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DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

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GENERIC SAFETY ANALYSIS REPORT

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CHAPTER 1

SITE CHARACTERISTICS

June 2007

Washington Savannah River Company
Aiken, SC 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

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ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
ASTM	American Society for Testing and Materials
BSRI	Bechtel Savannah River Incorporated
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIF	Consolidated Incineration Facility
CNSI	Chem Nuclear Systems, Incorporated
CSX	CSX Transportation Incorporated
CTF	Chemical Transfer Facility
DBE	Design Basis Earthquake
DETF	Dilute Effluent Treatment Facility
DOE	Department of Energy
DRB	Deep Rock Borings
DSA	Documented Safety Analysis
DWPF	Defense Waste Processing Facility
EA	Environmental Assessment
EBE	Evaluation Basis Earthquake
EDE	Effective Dose Equivalent
EG&G	Edgerton, Germeshausen, and Grier, Incorporated
EID	Environmental Information Document
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EPZ	Emergency Planning Zone
ETF	Effluent Treatment Facility
ETS	Environmental Technology Section
g/cm^3	grams per cubic centimeter
GSA	General Services Administration
gpm	gallons per minute
LLNL	Lawrence Livermore National Laboratory
LETF	Liquid Effluent Treatment Facility
MCE	Maximum Credible Earthquake
mgd	million gallons per day
mrem	milli roentgen equivalent, man
msl	mean sea level
NPDES	National Pollutant Discharge Elimination System

ACRONYMS AND ABBREVIATIONS (continued)

NPH	Natural Phenomena Hazard
NRC	Nuclear Regulatory Commission
NWS	National Weather Service
PBF	Pen Branch Fault
PGA	Peak Ground Acceleration
PHA	Probabilistic Hazards Assessment
RBOF	Receiving Basin for Offsite Fuel
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RTF	Replacement Tritium Facility
SAF	Soil Amplification Function
SAR	Safety Analysis Report
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCE&G	South Carolina Electric and Gas
SCS	Soil Conservation Service
SCSN	South Carolina Seismic Network
SMSA	Standard Metropolitan Statistical Area
SPT	Standard Penetration Test
SREL	Savannah River Ecology Laboratory
S/RIDS	Standards/Requirements Identification Documents
SRFS	Savannah River Forest Station
SRS	Savannah River Site
SRNL	Savannah River National Laboratory
SSCs	Structures, Systems, and Components
SWDF	Solid Waste Disposal Facility
SWMF	Solid Waste Management Facility
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
VEGP	Vogtle Electric Generating Plant
WSI	Wackenhut Services Incorporated
WSRC	Washington Savannah River Company

1.0 SAVANNAH RIVER SITE CHARACTERISTICS

1.1 INTRODUCTION

This document has been updated to address changes in facility functions. In addition, the level of detail contained in some sections of this Manual have been reduced by referencing existing documents in which the material may be found or eliminated as it was beyond the requirements of DOE-STD-3009-94 (Ref. 1).

Due to the dynamics of the updating of site program manuals and policies, if a conflict or inconsistency is encountered with this document, then the user will default to the Site Program Manuals.

1.1.1 OBJECTIVE

The purpose of this chapter is to provide generic safety basis information that satisfies the requirements of federal regulations (Ref. 2).

1.1.2 SCOPE

This chapter describes site characteristics and facility environs that are important to the safety basis. Information is provided to support and clarify assumptions used in the hazard and accident analyses to identify and analyze potential external accident initiators and accident consequence external to the facility. Products of this chapter, as outlined in DOE-STD-3009-94 (Ref. 1), include the following:

- Description of the location of the site, location of areas within the site, and their proximity to the public and to other facilities
- Quantification of those characteristics of the surrounding environment that influence the design, procedures, and safety of site operations
- Identification of the design or evaluation basis of external limits to be examined
- Historical bases for site characteristics in meteorological and geophysical phenomena
- Description of population sheltering, population location and density, and other aspects of the site that affect the surrounding area
- Description of onsite worker and transient populations relative to site and facility boundaries

When detailed information is provided in another chapter of this Manual, that chapter is referenced to limit repetition. Where policies, programs and practices important to safe operation are described in detail in other site documents, the pertinent features are summarized in this chapter and the documents are referenced (Ref. 1).

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1.2 REQUIREMENTS

1.2.1 STANDARDS/REQUIREMENTS IDENTIFICATION DOCUMENTS

The Savannah River Site (SRS) is required to comply with a number of DOE Orders, as well as codes, standards, and regulations that govern policies and programs. The Standards/ Requirements Identification Documents (S/RIDs) state the codes, standards, and regulations governing the operation of the Savannah River Site (Ref. 3). Programmatic compliance assessment has been performed against the S/RIDs and documented as specified in the Washington Savannah River Company (WSRC) Compliance Assurance Manual 8B (Ref. 4). The Standards Management/Compliance Section maintains records of the programmatic compliance assessments.

Chapter 14 of this Manual provides a discussion of these requirements. No additional requirements beyond those discussed are applicable.

1.2.2 WASHINGTON SAVANNAH RIVER COMPANY PROCEDURE MANUALS

A listing of WSRC documents that govern programmatic elements addressed in this chapter may be found on the SHRINE/ACCESS electronic database.

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1.3 SITE DESCRIPTION

1.3.1 GEOGRAPHY

LOCATION

SRS is a government owned tract of land occupying 310 square miles (198,344 acres) within Aiken, Barnwell, and Allendale Counties in southwestern South Carolina (Fig. 1.3-1). It was set aside in 1950, as a controlled area, for the production of nuclear materials for national defense. The center of SRS is approximately 25 miles (40 km) southeast of the city limits of Augusta, GA; 100 miles (160 km) from the Atlantic Coast; and about 110 miles (180 km) south-southeast of the North Carolina border. The SRS is bounded along 17 miles (27 km) of its southwest border by the Savannah River (Figs. 1.3-2 and 1.3-3).

SRS AREAS

SRS consists of 14 major areas (Fig. 1.3-4):

- Reactor areas (C-, K-, L-, P- and R-Areas)
- Separations and Tank Farm areas (F- and H-Areas)
- Waste management areas (E-, S-, and Z-Areas)
- Heavy water reprocessing area (D-Area)
- Reactor materials area (M-Area)
- Administration and support areas (A- and B-Area)

REACTOR AREAS

C-, K-, L-, P-, and R-Areas contain the five nuclear production reactor facilities that once operated at SRS. The reactors were all placed in the interior of the site to create a buffer between the reactors and the public. All of the reactors have been placed in cold shutdown. Although the reactor areas are being used for storage of moderator and nuclear materials, no effort is being expended to maintain production restart capability of the reactors.

The nearest site boundaries to the centers of the reactor areas are as follows: C-Area 5.8 miles (9.3 km), K-Area 5.5 miles (8.9 km), L-Area 5.7 miles (9.2 km), P-Area 5.7 miles (9.2 km), and R-Area 4.9 miles (7.9 km) (Ref. 5). .

SEPARATIONS AND TANK FARM AREAS

The two separations areas, F and H, occupy 364 and 395 acres, respectively. F Area is undergoing decommissioning while H-Area operations primarily address the stabilization of radioactive waste, maintaining tritium stockpiles, and reprocessing highly enriched weapons grade material to lower enrichment levels.

F-Area is centrally located within the SRS boundary, near the center of SRS, east of Road C and north of Road E. The nearest site boundary to F-Area is approximately 6 miles (9.5 km) to the west. The two main processing facilities, F Canyon and FB Line, were contained in a single building composed of two chemical separations plants and associated waste storage facilities. In the past, the F Canyon was used to chemically separate uranium, plutonium, and fission products from irradiated fuel and target assemblies. The separated uranium and plutonium were transferred to other facilities for further processing and final use. The waste was transferred to high-level waste tanks in the area for storage. FB Line converted plutonium solution produced in F Canyon to plutonium-239 metal to support defense programs. Both of these facilities were shut down in 2004 – 2005. F-Area waste tank farm consists of 22 underground storage tanks that store high-level aqueous radioactive waste and evaporated saltcake.

F/H Analytical Laboratories is also located in F-Area (Buildings 772-F, 772-1F and 772-4F) and principally supports F- and H-Area reprocessing and waste activities through sample analysis services.

H-Area is also near the center of SRS, to the east of F-Area. The nearest site boundary to H Areas is approximately 7.2 miles (11.5 km) to the west. In the past, H Canyon, a large, shielded chemical separations plant, processed irradiated fuel and target assemblies by utilizing solvent extraction and ion exchange to separate uranium, plutonium, and fission products from waste. The facility's operations historically recovered uranium-235 (U-235), the fuel source for nuclear reactors, by a chemical separation process to recover and recycle usable U-235 from aluminum-based enriched-uranium fuel rods from site reactors and other domestic and foreign research reactors. The separated uranium and plutonium were transferred to other H-Area facilities for processing into a solid form. The waste was transferred to high-level waste tanks in the area for storage, and some of the nuclear materials were shipped to other DOE sites for final use. In addition, H Canyon was equipped with capabilities to recover neptunium-237 (Np- 237) and plutonium-238 (Pu-238) from the reactor fuel and special irradiated targets. H-Area operations are now primarily the stabilization of radioactive waste, maintaining tritium stockpiles, and reprocessing highly enriched weapons grade material to lower enrichment levels.

HB-Line was originally constructed to support the production of plutonium-238. Plutonium-238 has a unique combination of heat output and long life allowing space vehicle designers to keep weight at a minimum and still have a power supply. For example, in the mid-1990s, the HB-Line completed a production run to supply plutonium-238 for the Cassini mission, an unmanned expedition to the planet Saturn. HB Line currently has three process lines. The Scrap Recovery Line is used to recycle legacy plutonium scrap for purification and concentration to a solid form. This line is called Phase I. The Neptunium237/Plutonium-239 Oxide Line (Phase II) can produce solid oxide material from MP-237 or Pu-239 nitrate solutions. The Pu-238 Oxide Line (Pu-238) can produce Pu-238 oxide from nitrate solutions. There is no current mission for Phase III.

The Receiving Basin for Offsite Fuels (RBOF) is also located in H-Area. Offsite fuels that were to be processed in H Canyon were stored and packaged at RBOF. The facility has been shutdown with only minimal surveillance and maintenance activities currently being conducted.

The Effluent Treatment Facility (ETF) is located on the south side of H-Area. The ETF treats low-level radioactive wastewater (which was formerly sent to seepage basins). The ETF removes radioactive and nonradioactive contaminants, except tritium, from process effluents and allows the water to discharge to Upper three Runs Creek.

The H-Area waste tank farm consists of 29 large (up to 1.3 million gallon capacity) underground storage tanks that store high-level aqueous radioactive waste and evaporated saltcake. Seven of these tanks are now dedicated as In-Tank Precipitation Facility (ITPF) process tanks.

The Consolidated Incineration Facility (CIF) is located on the east side of H-Area. The CIF incinerated SRS hazardous, mixed, and low-level radioactive waste and is now shutdown.

The Tritium facilities are also located in H-Area and are designed and operated to process tritium, a radioactive form of hydrogen gas that is a vital component of nuclear weapons. Tritium is loaded into stainless steel containers and shipped to the Department of Defense, where the containers are installed in nuclear weapons. The Tritium Facilities consist of four main process buildings whose functions include reclamation of previously used tritium reservoirs, receipt, packaging and shipping of reservoirs, and the recycling and enrichment of tritium gas. A new facility, the Tritium Extraction Facility (TEF), came online in 2007, and processes Tritium Producing Burnable Absorber Rods (TPBARs) which have been commercially irradiated.

WASTE MANAGEMENT AREAS

The E-Area Solid Waste Management Facility (SWMF) occupies 195 acres between the F and H Separations Areas. E-Area is located in Aiken County, South Carolina, near the approximate center of SRS between H-Area and F-Area. The nearest site boundary to E-Area is approximately 6.5 miles (10.5 km) to the west.

The SWMF is used for disposal and/or storage of radioactive, hazardous, and mixed solid waste generated at SRS, as well as occasional special shipments from offsite. The SWMF also provides assaying, repackaging, and interim storage of transuranic (TRU) waste .

S-Area is located in Aiken County, South Carolina, north of H-Area and is the site of the Defense Waste Processing Facility (DWPF) Vitrification Plant. The nearest site boundary to S-Area is approximately 6.8 miles (10.9 km) to the north. The DWPF immobilizes high level radioactive waste sludge and precipitate by "vitrifying" it into a solid glass waste form.

Z-Area, which contains the Saltstone Facility, is located north of the intersection of Road F and Road 4. The nearest site boundary to A-Area is approximately 6.2 miles (10 km) to the north. The Saltstone Facility treats and disposes of the filtrate by stabilizing it in a solid, cement-based waste form.

HEAVY WATER REPROCESSING AREA (400-D AREA)

The 400-D Area occupies 445 acres and is located in Barnwell County, South Carolina, near the plant west boundary of SRS near the Savannah River. The nearest site boundary to D-Area is the Savannah River, approximately 1 mile (1.6 km) to the west.

D-Area originally consisted of a heavy water production plant, a moderator rework facility and an analytical laboratory. The facility was shut down in 1981 because of a sufficient supply of heavy water. A coal-fired power plant is also located in D-Area. This facility is the site's largest coal-fired powerhouse; it provides approximately 70 megawatts of electric capacity and 420,000 lb/hr of process steam capacity. The power plant is leased and operated by Washington Safety Management Solutions (WSMS).

REACTOR MATERIALS AREA (300-M AREA)

M-Area is located in Aiken County, South Carolina, near the plant north boundary of SRS immediately adjacent to the Savannah River National Laboratory (SRNL). The nearest site boundary to M-Area is approximately 0.8 miles (1.3 km) to the northwest.

M-Area was used to provide support to the reactor facilities, heavy water facilities, and the fuel fabrication facilities. The operations of these laboratories have been discontinued and the area is in the process of decontamination and decommissioning with most buildings having already been demolished and removed.

ADMINISTRATION AND SUPPORT AREAS (A AND B AREAS)

A-Area is located in the northwest portion of SRS. The 700-Area occupies 348 acres and the nearest site boundary is approximately 0.4 miles (0.67 km) to the northwest. General site administrative functions were once centered in A-Area but most have now been transferred to B-Area. The Savannah River National Laboratory (SRNL) remains in A-Area and supports the missions of SRS through applied research and development. SRNL is housed in buildings in the Technical Area, located in the upper 700-Area.

