what would be present in a normal unimpacted bottomland hardwood or swamp forest. It is anticipated, therefore, that these stocking levels will provide sufficient numbers of trees to ensure reforestation success.



SRI/SRTC Graphic (modified)

Figure 12–3 Pen Branch Reforestation Areas
Each of five areas in the Pen Branch corridor and delta requires a specific regeneration strategy to ensure successful reforestation.

Within each area that has been planted are sections that will serve as untreated and unplanted controls to assess the effectiveness of the reforestation effort. Twenty-eight acres in the delta and 20 in the corridor were left in these control sections. This inclusion of control sections is allowing research to compare the treated and untreated areas for the purpose of measuring differences in ecological responses to the treatments. This control acreage is part of that committed to in the MAP. It will be assessed to determine if it will reforest naturally because of its proximity to the mitigated acreage; if it will not, it may receive plantings at a later date.

Because of the control/restoration comparison areas, a number of research and baselining activities were conducted to document the recovery of the floral and faunal component of the wetland system. These have been detailed in past editions of the *SRS Environmental Report*. All these studies have been concluded, and their results continued to be reported in 2000 at professional meetings, in peer-reviewed publications, and in graduate theses. Studies throughout the project have been conducted by cooperators at Clemson University, the University of South Carolina, the University of Georgia, the Savannah River Ecology Laboratory, Auburn University, Virginia Polytechnic Institute and State University, and the University of South Carolina at Aiken.

Several presentations to professional meetings (Society of Wetland Scientists and Soil Science Society of America) were made during 2000 to highlight the interdisciplinary assessment methodology being developed at SRS. Also, the proceedings of a symposium held in 1996 continued to be a regularly cited document relating to the broad effort that has taken place in the Pen Branch ecosystem [Nelson, 1996]. The symposium—organized by the Environmental Sciences Section of SRTC—provided all parties involved in the restoration, monitoring, and research efforts the opportunity to share their preliminary findings. At that time, many of the efforts still were ongoing and preliminary, so as an action item from that meeting, it was proposed that the group reconvene at a future date to present complete papers of the research programs.

Group members subsequently held a workshop, "Restoration of a Severely Impacted Southeastern Riparian Wetland System – The Pen Branch Project," in April 1999 at Clemson University. The workshop's purpose was to present at a single forum the results of all efforts at restoration. Bringing this material together before a knowledgeable group would contribute to defining a methodology to assess success in reforestation. Papers were presented from a variety of disciplines; topics included silvicultural establishment, vegetation characterization, hydrology, faunal recolonization, hydrogeochemistry and carbon cycling, and assessment indices. Twenty papers were presented during the workshop.

A peer-reviewed, special volume of *Ecological Engineering* (an environmental professional journal) was published in 2000 to document in scientific literature the successful restoration of the Pen Branch wetland system [Nelson et al., 2000]. The volume contains 15 of the papers that were presented at the workshop or that were part of the research effort, as well as a summary paper of the major points (from discussions at the workshop) that relate to success criteria for wetland restoration. This publication documents—at the year 2000 assessment that was part of the original MAP timetable—the successful restoration of the impacted area by planting. However, monitoring of the wetland hydrology and vegetation development is required over a longer period of time to demonstrate successful wetland restoration. This effort will continue periodically for the next 5 years to determine the continued maturation of the Pen Branch corridor and delta.

Compensatory Mitigation

The option existed to compensate for an inability to restore Pen Branch by enhancing degraded wetlands or creating new wetlands. Such mitigation was determined to be less desirable than restoring the degraded wetlands, however, and was to be implemented only if restoration efforts in Pen Branch proved unsuccessful. The mitigation option was considered following evaluation of the success of reforesting the Pen Branch corridor and delta in 2000. Based on SRTC's assessment of the project's success, this option was not needed to fulfill the MAP requirement.

Appendix A

Applicable Guidelines, Standards, and Regulations

THE Savannah River Site (SRS) environmental monitoring program is designed to meet state and federal regulatory requirements for radiological and nonradiological programs. These requirements are stated in U.S. Department of Energy (DOE) Order 5400.1, "General Environmental Protection Program," and DOE Order 5400.5, "Radiation Protection of the Public and the Environment"; in the Clean Air Act [Standards of Performance for New Stationary Sources, also referred to as New Source Performance Standards (NSPS), and the National Emission Standards for Hazardous Air Pollutants (NESHAP)]; in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA—also known as the Superfund); in the Resource Conservation and Recovery Act (RCRA); in the Clean Water Act (i.e., National Pollutant Discharge Elimination System—NPDES); and in the National Environmental Policy Act (NEPA). Compliance with environmental requirements is assessed by DOE–Savannah River (DOE–SR), the South Carolina Department of Health and Environmental Control (SCDHEC), and the U.S. Environmental Protection Agency (EPA).

The SRS environmental monitoring program's objectives incorporate recommendations of

- the International Commission on Radiological Protection (ICPR) in *Principles of Monitoring for the Radiation Protection of the Population*, ICRP Publication 43
- DOE orders 5400.1 and 5400.5
- DOE/EH–0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance"

In addition, SRS has implemented and adheres to the SRS Environmental Management System Policy. As a result, the site has obtained International Organization for Standardization (ISO) 14001 certification. The full text of the policy is included in this appendix and begins on page 222.

Drinking water standards and maximum allowable concentrations of toxic air pollutants can be found in appendix B, "Drinking Water Standards for Regulated Contaminants," and appendix C, "Standard No. 8 Toxic Air Pollutants." More information about certain media is presented in this appendix.

Air Effluent Discharges

DOE Order 5400.5 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 (*Recommendations of the International Commission on Radiological Protection*) and 30 (*Limits for the Intake of Radionuclides by Workers*), are used as reference concentrations for conducting environmental protection programs at DOE sites. DCGs are not considered release limits. DCGs for radionuclides in air are discussed in more detail on page 218.

Radiological airborne releases also are subject to EPA regulations cited in 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subpart H ("National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities").

Regulation of radioactive and nonradioactive air emissions—both criteria pollutants and toxic air pollutants—has been delegated to SCDHEC. SCDHEC, therefore, must ensure that its air pollution regulations are at least as stringent as federal regulations required by the Clean Air Act. This is accomplished by SCDHEC Regulation 61–62, "Air Pollution Control Regulations and Standards." As with many regulations found in the Code of Federal Regulations (CFR), many of SCDHEC's regulations and standards are source specific. Each source of air pollution at SRS is permitted or exempted by SCDHEC, with specific emission rate limitations or special conditions identified. The bases for the limitations and conditions are the applicable South

Carolina air pollution control regulations and standards. In some cases, specific applicable CFRs are also cited in the permits issued by SCDHEC.

Two SCDHEC standards, which govern criteria and toxic air pollutants and ambient air quality, are applicable to all SRS sources. Regulation 61–62.5, Standard No. 2, "Ambient Air Quality Standards," identifies eight criteria air pollutants commonly used as indices of air quality (e.g., sulfur dioxide, nitrogen dioxide, and lead) and provides allowable site boundary concentrations for each pollutant as well as the measuring intervals. Compliance with the various pollutant standards is determined by conducting air dispersion modeling for all sources of each pollutant using EPA-approved dispersion models and then comparing the results to the standard. The pollutants, measuring intervals, and allowable concentrations are given in table A–1. The standards are in micrograms per cubic meter unless noted otherwise.

Table A–1
Criteria Air Pollutants

Pollutant	Interval	μg/m3[a,b]
Sulfur Dioxide	3 hours	1300[c]
	24 hours	365[c]
	annual	80
Total Suspended Particulates	Annual Geometric Mean	75
PM10	24 hours	150[d]
	annual	50[d]
Carbon Monoxide	1 hour	40 mg/m3
	8 hours	10 mg/m3
Ozone	1 hour	0.12 ppm[d]
Gaseous Fluorides (as HF)	12-hour avg.	3.7
	24-hour avg.	2.9
	1-week avg.	1.6
Nitrogen Dioxide	annual	100
Lead	Calendar Quarterly Mean	1.5

a Arithmetic average except in case of total suspended particulate matter (TSP)

b At 25 °C and 760 mm Hg

c Not to be exceeded more than once a year

d Attainment determinations will be made based on the criteria contained in appendices H and K, 40 CFR 50, July 1, 1987.

Table A–2
Airborne Emission Standards for SRS Coal-Fired Boilers

Sulfur Dioxide	3.6 lb/10^6 BTU[a]
Total Suspended Particulates	0.6 b/10^6 BTU
Opacity	40%

a British Thermal Unit

Two-hundred fifty-six toxic air pollutants and their respective allowable site boundary concentrations are identified in Regulation 61–62.5, Standard No. 8, "Toxic Air Pollutants." As with Standard No. 2, compliance is determined by air dispersion modeling. The pollutants, chemical abstract numbers (CAS), and maximum allowable concentrations are shown in appendix C.

SCDHEC airborne emission standards for each SRS permitted source may differ, based on size and type of facility, type and amount of expected emissions, and the year the facility was placed into operation. For example, SRS powerhouse coal-fired boilers are regulated by Regulation 61–62.5, Standard No. 1, "Emissions From Fuel Burning Operations." This standard specifies that for powerhouse stacks built before February 11, 1971, the opacity standard is 40 percent. For new sources constructed after this date, the opacity standard typically is 20 percent. The standards for particulate and sulfur dioxide emissions are shown in table A–2.

Regulation 61–62.5, Standard No. 3, "Waste Combustion and Reduction," is applicable to several sources at SRS. Under this standard, the Consolidated Incinerator Facility (CIF) in H-Area is considered a hazardous waste incinerator. Several of the standards for the CIF, given in table A–3, are adjusted for British Thermal Unit (BTU) content of the waste being burned. In 2000, all operations at the CIF were suspended and it was placed in a cold standby status.

Likewise, under the regulation cited in the previous paragraph, catalytic oxidation units (COUs)—used as pollution control devices for some SRS soil vapor extraction (SVE) systems—are classified as industrial incinerators. As such, the COUs have an opacity limit of 20 percent. During 2000, the COUs for all SRS soil vapor extraction and groundwater air stripper systems were removed because they no longer were necessary to meet other overall

Table A–3
Airborne Emission Standards for SRS Consolidated Incinerator Facility

Opacity	10%
Hydrochloric acid (HCl)	4 lb/hr
Particulate Matter	0.08 gr/DSCF[a]
Nickel	0.11 lb/hr[b]
Cadmium	0.0018 lb/hr[b]
Chromium	0.0090 lb/hr[b]
Arsenic	0.0046 lb/hr[b]
Lead	0.090 lb/hr [b]
Organic Compounds	Various[c]
Dioxin	99.9999% DRE

a Corrected to 7% oxygen
b Adjusted for BTU content of waste
c Must be destroyed with an efficiency of at least 99.99%

standards. At this time, SRS does not have any facilities that are regulated by this standard.

Regulation 61–62.5, Standard No. 4, "Emissions from Process Industries," is applicable to all SRS sources except those regulated by a different source specific standard. For some SRS sources, particulate matter emission limits are dependent on the weight of the material being processed and are determined from a table in the regulation. For process and diesel engine stacks in existence on or before December 31, 1985, emissions shall not exhibit an opacity greater than 40 percent. For new sources, where construction was started after December 31, 1985, the opacity standard is 20 percent.

As previously mentioned, some SRS sources have both SCDHEC and CFRs applicable and identified in their permits. For the package steam generating boilers in K-Area and two portable package boilers, both SCDHEC and federal regulations are applicable. The standard for sulfur dioxide emissions is specified in 40 CFR 60, Subpart Dc, "Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units," while the standard for particulate matter is found in Regulation 61–62.5, Standard No. 1, "Emissions From Fuel Burning Operations." Because these units were constructed after applicability dates found in both regulations, the opacity limit for these units is the same in both regulations. The emissions standards for these boilers are presented in table A–4.

Table A–4
Airborne Emission Standards for SRS Fuel Oil-Fired Package Boilers

Sulfur Dioxide	0.5 lb/10^6 BTU
Total Suspended Particulates	0.6 b/10^6 BTU
Opacity	20%

Another federal regulation, 40 CFR 60, Subpart Kb, "Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for which Construction, Reconstruction, or Modification Commenced after July 23, 1984," specifies types of emission controls that must be incorporated into the construction of a source. In this regulation, the type of control device required is dependent on the size of the tank and the vapor pressures of the material being stored. This regulation is applicable to several sources at SRS, such as the two 30,000-gallon No. 2 fuel oil storage tanks in K-Area or the four mixed solvent storage tanks in H-Area. However, because of the size of these tanks and vapor pressures of the materials being stored, these tanks are not required to have control devices installed. The only requirements applicable to SRS storage tanks are those for record keeping.

(Process) Liquid Effluent Discharges

DOE Order 5400.5 establishes DCGs for radionuclides in process effluents. (DCGs for radionuclides in water are discussed in more detail on page 219.) DCGs were calculated by DOE using methodologies consistent with recommendations found in ICRP, 1987 and ICRP, 1979 and 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

DOE Order 5400.5 exempts aqueous tritium releases from best available technology requirements but not from ALARA (as low as reasonably achievable) considerations.

SRS discharges water into site streams and the Savannah River under four NPDES permits: one industrial wastewater permit (SC0000175), one general utility water discharge permit (SCG250162), and two stormwater runoff permits (SCR000000 for industrial discharges and SCR100000 for construction discharges).

A fifth permit (ND0072125) is a no-discharge water pollution control land application permit that regulates sludge generated at onsite sanitary waste treatment plants.

Detailed requirements for each permitted discharge point—including parameters sampled for, permit limits for each parameter, sampling frequency, and method for collecting each sample—can be found in the individual permits, which are available to the public through SCDHEC's Freedom of Information Office at (803) 734–5376.

Site Streams

SRS streams are classified as "Freshwaters" by the South Carolina Pollution Control Act. Freshwaters are defined as surface water suitable for

- primary- and secondary-contact recreation and as a drinking water source after conventional treatment in accordance with SCDHEC requirements
- fishing and survival and propagation of a balanced indigenous aquatic community of fauna and flora
- industrial and agricultural uses

Table A–5 provides some of the specific guides used in water quality surveillance, but because some of these guides are not quantifiable, they are not tracked in response form (i.e., amount of garbage found).

Savannah River

Because the Savannah River is defined under the South Carolina Pollution Control Act as a Freshwater system, the river is regulated in the same manner as are site streams (table A–5).

Drinking Water

The federal Safe Drinking Water Act (SDWA)—enacted in 1974 to protect public drinking water supplies—was amended in 1980, 1986, and 1996.

SRS drinking water systems are tested routinely by SRS and SCDHEC to ensure compliance with SCDHEC State Primary Drinking Water Regulations, R61–58, and EPA National Primary Drinking Water Regulations, 40 CFR 141.

SRS drinking water is supplied by 18 separate systems, all of which utilize groundwater sources. The three larger consolidated systems (A-Area, D-Area, and K-Area) are actively regulated by SCDHEC and are classified as nontransient/noncommunity systems because each serves more than 25 people. The remaining 15 site water systems, each of which serves fewer than 25 people, receive a lesser degree of regulatory oversight.

Under the SCDHEC-approved, ultra-reduced monitoring plan, lead and copper sampling will not be required again for the A-Area consolidated system until 2001. The D-Area and K-Area consolidated water systems qualified in 1997 for an ultra-reduced monitoring plan. Results of lead and copper sampling conducted in the summer of 2000 established compliance for both D-Area and K-Area.

The B-Area Bottled Water Facility, which was approved for operation in 1998, is listed as a public water system by SCDHEC and is required to be sampled for bacteriological analysis on a quarterly basis (initiated in 2000). Unlike the D-Area and K-Area consolidated water systems, lead and copper monitoring are not required.

Drinking water standards for specific radionuclides and contaminants are provided in appendix B, "Drinking Water Standards for Regulated Contaminants," of this document.

Groundwater

The analytical results of samples taken from SRS monitoring wells that exceed various standards are discussed in this report. Constituents discussed are compared to final federal primary drinking water standards (DWS), or other standards if DWS do not exist, because groundwater aquifers are defined as

Table A–5
South Carolina Water Quality Standards for Freshwaters

Note: This is a partial list only of 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 mL.
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–9.A, Regulation 61–68, “Water Classifications and Standards” (June 26, 1998).
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) above.	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–10 (list of water quality standards based on organoleptic data) and E–12 (water quality criteria for protection of human health), Regulation 61–68, “Water Classifications and Standards” (June 26, 1998).

SOURCE: [SCDHEC, 1998a]

potential drinking water sources by the South Carolina Pollution Control Act. The DWS can be found in appendix B, “Drinking Water Standards.” DWS are not always the standards applied by regulatory agencies to the SRS waste units under their jurisdiction. For instance, standards under RCRA are DWS, groundwater protection standards, background levels, and alternate concentration limits.

Two constituents having DWS—dichloromethane and bis(2-ethylhexyl) phthalate—are not discussed in this report. Both are common laboratory contaminants and are reported in groundwater samples with little or no reproducibility. Both are reported, with appropriate flags and qualifiers, in the data tables of the quarterly reports cited in chapter 10, “Groundwater.”

The standard used for lead, 50 µg/L, is the SCDHEC DWS. The federal standard of 15 µg/L is a treatment standard for drinking water at the consumer’s tap; thus, it is inappropriate for use as a groundwater standard.

Of the radionuclides discussed, only gross alpha, strontium-90, and tritium are compared to true primary DWS. The regulatory standards for radionuclide discharges from industrial and governmental facilities are set under the Clean Water Act, RCRA, and Nuclear Regulatory Commission and DOE regulations. The proposed drinking water maximum contaminant levels discussed in this report are only an adjunct to these release restrictions and are not used to regulate SRS groundwater.

The standard used for gross beta is a screening standard; when public drinking water exceeds this standard, the supplier is expected to analyze for individual beta and gamma emitters. A gross beta result above the standard is an indication that one or more radioisotopes are present in quantities that would exceed the EPA annual dose equivalent for persons consuming 2 liters daily. Thus, for the individual beta and gamma radioisotopes (other than strontium-90 and tritium), the standard discussed in this report is the activity per liter that would, if only that isotope were present, exceed the dose equivalent. Similarly, the standards for alpha emitters discussed in this report are calculated to present the same risk at the same rate of ingestion.

Although radium has a DWS of 5 pCi/L for the sum of radium-226 and radium-228, the standards discussed in this report are the proposed standards of 20 pCi/L for each isotope separately. Radium-226, an alpha emitter, and radium-228, a beta emitter, cannot be analyzed by a single method. Analyses for total alpha-emitting radium, which consists of radium-223, radium-224, and radium-226, are compared to the standard for radium-226.

Four other constituents without DWS are discussed in this report when their values exceed specified levels. These constituents are specific conductance at values equal to or greater than 100 µS/cm, alkalinity (as $CaCO_3$) 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 less than 4.0 or equal to or greater than 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 (as $CaCO_3$), 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.

Potential Dose

The radiation protection standards followed by SRS are outlined in DOE Order 5400.5 and include EPA regulations on the potential doses from airborne releases and treated drinking water.

The following radiation dose standards for protection of the public in the SRS vicinity are specified in DOE Order 5400.5.

Drinking Water Pathway . . . . 4 mrem per year
Airborne Pathway . . . . 10 mrem per year
All Pathways . . . . 100 mrem per year

The EPA annual dose standard of 10 mrem (0.1 mSv) for the atmospheric pathway, which is contained in 40 CFR 61, Subpart H, is adopted in DOE Order 5400.5.

These dose standards are based on recommendations of the ICRP and the National Council on Radiation Protection and Measurements (NCRP).

The DOE dose standard enforced at SRS for drinking water is consistent with the criteria contained in “National Interim Primary Drinking Water Regulations, 40 CFR Part 141.” 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).

In 2000, EPA promulgated 40 CFR, Parts 9, 141, and 142, “National Primary Drinking Water Regulations; Radionuclides; Final Rule.” This rule, which is applicable only to community drinking water systems, finalized maximum contaminant levels (MCLs) for radionuclides, including uranium. In essence, it reestablishes the MCLs from EPA’s original 1976 rule. Most of these MCLs are derived from dose conversion factors that are based on early ICRP–2 methods.

However, when calculating dose, SRS must use the more current ICRP–30-based dose conversion factors provided by DOE. Because they are based on different methods, most EPA and DOE radionuclide dose conversion factors differ. Therefore, a direct comparison of the drinking water doses calculated for showing compliance with DOE Order 5400.5 to the EPA drinking water MCLs cannot be made.

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, which are 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 (chapter 7, "Potential Radiation Doses"), this scenario is improbable.