The Savannah River Ecology Laboratory (SREL), which is a research unit of the University of Georgia, is also located in A Area. SREL occupies or uses approximately 30 acres of land in A Area. Land use includes offices, laboratories, shops, greenhouses, ponds and research facilities. A description of their activities is provided in the following section.

DOE and WSRC headquarters are now located in B Area. B Area is also the location of many of the site support services (e.g., radiological, engineering), Soil and Groundwater and WSI.

Detailed maps of SRS and the various areas described in this report may be found in the CD (Computer Disk) which is contained within the site Environmental Report (Reference 5) and Appendix 4 of Ref. 6 (SCD-7).

MISCELLANEOUS SITE ACTIVITIES

Activities conducted within SRS that are not under the control of the operating contractor, WSRC, and not related to production, are performed by the following organizations:

SAVANNAH RIVER ECOLOGY LABORATORY (SREL)

SREL is funded primarily by the Department of Energy Environmental Management Division and conducts ecological studies on SRS. The mission of SREL is to study and assess the impact of site operations on the environment. Research programs are organized into four main categories; radioecology, environmental chemistry, ecotoxicology and ecosystem health. In addition to an administrative complex in A-Area, the Laboratory has 891 acres set aside in ten separate reserve areas for special studies.

UNIVERSITY OF SOUTH CAROLINA INSTITUTE OF ARCHAEOLOGY AND ANTHROPOLOGY

The mission of the University of South Carolina Institute of Archaeology and Anthropology is to make compliance recommendations to DOE that will facilitate the management of archaeological resources at SRS. This includes compliance activities involving reconnaissance surveys, general intensive watershed surveys, specific intensive surveys, data recovery, coordination with major land users, and reconstruction of the environmental history of the SRS.

The Institute occupies offices in Building 760-11G, and uses adjacent grounds in the SRFS area.

SOIL CONSERVATION SERVICE, U.S. DEPARTMENT OF AGRICULTURE

The mission of SCS is to publish a soils report of SRS that meets the standards of the National Cooperative Soil Survey. Current land use includes one office in Building 760-11G and the surrounding grounds.

GENERAL SERVICES ADMINISTRATION

The GSA is a federal agency that operates at SRS under a Memorandum of Agreement with DOE. The GSA SRS Field Office, located at SRS, is part of the South Carolina Fleet Management Center. GSA maintains the federal vehicle fleet from “cradle to grave,” including acquisition, maintenance, and disposal.

WACKENHUT SERVICES, INC.

WSI provides security services for SRS. These include preventing unauthorized access to site facilities, equipment, information, and personnel; restricting the impact of any unauthorized access on the site; badging; manning the various site access portals; and providing appropriate training for all security personnel.

WSI is headquartered in 700-B-Area and performs security activities for the entire site. WSI facilities and personnel are distributed throughout the site. In addition, WSI uses the Small Arms Training Area and the Advanced Tactical Training Area.

SAVANNAH RIVER FOREST STATION

SRFS, an administrative unit of the U.S. Forest Service (USFS) provides timber management, plant and wildlife management, secondary road maintenance, and maintenance of the exterior boundaries at the SRS. Their headquarters are located at the former U.S. Army anti-aircraft headquarters site, approximately 1.25 miles (2 km) south of the SRS barricade on SCR 19 (SRS Road 2). SRFS manages approximately 175,000 acres or about 80% of the site area. SRFS fire crews, which have primary responsibility for fighting wild fires and conducting controlled burns, coordinate their efforts with the WSRC Fire Department.

MISCELLANEOUS SITE FEATURES

SRS is a self-contained site that provides its own security, fire protection, medical, maintenance, and other services. To enhance the safety of the facility, a large support staff provides services such as radiological protection, industrial hygiene, and safety. In addition to the onsite resources, which include specialized equipment for tracking tritium releases, meteorological assessment systems, and monitoring equipment, a large supply of specialized equipment is available from regional DOE offices. State agencies in South Carolina and Georgia, VEGP, Fort Gordon, and other nearby sources can also provide monitoring equipment, medical facilities, and laboratory facilities in emergencies. In addition, several municipal emergency organizations are located within 25 miles of SRS (See Chapter 15.0 of this report).

ACCESS CONTROL

The outer perimeter of SRS is fenced and access is controlled by the operating contractor with the assistance of the security contractor, WSI. General access to the plant site, with the exception of public transportation corridors, is limited to badged personnel. Employee access requirements vary from area to area and access is generally restricted to employees who have the appropriate designation on their security badges. More restrictive individual facilities (e.g., H-Areas) may have additional access requirements. Visitors to SRS must wear identification badges, and those entering areas where there is a radiation hazard are required to wear dosimeters.

Public transportation corridors which pass through site property include (Fig. 1.3-2):

- SCR 125 which is a public access corridor which extends from near the town of Jackson to the Allendale barricade
- Road 1, which traverses the western end of the site from SCR19 near New Ellenton to SCR 125 near Jackson
- U.S. Rt 278, which crosses through the northern end of the site from near U.S. Rt. 78 (White Pond) to New Ellenton (SCR19)
- The CSX rail line also maintains a right-of-way through the site.

These corridors are normally unsecured areas of SRS with further entry into secured areas restricted by barricades. The roads and railroad that pass through the site can be blocked by WSI personnel or with the assistance of local, law enforcement personnel.

BOUNDARIES FOR ESTABLISHING EFFLUENT RELEASE LIMITS

The outer perimeter fence line of SRS is used as the basis for limits on the release to the public of gaseous and liquid effluents from all SRS facilities. The closest potential release points are M-Area, which is approximately 1 mile (1.6 km) from the outer perimeter boundary, and SRTC, which is about 0.5 mile (0.8 km) from the outer perimeter boundary. The 200-Areas, where Separations and Waste Management facilities are located, have the largest inventory of radioactive materials that could potentially be released, and are located greater than 5 miles (8 km) from the site boundary.

Onsite personnel are provided with dosimeters if they are entering potential radiation areas. Production areas enforce more stringent access controls, including special dosimeters and protective clothing, additional access authorization, and escorts for visitors. Dose equivalents to the general public and site personnel are kept As Low As Reasonably Achievable (ALARA). The limits for radiation exposure from external and internal exposure are stated in 10 Code of Federal Regulations (CFR) 835, Occupational Radiation Protection (Ref. 7). The 10 CFR 835 limit to radiation workers is 5 roentgens equivalent man (rem) total Effective Dose Equivalent (EDE). However, the DOE Administrative Control Level for a radiation worker is 2 rem/year total EDE. 10 CFR 835 further limits exposure of nonworkers, during onsite access at a DOE facility, to no more than 0.1 rem (100 mrem) per year. DOE Order 5400.5, Radiation Protection of the Public and the Environment, limits the exposure of members of the public to all radioactive sources from DOE activities to no more than 100 mrem EDE per year (Ref. 8).

EFFLUENT RELEASE POINT

The WSRC Environmental Protection Department maintains an active permit inventory for National Pollutant Discharge Elimination System (NPDES) permitted outfalls and permitted air emission sources. The annual Environmental Data Report contains a listing of NPDES outfall locations and the sources of wastewater contained in each effluent. The Annual Environmental Report for SRS contains an annually updated listing of all air permits held by SRS, including permit number, permit title, and permitted source (Ref. 5).

1.3.2 DEMOGRAPHY

OFFSITE POPULATION

DOE-STD-3009 (Ref. 1) states that the minimum demographics area which is required to be addressed is defined by the area significantly affected by the accidents analyzed in Chapter 3, “Hazard and Accident Analysis. SRS facility accident analyses conservatively evaluate offsite consequences at the site boundary. Minimum distances from production facilities to the site boundary may be found in Section 1.3.1.1 of this report.

Offsite demographics are used only for emergency preparedness and planning purposes. Additional information may be found in Chapter 15 of this Manual.

SITE POPULATION

The total onsite employment at SRS during the day shift of a weekday was approximately 12,000 as of November 2006. The distribution of onsite employees working the day shift on a weekday was estimated to be WSRC 10,000; DOE 320; WSI 820; and the rest in the USFS, SREL, and other contractors to DOE-SR.

A limited number of casual transient personnel can also be on site property at any time. Casual transients are people who travel through the site on private business. Primarily, the casual transient population consists of vehicle passengers traveling U.S. Route 278, SCR 125, SCR 19 via SRS Road 1; freight train personnel of the CSX Railroad. Due to their mobility and resultant limited time on site and the ability to close these routes on short notice in the event of an emergency, they are not considered as factors when performing accident analyses.

OFFSITE DEMOGRAPHICS

The outer perimeter fence line of SRS is conservatively considered as the basis for limits on the release to the public of gaseous and liquid effluents from all SRS facilities. Offsite demographics are therefore not relevant to accident analysis considerations. Offsite demographics are a major consideration for emergency preparedness; however, offsite response in the event of an emergency is the responsibility of the state. For further information, refer to the SRS Emergency Plan (Ref. 6).

USE OF NEARBY LANDS AND WATERS

Information regarding the use of land and waters outside the boundaries of the Savannah River Site is not provided in this document but may be found in Ref. 9 – 12.

1.4 ENVIRONMENTAL DESCRIPTION

This section is required to describe the site's meteorology, hydrology and geology.

1.4.1 METEOROLOGY

Information on SRS meteorological conditions is primarily taken from Hunter with supplemental data from the National Oceanic and Atmospheric Administration Local Climatological Data (Ref. 13 - 16).

REGIONAL CLIMATOLOGY

The SRS region has a humid subtropical climate, characterized by relatively short, mild winters and long, warm, and humid summers.

Summer weather usually lasts from May through September, when the area is subject to the influence of the western extension of the semipermanent Atlantic subtropical anticyclone (the "Bermuda high" pressure system). As a result, winds are generally light and weather associated with low pressure systems and fronts usually remain well to the north of the area. Because the Bermuda high is a persistent feature, there are few breaks in the summer heat. High temperatures during the summer months are greater than 90°F on more than half of all days (Ref. 13). The relatively high heat and humidity often result in scattered afternoon and evening thunderstorms.

The influence of the Bermuda high begins to diminish during the fall, resulting in drier weather and temperatures that are more moderate. Average rainfall for the fall months is lower than average for the other months of the year. Frequently, fall days are characterized by cool, clear mornings and warm, sunny afternoons. Average daily temperatures during the fall months range from a high of 76°F to a low of 50°F.

During the winter, migratory low pressure systems and associated fronts influence the weather of SRS. Conditions frequently alternate between warm, moist, subtropical air from the Gulf of Mexico region and cool dry polar air. Occasionally, an arctic air mass will influence the area; however, the Appalachian Mountains to the north and northwest of SRS moderate the cold temperatures associated with the polar or arctic air. Consequently, less than one-third of the winter days have minimum temperatures below freezing, and temperatures below 20°F are infrequent.

Spring is characterized by a higher frequency of occurrence of tornadoes and severe thunderstorms than the other seasons of the year. This weather is often associated with the passage of cold fronts. Although weather during the spring is variable and relatively windy, temperatures are usually mild.

LOCAL METEOROLOGY

DATA SOURCES

A number of sources of data are used to describe the local climatology. These include eight meteorological towers adjacent to the major operations areas onsite, the Central Climatology Meteorological Facility located near N-Area, a meteorological instrument shelter in A-Area, and the NWS office at Bush Field in Augusta, GA. Locations of the onsite towers are shown on Figure 1.4-1. The NWS office at Augusta is approximately 12 miles (19 km) west-northwest of SRS.

The eight area towers are equipped with fast-response cup anemometers, bi-directional wind vanes (bivanes), slow response resistance temperature probes, and lithium chloride dew point sensors at a height of 38 feet (61 meters) above ground. The Central Climatology Facility tower is equipped with identical instrumentation at elevations of 4, 18, 36, and 61 meters. Central Climatology is also equipped with instrumentation for measuring precipitation, evaporation, solar radiation, barometric pressure, and soil temperature. Data collected at the A-Area instrument shelter consist of temperature, daily precipitation, and relative humidity. Parker and Addis (Ref. 17) provide a computer description of SRS Meteorological Monitoring Program.

The current meteorological monitoring program at SRS meets or exceeds criteria in Environmental Regulatory Guide DOE/EH-0173T, Safety Guide 23 of the NRC, Guide 2.5 of the American Nuclear Society, and the Environmental Protection Agency (EPA), as reported by Parker and Addis (Ref. 17).

Temperature

Monthly and annual average temperatures for SRS for the 30-year period 1967-1996 are included in Table 1.4-1. At SRS, the annual average temperature is 64.7°F. July is the warmest month with an average daily high temperature of 92.1°F and an average minimum of 71.5°F. January is the coldest month with an average maximum temperature of 55.9°F and an average minimum temperature of 36.0°F. Observed temperature extremes for SRS over the period 1961-1996 ranged from 107°F to -3°F.

Data for Augusta, GA indicate that prolonged periods of cold weather seldom occur. Daytime high temperatures during the winter months are rarely below 32°F. Conversely, high temperatures in the summer months are above 90°F on more than half of all days. The average dates of the first and last freeze are November 12 and March 16, respectively (Ref. 16).

Humidity

Monthly and annual values of relative humidity for SRS (1967-1996) are given in Table 1.4-2. Average relative humidities are highest in August (ranging from an average of 97% in the morning to 50% in the afternoon) and lowest in April (ranging from an average of 88% in the morning to 36% in the afternoon).

Table 1.4-2 also summarizes monthly and annual average absolute humidities from the Central Climatology station for the 2-year period 1995-96. The annual average humidity was 11.1g/m^3. Monthly average values range from 18.4 g/m^3 in July to 6.0 g/m^3 in December and January (Ref. 14).

Precipitation

Annual average precipitation for SRS over the 30-year period 1967-1996 is 49.5 inches (see Table 1.4-3). Precipitation is fairly evenly distributed throughout the year. Average precipitation for the fall months (September, October, and November) is less than that for the other seasons, accounting for about 20% of the average annual total. For Augusta, precipitation totals greater than 0.01 inch occur on an average of about 108 days per year. The average number of days per month with measurable precipitation ranges from about 6 days in October to about 12 days in July (Ref. 16).

An average of about 54 thunderstorm days per year was observed in the SRS area during the period 1951-1995. Average thunderstorm days per month are listed in Table 1.4-4. Fifty percent of the annual average total occurred in June, July, and August. Thunderstorm occurrence was least frequent during the months of October through January, with an average of about one day per month observed (Ref. 13).