Average annual radionuclide concentrations in SRS air effluent can be referenced to DOE DCGs as a screening method to determine if existing effluent treatment systems are proper and effective.

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. These considerations are applicable to direct discharges but not to seepage basin and Solid Waste Disposal Facility (SWDF) migration discharges. 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 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 an investigation 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 for all radionuclides detectable in the effluent is less than 1.00, based on consecutive 12-month average concentrations.

DCGs, 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 highly improbable, if not impossible.

For each site facility that releases radioactivity, the site's Environmental Monitoring Section (EMS) compares the monthly liquid effluent concentrations and 12-month average concentrations against the DOE DCGs.

Environmental Management

SRS began its cleanup program in 1981. Two major federal statutes provide guidance for the site's environmental restoration and waste management activities—RCRA and CERCLA. RCRA addresses the management of hazardous waste and requires that permits be obtained for facilities that treat, store, or dispose of hazardous or mixed waste. It also requires that DOE facilities perform appropriate corrective action to address contaminants in the environment. CERCLA (also known as Superfund) addresses the uncontrolled release 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, corrective/remedial action. SRS was placed on this list December 21, 1989 [Fact Sheet, 2000d]. In August 1993, SRS entered into the Federal Facility Agreement (FFA) with EPA Region IV and SCDHEC. This agreement governs the corrective/remedial action process from site investigation through site remediation. It also describes procedures for setting annual work priorities, including schedules and deadlines, for that process [FFA under section 120 of CERCLA and sections 3008(h) and 6001 of RCRA].

Additionally, DOE is complying with Federal Facility Compliance Act requirements for mixed waste management—including high-level waste, most transuranic waste, and low-level waste with hazardous constituents. This act requires that DOE develop and submit site treatment plans to the EPA or state regulators for approval.

The disposition of facilities after they are declared excess to the government's mission is managed by the Facilities Disposition Division. The facility disposition process is conducted in accordance with DOE Order 430.1A, "Life Cycle Asset

Management," and its associated guidance documents. The major emphases are (1) to reduce the risks to workers, the public, and the environment, and (2) to reduce the costs required to maintain the facilities in a safe condition through a comprehensive surveillance and maintenance program.

Quality Assurance/Quality Control

DOE Order 414.1, "Quality Assurance," sets requirements and guidelines for departmental quality assurance (QA) practices. To ensure compliance with regulations and to provide overall quality requirements for site programs, Westinghouse Savannah River Company (WSRC) developed its *Quality Assurance Management Plan, Rev. 8* (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 *Savannah River Site Environmental Monitoring Section Quality Assurance Plan*, (WSRC–3Q1–2, Volume 3, Section 8000), 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.

QA requirements for monitoring radiological air emissions are specified in 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants." For radiological air emissions at SRS, the responsibilities and lines of communication are detailed in *National Emission Standards for Hazardous Air Pollutants Quality Assurance Project Plan (U)* (WSRC–IM–91–60).

To ensure valid and defensible monitoring data, the records and data generated by the monitoring program are maintained according to the requirements of DOE Guide 1324.5B, "Implementation Guide for Use with 36 CFR Chapter XII – Subchapter B Records Management," 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 Sitewide Records Inventory and Disposition Schedule* (WSRC–1M–93–0060).

EMS assessments are implemented according to the following documents:

- WSRC 12Q, *Assessment Manual*
- WSRC 1Q
- DOE Order 414.1, "Quality Assurance"
- DOE/EM–0159P, "Analytical Laboratory Quality Assurance Guidance"
- DOE/EM–0157P, "Laboratory Assessment Plates"
- DOE/EH–0173T

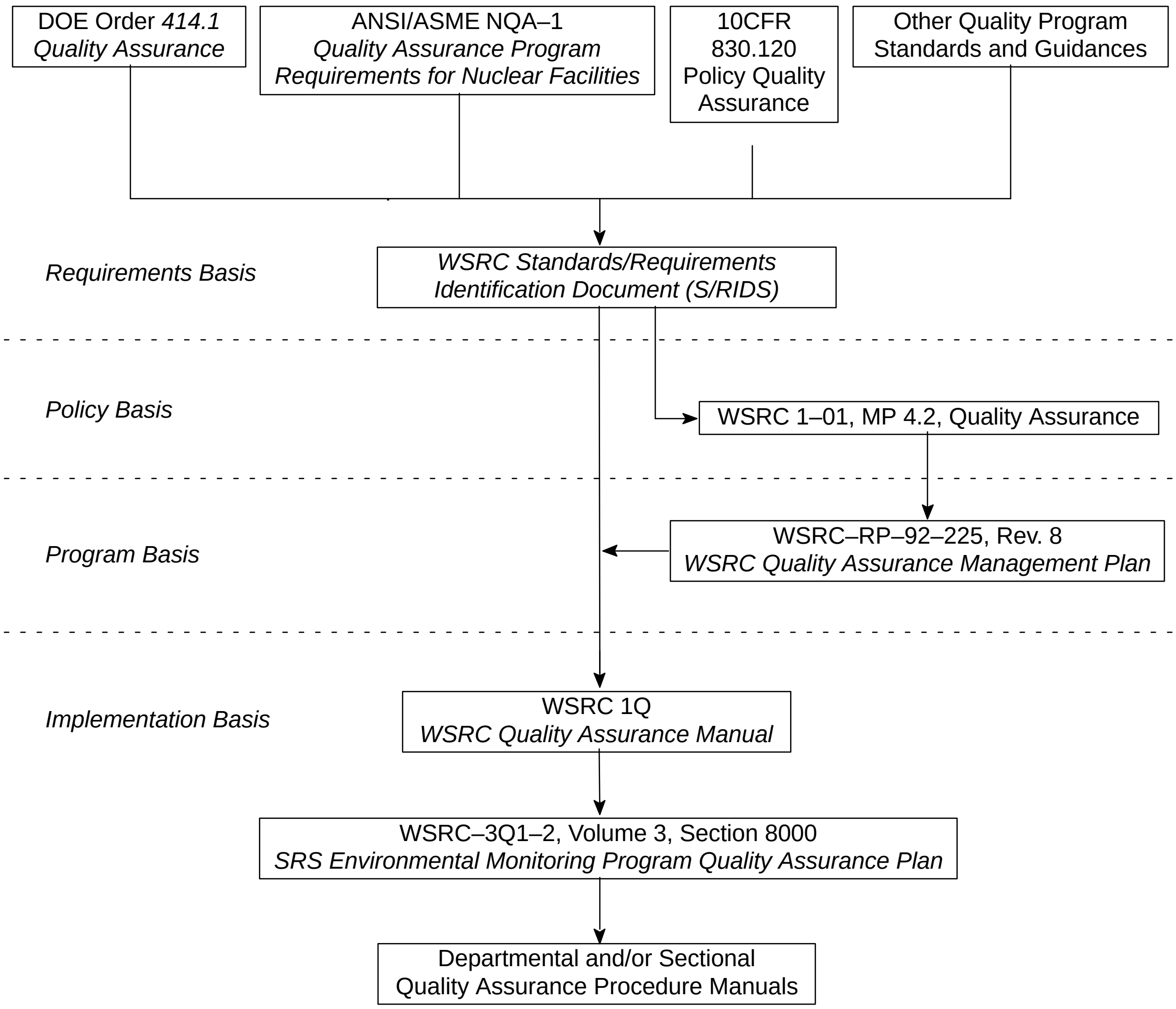
The *FY 2000 Environmental Protection Department Self-Assessment Unit Assessment Plan* (ESH–ENV–99–0073) defines the requirements for self assessment and provides for verification of the compliance and effectiveness of the EMS QA/QC program. The plan's purpose is to assist management in evaluating the performance of EMS activities and the effectiveness of management controls and procedures.

Figure A–1 illustrates the hierarchy of relevant guidance documents that support the program.

Reporting

DOE Order 231.1, "Environment, Safety and Health Reporting," requires that SRS submit an annual environmental report.

This report, the *Savannah River Site Environmental Report for 2000,* is an overview of effluent monitoring and environmental surveillance activities conducted on and in the vicinity of SRS from January 1 through December 31, 2000.



Other Quality Program Standards and Guidances

- International Organization for Standardization (ISO) 9000 Series of Standards, including ISO 14001, Environmental Management System
- *Specifications and Guidelines for Environmental Data Collection and Environmental Technology Programs* (ANSI/ASQC E–4)
- General Requirements for the Competence of Calibration and Testing Laboratories (ISO/IEC Guide 25–1990)

Figure A–1 SRS EM Program QA/QC Document Hierarchy
This diagram depicts the hierarchy of relevant guidance and supporting documents for the QA/QC program.

ISO 14001 Environmental Management System

ISO 14001 is the Environmental Management System Standard within the ISO 14000 series of standards, a family of voluntary environmental management standards and guidelines. SRS first achieved ISO 14001 certification in 1997 by demonstrating adherence to and programmatic implementation of the SRS Environmental Management System Policy. Annual audits are conducted to maintain certification, and a recertification audit is conducted every 3 years. The site was recertified in 2000 following the recertification audit, The full text of the policy (without the names of the signatories) follows.

Savannah River Site (SRS)
Environmental Management System Policy
November 1, 1999

OBJECTIVE:

The objective of this policy is to ensure every employee of the DOE Savannah River Operations Office (SR), all contractors, subcontractors, and other entities performing work at the Savannah River Site (SRS) do so in accordance with the requirements of ISO 14001, DOE Order 5400.1 and the mission, the vision, the core values, and the environmental goals and objectives of the Savannah River Site Strategic Plan.

DIRECTIVE:

Recognizing that all aspects of operations carried out at the SRS may impact the environment, the DOE–SR policy is that all employees, contractors, subcontractors, and other entities performing work at the SRS shall abide by the directives in this document. Westinghouse Savannah River Company (WSRC), Wackenhut Services, Inc. – Savannah River Site (WSI), Savannah River Ecology Laboratory (SREL), General Services Administration – Savannah River Site (GSA), and the Savannah River Natural Resources Management and Research Institute (SRI) shall, by virtue of their signature, endorse the principles stated in this policy.