Hail may occasionally occur with thunderstorms. Based on observations in a 1-degree square of latitude and longitude that includes SRS, hail occurs once every 2 years on the average (Ref. 18).

The frequency of cloud-to-ground lightning strikes has been estimated using an empirical relationship described in Ref. 19. The number of flashes to earth per square kilometer was estimated to be ten per year. Measurements of cloud-to-ground lightning strikes recorded from the National Lightning Detection Network over the 5-year period 1989-1993 show an average of four strikes per square kilometer, per year in the SRS area (Ref. 20).

Monthly precipitation extremes for SRS range from a maximum of 19.62 inches, recorded in October 1990, to a trace observed in October 1963. The greatest observed rainfall for a 24-hour period was 7.5 inches in October 1990 (Ref. 21). Hourly observations at Augusta indicate that rainfall rates are usually less than 0.5 in./h, although rainfall rates of up to 2 in./h can occur during summer thunderstorms (Ref. 16).

Snow and ice storms in the region may occur. Snowfalls of 1 inch or greater occur once every 3 years on the average. The average annual snowfall for the SRS area (Augusta) for the period 1966-1995 was 1.1 in./year, and the average number of days per year with snow was 0.6 day. Any accumulation of snow rarely lasts for more than 3 days (Ref. 16). Significant snowfall is most likely to occur in February. For the reported period of record, snow has been observed during all of the months November through March.

The maximum ground snow load for the SRS area for a 100-year recurrence period is estimated to be about 5 lb.-force/ft^2 (Ref. 13).

For a 9-year period of record reported by Tattelman (Ref. 22), storms resulting in an accumulation of ice on exposed surfaces occurred in the SRS area an average of about once every 2 years. Average ice accumulations for various recurrence intervals for a region that includes SRS and consists of the Gulf Coast states are given in Table 1.4-5. The 100-year recurrence ice storm is estimated to produce an accumulation of approximately 0.67 inches

Extreme Precipitation

Maximum observed rainfall recorded at Augusta's Bush Field and the Columbia, SC, airport for various accumulation periods is summarized in Table 1.4-6 (Ref. 15, 21). These data were based on a 48-year period of record (1948-1995). Predicted rainfall extremes at SRS for durations from 15 minutes to 2 days and return periods from 10 to 100,000 years are summarized in Table 1.4-7 (Ref. 23, 24). The predicted values were generated from a Fisher –Tippett Type I or Type II extreme value distribution function using historical precipitation data from the SRS meteorological database and nearby NWS stations. Several significant rainfall events occurred at SRS in the summer and fall of 1990 (Ref. 21). Table 1.4-7 includes the observed rainfall totals from these storms that exceeded the predicted extreme rainfall values. Short duration extreme rainfalls are generally produced by spring and summer thunderstorms. Longer duration extreme rains are usually produced by remnants of tropical weather systems.

Tornadoes

Weber, et al, (Ref. 23) identified a total of 165 tornadoes occurring within a 2-degree square of latitude and longitude centered on SRS over a 30-year period 1967-96. Tornado occurrences by month and F-scale intensity category for this data set are summarized in Table 1.4-8. The F-scale intensity categories are defined in Table 1.4-9. About half of the total number of observed tornadoes occurred in the months of March, April, May, and November. However, tornadoes have been observed in the SRS region every month of the year. Based on these data, the average frequency of a tornado striking any point at SRS was estimated to be 2 x 10-4 per year, or approximately once every 5000 years. Predicted maximum tornado wind speeds (3-second gusts) at a given point for return periods up to 1 million years are summarized in Table 1.4-10. These data are presented as a general indication of tornadic wind hazards for the SRS region; hazards for specific facilities will vary depending on building size and geometry.

Nine tornadoes have occurred at or in close proximity to SRS since operations began in the 1950s. A tornado that occurred on October 1, 1989 knocked down several thousand trees over a 16-mile path across the southern and eastern portions of the site. Wind speeds produced by this F-2 tornado were estimated to be as high as 150 mph (240 km/h). Four F-2 tornadoes struck forested areas of SRS on three separate days during March 1991 (Ref. 25). Considerable damage to trees was observed in the affected area. The other four confirmed tornadoes were classified as F-1 and produced relative minor damage. None of the nine tornadoes caused damage to buildings.

Wind speeds for design of the facilities at SRS are specified in DOE-STD-1020-94 (Ref. 26).

Hurricanes

A total of 36 hurricanes have caused damage in South Carolina over the 290-year period from 1700-1992. The average frequency of occurrence of a hurricane in the state is once every 8 years; however, the observed interval between hurricane occurrences has ranged from 2 months to 27 years. The percentages of hurricane occurrences by month in South Carolina are given in Table 1.4-11. Approximately 80% of hurricanes in South Carolina have occurred in August and September.

Because SRS is approximately 100 miles (160 km) inland, winds associated with tropical weather systems usually diminish below hurricane force (sustained speeds of 75 mph (120 km/h) or greater). However, winds associated with Hurricane Gracie, which passed to the north of SRS on September 29, 1959, were measured as high as 75 mph (120 km/h) on an anemometer located in F-Area. No other hurricane-force wind has been measured on the site. On September 22, 1989, the center of Hurricane Hugo passed about 100 miles (160 km) northeast of SRS. The maximum 15-minute average wind speed observed onsite during this hurricane was 38 mph (61 km/h). The highest observed instantaneous wind speed was 62 mph (100 km/h). The data were collected from the onsite tower network (measurements taken at 200 feet [60 meters] above ground). Extreme rainfall and tornadoes, which frequently accompany tropical weather systems, usually have the most significant hurricane-related impact on SRS operations.

Other Extreme Winds

Extreme Winds in the SRS area, excluding tornado winds, are associated with tropical weather systems, thunderstorms, or strong winter storms. Extreme fastest 1-minute wind speeds for the 30-year period 1967-1996 are summarized in Table 1.4-12. The maximum 1-minute wind speed observed value since 1950 was 83 mph (133 km/h) in May 1950. The data in Table 1.4-12 are referenced to an anemometer height of 32.8 feet (10 meters) (Ref. 14).

Predicted maximum “straight-line” (non-tornadic) wind speeds (3-second gusts) for any point on the Site for return periods from 10 to 100,000 years are summarized in Table 1.4-10 (Ref. 23). The predicted values were generated from a Fisher-Tippet Type I extreme value distribution function using historical wind speed (gust) data from the SRS meteorological database and from nearby National Weather Service stations (Columbia, SC and Augusta, Macon, and Athens, GA). The 100-year 3-second wind speed was estimated to be 88 mph (141 km/h).

Low-Level Inversions

In 1961, Hosler analyzed 2 years of radiosonde and surface observations of the NWS to determine occurrence frequencies for low-level inversions in the U.S. Hosler's statistics show that inversions occur in the SRS area approximately 40% of all hours and 70% of all night hours (Ref. 27).

Pendergast analyzed temperature data collected from sensors located on multiple levels of the WJBF television tower for a 1-year period (1974) (Ref. 28). The WJBF tower is located approximately 9 miles (14 km) northwest of SRS. For approximately 30% of the time, an inversion extended through the entire 10- to 1,099-foot layer for which temperature measurements were made. For about 12% of the time, an inversion was observed through the upper portion of the 10- to 1,099-foot layer, and unstable conditions were observed through the lower portion. For about 9% of the time, the ground-based inversion layer height was less than the height of the tower. The latter two cases generally were found to represent the transition periods from night to day and from day to night, respectively.

Onsite Air Quality

The South Carolina Department of Health and Environmental Control (SCDHEC) regulates nonradioactive air emissions, both criteria pollutants and toxic air pollutants, from SRS sources. Each source is permitted by SCDHEC, with specific limitations identified, as outlined in various South Carolina air pollution control regulations and standards. Results of the most recent regulatory compliance modeling for SRS emissions are summarized in the SRS Annual Environmental Report (Ref. 5). A list of the SCDHEC-issued air quality permits and a description of the Airborne Emissions programs are in the SRS Annual Environmental Report.

Extreme Air Pollution Episodes

High air pollution potential in the southeastern U.S. is frequently associated with stagnating anticyclones (high pressure systems). According to routine radiosonde (upper air) data summarized by Holzworth, episodes of poor dispersion conditions in the SRS area lasted for 2 days on twelve occasions over a 5-year period (1960-1964) (Ref. 29). Episodes lasting at least 5 days occurred on two occasions. An episode is defined by mixing heights less than 5,000 feet (1,525 m) and average boundary layer wind speeds less than 9 mph (14.5 km/h). Results of a study reported by Korshover indicate that an average of two air stagnation episodes occurred in the SRS area each year over the 40-year period from 1936 to 1975 (Ref. 30). The total number of stagnation days averaged about 10 per year. Korshover defined stagnation days as conditions characterized by limited dispersion lasting 4 days or more.

Surface Wind Patterns and Dispersion Climatology

Wind rose plots for each of the eight SRS towers for the 1992 – 1996 timeframe are shown in Figures1.4-2 through 1.4-10. As indicated by these plots, there is no strongly prevailing wind direction at the Site. Northeasterly winds occurred approximately 10% of the time, and west to southwest winds occurred about 8% of the time. Winds at D-Area exhibited slightly higher frequencies of southeast and west-northwesterly winds due to the effects of the terrain that defines the Savannah River valley. Annual average wind speeds at each of the towers ranged from 9.4 mph (4.2 m/s) to 8.0 mph (3.5 m/s). Updated wind plots (as well as other meteorological data) may be obtained from the SRS Atmospheric Technologies Center.

The relative ability of the atmosphere to disperse air pollutants is commonly characterized in terms of Pasquill stability class. The Pasquill stability classes range from class A (very unstable conditions characterized by considerable turbulence producing rapid dispersion) to class G (extremely stable conditions with little turbulence and very weak dispersion). The percent occurrence of Pasquill stability class for each of the eight area towers is summarized in Table 1.4-13. Stable conditions were observed between 20 and 30 percent of the time during the aforementioned 5-year report. Wind rose plots by stability class for each tower are shown in Figures 1.4-2 through 1.4-10 (Ref. 15).

Mixing Height

The mixing height is the level of the atmosphere below which pollutants are easily mixed; it is often equal to the base of an elevated inversion. The following estimates of seasonally averaged morning mixing heights for SRS were interpolated from data presented in Holzworth (Ref. 29). The Holzworth data are derived from radiosonde observations during the 5-year period, 1960-1964.

	Mixing Height (meters)	
Season	Morning	Afternoon
Winter	1148	3362
Spring	1230	5576
Summer	1312	5904
Fall	984	4592
Annual	1230	4756

USE OF METEOROLOGICAL DATA

Meteorology data is used to estimate the meteorological dispersion of released materials. The methodology is discussed in DSA for the specific facility. A description of many of the calculational codes in use is given in the WSRC Environmental Dose Assessment Manual (Ref. 31).

1.4.2 HYDROLOGY

Note: This revision of the Site Characteristics and Program Descriptions DSA Support Document has been significantly reduced and provides a less detailed description of the surface hydrology than the previous revision. Additional references which can provide detailed information on hydrology of the Site may be found at the end of this section.

GENERAL

Much of SRS is located on the Aiken Plateau (Figure 1.4-11). The plateau slopes to the southeast approximately 5 feet per mile (1 m/km). The plateau is dissected by streams that drain into the Savannah River. The Savannah River Basin (see Figure 1.4-12) is one of the major river basins in the southeastern U.S. and is the principal surface-water system near SRS. It has a drainage area of 10,577 square miles, of which 8,160 square miles are upstream of SRS. The River Basin is located in three physiographic regions or provinces: the Mountain, the Piedmont, and the Coastal Plain.

The headwaters of the Savannah River are in the Blue Ridge Mountains of North Carolina, South Carolina, and Georgia. The river forms at the junction of the Tugaloo and Seneca Rivers approximately 100 miles northwest of SRS and empties into the Atlantic Ocean near Savannah, GA, approximately 95 miles southeast of SRS. From the Hartwell Reservoir Dam to the Savannah Harbor, the river runs a course of 289 river miles.

Three large reservoirs on the Savannah River upstream of SRS provide hydroelectric power, flood control, and recreation. Strom Thurmond Reservoir (2.51 million acre-feet), completed in 1952 is approximately 35 miles (65 river km) upstream of SRS. The Richard B. Russell Reservoir (1.026 million acre-feet), completed in 1984, is approximately 72 miles (103 river km) upstream of SRS. Hartwell Reservoir (2.549 million acre-feet), completed in 1961, is approximately 90 miles (133 river km) upstream of SRS (see Figure 1.4-13). These three dams are owned by the U.S. Army Corps of Engineers. The Stevens Creek Dam, also on the Savannah River, is owned by SCE&G.

Additional dams lie upstream of Hartwell Reservoir and are used primarily for hydroelectric power generation (see Figure 1.4-13). The Yonah, Tugaloo, Tallulah Falls, Mathis, Nacoochee, and Burton Dams are owned by Georgia Power Company, and the Keowee, Little River, and Jocassee Dams are owned by Duke Power Company. Although many of these dams impound water to depths in excess of 100 feet, only Jocassee Dam and the combined Little River-Keowee Dams impound significant quantities (approximately 1 million acre-feet each).

Upstream of SRS, the river supplies domestic and industrial water needs for Augusta, GA, and North Augusta, SC. The river receives treated wastewater from these municipalities and from Horse Creek Valley (Aiken, SC). VEGP withdraws an average of 92 cfs from the river for cooling and returns an average of 25 cfs. The Urquhart Steam Generating Station at Beech Island withdraws approximately 261 cfs of once-through cooling water. No uses of the Savannah River for irrigation have been identified in either South Carolina or Georgia.

SRS VICINITY

The Savannah River is about 340 feet wide and from 9 to 16 feet deep in the vicinity of SRS under normal conditions. The river is gauged above SRS near Augusta, GA (station 02197000), 0.5 mile downstream from Upper Three Runs Creek at Ellenton Landing (station 02197320), at Steel Creek (station 02197357), and below SRS at Burtons Ferry Bridge (station 02197500) and 3 miles north of Clyo, GA (station 02198500) (see Figure 1.4-12) (Ref. 32).