- This document describes the SRS Environmental Management System Policy. It shall serve as the primary documentation for the environmental goals and objectives of the SRS and shall be available to the public. It shall be centrally maintained and updated as necessary to reflect the changing needs, missions, and goals of the SRS.
- The Environmental Management System shall pursue and measure continual improvement in performance by establishing and maintaining documented environmental objectives and targets that correspond to SRS's mission, vision, and core values. The environmental objectives and targets shall be established for each relevant function and level within DOE–SR and all contractors, subcontractors, and other entities performing work at the SRS for all activities having actual or potentially significant environmental impacts.
- DOE–SR and all contractors, subcontractors, and other entities performing work at SRS shall:

    1 Manage the SRS environment, natural resources, products, waste, and contaminated materials so as to eliminate or mitigate any threat to human health or the environment at the earliest opportunity and implement process improvements as appropriate to ensure continued improvement of performance in environmental management.

    2 Implement a pollution prevention program to reduce waste generation, releases of pollutants, future waste management/pollution control costs; and to minimize environmental impacts as well as promote increased energy efficiency.

    3 Conduct operations in compliance with the letter and spirit of all applicable federal, state, and local laws, regulations, statutes, executive orders, DOE directives and standards/requirements identification documents.

    4 Work cooperatively and openly with appropriate local, state, federal agencies, public stakeholders, and site employees to prevent pollution, achieve environmental compliance, conduct cleanup/restoration activities, enhance environmental quality, and ensure the protection of workers and the public health.

5 Design, develop, construct, operate, maintain, decommission and deactivate facilities and operations in a manner that shall be resource efficient and will protect and improve the quality of the environment for future generations and continue to maintain the SRS as a unique national environmental asset.

6 Recognize that the responsibility for quality communications rests with each individual employee and that it shall be the responsibility of all employees to identify and communicate ideas for improving environmental protection activities and programs at the site.

Adherence to and programmatic implementation of this policy shall be monitored by the DOE–SR Assistant Manager for Environmental Programs in coordination with the contractors, subcontractors, and other entities performing work on the SRS. An annual evaluation of the Environmental Management System, with recommendations for improvement, shall be provided to the undersigned managers. *[Editors' note: The names of the signatories that appeared at the end of the full text of the policy have not been included here.]*

Appendix B

Drinking Water Standards for Regulated Contaminants

Analyte	Maximum Contaminant Level[a]	Units	Status	Reference[b]
Note: *The Environmental Protection Agency is revising the national primary drinking water standards for radionuclides, which have been in effect since 1977. Revisions had not been received by December 31, 2000.*				
Alachlor	0.002	mg/L	final	CFR
Aldicarb	0.003	mg/L	final	CFR
Aldicarb sulfone	0.002	mg/L	final	CFR
Aldicarb sulfoxide	0.004	mg/L	final	CFR
Antimony	0.006	mg/L	final	CFR
Arsenic	0.05	mg/L	final	CFR
Asbestos	7,000,000	fibers/L[c]	final	CFR
Atrazine	0.003	mg/L	final	CFR
Barium	2.0	mg/L	final	CFR
Benzene	0.005	mg/L	final	CFR
Benzo[a]pyrene	0.0002	mg/L	final	CFR
Beryllium	0.004	mg/L	final	CFR
Bromate	0.010	mg/L	final	CFR
2-sec-Butyl-4, 6-dinitrophenol (Dinoseb)	0.007	mg/L	final	CFR
Cadmium	0.005	mg/L	final	CFR
Carbofuran	0.04	mg/L	final	CFR
Carbon tetrachloride	0.005	mg/L	final	CFR
Cesium-137	200	pCi/L	final	CFR
Chlordane	0.002	mg/L	final	CFR
Chlorite	1.0	mg/L	final	CFR
Chlorobenzene (Monochlorobenzene)	0.1	mg/L	final	CFR
Chloroethene (Vinyl chloride)	0.002	mg/L	final	CFR
Chloroform[d]	0.080	mg/L	final	CFR
Chromium	0.1	mg/L	final	CFR
Cobalt-60	100	pCi/L	final	CFR
Copper	1.3[e]	mg/L	final	SCDHEC
Cyanide	0.2	mg/L	final	CFR

a Standards for beta- and gamma-emitting radionuclides are based on the 4-mrem/yr to the total body or critical organ dose [CFR].
b Bibliographical information concerning the references is included at the end of this table, page 227.
c Longer than 10 µm
d The level for total trihalomethanes is set at 0.080 mg/L. Because bromated methanes are rarely detected in SRS groundwater, the Environmental Protection Department presumes that most of the trihalomethanes present in site groundwater are chloroform.
e This is a South Carolina state drinking water “action level” used by the SRS groundwater monitoring program.

Analyte	Maximum Contaminant Level[a]	Units	Status	Reference[b]
Dalapon	0.2	mg/L	final	CFR
1,2-Dibromo-3-chloropropane	0.0002	mg/L	final	CFR
1,2-Dichlorobenzene (o-Dichlorobenzene)	0.6	mg/L	final	CFR
1,4-Dichlorobenzene (p-Dichlorobenzene)	0.075	mg/L	final	CFR
1,2-Dichloroethane	0.005	mg/L	final	CFR
1,1-Dichloroethylene	0.007	mg/L	final	CFR
cis-1,2-Dichloroethylene	0.07	mg/L	final	CFR
trans-1,2-Dichloroethylene	0.1	mg/L	final	CFR
Dichloromethane (Methylene chloride)	0.005	mg/L	final	CFR
2,4-Dichlorophenoxyacetic acid (2,4-D)	0.07	mg/L	final	CFR
1,2-Dichloropropane	0.005	mg/L	final	CFR
Di(2-ethylhexyl) adipate (Deha)	0.4	mg/L	final	CFR
Di(2-ethylhexyl) phthalate [Bis(2-ethylhexyl) phthalate]	0.006	mg/L	final	CFR
Dioxin (2,3,7,8-TCDD) (2,3,7,8-TCDD)	00000003.	mg/L	final	SCDHEC
Diquat (Diquat dibromide)	0.02	mg/L	final	CFR
Endothall	0.1	mg/L	final	CFR
Endrin	0.002	mg/L	final	CFR
Ethylbenzene	0.7	mg/L	final	CFR
Ethylene dibromide (1,2-Dibromoethane)	0.00005	mg/L	final	CFR
Fluoride	4	mg/L	final	CFR
Glyphosate	0.7	mg/L	final	CFR
Gross alpha	15	pCi/L	final	CFR
Haloacetic acids (sum of 5 [HAA5])[c]	0.060	mg/L	final	CFR
Heptachlor	0.0004	mg/L	final	CFR
Heptachlor epoxide	0.0002	mg/L	final	CFR
Hexachlorobenzene	0.001	mg/L	final	CFR
Hexachlorocyclopentadiene	0.05	mg/L	final	CFR
Iodine-129	1	pCi/L	final	CFR
Lead	0.015[d]	mg/L	final	SCDHEC
Lindane	0.0002	mg/L	final	CFR
Mercury	0.002	mg/L	final	CFR
Methoxychlor	0.04	mg/L	final	CFR

a Standards for beta- and gamma-emitting radionuclides are based on the 4-mrem/yr to the total body or critical organ dose [CFR].
b Bibliographical information concerning the references is included at the end of this table, page 227.
c Sum of the concentrations of mono-, di-, and trichloroacetic acids and mono- and dibromoacetic acids
d This is a South Carolina state drinking water “action level” used by the SRS groundwater monitoring program.

Analyte	Maximum Contaminant Level[a]	Units	Status	Reference[b]
Nickel	0.1	mg/L	final	CFR
Nitrate + Nitrite (As N)	10	mg/L	final	CFR
Nitrate (as N)	10	mg/L	final	CFR
Nitrite (as N)	1	mg/L	final	CFR
Nonvolatile beta	4	mrem/yr	final	CFR
Oxamyl (Vydate)	0.2	mg/L	final	CFR
Polychlorinated Biphenyls (PCBs)	0.0005	mg/L	final	CFR
Pentachlorophenol	0.001	mg/L	final	CFR
Picloram	0.5	mg/L	final	CFR
Total Radium (Radium-226 and Radium-228)	5	pCi/L	final	CFR
Selenium	0.05	mg/L	final	CFR
Simazine	0.004	mg/L	final	CFR
Strontium-89/90	8[c]	pCi/L	final	CFR
Strontium-90	8	pCi/L	final	CFR
Styrene	0.1	mg/L	final	CFR
Tetrachloroethylene	0.005	mg/L	final	CFR
Thallium	0.002	mg/L	final	CFR
Toluene	1.0	mg/L	final	CFR
Total Trihalomethanes[d] (includes bromodichloro-methane, bromoform, chloroform, and dibromochloromethane)	0.080	mg/L	final	SCDHEC
Toxaphene	0.003	mg/L	final	SCDHEC
2,4,5-TP (Silvex)	0.05	mg/L	final	CFR
1,2,4-Trichlorobenzene	0.07	mg/L	final	CFR
1,1,1-Trichloroethane	0.2	mg/L	final	CFR
1,1,2-Trichloroethane	0.005	mg/L	final	CFR
Trichloroethylene	0.005	mg/L	final	CFR
Tritium	20,000	pCi/L	final	CFR
Uranium	30	µg/L	final	CFR
Xylenes	10	mg/L	final	CFR

References:

CFR (Code of Federal Regulations), 2000. "National Primary Drinking Water Regulations," *40 CFR, Part 141*, Washington, D.C.

SCDHEC (South Carolina Department of Health and Environmental Control), 1999. "State Primary Drinking Water Regulations," R.61–58.5, Columbia, S.C.

a Standards for beta- and gamma-emitting radionuclides are based on the 4-mrem/yr to the total body or critical organ dose [CFR].
b Bibliographical information concerning the references is included at the end of this table below.
c For double radionuclide analyses where each separate radionuclide has its own standard, the more stringent standard is used.
d EMS does not test for total trihalomethanes, but each of these analytes is tested separately.

Appendix C

Standard No. 8 Toxic Air Pollutants

Chemical Name	Chemical Abstract Number (CAS)	Toxicity Category[a]	Maximum Allowable Concentration ($\mu g/m^3$)[b]
Note: For all listings that contain the word “compounds” and for glycol ethers, the following applies: Unless otherwise specified, these listings are defined as including any unique chemical substance that contains the named chemical (i.e., antimony, arsenic, etc.) as part of that chemical infrastructure.			
Acetaldehyde	75–07–0	2	1800.00
Acetamide	60–35–5	3	c
Acetic Anhydride	108–24–7	1	500.00
Acetonitrile	75–05–8	1	1750.00
Acetophenone	98–86–2	3	c
2–Acetylaminofluorne	53–96–3	3	c
Acrolein	107–02–8	3	1.25
Acrylamide	79–06–1	2	0.30
Acrylic Acid	79–10–7	3	147.50
Acrylonitrile	107–13–1	3	22.50
Aldicarb	116–06–3	2	6.00
Allyl Chloride	107–05–1	2	30.00
p–Aminodiphenyl (4–Aminobiphenyl)	92–67–1	3	0.00
Ammonium Chloride	12125–02–9	1	250.00
Aniline	62–53–3	3	50.00
o–Anisidine	90–04–0	3	2.50
p–Anisidine	104–94–9	3	2.50
Antimony Compounds	d	1	2.50
Arsenic Pentoxide	1303–28–2	3	1.00
Arsenic	7440–38–2	3	1.00
Benzene	71–43–2	3	150.00
Benzidine	92–87–5	3	0.00
Benzotrichloride	98–07–7	3	300.00
Benzyl Chloride	100–44–7	3	25.00
Beryllium Oxide	1304–56–9	3	0.01
Beryllium Sulfate	13510–49–1	3	0.01
Beryllium	7440–41–7	3	0.01
Biphenyl	92–52–4	3	6.00
Bis(Chloromethyl) Ether	542–88–1	3	0.03
Bis(2–ethylhexyl)phthalate (DEHP)	117–81–7	3	25.00

a Category 1 = low toxicity; category 2 = moderate toxicity; and category 3 = high toxicity.
b For the purpose of this standard, these values shall be rounded to the nearest hundredth of a $\mu g/m^3$. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01, but values less than 0.005 would be rounded to 0.00.
c To be determined
d No CAS number

Chemical Name	Chemical Abstract Number (CAS)	Toxicity Category[a]	Maximum Allowable Concentration ($\mu g/m^3$)[b]
Bromoform	75–25–2	3	25.85
1,3–Butadiene	106–99–0	3	110.50
1–Butanethiol (n–Butyl Mercaptan)	109–79–5	2	15.00
n–Butylamine	109–73–9	3	75.00
Cadmium Oxide	1306–19–0	3	0.25
Cadmium Sulfate	10124–36–4	3	0.20
Cadmium	7440–43–9	3	0.25
Calcium Cyanamide	156–62–7	3	2.50
Caprolactam, vapor	105–60–2	1	500.00
Caprolactam, dust	105–60–2	1	25.00
Captan	133–06–2	3	25.00
Carbaryl	63–25–2	3	25.00
Carbon Disulfide	75–15–0	3	150.00
Carbon Tetrachloride	56–23–5	3	150.00
Carbonyl Sulfide	463–58–1	3	12250.00
Catechol	120–80–9	3	297.00
Chloramben	133–90–4	3	c
Chlordane	57–74–9	3	2.50
Chlorine	7782–50–5	1	75.00
Chloroacetic Acid	79–11–8	3	900.00
2–Chloroacetophenone	532–27–4	1	7.50
Chlorobenzene	108–90–7	3	1725.00
Chlorobenzilate	510–15–6	3	c
Chloroform	67–66–3	3	250.00
Chloromethyl Methyl Ether	107–30–2	3	c
p–Chloronitrobenzene	100–00–5	3	5.00
Chloroprene	126–99–8	3	175.00
Chromium(+6) Compounds	d	3	2.50
Cobalt Compounds	d	3	0.25
Coke Oven Emissions	d	3	c
Cresols/cresylic acid and mixture	1319–77–3	3	220.00
m–Cresol	108–39–4	3	110.50
o–Cresol	95–48–7	3	110.50
p–Cresol	106–44–5	3	110.50
Cumene	98–82–8	2	9.00[e]
Cyanamide	420–04–2	1	50.00

a Category 1 = low toxicity; category 2 = moderate toxicity; and category 3 = high toxicity.
b For the purpose of this standard, these values shall be rounded to the nearest hundredth of a $\mu g/m^3$. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01, but values less than 0.005 would be rounded to 0.00.
c To be determined
d No CAS number
e Verified reference concentration (RfC) established by the U.S. Environmental Protection Agency

Chemical Name	Chemical Abstract Number (CAS)	Toxicity Category[a]	Mbaximum Allowable Concentration (μg/m³)[b]
Cyanic Acid	420–05–3	1	500.00
Cyanide	57–12–5	1	125.00
Cyanide compounds[c]	d	1	e
Cyanoacetamide	107–91–5	1	125.00
Cyanogen	460–19–5	1	500.00
2,4–D,salts and esters	94–75–7	3	50.00
DDE	3547–04–4	3	e
Diazomethane	334–88–3	3	2.00
Dibenzofuran	132–64–9	3	e
1,2–Dibromo–3–chloropropane	96–12–8	3	0.05
Dibutylphthalate	84–74–2	3	25.00
p–Dichlorobenzene	106–46–7	2	4500.00
3,3 –Dichlorobenzidine	91–94–1	3	0.15
1,3–Dichloropropene	542–75–6	3	20.00[f]
Dichlorvos	62–73–7	3	4.52
Diethanolamine	111–42–2	2	129.00
n,n–Diethylaniline(n,n–Dimethylaniline)	121–69–7	2	250.00
Diethyl Phthalate	84–66–2	3	25.00
Diethyl Sulfate	64–67–5	3	e
Diisodecyl Phthalate	2671–40–0	2	50.00
3,3–Dimethoxybenzidine	119–90–4	3	0.30
3,3'–Dimethyl Benzidine	119–93–7	3	e
Dimethyl Carbamoyl Chloride	79–44–7	3	e
Dimethyl Formamide	68–12–2	2	300.00
1,1–Dimethyl Hydrazine	57–14–7	3	5.00
1,2–Dimethyl Hydrazine	540–73–8	3	5.00
Dimethyl Phthalate	131–11–3	3	25.00
Dimethyl Sulfate	77–78–1	3	2.50
4–Dimethylaminoazobenzene	60–11–7	3	125.00
m–Dinitrobenzene	99–65–0	2	10.00
4,6–Dinitro–o–cresol and salts	534–52–1	2	2.00
2,4–Dinitrophenol	51–28–5	3	e
2,4–Dinitrotoluene	121–14–2	3	1.50
Dioctyl Phthalate	117–84–0	2	50.00
1,4–Dioxane	123–91–1	3	450.00

a Category 1 = low toxicity; category 2 = moderate toxicity; and category 3 = high toxicity.
b For the purpose of this standard, these values shall be rounded to the nearest hundredth of a μg/m³. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01, but values less than 0.005 would be rounded to 0.00.
c XCN where X=H+ or any other group where a formal dissociation may occur. For example, KCN or $Ca(CN)_2$.
d No CAS number
e To be determined
f Verified reference concentration (RfC) established by the U.S. Environmental Protection Agency

Chemical Name	Chemical Abstract Number (CAS)	Toxicity Category[a]	Maximum Allowable Concentration (μg/m^3)[b]
1,2–Diphenylhydrazine	122–66–7	3	c
Epichlorohydrin	106–89–8	3	50.00
1,2–Epoxybutane	106–88–7	3	c
Ethanethiol	75–08–1	2	10.00
Ethanolamine	141–43–5	1	200.00
Ethyl Acrylate	140–88–5	3	102.50
Ethyl Benzene	100–41–4	2	4350.00
Ethyl Chloride	75–00–3	2	26400.00
Ethylene Dibromide	106–93–4	2	770.00
Ethylene Dichloride	107–06–2	3	200.00
Ethylene Glycol	107–21–1	3	650.00
Ethylene Oxide	75–21–8	3	10.00
Ethylene Thiourea	96–45–7	3	c
Ethylene Imine	151–56–4	3	5.00
Ethylidene Dichloride	75–34–3	3	2025.00
Formaldehyde	50–00–0	2	15.00
Formamide	75–12–7	1	750.00
Formic Acid	64–18–6	1	225.00
Furfural	98–01–1	1	200.00
Furfuryl Alcohol	98–00–0	2	400.00
Glycidaldehyde	765–34–4	3	75.00
Glycol Ethers[d] (mono- and di-ethers of diethylene glycol or triethylene glycol)	e	1	c
Glycol Ethers[d] (mono- and di-ethers of ethylene glycol)	e	3	c
Heptachlor	76–44–8	3	2.50
Hexachlorobenzene	118–74–1	3	c
Hexachlorobutadiene	87–68–3	3	l.20
Hexachlorocyclohexane (multiple isomers)	608–73–1	2	5.00
Hexachlorocylopentadiene	77–47–4	3	0.50
Hexachloroethane	67–72–1	3	48.50
Hexachloronapthalene	1335–87–1	3	1.00
Hexamethylene–1, 6–diisocyanate	822–06–0	2	0.34
Hexamethylphosphoramide	680–31–9	3	l4.50

a Category 1 = low toxicity; category 2 = moderate toxicity; and category 3 = high toxicity.
b For the purpose of this standard, these values shall be rounded to the nearest hundredth of a μg/m^3. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01, but values less than 0.005 would be rounded to 0.00.
c To be determined
d Includes mono- and di-ethers of ethylene glycol, diethylene glycol, and triethylene glycol R–(OCH$_2$CH$_2$)n–OR', where n=1, 2, or 3; R=alkyl or aryl groups; and R' = R, H, or groups which, when removed, yield glycol ethers with the structure: R–(OCH$_2$CH)n–OH. Polymers are excluded from the glycol category.
e No CAS number