From SRS, river water usually reaches the coast in approximately 5 to 6 days, but can take as few as 3 days (Ref. 32). The average flow at Augusta, GA, since the filling of Thurmond Lake (Clarks Hill) has been 9,571 cfs (Table 1.4-14). Flows increase below Augusta, GA, to about 12,009 cfs near Clyo, GA, about 100 miles downriver (Table 1.4-14). The flow data used for computing statistics for the Savannah River and SRS streams were obtained from U.S. Geological Survey (USGS) stream measurement data. The data set consisted of daily average flows with varying periods of record (from 2 to 81 years) for SRS streams and the Savannah River.

The river overflows its channel and floods the swamps bordering the site when its elevation rises higher than 88.5 feet above msl (which corresponds to flows equal to or greater than 15,470 cfs). River elevation measurements made at the SRS Boat Dock indicate that the swamp was flooded approximately 20% of the time (74 days per year on the average) during the period from 1958 through 1967. The peak historic flow for the 81-year period of record was 350,021 cfs in 1929. The 7Q10 (7-day flow with a 10-year recurrence interval) flow at Augusta, GA, is 3,746 cfs. Since the construction of the upstream reservoirs, the maximum average monthly flow has been 43,867 cfs for the month of April. The minimum flow that is required for navigation downstream from Strom Thurmond Dam is 5,800 cfs. with river water typically reaching the coast in 3-5 days. Flow statistics are summarized in Table 1.4-14 (average flow, standard deviation, 7Q10, and 7-day low flow) and flow extremes are discussed in Section 1.5.1.

The major tributaries at SRS that flow to the Savannah River include Upper Three Runs Creek, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs Creek. Beaver Dam Creek, the smallest of the six SRS tributaries of the Savannah River, is located north of Fourmile Branch, primarily in the floodplain of the Savannah River. Tinker Creek and Tims Branch are tributaries of Upper Three Runs Creek; Indian Grave Branch is a tributary of Pen Branch. Each creek originates on the Aiken Plateau and descends 49 to 200 feet (15 to 61 meters) before discharging to the Savannah River. The interstream upland area is flat to gently rolling and is characterized by gently dipping units of sand, sandy clay, and clayey sand.

The Savannah River Swamp lies within the SRS floodplain for a distance of about 10 miles and averages about 1.5 miles wide. A small embankment or natural levee has built up along the north side of the river from sediments deposited during periods of flooding. The top of the natural levee is approximately 3 to 6 feet above the river during normal flow (river stage 85 feet) at the SRS boat dock. Three breaches in this levee (at the confluences with Beaver Dam Creek, Fourmile Branch, and Steel Creek) allow discharge of stream water to the river. During periods of high river level (above 88 feet), river water overflows the levee and stream mouths and floods the entire swamp area. The water from these streams mixes with river water and then flows through the swamp parallel to the river and combines with the Pen Branch flow. The flows of Steel Creek and Pen Branch converge 0.5 miles above the Steel Creek mouth. However, when the river level is high, the flows are diverted parallel to the river across the offsite Creek Plantation Swamp; ultimately they join the Savannah River flow near Little Hell Landing.

SRS was once a major user of water from the Savannah River but all SRS reactors are now shut down, and river water withdrawals are minimal. Past operations typically removed about 9% of the average annual Savannah River flow, but river water usage only averaged 0.133 cfs during the second quarter of 1995 (Ref. 33). Currently, one pump is operated to provide water from the Savannah River to the site (Pumphouse #3). It can supply up to 5,000 gallons per minute (gpm) which is typically more than is needed for system uses. The water is used to maintain the L Area fire system and L Lake levels, K Area stream outfall and as standby for maintenance of PAR Pond level (e.g., drought conditions) if needed. Two additional 30,000 gpm pumps are still operable if needed.

DOWNSTREAM

The Coastal Plain downstream of SRS has a negligible gradient ranging from an elevation of 200 feet to sea level. The soils of this region are primarily stratified sand, silts, and clays. The Coastal Plain contains 3,366 square miles (31%) of the total Savannah River drainage area (10,681 square miles), and includes the city of Savannah, GA. In the Coastal Plain, the Savannah River is slow moving. Tidal effects may be observed up to 40 miles (65 km) upriver, and a salt front extends upstream along the bottom of the riverbed for about 20 miles (32 km).

The Savannah River downstream from Augusta, GA, is classified by the State of South Carolina as a Class B waterway, which is suitable for agricultural and industrial use, the propagation of fish, and after treatment, domestic use. Three locations below the mouth of Upper Three Runs Creek pump raw water from the Savannah River for drinking water supplies. The Cherokee Hill Water Plant at Port Wentworth, GA (see Figure 1.4-12) can withdraw about 70 cfs for an effective consumer population of about 20,000. The Beaufort-Jasper Water Treatment Plant at Hardeeville, SC (see Figure 1.4-12) can withdraw about 12 cfs for a consumer population of approximately 51,000.

Use of impoundments on the Savannah River, including water contact recreation, is less extensive than it is upstream of SRS.

HYDROSPHERE – SAVANNAH RIVER SITE -AREAS

The location, size, shape, and other hydrological characteristics of streams, rivers, lakes, shore regions, and groundwater environments that influence the general site are described below.

Surface Waters

The source of most of the surface water on SRS is either natural rainfall, which averages 48 inches annually, water pumped from the Savannah River to facilities, or groundwater discharging to the surface streams.

PAR Pond

PAR Pond, the largest impoundment on SRS, is an artificial lake located in the eastern part of the site that covers approximately 2,700 acres. In 1995, DOE decided to allow the water level in Par Pond to fluctuate naturally near its operating level (200 feet above msl), but not allowing the water level to fall below 195 feet.

L Lake

A second large artificial impoundment, L Lake, lies in the southern portion of SRS and covers approximately 1,000 acres. It was decided to reduce the flow to L Lake so long as the normal operating level of 190 feet was maintained and the flow in Steel Creek (downstream of L Lake) was greater than 10 cfs (Ref. 34).

Water from both Par Pond (200 feet) and L Lake (190 feet) drains to the south via Lower Three Runs Creek and Steel Creek, respectively, into the Savannah River. Water is also retained intermittently in natural lowland and upland marshes and natural basins, some of which are Carolina bay depressions (Ref. 35, 36).

Upper Three Runs Creek

Upper Three Runs Creek is the longest of the plant streams. It drains an area of over 195 square miles and differs from the other five onsite streams in two respects. It is the only stream with headwaters originating offsite and it is the only stream that has never received heated discharges of cooling water from the production reactors. .

The Upper Three Runs Creek stream channel has a low gradient and is meandering, especially in the lower reaches. Its floodplain ranges in width from 0.25 to 1 mile and contains extensive stands (about 98% coverage) of bottomland hardwood forest (Ref. 37). Within SRS, the Upper Three Runs Creek valley is asymmetrical, having a steep southeastern side and a gently sloping northwestern side.

Upper Three Runs Creek is gauged near Highway 278 (station 02197300 relocated downstream), at SRS Road C (station 02197310), and at SRS Road A about 3 miles above the confluence of Upper Three Runs Creek with the Savannah River (station 02197315). The Highway 278 station is a National Hydrologic Benchmark Station. Benchmark streams are measured monthly for water flow, temperature, and quality to provide hydrologic data on river basins governed by natural conditions.

The average Upper Three Runs Creek flow at Highway 278 from 1966 to 1986 was 106 cfs, which represents a water yield of about 1.0 cubic feet per square mile or 16.55 inches/year from the drainage basin (Ref. 37). The average annual precipitation at SRS is 48.3 inches (Ref. 38). Thus, in the upper reaches of Upper Three Runs Creek, about 35% of the rainfall appears as stream discharge. Flow rates are also measured downstream of the Route 278 site at SRS Road C and at SRS Road A. Average daily flows were calculated to be 102, 203, and 251 cfs, respectively. The minimum daily flow rates recorded at these sites during this period were 45, 117, and 124 cfs, respectively.

Fourmile Branch

Fourmile Branch drains about 23 square miles within SRS, including much of the F, H, and C-Areas. The creek flows to the southwest into the Savannah River Swamp and then into the Savannah River. The valley is V-shaped, with the sides varying from steep to gently sloping. The floodplain is up to 1,000 feet wide. There is no human population resident in the Fourmile Branch drainage.

Fourmile Branch receives effluents from F, H, and C-Areas; and a groundwater plume from the burial ground, F Seepage Basin, and H Seepage Basin (use discontinued in November 1988). Until June 1985, it received large volumes of cooling water from the production reactor in C-Area. The creek valley has been modified by the cooling water discharge, which has created a delta into the Savannah River Swamp. Fourmile Branch also receives tritium and strontium-90 migrating from the F- and H-Area seepage basins and the SWMF.

Water flow measurements have been made on Fourmile Branch near Road A-12.2 at SRS (station 02197344) since November 1976. Mean monthly flows for water years 1986 and 1987, after C Reactor shutdown, ranged from 88 cfs in January 1986 to 17 cfs in August 1987 (Ref. 32, 39). Extreme flows for this period were 436 cfs (gage height 3.14 feet) on March 1, 1987, to 13 cfs on August 24-25 and 28-29, 1987. The maximum and minimum discharges for the period of record are 903 cfs (gage height 3.93 feet) on March 13, 1980, and 13 cfs on August 24-25 and 28-29, 1987, respectively (Ref. 32).

Beaver Dam Creek

Observations on the drainage topography of Beaver Dam Creek indicate that it was an intermittent flowing stream before SRS operation. The stream is located 1 to 2 miles west of Fourmile Branch and flows in a southwest direction from D-Area through the swamp to the Savannah River. Beaver Dam Creek received effluent from both the heavy water production plant and the coal-fired generating station until 1982. The heavy water production plant was placed on standby in 1982. Currently, Beaver Dam Creek receives cooling water from the coal-fired powerhouse located in D-Area, which provides electricity and steam for site use.

Since June 1974, a flow recorder (station 02197326) located 1 mile downstream from D-Area on Beaver Dam Creek has recorded a mean discharge of 86.7 cfs.

Pen Branch and Indian Grave Branch

Pen Branch follows a path roughly parallel to Fourmile Branch until it enters the Savannah River Swamp. The only significant tributary to Pen Branch is Indian Grave Branch, which flows into Pen Branch about 5 miles upstream from the swamp. Pen Branch enters the swamp about 3 miles from the Savannah River. It flows directly toward the river for about 1.5 miles, and then turns and runs parallel to the river for about 5 miles before discharging into Steel Creek at about 0.5 mile from its mouth. Pen Branch and Indian Grave Branch drain about 22 square miles of watershed upstream from the swamp. Pen Branch formerly received heat exchanger cooling water from K-Area and flow from Indian Grave Branch. Tritium migration from the K-Reactor containment basin outcrops into Indian Grave Branch.

Upstream of K-Area discharges, Indian Grave Branch flow averages only about 1 cfs, and Pen Branch proper is a small stream averaging 8 cfs.

Steel Creek

Steel Creek flows southwest for about 4.5 miles, then turns to flow almost due south for about 5.5 miles, and enters the Savannah River Swamp about 3 miles from the river. In the swamp, it is joined by the flow from Pen Branch and part of the flow from the Fourmile Branch/Beaver Dam Creek system. The drainage area of Steel Creek and its main tributary, Meyers Branch, is about 35 square miles. Steel Creek formerly received cooling water discharges from two reactors (L and P). The discharge of cooling water effluent from P-Reactor to Steel Creek was discontinued in 1963 when coolant supply for this reactor was switched to recirculated cooling water from Par Pond. Thermal discharge from L Reactor ceased in 1968, when the reactor was placed in standby condition. L Reactor was restarted in 1985 and shutdown in 1988.

The USGS maintains a continuous flow recorder on Steel Creek at Old Hattiesville Bridge (station 02197359), which is located about 0.5 mile upstream of the confluence with the onsite swamp. This station has since been moved to Road A (station 021973565). The mean discharge at this station is 54 cfs (Ref. 40).

Lower Three Runs Creek

Lower Three Runs Creek has the second largest watershed (about 178 square miles) of streams within SRS. The three main branches of the pond follow the former streambeds and drainage areas of the upper reaches of Lower Three Runs Creek and its tributaries, Poplar Branch and Joyce Branch. Below the dam, Lower Three Runs Creek flows in a southerly, then southwesterly course for about 20 miles to the Savannah River. Several small tributaries draining portions of SRS flow into the creek in its lower reaches.

Near its headwaters, two large impoundments, Par Pond and Pond B, have been formed by the construction of an earthen dam. The Par Pond impoundment covers 2,640 acres to an average depth of about 20 feet. The maximum depth near the dam is about 56 feet. Pond C, a 140-acre "precooler" body of water, is separated from Par Pond by a dam and is part of the P Reactor effluent canal system. Par Pond receives discharges from all storm sewer outfalls from the deactivated R-Area and from a few storm sewers in P-Area.

PAR Pond overflows to the Lower Three Runs Creek. In addition, about 5.3 cfs seeps through and under the dam to enter Lower Three Runs Creek. This seepage is usually several degrees cooler than the surface water in the pond during the summer months.

Savannah River Swamp

The floodplain swamp parallels the Savannah River for a distance of about 10 miles and averages about 1.75 miles in width. A small embankment or natural levee has built up along the north side of the river from sediments deposited during periods of flooding. On the SRS side of the levee, the ground slopes downward, is marshy, and contains large stands of cypress tupelo forest and bottomland hardwoods. During periods of high river level (about 88 feet above msl), river water overflows the levee and stream mouths and floods the entire swamp area, leaving only isolated islands. During extremely high water levels, these islands may also be inundated.

Beaver Dam Creek, Fourmile Branch, and Steel Creek have breached the natural levee and discharge directly to the Savannah River, near their points of entry to the river swamp. Pen Branch does not discharge directly to the river, but flows through the swamp and joins Steel Creek about 0.5 mile above the mouth of the stream. During swamp flooding, water from Beaver Dam Creek, Fourmile Branch, Pen Branch, and Steel Creek flows through the swamp parallel to the river and across the offsite Creek Plantation swamp. The flow recombines with the main flow of the Savannah River flow near Little Hell Landing.

Tims Branch

The Tims Branch drainage basin is about 22.5 square miles, most of which lies within SRS. Tims Branch is a tributary of Upper Three Runs Creek, and receives effluents from M-Area and SRNL. Releases to Tims Branch eventually flow downstream and enter Upper Three Runs Creek. The stream flow is to the south-southeast into Upper Three Runs Creek. It has a gradient ranging from 10 to 30 feet per mile. The valley is V-shaped, and the sides vary from steep to gently sloping. The floodplain is up to 1,000 feet wide. The drainage basin outside the SRS boundary includes areas of low density population and some farmland. For many years, Steed Pond was maintained; in recent years, DOE decided to not rebuild the failed dam structure on Steed Pond.

Mean annual flow on Tims Branch is 5.63 cfs just before discharging into Upper Three Runs Creek (Ref. 41).

McQueen Branch

McQueen Branch drains 4.4 square miles within SRS. McQueen Branch flows north into Tinker Creek, just above its intersection with Upper Three Runs Creek. The stream valley is V-shaped, with relatively steep sides (up to 100 feet high) and little floodplain. The hilltops within the drainage basin are gently sloping.

Stream flow measurements were taken in McQueen Branch from 1982 to 1984 as part of a hydrogeological study that included the effects of 48 storms (Ref. 42). Three of these storms produced runoff exceeding the 30 cfs capacity of a weir located downstream of the DWPF site (drainage area 3.47 square miles). The runoff included rainwater from H-Area, south of the DWPF site. The study indicated that the time lag between the beginning of a storm and an increased flow at the weir was usually less than 2 hours. The water-level rise generally took 1 to 3 hours to peak; the water-level decline took only slightly longer. Even the impact of large storms usually was gone within 2 to 3 days.

Crouch Branch

Crouch Branch drains 1.2 square miles within SRS. Crouch Branch flows northwest into Upper Three Runs Creek and has a topography similar to that of McQueen Branch. Flow determinations have not been made for Crouch Branch.

F- and E-Areas

F-Area is on a near-surface groundwater divide between Upper Three Runs Creek and an unnamed tributary of Fourmile Branch. The near-surface groundwater from the southern part of F-Area discharges to an unnamed tributary of Fourmile Branch, approximately 2,000 feet to the south. The near-surface groundwater from the northern part of F-Area discharges to one of many tributaries of Upper Three Runs Creek, approximately 1,500 feet to the north.

The F-Canyon building site is at an elevation of over 300 feet above msl. The nearest significant stream to F Canyon is Upper Three Runs Creek. It is located about 0.7 miles north and west of the F-Canyon facility. This creek flows at elevations below 150 feet. The mean annual flow at a gauging station approximately 3 miles from F-Canyon is 215 cfs. The measured maximum flow for the period 1974 to 1986 was about 950 cfs. Runoff from precipitation is diverted into storm sewers, then discharged to an unnamed tributary of Upper Three Runs Creek, which empties into the Savannah River.

E-Area SWMF is located on a water-table divide. The relatively level land and a cover growth of Pensacola Bahia grass effectively control surface erosion at the SWMF. Surface drainage ditches channels are cut to control the runoff of rainwater to provide further erosion control. From the original Solid Waste Storage Facility (Old Burial Ground), surface flow is southwest towards a small tributary of Fourmile Branch. Groundwater from the northeastern parts of the Solid Waste Disposal Facility (SWDF) and the Mixed Waste Management Facility (MWMF) flows toward the north-northwest. All drainage is to the Savannah River. Groundwater from the southwestern portions of SWMF and the MWMF flows toward the west-southwest. Groundwater under the northwestern parts of SWMF and the MWMF flows toward the west, and groundwater under the eastern portions of SWMF and the MWMF flows toward the east-southeast.

H- Area

H-Area is located near a water-table divide between Upper Three Runs Creek and Fourmile Branch. Near-surface groundwater from the southern part of H-Area discharges to an unnamed tributary of Fourmile Branch, approximately 1,000 feet south of H-Area. Near-surface groundwater from the northern part of H-Area discharges to one of two tributaries of Upper Three Runs Creek, which are approximately 1,500 and 4,000 feet north of H-Area, respectively. Runoff from precipitation is carried away from structures by natural contours or catch basins that divert water into the Upper Three Runs Creek watershed. Upper Three Runs Creek empties into the Savannah River.

S-, and Z-Areas

S- and Z-Areas are located on a local topographic high (minimum grade level 275 feet msl). S-Area is within the Savannah River drainage basin at the divide between Crouch Branch and McQueen Branch watersheds. Z-Area is located north of S-Area. Runoff from Z-Area is diverted indirectly to McQueen Branch. McQueen Branch drains into Tinker Creek near its junction with Upper Three Runs Creek, and Crouch Branch drains directly into Upper Three Runs Creek. All streams in the area are at substantially lower elevations than S and Z-Areas. Near-surface groundwater flows toward McQueen Branch, approximately 0.75 mile (1.2 km) to the northeast.

M-Area

M-Area is located on a hilltop at elevations ranging from 350 to 380 feet above msl. Surface drainage is to the east toward Tims Branch, which is located about 0.75 mile east of M-Area, and flows at elevations below 250 feet. Tims Branch flowed into an 11.2 acre impoundment called Steed Pond (until the dam barrier failed and was not repaired) about 1.25 miles southeast of M-Area before draining into Upper Three Runs Creek.

Runoff from M-Area that does not reach Tims Branch either infiltrates the soil or drains to the northwest into an unnamed, intermittent surface channel. This surface channel flows southward into the Savannah River Swamp. The western portion of M-Area drains into a small, unnamed, intermittent stream outside SRS. This stream flows around the northwest boundary of SRS and empties into a swamp near the Savannah River.

A-Area and the Savannah River National Laboratory

The 3/700-Areas are located on a hilltop at elevations ranging from 350 to 390 feet above msl. Surface drainage is away from the site with radial flow to the east toward Tims Branch. Tims about 1.25 miles southeast of the 3/700-Areas before draining into Upper Three Runs Creek. Process and non-process effluents are released to Tims Branch from the 3/700-Areas. Runoff from the 3/700-Areas that does not reach Tims Branch either infiltrates the soil or drains to the northwest into an unnamed, intermittent surface channel. This surface channel flows southward into the Savannah River Swamp.

D-Area

Beaver Dam Creek, which drains D-Area, also received a large portion of flow from Fourmile Branch when C Reactor was operating. Since C Reactor was shut down in June 1985, the flow from Fourmile Branch to Beaver Dam Creek ceased. Flow from D-Area, including effluents from power generating facilities, and miscellaneous operations, varies from 65 to 130 cfs. The Savannah River is approximately 0.75 mile (1.2 km) to the west. The water-table discharges to the Savannah River and to the nearby swamp.

CHEMICAL AND BIOLOGICAL COMPOSITION OF ADJACENT WATERCOURSES

This discussion has been deleted as it is non-relevant to accident analysis.

FURTHER INFORMATION

Additional detailed information on hydrology of the Site may be found in References 43 – 99.

1.4.3 GEOLOGY

DOE-STD-3009 (Ref. 1) requires this section to provide the geological information necessary to understand any regional geological phenomena of concern for facility operation, including the geologic history, soil structures and other aspects of the geologic character of the site.

The extensive level of detail pertaining to the geography of the Southeastern region of the United States which was originally provided in this document has been significantly reduced. This level of information was not considered necessary to conduct safety analysis of SRS nuclear facilities. In addition, the information is contained in referenced documents.

1.4.3.1 Regional Geology (320 km [200 mile] Radius)

Extensive information pertaining to the geology of the Southeastern section of the United States is documented in Ref. 100 – 381. An overview of geologic information pertaining to SRS follows.

REGIONAL PHYSIOGRAPHY

The site region, defined as the area within a 320-km (200-mile) radius of the center of SRS, includes parts of the Atlantic Coastal Plain, Piedmont and Blue Ridge physiographic provinces. SRS is located on the upper Atlantic Coastal Plain, about 50 km (30 miles) southeast of the Fall Line.

The Atlantic Coastal Plain extends southward from Cape Cod, Massachusetts, to south central Georgia where it merges with the Gulf Coastal Plain. The surface of the Coastal Plain slopes gently seaward. Colquhoun and Johnson (Ref. 100, 101) divided the South Carolina Coastal Plain into three physiographic belts: Upper, Middle, and Lower Coastal Plain. The Upper Coastal Plain slopes from a maximum elevation of 200 meters (650 feet) msl at the Fall Line to about 75 meters (250 feet) msl on its southeastern boundary (see Figure 1.4-11). Primary depositional topography of the Upper Coastal Plain has been obliterated by fluvial erosion. The Upper Coastal Plain is separated from the Middle Coastal Plain by the Orangeburg scarp, which has a relief of approximately 30 meters (100 feet) over a distance of a few miles. The Orangeburg scarp is the locus of Eocene, Upper Miocene, and Pliocene shorelines (Ref. 100, 101). The Middle Coastal Plain, separated from the Lower Coastal Plain by the Surry scarp, is characterized by lower elevations and subtle depositional topography that has been significantly modified by fluvial erosion. The Lower Coastal Plain is dominated by primary depositional topography that has been modified slightly by fluvial erosion.

Siple (Ref. 84) and Cooke (Ref. 102) previously divided the Upper Coastal Plain of South Carolina into the Aiken Plateau and Congaree Sand Hills. The Aiken Plateau, where SRS is located, is bounded by the Savannah and Congaree Rivers and extends from the Fall Line to the Orangeburg scarp. The plateau's highly dissected surface is characterized by broad interfluvial areas with narrow, steep-sided valleys. Local relief is as much as 90 meters (295 feet). The plateau is generally well drained, although many poorly drained sinks and depressions exist, especially on the topographically high (above 76 meters [250 feet] msl) “Upland unit”. The Congaree Sand Hills trend along the Fall Line northeast and north of the Aiken Plateau. The sand hills are characterized by gentle slopes and rounded summits that are interrupted by valleys of southeast-flowing streams and their tributaries. The site region contains Carolina bays.

The Piedmont province extends southwest from New York to Alabama and lies adjacent to the Atlantic Coastal Plain. It is the eastern-most physiographic and structural province of the Appalachian Mountains. The Piedmont is a seaward-sloping plateau whose width varies from about 10 miles (16 km) in southeastern New York to almost 125 miles (200 km) in North Carolina; it is the least rugged of the Appalachian provinces. Elevation of the inland boundary ranges from about 60 meters (200 feet) msl in New Jersey to over 550 meters (1,800 feet) msl in Georgia.

The Blue Ridge province extends from Pennsylvania to northern Georgia. It varies from about 48 km (30 miles) to 120 km (75 miles) wide north to south. Elevations are highest in North Carolina and Georgia, with several peaks in North Carolina exceeding 1,800 meters (5,900 feet) msl. Mount Mitchell, North Carolina, is the highest point (2,000 meters , 6,560 feet) msl in the Appalachian Mountains. The Blue Ridge front, with a maximum elevation of 1,200 meters (4,000 feet) msl in North Carolina, is an east-facing escarpment between the Blue Ridge and Piedmont provinces in the southern Appalachians.

SITE GEOLOGIC MAP

General geologic setting at savannah River site (40 km radius)

The 40-km (25-mile) radius study area is taken from DOE-STD-1022-94 as the area in which to conduct geoscience investigations to locate possible seismogenic sources and surface deformation or to demonstrate that such features do not exist.

The SRS is located on the Atlantic Coastal Plain, which is an essentially flat-lying, undeformed wedge of unconsolidated marine and fluvial sediments. The sediments are stratified sand, clay, limestone, and gravel that dip gently seaward and range in age from Late Cretaceous to Holocene. The sedimentary sequence thickens from zero at the Fall Line to more than 4,000 feet (1,200 meters) at the coast. The Coastal Plain section is divided into several rock-stratigraphic groups, based principally on age and lithology .

A geologic map of the SRS was completed by the USGS and provided to SRS in 1994 (Ref. 103) (see Figure 1.4-14).

1.4.3.2 Tectonic Features

DEFINITION OF PLATE TECTONICS

Plate tectonics is the concept that the earth's crust is broken into large blocks with portions of each block being continually renewed or destroyed. The theory integrates the concepts of rift zone/sea-floor spreading, continental collision/subduction zone, and seismic/volcanic zones into a unified theory. Plate tectonics within the 320-km (200-mile) radius of the SRS would provide the description of the major structural or deformational features of the region, as well as the origins, evolution, and interrelationship of these features.

The implementation of Natural Phenomena Hazards Mitigation requires that the tectonic elements of the site region should be understood and described in sufficient detail to allow an evaluation of the safety of a proposed or existing facility. The major issue with respect to the tectonic framework and site suitability is concern for tectonic features influencing the seismicity of the region.

Based on previous studies at SRS and elsewhere, there are no known capable or active faults within the 320-km radius of the site that influence the seismicity of the region with the exception of the blind, poorly constrained faults associated with the Charleston seismic zone (see Section 1.4.4).

CRUSTAL GEOMETRY OF THE REGION AND SRS AREA

Thickness of the Crust

Along continental margins the nature of the crust changes from continental-type crust to oceanic-type crust. Continental crust is generally thicker, less dense, and chemically distinct from ocean crust. The boundary at the base of either continental or oceanic crust also marks a fundamental change in physical parameters and is referred to as the Mohorovicic discontinuity. Density and P-wave velocity is significantly greater below this layer than above. In general, the thickness of continental crust thins from west to east across the eastern U.S. continental margin. The zone of transition from continental crust to oceanic crust is thought to underlie the offshore Carolina Trough and the Blake Plateau basin. This is a typical Atlantic-type margin showing the geometry of oceanic crust to the east and continental crust to the west. The Moho deepens from east to west from about 15 km (9 miles) to about 40 km (25 miles), respectively. The continental crust along the margin has been extended and intruded during Mesozoic rifting and is described as rift stage crust. Further east in the middle of the cross section is a complicated zone of transition from continental crust to oceanic crust. The data that support this interpretive model come largely from seismic reflection and refraction surveys and potential field surveys. Offshore South and North Carolina show a similar geometry of thinning crust.

From seismic reflection data collected at SRS, the crust is interpreted to be about 30.0 to 31.5 km (18.6 to 19.6 miles) in depth. Crustal thickness changes along a survey from SRS southeast to Walterboro, SC. They find a crust that thins from 37 km (23 miles) beneath the Dunbarton basin to 32 km (19.9 miles) near Walterboro, SC. This interpretation is based on long seismic refraction and wide-angle seismic reflection data and constrained by gravity and aeromagnetic data. The effect of continental extension and thinning during the Mesozoic rifting event is thus observed in the configuration of the Moho as well as the geologic evidence from the existence of the Dunbarton basin.