Chemical Name	Chemical Abstract Number (CAS)	Toxicity Category[a]	Maximum Allowable Concentration (μg/m^3)[b]
Hexane	110–54–3	3	900.00
Hydrazine	302–01–2	3	0.50
Hydrochloric Acid	7647–01–0	1	175.00
Hydrogen Cyanide	74–90–8	1	250.00
Hydrogen Sulfide	7783–06–4	2	140.00
Hydroquinone	123–31–9	2	20.00
Isophorone	78–59–1	2	250.00
Isopropylamine	75–31–0	1	300.00
Kepone (Chlordecone)	143–50–0	3	0.00
Ketene	463–51–4	3	4.50
Lead Arsenate	7645–25–2	3	0.75
Lead(+2) Arsenate	7784–40–9	3	0.75
Lindane	58–89–9	3	2.50
Malathion	121–75–5	2	100.00
Maleic Anhydride	108–31–6	2	10.00
Manganese Compounds	c	3	25.00
Mercury	7439–97–6	3	0.25
Methanol	67–56–1	3	1310.00
Methoxychlor	72–43–5	3	50.00
Methyl Bromide	74–83–9	3	100.00
Methyl Chloride	74–87–3	3	515.00
Methyl Chloroform (1,1,1– Trichloroethane)	71–55–6	3	9550.00
Methylene Biphenyl Isocyanate	101–68–8	2	2.00
4,4–Methylene Bis (2–chloroaniline)	101–14–4	3	1.10
4,4–Methylenedianiline	101–77–9	3	4.00
Methyl Ethyl Ketone (2–Butone)	78–93–3	1	14750.00
Methyl Hydrazine	60–34–4	3	1.75
Methyl Iodide	74–88–4	3	58.00
Methyl Isobutyl Ketone	108–10–1	2	2050.00
Methyl Isocyanate	624–83–9	3	0.23
Methyl Mercaptan	74–93–1	2	10.00
Methyl Methacrylate	80–62–6	1	10250.00
Methylamine	74–89–5	1	300.00
Methylene Chloride	75–09–2	1	8750.00
Methyl–t–Butyl Ether	1634–04–4	1	d

a Category 1 = low toxicity; category 2 = moderate toxicity; and category 3 = high toxicity.
b For the purpose of this standard, these values shall be rounded to the nearest hundredth of a μg/m^3. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01, but values less than 0.005 would be rounded to 0.00.
c No CAS number
d To be determined

Chemical Name	Chemical Abstract Number (CAS)	Toxicity Category[a]	Maximum Allowable Concentration ($\mu g/m^3$)[b]
Mineral Fibers, Fine[c]	d	3	e
Mineral Oil Mist (Paraffin Oil)	8012–95–1	3	25.00
Mirex	2385–85–5	3	4500.00
Naphthalene	91–20–3	1	1250.00
a–Naphthylamine	134–32–7	3	0.00
b–Naphthylamine	91–59–8	3	0.00
Nickel Carbonyl	13463–39–3	3	1.75
Nickel Oxide	1313–99–1	3	5.00
Nickel Sulfate	7786–81–4	3	5.00
Nickel	7440–02–0	3	0.50
Nitric Acid	7697–37–2	1	125.00
p–Nitroaniline	100–01–6	3	15.00
Nitrobenzene	98–95–3	3	25.00
4–Nitrobiphenyl	92–93–3	3	0.00
Nitrogen Mustard	51–75–2	3	0.00
Nitroglycerin	55–63–0	2	5.00
p–Nitrophenol	100–02–7	3	0.00
1–Nitropropane	108–03–2	1	2250.00
2–Nitropropane	79–46–9	3	182.00
p–Nitrosophenol	104–91–6	3	0.00
n–Nitroso–n–methylurea	684–93–5	3	e
n–Nitrosodimethylamine	62–75–9	3	0.00
n–Nitrosomorpholine	59–89–2	3	5000.00
p–Nitrotoluene	99–99–0	3	5.50
Octachloronaphthalene	2234–13–1	3	0.50
Oxalic Acid	144–62–7	2	10.00
Paraquat	1910–42–5	3	0.50
Parathion	56–38–2	3	0.50
Pentachloronitrobenzene (Quintobenzene)	82–68–8	3	e
Pentachlorophenol	87–86–5	2	5.00
Phenol	108–95–2	2	190.00
p–Phenylenediamine	106–50–3	2	1.00
Phenylhydrazine	100–63–0	2	200.00
Phosgene (Carbonyl Chloride)	75–44–5	2	4.00
Phosphine	7803–51–2	3	2.09

a Category 1 = low toxicity; category 2 = moderate toxicity; and category 3 = high toxicity.
b For the purpose of this standard, these values shall be rounded to the nearest hundredth of a $\mu g/m^3$. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01, but values less than 0.005 would be rounded to 0.00.
c Includes mineral fiber emissions from facilities manufacturing or processing glass, rock, and slag fibers (or other mineral-derived fibers) of average diameter 1 micrometer or less
d No CAS number
e To be determined

Chemical Name	Chemical Abstract Number (CAS)	Toxicity Category[a]	Maximum Allowable Concentration ($\mu g/m^3$)[b]
Phosphoric Acid	7664–38–2	1	25.00
Phosphorus	7723–14–0	2	0.50
Phthalic Anhydride	85–44–9	3	30.30
Picric Acid	88–89–1	2	1.00
Polychlorinated Biphenyls (PCB) (multiple compounds)	c	3	2.50
Polycyclic Organic Matter[d]	c	3	160.00
1,3–Propane Sultone	1120–71–4	3	e
b–Propiolactone	57–57–8	3	7.50
Proprionaldehyde	123–38–6	1	e
Propoxur	114–26–1	3	2.50
Propylene Dichloride	78–87–5	3	1750.00
Propylene Oxide	75–56–9	3	250.00
1,2–Propylenimine	75–55–8	3	23.35
Pyrethrin I	121–21–1	3	25.00
Pyrethrin II	121–29–9	3	25.00
Pyrethrum	8003–34–7	2	50.00
Quinoline	91–22–5	3	e
Quinone	106–51–4	3	2.00
Rotenone	83–79–4	2	50.00
Selenium Compounds	c	3	1.00
Sodium Hydroxide[f]	1310–73–2	1	50.00
Styrene	100–42–5	1	5325.00
Styrene Oxide	96–09–3	3	e
Sulfuric Acid	7664–93–9	2	10.00
Tetrachlorinate Dibenzo–p–dioxins	1746–01–6	3	0.00
1,1,2,2–Tetrachloroethane (Acetylene Tetrachloride)	79–34–5	3	35.00
Tetrachloroethylene (Perchloroethylene)	127–18–4	2	3350.00
Titanium Tetrachloride	7550–45–0	1	2500.00
Toluene	108–88–3	3	2000.00
2,4–Toluenediamine	95–80–7	3	e
Toluene Diisocyanate	26471–62–5	2	0.40
Toluene–2,4– diisocyanate	584–84–9	2	0.40
o–Toluidine	95–53–4	3	43.85

a Category 1 = low toxicity; category 2 = moderate toxicity; and category 3 = high toxicity.
b For the purpose of this standard, these values shall be rounded to the nearest hundredth of a $\mu g/m^3$. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01, but values less than 0.005 would be rounded to 0.00.
c No CAS number
d Includes organic compounds with more than one benzene ring and that have a boiling point greater than or equal to 100 °C
e To be determined
f The use of sodium hydroxide in a scrubber for air pollution control purposes is exempt from this standard.

Chemical Name	Chemical Abstract Number (CAS)	Toxicity Category[a]	Maximum Allowable Concentration ($\mu g/m^3$)[b]
Toxaphene	8001–35–2	3	2.50
1,2,4–Trichlorobenzene	120–82–1	2	400.00
1,1,2–Trichloroethane	79–00–5	3	273.00
Trichloroethylene	79–01–6	1	6750.00
2,4,5–Trichlorophenol	95–95–4	3	c
2,4,6–Trichlorophenol	88–06–2	3	c
Triethylamine	121–44–8	3	207.00
Trifluralin	1582–09–8	3	c
2,2,4–Trimethylpentane	540–84–1	1	8750.00
Urethane (Carbamic Acid Ethyl Ester)	51–79–6	2	5000.00
Vinyl Acetate	108–05–4	3	176.00
Vinyl Bromide	593–60–2	3	100.00
Vinyl Chloride	75–01–4	3	50.00
Vinyl Fluoride	75–02–5	2	19.00
Vinylidene chloride	75–35–4	3	99.00
Xylene	1330–20–7	2	4350.00
m–Xylene	108–38–3	2	4350.00
o–Xylene	95–47–6	2	4350.00
p–Xylene	106–42–3	2	4350.00
Xylidine	1300–73–8	3	50.00

a Category 1 = low toxicity; category 2 = moderate toxicity; and category 3 = high toxicity.

b For the purpose of this standard, these values shall be rounded to the nearest hundredth of a $\mu g/m^3$. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01, but values less than 0.005 would be rounded to 0.00.

c To be determined

Appendix D

Radionuclide and Chemical Nomenclature

Nomenclature and Half-Life for Radionuclides

Radionuclide	Symbol	Half-life[a,b]	Radionuclide	Symbol	Half-life[a,b]
Actinium-228	Ac-228	6.15 h	Mercury-203	Hg-203	46.61 d
Americium-241	Am-241	432.7 y	Neptunium-237	Np-237	2.14E6 y
Americium-243	Am-243	7370 y	Neptunium-239	Np-239	2.355 d
Antimony-124	Sb-124	60.2 d	Nickel-59	Ni-59	7.6E4 y
Antimony-125	Sb-125	2.758 y	Nickel-63	Ni-63	100 y
Argon-39	Ar-39	269 y	Niobium-94	Nb-94	2.0E4 y
Barium-133	Ba-133	10.7 y	Niobium-95	Nb-95	34.97 d
Beryllium-7	Be-7	53.28 d	Plutonium-238	Pu-238	87.7 y
Bismuth-212	Bi-212	2.14 m	Plutonium-239	Pu-239	2.41E4 y
Bismuth-214	Bi-214	19.9 m	Plutonium-240	Pu-240	6560 y
Carbon-14	C-14	5714 y	Plutonium-241	Pu-241	14.4 y
Cerium-141	Ce-141	32.5 d	Plutonium-242	Pu-242	3.75E5 y
Cerium-144	Ce-144	284.6 d	Potassium-40	K-40	1.27E9 y
Cesium-134	Cs-134	2.065 y	Praseodymium-144	Pr-144	17.28 m
Cesium-137	Cs-137	30.07 y	Praseodymium-144m	Pr-144m	7.2 m
Chromium-51	Cr-51	27.702 d	Promethium-147	Pm-147	2.6234 y
Cobalt-57	Co-57	271.8 d	Protactinium-231	Pa-231	3.28E4 y
Cobalt-58	Co-58	70.88 d	Protactinium-233	Pa-233	27.0 d
Cobalt-60	Co-60	5.271 y	Protactinium-234	Pa-234	6.69 h
Curium-242	Cm-242	162.8 d	Radium-226	Ra-226	1599 y
Curium-244	Cm-244	18.1 y	Radium-228	Ra-228	5.76 y
Curium-245	Cm-245	8.50E3 y	Ruthenium-103	Ru-103	39.27 d
Curium-246	Cm-246	4.76E3 y	Ruthenium-106	Ru-106	1.020 y
Europium-152	Eu-152	13.54 y	Selenium-75	Se-75	119.78 d
Europium-154	Eu-154	8.593 y	Selenium-79	Se-79	6.5E5 y
Europium-155	Eu-155	4.75 y	Sodium-22	Na-22	2.604 y
Iodine-129	I-129	1.57E7 y	Strontium-89	Sr-89	50.52 d
Iodine-131	I-131	8.0207 d	Strontium-90	Sr-90	28.78 y
Iodine-133	I-133	20.3 h	Technetium-99	Tc-99	2.13E5 y
Krypton-85	Kr-85	10.76 y	Thallium-208	Tl-208	3.053 m
Lead-212	Pb-212	10.64 h	Thorium-228	Th-228	1.913 y
Lead-214	Pb-214	27 m	Thorium-230	Th-230	7.54E4 y
Manganese-54	Mn-54	312.1 d	Thorium-232	Th-232	1.40E10 y

a m=minute; h = hour; d = day; y = year
b Reference: Chart of the Nuclides, 15th edition, revised 1996, General Electric Company