TECTONIC STRUCTURES: FAULTING, FOLDING, AND RIFT BASINS

Tectonic structures of interest in the SRS region include faults, folds, arches, basins (rift and post-rift) and paleoliquefaction features from earthquakes. At this time, there are no faults classified as active or capable at SRS.

1.4.4 SEISMOLOGY

1.4.4.1 Earthquake History of the General Site Region

This section includes a broad description of the historic seismic record (non-instrumental and instrumental) of the southeastern U.S. and SRS. Aspects that are of particular importance to SRS include the following:

- The Charleston, SC, area is the most significant seismogenic zone affecting the SRS.
- Seismicity associated with the SRS and surrounding region is more closely related to South Carolina Piedmont-type activity. This activity is characterized by occasional small shallow events associated with strain release near small scale faults, intrusive bodies, and the edges of metamorphic belts.

HISTORIC RECORD

The earthquake history of the southeastern U.S. (of which the SRS is a part) spans a period of nearly three centuries, and is dominated by the catastrophic Charleston earthquake of August 31, 1886. The historical database for the region is essentially composed of two data sets extending back to as early as 1698. The first set is comprised of pre-network, mostly qualitative data (1698-1974), and the second set covers the relatively recent period of instrumentally recorded or post-network seismicity (1974-present). Table 1.4-15 lists significant pre-network earthquake locations within 200 miles (327 km) of SRS.

The information chronicled on pre network earthquakes within the Southeast and the SRS region consists of intensity data. Intensity refers to the measure of an earthquake's strength by reference to "intensity scales" that describe, in a qualitative sense, the effects of earthquakes on people, structures, and land forms. A number of different intensity scales have been devised over the past century, but the scale generally used in North America and many other countries is the modified Mercalli (MMI) Scale (Table 1.4-16). Using this intensity scale, it is possible to summarize the macroseismic data for an earthquake by constructing maps of the affected region that are divided into areas of equal intensity. These maps are known as isoseismal maps. It was through construction of isoseismal maps that epicenters of pre-network earthquakes were located at or near centers of areas experiencing highest ground shaking intensity. There is considerable uncertainty (up to several tens of miles) in locating the epicenters with this method because it depends heavily upon population density of the region in which the earthquake occurred.

Today seismic monitoring results from all southeastern seismic networks are cataloged annually in the Southeast U.S. Seismic Network bulletins.

The Charleston, SC, area is the most significant source of seismicity affecting SRS, in terms of both the maximum historical site intensity and the number of earthquakes felt at SRS. The greatest intensity felt at the SRS has been estimated at MMI VI-VII and was produced by the intensity X earthquake that struck Charleston, SC, on August 31, 1886, at 9:50 p.m. local time. An earthquake that struck Union County, South Carolina (about 100 miles [160 km] north-northeast of SRS), on January 1, 1913, is the largest event located closest to SRS outside of the Charleston area. It had an intensity greater than or equal to MMI VII. This earthquake was felt in the Aiken-SRS area with an intensity of MMI II-III. Several other earthquakes, including some aftershocks of the 1886 Charleston event, were felt in the Aiken-SRS area with intensities estimated to be equal to or less than MMI IV.

Several large earthquakes outside the region were probably felt at SRS, including the earthquake sequence of 1811 and 1812 that struck New Madrid, Missouri (about 535 miles west-northwest of SRS) and the earthquake that struck Giles County, Virginia (about 280 miles north of SRS), on May 31, 1897. Bollinger et al. (Ref. 104) judged the temporal completeness of the existing earthquake catalog to be complete for recent network data to mb = 2.5, historical period between 1939 and 1977 complete to mb = 4.5 and the historical period between 1870 and 1930 to mb = 5.7 level.

SRS ACTIVITY (WITHIN 50 MILE RADIUS)

The SRS is located within the Coastal Plain physiographic province of South Carolina. However, seismic activity associated with SRS and the surrounding region displays characteristics more closely associated with the Piedmont province, that is, a marked lack of clustering in zones. The activity is more characteristic of the occasional energy strain release occurring through a broad area of central Piedmont of the state.

A description of each historical event is presented below.

1897, May 06, 24, and 27 (1,3,4):

These three small earthquakes were reported to have occurred around the farming community of Blackville, SC. They were lightly felt by residents of the town and surrounding farms. No intensity values have been assigned to these events as they have only been mentioned as being felt (Ref. 105). When researching local newspapers of the area, the only reference found to any of these small events appeared as a small sentence in the May 13 issue of the Barnwell People from Blackville, which said, "Quite an earthquake shock was felt here on last Friday evening at 8:10." No mention of the 24th or 27th events was found in newspapers published shortly following those dates.

1897, May 09 (2):

This has been documented as a small "lightly" felt event in the area of Batesburg, SC (Ref. 105). No intensity values have been assigned to this event.

1945, July 26:

This event was felt most in the Columbia and Camden, SC areas. Historically it has been more closely associated with Lake Murray, near Columbia, SC. However, Dewy (Ref. 106) relocated it using some instrumental recordings at regional and teleseismic distances. Dewy's relocation moved the epicenter some 50 km to an area southwest of Columbia and to within the 80-km radius of interest for this study. This location, though instrumental, seems extremely questionable. An isoseismal map for this event prepared by Vivanathan ((Ref. 105) defined the area of greatest intensity (VI) to be near Camden, SC. Newspaper reports from Aiken, Columbia and Camden, SC the day following the event tend to confirm this original location. In this case, the location indicated from the intensity felt reports is favored over the Dewy instrumental location.

1972, August 14 (5):

Felt reports for this earthquake were reported at Barnwell, Bowman, Cordova, Horatio, North, Springfield, and Summerton, SC with an intensity of between I and III (Ref. 105). Location of this earthquake also seems tenuous. Although the event was instrumentally located, the location can only be assumed approximate because the nearest station was over 100 km northeast of the computed epicenter. It may possibly have occurred closer to the Bowman area and outside the area of interest for this study.

1974, October 28 (6), and November 5 (7):

These two events were estimated to have occurred in McCormick and southern Edgefield counties, South Carolina. Magnitudes of 3.0 and 3.7 respectively were assigned on the basis of felt reports collected at the time. An isoseismal map constructed by Talwani (Ref. 107) for the October event shows an elongated isoseismal roughly following the Fall Line with a maximum felt intensity of III-IV. No instrumental locations are available for either of these events.

INSTRUMENTAL RECORD (POST-NETWORK SEISMICITY)

By the middle of the 20th century, instrumental recordings from a few regional seismographic stations (less than ten for the entire southeastern U.S.) reduced uncertainty in locating epicenters to fewer than 10 miles (16 km). However, it was not until the early 1970s that the detection and location of earthquakes in the region greatly improved with the installation of seismic networks in South Carolina as well as other regions of the eastern U.S.

The seismic network in the region currently consists of some 28 stations strategically located throughout the state. By 1976, a three-station short-period vertical component network was also established at SRS to monitor potential earthquake activity near the SRS. A fourth station, consisting of a vertical and two horizontal instruments, was added to the network in 1986.

SMA NETWORK

Ten new SMAs have been installed in selected mission-critical structures at foundation level, other selected elevations and in the free-field. In the event of an earthquake of sufficient size to trigger the installed instrumentation, free-field instrumentation data will be used to compare measured response to the design input motion for the structures and to determine whether the OBE has been exceeded. The instruments located at the foundation level and at elevation in the structures will be used to compare measured response to the design input motion for equipment and piping, and will be used in long-term evaluations. In addition, foundation-level instrumentation will provide data on the actual seismic input to the mission critical structures and will be used to quantify differences between the vibratory ground motion at the free-field and at the foundation level.

A-Area	(1) One free-field SMA is located on floor of seismic laboratory.
F-Area	(2) One SMA is located in close proximity to top of tanks in F-tank farm. (3) One SMA is located at foundation level in F-Canyon.
H-Area:	(4,5) Two SMAs are located near H-Tank farm. One at the top of the tanks and one at the bottom. (6,7) Two SMAs are located at H-Canyon. One at elevation on the roof and one at the foundation level. (8) One SMA is located in Replacement Tritium Facility (RTF) at foundation level
K-Area	(9) One SMA is located in K-Reactor building at foundation level
L-Area1	(10) One SMA is located in L-Reactor building at foundation level.
S-Area	(11) One SMA is located at Defense Waste Processing Facility (DWPF)
Other	Two additional SMAs are located in remote field locations at: (12) PAR Pond and (13) Gun Site 51

SHORT-PERIOD SEISMIC MONITORING NETWORK (1991-PRESENT)

From 1991 to the present, the following short-period instrumentation has been operated and maintained onsite:

- Vertical short-period digital seismic array. This consists of geophones (sensors) placed at different levels within a deep borehole located near the center of SRS to monitor effects of soil column for engineering analysis and design.
- Seven-station continuous-recording short-period telemetered seismic monitoring network for location and depth determination of locally occurring seismic activity.

Magnitudes are more quantitative estimates of an earthquake's size using instrumentally recorded data. They are based on the amplitude of motion on a standard instrument (seismograph) normalized to account for the separation of the instrument and the earthquake. With the advent of modern seismic network installation, it was possible to estimate local magnitudes from collected data. .

The largest felt event to have occurred within a 50-mile radius of SRS is the August 8, 1993 (09:24 UCT, 5:24 a.m. EDST), Couchton earthquake near Aiken, SC (approximately 40 miles [65 km] north of SRS). It was widely felt throughout the region in Williston, New Ellenton, and the SRS. The MMI intensity for this event was estimated at IV-V with a duration magnitude of 3.2. No alarms were triggered. The location of this event plotted on the flanks of a localized gravity low indicating relation to Piedmont-type activity associated with the boundary of a buried intrusive rather than a large-scale regional feature.

SRS, ON-SITE EARTHQUAKE ACTIVITY

Three earthquakes of MMI III or less have occurred with epicentral locations within the boundaries of SRS. On June 9, 1985, an intensity III earthquake with a local duration magnitude of 2.6 occurred at SRS (Ref. 108, 109). Felt reports were more common at the western edge of the central portion of the plant site. Another event occurred at SRS on August 5,1988, with an MMI I-II and a local duration magnitude of 2.0. A survey of SRS personnel who were at the plant during the 1988 earthquake indicated that it was not felt at SRS (Ref. 110). Neither of these earthquakes triggered the seismic alarms (set point 0.002g) at SRS facilities (Ref. 109, 110). These earthquakes were of similar magnitude and intensity as several recent events with epicenters southeast of SRS (Table 1.4-17).

On the evening of May 17, 1997, at 23:38:38.6 UTC (7:38 pm EDST) an MD ~ 2.3 (Duration Magnitude) earthquake occurred within the boundary of the Savannah River Site. It was reported felt by workers in K-Area and by Wackenhut guards at a nearby barricade. An SMA (strong motion accelerograph) located 3 miles southeast of the epicenter at GunSite 51 was **not** triggered by the event. The SMA located approximately 10 miles (16 km) north of the event in the seismic lab building 735-11A was **not** triggered. The closest instrument to the epicenter (GunSite 51) is set at a trigger threshold of 0.3% of full scale where full scale is 2.0g (0.006g). The more distant lab SMA is set to trigger at a threshold of 0.1% of full scale where full scale is 1.0g (0.001g).

1.4.4.2 Development of Design Basis Earthquake

This section describes the basic approach to the development of the Design Basis Earthquake (DBE) spectra for the SRS. Probabilistic hazard, deterministic ground motion prediction methodologies, and the DBE history for the SRS are described.

For engineering design of earthquake-resistant structures, empirically derived seismic response spectra are most commonly used to characterize ground motion as a function of frequency. These motions provide the input parameters used in the analysis of structural response and/or geotechnical evaluation. Response spectra are described in terms of oscillator damping, amplitude, and frequency and are defined as the maximum earthquake response of a suite of damped single degree-of-freedom oscillators. The response spectra are related to earthquake source parameters, the travel path of the seismic waves, and local site conditions.

Over the last two decades, SRS response spectra have evolved from the use of a single scaled record of a western U.S. earthquake to a composite spectra that may represent the response of more than one earthquake. In the latter approach, controlling DBEs represent a suite of earthquake magnitude and distance pairs that provide the maximum oscillator response in discrete frequency bands. The basis for controlling earthquakes is derived from detailed geologic and seismologic investigations conducted in accordance with 10 CFR 100 Appendix A and taking into consideration proposed changes as described in Draft 10 CFR 100, Appendix B. This approach is typically labeled the “deterministic” approach. The primary disadvantage of this approach is that the selection of controlling earthquakes does not explicitly incorporate the rate of seismicity or the uncertainty in earthquake source parameters and ground motion.

An important alternative to the deterministic approach is the Probabilistic Hazards Assessment (PHA). The PHA incorporates the source zone definition and ground motion prediction assessments required for the deterministic approach, but also considers the estimated rates of occurrence of earthquakes, and explicitly incorporates the uncertainties in all parameters. This approach predicts the probability of exceeding a particular ground motion value at a location during a specified period of time. This approach is essential for hazard mitigation of spatially distributed facilities having different risk factors. The current DOE criteria are probabilistic based.

For SRS, design spectral shapes are employed for earthquakes of different magnitudes and travel paths. Over the years, several different principal spectra have been developed for the SRS using deterministic methodologies or combinations of deterministic methodologies.

Current design basis spectra are based on a hybrid of deterministic and probabilistic approaches. Some analyses (e.g., RTF and H-Area facilities) have required site-specific design basis motion for determination of liquefaction susceptibility and structural integrity.

CRITERIA

Earlier estimates of ground motion for SRS critical facilities have generally adopted U.S. NRC regulatory guidance provided in 10 CFR 100, Appendix A. This deterministic guidance was applied, for example, at K-Reactor. Seismic design criteria for nonreactor DOE facilities are contained in DOE Order 420.1 and DOE-STD-1020-94 and DOE-STD-1024-92. However, the more recent seismic evaluations have employed the probabilistic guidance contained in DOE-STD-1024-94 and DOE-STD-1023-95. Additionally, criteria can be found in DOE STD-1022-94.

DOE Order 420.1 provides requirements for mitigating natural phenomena hazards that include seismic, wind, flood, and lightning.

DOE-STD-1020-94 defines the performance goals for seismic, wind, tornado, and flood hazards.

DOE-STD-1021-93 provides guidelines for selecting performance categories of SSCs for the purpose of Natural Phenomena Hazard (NPH) design and evaluation. This standard recommends general procedures for consistent application of DOE's performance categorization guidelines.