Nomenclature and Half-Life for Radionuclides, Continued					
Radionuclide	**Symbol**	**Half-life[a,b]**	**Radionuclide**	**Symbol**	**Half-life[a,b]**
Thorium-234	Th-234	24.10 d	Uranium-235	U-235	7.04E8 y
Tin-113	Sn-113	115.1 d	Uranium-236	U-236	2.342E7 y
Tin-126	Sn-126	2.5E5 y	Uranium-238	U-238	4.47E9 y
Tritium (Hydrogen-3)	H-3	12.32 y	Xenon-135	Xe-135	9.10 h
Uranium-232	U-232	69.8 y	Zinc-65	Zn-65	243.8 d
Uranium-233	U-233	1.592E5 y	Zirconium-85	Zr-85	7.7 m
Uranium-234	U-234	2.46E5 y	Zirconium-95	Zr-95	64.02 d

a m=minute; h = hour; d = day; y = year
b Reference: Chart of the Nuclides, 15th edition, revised 1996, General Electric Company

Nomenclature for Elements and Chemical Constituent Analyses

Note: Some of the symbols listed in this table came from various databases used to format the data tables in this book and are included here to assist the reader in understanding the tables.

Constituent	Symbol	Constituent	Symbol
Aluminum	Al (or AL)	Nitrite, Nitrate	NO2,NO3 (or NO_2, NO_3 or NO2/NO3))
Ammonia	NH_3	pH	pH (or PH)
Ammonia as Nitrogen	NH_3–N (or AN)	Phenol	PHE
Antimony	Sb (or SB)	Phosphorus	P
Arsenic	As (or AS)	Phosphate	PO_4 (or PO4–P or PO_4–P)
Barium	Ba (or BA)	Polychlorinated Biphenyl	PCB
Biological Oxygen Demand	BOD	Potassium	K
Beryllium	Be	Selenium	Se (or SE)
Boron	B	Silver	Ag (or AG)
Bromide	B–	Sulfate	SO_4 (or SO4)
Cadmium	Cd (or CD)	Tetrachloroethene	PERCL
Chemical Oxygen Demand	COD	Tetrachloroethylene (Perchloroethylene)	PERCL
Chlorine	Cl (or CHL)	Trichloroethene	TRICL
Chromium	Cr (or CR)	Trichloroethylene	TRICL
Cobalt	Co	Tin	SN
Copper	Cu (or CU)	Total Dissolved Solids	TDS
Cyanide	CN	Total Kjeldahl Nitrogen	TKN
Dissolved Oxygen	DO	Total Organic Carbon	TOC
Iron	Fe (or FE)	Total Suspended Particulate Matter	TSP
Lead	Pb (or PB)	Total Suspended Solids	TSS
Magnesium	Mg (or MG)	Total Volatile Solids	TVS
Manganese	Mn (or MN)	Uranium	U
Mercury	Hg (or HG)	Vinyl Chloride	VC
Molybdenum	Mo	Zinc	Zn (or ZN)
Nickel	Ni (or NI)		
Nitrate	NO_3		
Nitrate as Nitrogen	NO_3–N		
Nitrite as Nitrogen	NO_2–N		

Appendix E

Errata from 1999 Report

The following information was reported incorrectly in the *Savannah River Site Environmental Report for 1999* (WSRC–TR–99–00299):

Page 33, right column, second paragraph, last two sentences: The references to the nomination of three Plutonium Immobilization Plant sites to the National Register of Historic Places should have been to the *eligibility* for nomination.

Page 41, second bullet, lines 3 and 4: The percent of annualized radioactive and hazardous solid waste generation volume decrease should have been 72. The number of cubic meters of radioactive and hazardous solid waste generated in calendar year 1991 should have been 22,780.

Page 47, right column, first paragraph under "Waste Minimization," sentences 1 and 2: The percent of annualized radioactive and hazardous solid waste generation volume decrease should have been 72. The number of cubic meters of radioactive and hazardous solid waste generated in calendar year 1991 should have been 22,780.

Page 144, left column, second full paragraph, first sentence: "B-Area" should have been "D-Area."

Page 191, table 10–13, last line: The reference to the years 1996, 1997, and 1998 should have been to the years 1997, 1998, and 1999.

Page 199, right column, second paragraph, line 3: The number of isotopes that EMS analyzed in water in QAP set 51 should have been 11.

Glossary

A

accuracy – Closeness of the result of a measurement to the true value of the quantity.

actinide – Group of elements of atomic number 89 through 103. Laboratory analysis of actinides by alpha spectrometry generally refers to the elements plutonium, americium, uranium, and curium but may also include neptunium and thorium.

activity – See radioactivity.

air flow – Rate of flow, measured by mass or volume per unit of time.

air stripping – Process used to decontaminate groundwater by pumping the water to the surface,"stripping" or evaporating the chemicals in a specially-designed tower, and pumping the cleansed water back to the environment.

aliquot – 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 – 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 – Surrounding atmosphere as it exists around people, plants, and structures.

analyte – Constituent or parameter that is being analyzed.

analytical detection limit – Lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

aquifer – Saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

aquitard – Geologic unit that inhibits the flow of water.

Atomic Energy Commission – 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. Functions of the Energy Research and Development Administration eventually were taken over by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission.

B

background radiation – Naturally occurring radiation, fallout, and cosmic radiation. Generally, the lowest level of radiation obtainable within the scope of an analytical measurement, i.e., a blank sample.

bailer – Container lowered into a well to remove water. The bailer is allowed to fill with water and then is removed from the well.

best management practices – Sound engineering practices that are not, however, required by regulation or by law.

beta particle – Negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

blank – 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. The Environmental Protection Agency does not permit the subtraction of blank results in Environmental Protection Agency-regulated analyses.

blind blank – Sample container of deionized water sent to a laboratory under an alias name as a quality control check.

blind replicate – In the Environmental Monitoring Section 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 – Control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

C

calibration – Process of applying correction factors to equate a measurement to a known standard. Generally, a documented measurement control program of charts, graphs, and data that demonstrate that an instrument is properly calibrated.

Carolina bay – 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.

Central Savannah River Area (CSRA) – Eighteen-county area in Georgia and South Carolina surrounding Augusta, Georgia. The Savannah River Site is included in the Central Savannah River Area. Counties are Richmond, Columbia, McDuffie, Burke, Emanuel, Glascock, Jenkins, Jefferson, Lincoln, Screven, Taliaferro, Warren, and Wilkes in Georgia and Aiken, Edgefield, Allendale, Barnwell, and McCormick in South Carolina.

chemical oxygen demand – 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.

cleanup – Actions taken to deal with release or potential release of hazardous substances. This may mean complete removal of the substance; it also may mean stabilizing, containing, or otherwise treating the substance so that it does not affect human health or the environment.

closure – Control of a hazardous waste management facility under Resource Conservation and Recovery Act requirements.

compliance – Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

composite – Blending of more than one portion to make a sample for analysis.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – This act addresses the cleanup of hazardous substances and establishes a National Priorities List of sites targeted for assessment and, if necessary, restoration (commonly known as “Superfund”).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-reportable release – Release to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

concentration – Amount of a substance contained in a unit volume or mass of a sample.

conductivity – 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 – State of being made impure or unsuitable by contact or mixture with something unclean, bad, etc.

count – Signal that announces an ionization event within a counter; a measure of the radiation from an object or device.

counting geometry – Well-defined sample size and shape for which a counting system has been calibrated.

criteria pollutant – any of the pollutants commonly used as indices for air quality that can have a serious effect on human health and the environment, including sulfur dioxide, nitrogen dioxide, total suspended particulates, PM_{10}, carbon monoxide, ozone, gaseous fluorides, and lead.

curie – 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 (μCi) – 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.

D

decay (radioactive) – Spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

decay time – Time taken by a quantity to decay to a stated fraction of its initial value.

deactivation – The process of placing a facility in a stable and known condition, including the removal of hazardous and radioactive materials to ensure adequate protection of the worker, public health and safety, and the environment—thereby limiting the long-term cost of surveillance and maintenance.

decommissioning – Process that takes place after deactivation and includes surveillance and maintenance, decontamination, and/or dismantlement.

decontamination – The removal or reduction of residual radioactive and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

deactivation and decommissioning – Program that reduces the environmental and safety risks of surplus facilities at SRS.

derived concentration guide – 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 Department of Energy Order 5400.5.

detection limit – See analytical detection limit, lower limit of detection, minimum detectable concentration.

detector – Material or device (instrument) that is sensitive to radiation and can produce a signal suitable for measurement or analysis.

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.

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.

disposal – Permanent or temporary transfer of Department of Energy control and custody of real property to a third party, which thereby acquires rights to control, use, or relinquish the property.

disposition – Those activities that follow completion of program mission—including, but not limited to, surveillance and maintenance, deactivation, and decommissioning.

dissolved oxygen – 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.

dose – 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 – 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 – 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 – 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 – 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 – 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 – 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 Department of Energy program activities.

dosimeter – Portable detection device for measuring the total accumulated exposure to ionizing radiation.

downgradient – In the direction of decreasing hydrostatic head.

drinking water standards – Federal primary drinking water standards, both proposed and final, as set forth by EPA.

duplicate result – 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.

E

effluent – Any treated or untreated air emission or liquid discharge to the environment.

effluent monitoring – 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.

environmental compliance – Actions taken in accordance with government laws, regulations, orders, etc., that apply to site operations' effects on onsite and offsite natural resources and on human health; used interchangeably in this document with regulatory compliance.

environmental monitoring – Program at Savannah River Site that includes effluent monitoring and environmental surveillance with dual purpose of (1) showing compliance with federal, state, and local regulations, as well as with U.S. Department of Energy orders, and (2) monitoring any effects of site operations on onsite and offsite natural resources and on human health.

environmental restoration – Department of Energy program that directs the assessment and cleanup of inactive waste units and groundwater (remediation) contaminated as a result of nuclear-related activities.

environmental surveillance – Collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from Department of Energy 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.

exceedance – Term used by the Environmental Protection Agency and the South Carolina Department of Health and Environmental Control that denotes a report value is more than the upper guide limit. This term is found on the Discharge Monitoring Report forms that are submitted to the Environmental Protection Agency or the South Carolina Department of Health and Environmental Control.

exposure (radiation) – 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.

exposure pathway – Route that materials follow to get to the environment and then to people.

F

fallout – See worldwide fallout.

Federal Facility Agreement (FFA) – Agreement negotiated among the Department of Energy, the Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control, specifying how the Savannah River Site will address contamination or potential contamination to meet regulatory requirements at the Savannah River Site waste units identified for evaluation and, if necessary, cleanup.

feral hog – Hog that has reverted to the wild state from domestication.

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-emitter – Any nuclide that emits a gamma ray during the process of radioactive decay. Generally, the fission products produced in nuclear reactors.

gamma spectrometry – System consisting of a detector, associated electronics, and a multichannel analyzer that is used to analyze samples for gamma-emitting radionuclides.

grab sample – Sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

H

half-life (radiological) – Time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

heavy water – Water in which the molecules contain oxygen and deuterium, an isotope of hydrogen that is heavier than ordinary hydrogen.

hydraulic gradient – Difference in hydraulic head over a specified distance.

hydrology – Science that treats the occurrence, circulation, distribution, and properties of the waters of the earth, and their reaction with the environment.

I

in situ – In its original place. Field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

inorganic – Involving matter other than plant or animal.

instrument background – Instrument signal due to electrical noise and other interferences not attributed to the sample or blank.

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.

isotopes – Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

> **long-lived isotope –** 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 –** 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 – Deionized water sample generated by the laboratory; a laboratory blank is analyzed with each batch of samples as an in-house check of analytical procedures. Also called an internal blank.

legacy – Anything handed down from the past; inheritance, as of nuclear waste.

lower limit of detection – Smallest concentration/amount of analyte that can be reliably detected in a sample at a 95 percent confidence level.

M

macroinvertebrates – Size-based classification used for a variety of insects and other small invertebrates; as defined by the Environmental Protection Agency, those organisms that are retained by a No. 30 (590 micron) U.S. Standard Sieve.

macrophyte – A plant that can be observed with the naked eye.

manmade radiation – Radiation from sources such as consumer products, medical procedures, and nuclear industry.

maximally exposed individual – 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.

mean relative difference – Percentage error based on statistical analysis.

mercury – 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.

migration – Transfer or movement of a material through the air, soil, or groundwater.

minimum detectable concentration – 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.

moderate – To reduce the excessiveness of; to act as a moderator.

moderator – Material, such as heavy water, used in a nuclear reactor to moderate or slow down neutrons from the high velocities at which they are created in the fission process.

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.

N

nonroutine radioactive release – Unplanned or nonscheduled release of radioactivity to the environment.

nuclide – Atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

O

opacity – The reduction in visibility of an object or background as viewed through the diameter of a plume.

organic – Of, relating to, or derived from living organisms (plant or animal).

outcrop – Place where groundwater is discharged to the surface. Springs, swamps, and beds of streams and rivers are the outcrops of the water table.

outfall – Point of discharge (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

P

parameter – Analytical constituent; chemical compound(s) or property for which an analytical request may be submitted.

permeability – Physical property that describes the ease with which water may move through the pore spaces and cracks in a solid.

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 – 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.

piezometer – Instrument used to measure the potentiometric surface of the groundwater. Also, a well designed for this purpose.

plume – Volume of contaminated air or water originating at a point-source emission (e.g., a smokestack) or a waste source (e.g., a hazardous waste disposal site).

point source – any defined source of emission to air or water such as a stack, air vent, pipe, channel or passage to a water body.

population dose – See collective dose equivalent under dose.

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 removed prior to sampling; 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.

Q

quality assurance (QA) – In the Environmental Monitoring System program, QA consists of the system whereby the laboratory can assure clients and other outside entities, such as government agencies and accrediting bodies, that the laboratory is generating data of proven and known quality.

quality control (QC) – In the Environmental Monitoring System program, QC refers to those operations undertaken in the laboratory to ensure that the data produced are generated within known probability limits of accuracy and precision.

R

rad – Unit of absorbed dose deposited in a volume of material.

radioactivity – Spontaneous emission of radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

radioisotopes – Radioactive isotopes.

radionuclide – 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.

real-time instrumentation – Operation in which programmed responses to an event are essentially simultaneous with the event itself.

reforestation – Process of planting new trees on land once forested.

regulatory compliance – Actions taken in accordance with government laws, regulations, orders, etc., that apply to site operations’ effects on onsite and offsite natural resources and on human health; used interchangeably in this document with environmental compliance.

release – Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem – 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 – Assessment and cleanup of Department of Energy sites contaminated with waste as a result of past activities. See environmental restoration.

remediation design – Planning aspects of remediation, such as engineering characterization, sampling studies, data compilation, and determining a path forward for a waste site.

replicate – In the Environmental Monitoring Section 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.

Resource Conservation and Recovery Act (RCRA) – Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes. This act also requires corrective action for releases of hazardous waste at inactive waste units.

Resource Conservation and Recovery Act (RCRA) site – Solid waste management unit under Resource Conservation and Recovery Act regulation. See Resource Conservation and Recovery Act.

retention basin – Unlined basin used for emergency, temporary storage of potentially contaminated cooling water from chemical separations activities.

RFI/RI Program – RCRA Facility Investigation/Remedial Investigation Program. At the Savannah River Site, the expansion of the RFI Program to include Comprehensive Environmental Response, Compensation, and Liability Act and hazardous substance regulations.

routine radioactive release – Planned or scheduled release of radioactivity to the environment.

S

seepage basin – 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.

sensitivity – Capability of methodology or instruments to discriminate between samples with differing concentrations or containing varying amounts of analyte.

settling basin – Temporary holding basin (excavation) that receives wastewater which is subsequently discharged.

site stream – Any natural stream on the Savannah River Site. Surface drainage of the site is via these streams to the Savannah River.

source – Point or object from which radiation or contamination emanates.

source check – 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.

spent nuclear fuel – Used fuel elements from reactors.

spike – Addition of a known amount of reference material containing the analyte of interest to a blank sample.

stable – Not radioactive or not easily decomposed or otherwise modified chemically.

stack – Vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

standard deviation – Indication of the dispersion of a set of results around their average.

stormwater runoff – Surface streams that appear after precipitation.

Superfund – see Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

supernate – Portion of a liquid above settled materials in a tank or other vessel.

surface water – All water on the surface of the earth, as distinguished from groundwater.

T

tank farm – Installation of interconnected underground tanks for storage of high-level radioactive liquid wastes.

temperature – Thermal state of a body considered with its ability to communicate heat to other bodies.

thermoluminescent dosimeter (TLD) – Device used to measure external gamma radiation.

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 suspended particulates – Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transport pathway – pathway by which a released contaminant physically is transported from its point of discharge to a point of potential exposure to humans. Typical transport pathways include the atmosphere, surface water, and groundwater.

transuranic waste – Solid radioactive waste containing primarily alpha-emitting elements heavier than uranium.

trend – General drift, tendency, or pattern of a set of data plotted over time.

turbidity – Measure of the concentration of sediment or suspended particles in solution.

U

unspecified alpha and beta emissions – the unidentified alpha and beta emissions that are determined at each effluent location by subtracting the sum of the individually measured alpha-emitting (e.g., plutonium-239 and uranium-235) and beta-emitting (e.g., cesium-137 and strontium-90) radionuclides from the measured gross alpha and beta values, respectively.

V

vitrify – Change into glass.

vitrification – Process of changing into glass.

volatile organic compounds – Broad range of organic compounds, commonly halogenated, that vaporize at ambient, or relatively low, temperatures (e.g., acetone, benzene, chloroform, and methyl alcohol).

W

waste management – The Department of Energy uses this term to refer to the safe, effective management of various kinds of nonhazardous, hazardous, and radioactive waste generated on site.

waste unit – Inactive area that is known to have received contamination or had a release to the environment.

water table – Planar, underground surface beneath which earth materials, as soil or rock, are saturated with water.

weighting factor – 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 attributed to that particular tissue. The weighting factors used in this report are recommended by the International Commission on Radiological Protection (Publication 26).

wetlands – 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 rose – 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.

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Units of Measure		Units of Measure	
Symbol	**Name**	**Symbol**	**Name**
Temperature		*Concentration*	
°C	degrees Centigrade	ppb	parts per billion
°F	degrees Fahrenheit	ppm	parts per million
Time			
d	day	*Rate*	
h	hour	cfs	cubic feet per second
y	year	gpm	gallons per minute
Length			
cm	centimeter	*Conductivity*	
ft	foot	µmho	micromho
in.	inch		
km	kilometer		
m	meter	*Radioactivity*	
mm	millimeter	Ci	curie
µm	micrometer	cpm	counts per minute
		mCi	millicurie
Mass		µCi	microcurie
g	gram	pCi	picocurie
kg	kilogram	Bq	becquerel
mg	milligram		
µg	microgram	*Radiation Dose*	
		mrad	millirad
Area		mrem	millirem
mi^2	square mile	Sv	sievert
ft^2	square foot	mSv	millisievert
		µSv	microsievert
Volume		R	roentgen
gal	gallon	mR	milliroentgen
L	liter	µR	microroentgen
mL	milliliter	Gy	gray

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 (Units of Radiation Measure)		
Current System	***Systéme International***	**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

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}	µCi	µCi	10^6	pCi
pCi/L (water)	10^{-9}	µCi/mL (water)	µCi/mL (water)	10^9	pCi/L (water)
pCi/m^3 (air)	10^{-12}	µCi/mL (air)	µCi/mL (air)	10^{12}	pCi/m^3 (air)

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If you have any questions, please contact

Scientific and Technical Information
703-43A
Cathie Witker, 725-3510
Wileva Dunbar, 725-5744
E-mail: STI@SRS.GOV