DOE-STD-1020-94 and DOE-STD-1024-92 require the use of median input response spectra that are determined from site-specific geotechnical studies and anchored to Peak Ground Accelerations (PGAs) determined for the appropriate facility-use annual rate of exceedance. Guidance regarding the specific characterization of seismic hazard is found in the Systematic Evaluation Program guidance and DOE-STD-1022-94.

DOE-STD-1024-92 was an interim standard that requires that deterministic and probabilistic methodologies be used for hazard evaluation, and superseded by DOE-STD-1023-95. The guidelines for probabilistic hazard analyses are: (1) sites can use a combined Electric Power Research Institute (EPRI) and Lawrence Livermore National Laboratory (LLNL) result if applicable, or (2) complete a new estimate using site-specific data including definition of source zones, earthquake recurrence rates, ground motion attenuation, and computational methodologies that are spelled out in the Systematic Evaluation Program.

DOE-STD-1023-95 provides guidelines for developing site-specific probabilistic seismic hazard assessments, and criteria for determining ground motion parameters for the design earthquakes. It also provides criteria for determination of design response spectra. Five performance categories are specified, from Performance Category 0 (PC0) for SSCs that require no hazard evaluation, to design of PC4, a desired performance level comparable to commercial nuclear power plants. These criteria address weaknesses in prior guidance by specifying Uniform Hazard Spectrum (UHS) controlling frequencies, requiring a site-specific spectral shape and a historic earthquake check, to assure that the DBE contains sufficient breadth to accommodate anticipated motions from historic earthquakes above moment magnitude (Mw) 6.

The fundamental elements of the criteria for higher hazard nuclear facilities (PC3 and PC4) are as follows:

1. A probabilistic seismic hazard assessment (PSHA) must be conducted for the site (or use an existing PSHA that is less than 10 years old).

2. A target DBE response spectrum is defined by the mean UHS.

3. Mean UHS shapes are checked by median site-specific spectral shapes, which are derived from de-aggregated PSHA earthquake source parameters. The median site-specific spectral shapes are scaled to the UHS at two specific frequencies (average 1-2.5, and 5-10 Hz).

4. Estimated site-specific ground motions from historical earthquakes (significant felt or instrumental with Mw > 6) are developed using best estimate magnitude and distance.

5. Spectral shapes are adjusted until DBE response spectra have a smooth site-specific shape.

6. Probabilistic assessment of ground failure should be applied if necessary (i.e., wherever there may be instances of liquefaction or slope failure).

More recently, NEHRP-97 (Ref. 111) criteria were adopted by WSRC and DOE for evaluation of spectra for PC1 and PC2 facilities and structures (Ref. 112). DOE-STD-1023-95 (Ref. 113) allows the use of building codes and/or alternate design criteria for PC1 and PC2 design. The NEHRP design criteria is defined as 2/3 of the maximum considered earthquake ground motion (i.e., 2/3 of the 2500-year UHS).

<u>HISTORICAL PERSPECTIVE ON DESIGN BASIS EARTHQUAKES AT THE SAVANNAH RIVER SITE</u>

Because maximum potential causative fault structures within the Coastal Plain, Piedmont, and Blue Ridge provinces are not clearly delineated by lower-level seismicity or geomorphic features, past regulatory guidance prescribes the use of an assumed local earthquake. The magnitude/intensity is conservatively assumed to be a repeat of the largest historic event in a given tectonic province located at that province's closest approach to the site. Application of this guidance has resulted in the definition of two controlling earthquakes for the seismic hazard at SRS. One earthquake is a local event comparable in magnitude and intensity to the Union County earthquake of 1913 but occurring within a distance of about 25 km (15 miles) from the site. The other controlling earthquake represents a potential repeat of the 1886 Charleston earthquake. Selection of these controlling earthquakes for design basis spectra has not changed significantly in over 20 years. However, the assumed maximum earthquake moment and magnitude estimates have increased in the more recent assessments of the 1886 Charleston earthquake. In addition, the assumed distance to a repeat of the 1886 Charleston-type earthquake has slightly decreased.

Until the late 1980s, investigations performed for the NRC focused on the uniqueness of the location of the Charleston earthquake, due to a lack of knowledge of a positive causative structure at Charleston. At issue was the possibility of a rupture on any one of the numerous northeast-trending basement faults located throughout the eastern seaboard. Further, there were no obvious geomorphic expressions that might suggest large repeated faulting.

Evidence that defines the Charleston Seismic Zone (CSZ) is as follows:

- The detailed analyses of isoseismals following the 1886 Charleston earthquake (Ref. 114, 115).
- Instrumental locations and focal mechanisms of seismicity defining the 50-km long Woodstock fault lineament, which closely parallels the north-northeast trending Dutton isoseismals
- The remote-sensed 2.5-meter high, 25-km long lineament that also parallels the Woodstock fault (Ref. 116, 117).

Paleoliquefaction investigations along the Georgia, North and South Carolina coasts (Ref. 118, 119) have identified and dated multiple episodes of paleoliquefaction that have constrained the latitude of the episodes. Crater frequency and width are greatest in the Charleston area, and decrease in frequency and width with increased distance along the coast, away from Charleston. This evidence led the NRC in 1992 to its position that a repeat of the Charleston earthquake was assumed to be restricted to the Charleston, Middleton Place region. NRC guidance for the nearby VEGP commercial nuclear power plant has, therefore, been based on an assumed recurrence of the 1886 Charleston earthquake in the Summerville-Charleston area (Ref. 120). Sporadic and apparently random low level seismicity is characteristic of the Coastal Plain and Piedmont geologic provinces (excepting clusters of seismicity in Bowman and Middleton Place). Regulatory guidance has prescribed a design basis local event to occur at a random location within a specified radius of the site.

The length of the 1886 Charleston seismogenic zone was estimated as 50 km based on the elongation of the highest intensity isoseismal and on the length and location of the inferred Woodstock fault as determined by instrumental location and mechanisms of earthquakes (Ref. 114, 116). A displacement of 200 cm was estimated for the Charleston event based on the source dimension and the seismic moment. The source mechanism was assumed to be similar to the mechanisms recorded along the Woodstock fault: steeply dipping right lateral strike-slip fault oriented N10°E.

The estimated PGAs for postulated maximum events were based on the following:

- A local earthquake of MMI VII as a maximum credible earthquake (MCE) for the Atlantic Coastal Plain.
- A Fall Line event, MMI VIII with distance > 45 km, is an MCE for the Piedmont.
- A Middleton Place event of MMI X, a repeat of the Charleston 1886 earthquake
- A Bowman seismicity zone MMI X event, which is considered to be an extremely unlikely occurrence of a 1886 type-event at closest credible distance of 95 km.

Blume applied a confidence margin of one intensity unit to the estimates in Table 1.4-18, resulting in a site intensity of VIII with a corresponding doubling of the estimated PGA (to 0.2g). Using the PHA, Blume noted that a doubling of the PGA results in an approximate order of magnitude smaller probability of exceedance.

Local and distant earthquake response spectral shapes were derived from statistical analysis of primarily western U.S. (western) data. The recommended response spectra were computed from the envelope of the mean spectral shapes.

For the 1993 liquefaction studies at RTF, the design basis envelope spectra contained in the Blume report were not recommended because the spectra were not representative of a specific earthquake (Ref. 121). Seismic hazard results show that the site can be characterized by local events with R <25 km, controlling the PGA. Larger events, at some distance from the site, controlled peak ground velocity at SRS. These results compared favorably with the deterministic analyses performed for the site by Blume and Geomatrix (Tables 1.4-18 and 1.4-19).

The controlling earthquakes used in the liquefaction study at RTF were selected to be consistent with the DOE probabilistic acceptance criteria (Ref. 121). A spectral shape was taken from the local event spectra developed for K-Reactor (Ref. 122). The distant event spectra were recommended unscaled . The results were then compared to the past deterministic study of Blume and the disaggregated LLNL and EPRI hazard analyses. Induced stresses were calculated for the liquefaction analysis based on the two controlling earthquakes. Separate analysis is warranted based on the difference in shape of the two spectra.

The RTF spectra were later named the Evaluation Basis Earthquake (EBE), and used to support initial geotechnical evaluations for the ITPF and H-Area Tank Farms. The EBE spectra were used until site-specific spectra could be developed to judge adequacy. The EBE spectra, which account for local and distant earthquakes, were consistent with DOE criteria, and were used for the initial geotechnical evaluation.

WSRC (H-AREA SPECTRUM)

Following initial site-specific evaluations done for the ITPF and H-Area, a revised spectrum (84^{th} percentile deterministic spectrum) was developed and recommended for structural engineering and geotechnical analysis of facilities in H-Area (Ref. 123). The geotechnical analysis utilized the basement results in a convolution analysis and the structural engineering groups developed an envelope for use in analysis of SSCs.

The fundamental change was to the distant earthquake component. The parameters used to develop a 50^{th} and 84^{th} percentile spectra were site-specific soil and revised stress drop for a Charleston earthquake.

EPRI and LLNL hazard spectra were used to estimate the probability of exceedance of the spectra. The local event spectrum was unchanged from the EBE. The resulting local and distant spectra were then enveloped into a surface design spectrum.

WSRC (PC-3 AND PC-4 SITEWIDE DESIGN SPECTRA)

The sitewide design spectra fully implement DOE-STD-1023-95 (Ref. 113). DOE-STD-1023-95 specifies a broadened mean-based UHS representing a specified annual probability of exceedance (for an SSC performance category) and a historical earthquake deterministic spectrum that ensures breadth of the UHS. For the SRS, the deterministic spectrum is represented by a repeat of the 1886 Charleston earthquake. The development of the SRS design basis spectra uses a statistical methodology to verify that a mean-based response is achieved at the soil free surface.

The design spectra were intended for simple response analysis of SSCs and are not appropriate for soil-structure interaction analysis or geotechnical assessments.

The EPRI and LLNL bedrock level uniform hazard spectra were averaged and broadened per DOE-STD-1023-95. Available SRS soil data were used to parameterize the soil shear-wave velocity profile. The parameterization was used to establish statistics on site response for ranges of soil column thickness present at the SRS. The mean soil UHS was obtained by scaling the bedrock UHS by the ground motion dependent mean site amplification functions.

The soil data used to develop the sitewide spectra incorporate the available SRS velocity and dynamic property database available to about mid-1996. The spectra are based on soil properties and stratigraphy from specific locations at the SRS, and are parameterized to represent the variability in measured properties. Because of the potential for variation of soil properties in excess of what have been measured at the SRS, the design basis spectra are issued as "committed" in accordance with the WSRC Quality Assurance Manual 1Q. The open item is the soil column variability used in the calculations. To eliminate the open item and upgrade the design basis spectrum to "confirmed," the soil parameters available at the specific site or facility where it is being used must be reviewed and determined to be consistent with the data parameterized in the study.

Comparison of PC3 and PC4 design spectra to the SRS interim spectrum and the Blume envelope spectrum are provided in Ref. 122 and 124. There is broad general agreement between the PC3 and interim spectral shape. The SRS Interim Spectrum shape is significantly more conservative in the 0.5 to 2.0 Hz frequency range compared to the PC3 spectrum because the interim shape enveloped the 84th percentile Charleston deterministic spectrum rather than the 50th percentile as required by DOE-STD-1023-95. Comparisons of the Blume 0.20g anchored spectrum to the PC3 design spectrum indicate significant shape differences. The Blume spectrum was derived from deep soil recordings of western U.S. earthquakes and is not representative of eastern U.S. spectral shapes. The spectra show a generally more broadened shape as compared to the Blume spectra. Low frequencies are enhanced with respect to Blume because the Blume spectra do not contain the fundamental site resonance (about 0.6 Hz). High frequencies are also enhanced with respect to Blume because of the difference in eastern and western U.S. attenuative properties. Both the PC3 spectrum and the Blume spectrum have a dynamic amplification of about 2.7 at 3 Hz. The significantly larger Blume PGA scaling factor causes the excess (as compared to the design basis spectrum) spectral values at the mid-range.

WSRC (PC1 AND PC2 SITEWIDE DESIGN SPECTRA)

Design spectra guidelines for PC1 and PC2 facilities are reported by WSRC (Ref. 124). The PC1 and PC2 design spectra were derived using DOE-STD-1023-95 guidelines and NEHRP-97 (Ref. 125) design criteria and account for the wide range in SRS material properties and geometries including soil shear-wave velocities, uncertainty or range in soil column thickness, and type of basement material. Additional design guidance is contained in the current revision of WSRC Engineering Standard 01060.

SRS-SPECIFIC PROBABILISTIC SEISMIC HAZARD ASSESSMENTS

An SRS-specific Probabilistic Seismic Hazard Assessment (PSHA) is critically dependent upon the local geological and geotechnical properties at the site or facility location. An SRS-specific PSHA should account for soil properties derived from site geological, geophysical, geotechnical and seismic investigations. An SRS-specific PSHA was developed using bedrock outcrop EPRI and LLNL hazard and SRS site properties including soil column thickness, soil and bedrock shear-wave velocity, and dynamic properties (Ref. 112).

1.4.4.3 Ground Motion Prediction Methodologies

This section briefly describes current ground motion prediction methodology and earthquake source, path, and site assumptions used for H-Area, the most recent DBE work conducted for the SRS.

RANDOM VIBRATION THEORY (RVT) MODELING

To model ground motion, an RVT model (also called Band Limited White Noise) is used to estimate ground motion for the distant Charleston-type event (Ref. 126 - 128). The RVT model is widely accepted and, with proper parameterization, is found to predict ground motion as successfully as empirically derived relationships.

EARTHQUAKE SOURCE PARAMETERS

This section discusses the earthquake source parameter uncertainty affecting ground motion prediction for the SRS. Source parameters for the "distant event" or Charleston-type earthquake have been the most contentious in past design studies. The distance from the SRS site center to the 1886 Charleston MMI X isoseismal contour is approximately 120 km. The SRS center to the southern end of the Woodstock fault is approximately 130 km. The center of SRS to the center of the 1886 MMI X isoseismal, close to Middleton Place and central to Dutton's isoseismals, measures approximately 145 km. URS/Blume used 145 km as the distance from the SRS center to the 1886 Charleston earthquake epicenter (Ref. 122). Current ground motion studies analyze a recurrence of the 1886 event with a distance of 120 km. For estimates of median ground motions for a recurrence of the 1886 earthquake, a source distance of 120 km is conservative since the center of the isoseismal zone is at a distance of approximately 145 km.

For simplicity, the RVT models of ground motion assume a point source. The effects of focal depth and crustal structure on predicted ground motion are described in Lee (Ref. 123).

The distance and stress drop effects on rock motion predictions for a repeat of the Charleston Mw 7.5 event were described in Lee (Ref. 123). The 100-150 bar range in stress-drop is a probable range for the median value of an eastern U.S. earthquake. Somerville et al. (Ref. 129) found a value of 100 bars as the median stress-drop for eastern U.S. earthquakes; the EPRI guidelines (Ref. 130) report estimated a value of 120 bars as a median for stress drop, from data with reported stress-drops in the range of 20-600 bars.

Prior ground motion studies for SRS have used expected or median stress drops of 100-150 bars for a Charleston-type event. Peak ground motion is sensitive to the selection of stress drop (Ref. 124).

The 1886 isoseismal data are consistent with ground motion models with a slightly reduced earthquake moment magnitude of Mw 7.3, but with a corresponding higher stress-drop. The favored median model uses a Mw 7.3 at 120 km and stress drop of 150 bars (Ref. 124).

BEDROCK AND CRUSTAL PATH PROPERTIES

Ground motion estimates used a modified Herrmann crustal model developed from surface wave dispersion from Bowman, SC, to Atlanta, GA (Ref. 123, 124).

For geometrical attenuation, a plane-layered crustal model approximation by Ou and Herrmann is used that accounts for the post critical reflection (Ref. 130). The effect of this approximation is to decrease the attenuating loss between about 80-120 km. Using a point source and the local crustal structure for the Charleston event, the attenuation model predictions were found sensitive to source depth and source distance.

For development of the RVT rock spectra, anelastic attenuation is accounted for in two ways: (1) the crustal path operator Q that is frequency dependent; and (2) the site-dependent factor Kappa, related to Q by H/(Vs*Qs). Where Qs is the average quality factor over a several kilometer range of the near surface rock. The preferred Q model for these investigations is EPRI (Ref. 131).

The best mean EPRI model is given by:

$$Qc = Qo*(f/f_o)^n = 670*f^{0.33}$$

(Eq. 1.4-4)

The ranges of the rock site attenuation operator Kappa are estimated to be 0.010-0.004 seconds with a median of 0.006 seconds. RVT calculations for the SRS ground motion predictions use this median value of 0.006 seconds for Kappa.

For SRS ground motion predictions, bedrock properties underlying most of the SRS facilities are assumed uniform with a Vs of approximately 3.4 km/s (11,500 fps). For facilities situated above the Triassic rift basin (Dunbarton basin), filled with 3 km (1.8 miles) of sedimentary rock, a Vs estimated to be 2.4 km/s (8,000 fps) is used. This basin is surrounded by crystalline rock. For a first approximation to the ground motion effects of the basin, a one-dimensional plane-layer model is used to approximate the effect of contrasting velocities.

SOIL PROPERTIES

The SRS is located on soils (sedimentary strata) ranging in thickness from 180 to 460 meters (600 to 1,500 feet) overlying crystalline or Triassic basement. A sitewide design basis spectrum must account for the range and variability in SRS soil properties. Deep stiff soils, such as those present at the SRS, severely condition bedrock spectra by frequency-dependent amplification or deamplification. Depending upon the frequency and amplitude of bedrock motion, the key soil properties controlling the soil spectrum are the soil column thickness, the dynamic properties (strain dependent shear-modulus ratio and damping), low-strain soil shear-wave velocity structure and impedance contrast with the basement.

To accommodate the range of shear wave-velocity in the soil column, a database of velocity profiles was compiled for the SRS (Ref. 124). This database contains the range of soil and rock shear-wave velocities available from various borings and seismic surveys that have been conducted at the SRS using seismic cross-hole, down-hole, velocity logger, and refraction techniques. The shallow profiles database for the SRS is based primarily on site-specific seismic piezocone penetration test soundings (SCPTU).

Other, more numerous, deep holes are used for stratigraphic purposes and to estimate the elevation of the top of bedrock. Nearly all of the velocity data are from the SRS F-, H-, A-, K-, and L-Areas, and the New Production Reactor site.

Basement shear-wave velocities are estimated from compressional-wave velocities measured at the SRS and collected using seismic refraction techniques. These data show that there is a significant shear-wave velocity contrast in the SRS basement between the Dunbarton Triassic basin rock and crystalline rock. The Pen Branch fault is the demarcation for basement contrasts in velocity.

Predicted peak soil strains for the SRS are sufficient to exceed the linear range of the constitutive relations (stress-strain). Consequently, laboratory testing of site-specific soil samples was required for reliable ground motion prediction of all critical facilities.

The normalized shear modulus and damping ratio versus shear strain relationships were developed for specific stratigraphic layers. Stratigraphic formation identification and their corresponding dynamic properties were developed specifically for the SRS by K.H. Stokoe of the University of Texas (Ref. 132, 133).

Stokoe et al. compiled a dynamic soil property database from available SRS reports on dynamic soil properties and new dynamic measurements made by the University of Texas. The SRS areas from which data were obtained are:

1 Area of the Pen Branch Fault Confirmatory Drilling Program;

2 H-Area ITPF;

3 H-Area RTF;

4 H-Area Building 221-H;

5 Proposed New Production Reactor site,

6 Par Pond Dam;

7 K-Reactor Area;

8 Burial Ground Expansion;

9 L-Reactor Area;

10 L-Area Cooling Pond Dam; and

11 F-Area, Sand Filter Structure.

These eleven areas represent eight general locations at the SRS.

VELOCITY MODEL PARAMETERIZATION

An SRS generic shear-wave velocity profile was developed from the location-specific data and includes randomness in both stratigraphic layer thickness and velocity. Because the area-specific simulations were generally consistent with the generic simulations, the SRS generic (sitewide) simulation is applied to all areas of the SRS. There is no significant reduction in the site amplification variability by applying area-specific velocity model simulations for ground motion evaluations.

1.4.4.4 Current Design Response

This section describes the current recommended SRS design basis spectra.

The current PC-3 and PC-4 sitewide spectra are based on the WSRC analysis (Ref. 124) developed in 1997, and incorporates variability in soil properties and soil column thickness. Following the development of PC3 and PC4 design basis spectra (Ref. 124) and the PC1 and PC2 design basis spectra (Ref. 123), the Defense Nuclear Facilities Safety Board (DNFSB) had several interactions with the DOE and WSRC on seismic design spectra. As a result, additional conservatisms were applied to the PC3 spectral shape at high and intermediate frequencies (Ref. 134).

The WSRC Civil/Structural Committee reviewed the PC1 and PC2 design spectra (Ref. 112) and recommended to the Engineering Standards Board (ESB) that the current Uniform Building Code (UBC) be used for the Site Engineering Standard.

1.4.5 STABILITY OF SUBSURFACE MATERIALS

Soil properties vary across the SRS due to changes in depositional processes from area to area over time. Consequently, soil properties at SRS are highly site-specific and are detailed in the facility-specific SARs/DSAs. However, geotechnical stability concerns at the SRS are categorized generically and listed below with the intent of defining the approaches and methods used to address stability of subsurface materials in site-specific studies. Geotechnical stability concerns at SRS fall into the following categories:

- Excavation and Backfill (Section 1.4.5.1),
- Foundation Settlement (Section 1.4.5.2),
- Liquefaction (Section 1.4.5.3), and
- Soft Zones (Section 1.4.5.4).

1.4.5.1 Excavation and Backfill

Quality of backfill affects the stability of structures built on fill areas. The requirements and specifications for excavation and backfill have changed with time. Currently there are SRS guidelines for excavation and backfill (Ref. 135), however, project specifications take precedence over the general site guidelines. Geotechnical investigations should identify areas where fill has been placed and give some indication of the quality of the fill prior to building new structures. Following is a summary of excavation and backfill requirements that have been used at the SRS.

Since 1995, excavation and backfill have been controlled by project specifications. Specifications are prepared to satisfy project-specific needs and may be more restrictive than the Requirement Document. The project specifications take precedence over the Requirement Documents.

In 1997, Engineering Guide 02224-G was issued to provide guidance for the excavation, backfill, and grading. Provisions provided in the Engineering Guide can be mandatory, if the Engineering Guide is invoked by the project or operation documents. Provisions in the Engineering Guide include:

- General requirements for excavation, drainage, fill materials, fill placement, CLSM, moisture control, compaction, test fill, grading, testing, erosion control, and inspection
- Requirements for structural fill including:
    a. Soil classified as well-graded sand or silty sand
    b. Range of gradation distribution
    c. Maximum plastic index of 15
    d. Compaction to a minimum density of 95% of the maximum dry density as determined by ASTM D1557.
- Requirements for common fill including:
    a. Soil classified as well-graded sand, poorly graded sand, silty sand, or clayey sand
    b. Range of gradation distribution
    c. Compaction to a minimum density of 90% of the maximum dry density as determined by ASTM D1557.
- Requirements for CLSM are also provided in the Engineering Guide 02224-G (Ref. 135).

1.4.5.2 Foundation Settlement

Settlement estimates are generally made prior to design of major facilities. Estimates require facility-specific structure information and site-specific geotechnical information for evaluation. Settlement issues are discussed in the facility-specific SARs/DSAs. Major facilities are surveyed, analyzed, and evaluated routinely for settlement during construction and throughout service life. Allowable settlement is a function of the soil conditions, structure geometry, and loading and the magnitude of settlement that a facility may withstand without adversely affecting performance. Settlement may occur through (1) static settlement due to loading during operation and secondary consolidation, and (2) dynamic settlement due to dissipation of seismically induced pore water pressures. Estimation of static settlement has been performed for many years using various techniques proposed by many authors. There are currently many accepted analytical and empirical methods for estimating settlement published in the geotechnical literature.

Two such references (by the U.S. Army Corps of Engineers and Department of the Navy) contain accepted methods for estimating settlement (Ref. 137, 138). Static settlements for larger SRS facilities generally fall in the range of 0.5 to 3 inches (1 to 8 cm) (Ref. 139, 140).

Seismically induced dynamic settlement is due to liquefaction or soft zone collapse discussed in the following sections.

1.4.5.3 Liquefaction Susceptibility

The liquefaction susceptibility of the subsurface materials at SRS has been evaluated using qualitative and quantitative approaches. Site-specific investigations have been conducted for F-Area (to include F-Separations, F-Tank Farm, and general F-Area), the CIF, the RTF, ITPF, H-Tank Farm, APSF, and CLWR-TEF (Ref. 141 - 146). In each case, the potential for liquefaction has been determined to be either small or negligible. Approaches implemented include criteria for clayey soils, shear wave velocity evaluation, the stress method and the strain method. Field and laboratory testing programs have been conducted to characterize site conditions and to measure the cyclic shear strength and strain behavior of the native SRS soils. In this section, a summary of liquefaction evaluation methodologies used currently at SRS is presented. Each facility has its own particular soil profile and characteristics and requires site-specific characterization using one or more of the methodologies described below.

CRITERIA FOR CLAYEY SOILS

Laboratory tests and field performance data have shown that the majority of clayey soils will not liquefy during earthquakes. Criteria expressing these observations have been formulated by Wang (Ref. 147) and have been extended to laboratory testing conditions in the United States by Koester and Franklin (Ref. 148). The extended criteria state that clayey soils must satisfy all three of the following conditions to be considered potentially liquefiable:

- Laboratory-determined water content (increased by 2%) is greater than 90% of the laboratory-determined liquid limit (increased by 1%).
- Liquid limit (increased by 1%) is less than 35%.
- Clay content (decreased by 5%) is less than 15%.

In general, the SRS soils do not meet these criteria and are therefore considered non-liquefiable.

SHEAR WAVE VELOCITY EVALUATION

Several investigators have correlated liquefaction susceptibility to shear wave velocity using field performance data. For example, Seed et al. (Ref. 149) concluded, "Liquefaction will never occur in any earthquake if the shear wave velocity in the upper 50 feet (15 meters) of soil exceeds about 1200 fps (365 m/s)." This conclusion was based on the actual levels of cyclic shear stresses and corresponding shear moduli required to induce liquefaction and on the world-wide field observations of earthquakes.

In 1997, the National Center for Earthquake Engineering Research published proceedings of its workshop on evaluation of liquefaction resistance of soils (Ref. 150). The proceedings contain a chapter on Liquefaction Resistance Based on Shear Wave Velocity. In that chapter Andrus and Stokoe have compiled field data from earthquakes that showed relationships between cyclic stress ratio and normalized shear wave velocity. These relationships separate sands into liquefaction-susceptible or liquefaction-nonsusceptible groups. In general, based on measured shear wave velocities and site-specific Cyclic Stress Ratios, SRS soils are not subject to liquefaction.

THE STRESS METHOD

The stress method compares the cyclic shear stress imposed by the earthquake with the cyclic shear strength of the soil. In cases where the earthquake-induced stress exceeds the cyclic shear strength of the soil, the soil is considered potentially liquefiable. To estimate the shear stress imposed by the earthquake, dynamic response analysis is used with SRS soil profiles. The cyclic shear strength is estimated from earthquake field performance data or from laboratory test data correlated with field results, such as Standard Penetration Test (SPT) N-value or Cone Penetrometer Test (CPT) tip resistance.

The empirical chart proposed by Seed et al. (Ref. 149) is considered inappropriate for use at SRS because of the geologically older soils present at the site (Ref. 151). In its present form, this chart was developed from liquefaction case histories of recent (Holocene) sands and silty sands. In all cases, the liquefied sands were recent alluvial, beach, or deltaic deposits and are granular, clean sands with silty fines in some cases. However, older sand deposits exhibit greater liquefaction resistance than younger deposits (Ref. 152-159). From these studies, it appears that liquefaction is greatly restricted in deposits older than about 10,000 years.

Increased liquefaction resistance in older sand deposits may be a result of cementation, weathering (which chemically breaks down micas and feldspars into clays that inhibit liquefaction), increased exposure to low-level seismic shaking, cold bonding, and consolidation. All of these factors tend to increase the liquefaction resistance of sands. In addition to increasing liquefaction resistance, most of these factors probably increase, to some degree, the CPT tip resistance and the SPT blow count. Therefore, laboratory cyclic shear testing and the development of site-specific liquefaction curves are recommended when employing the stress method at the SRS.

Settlement due to liquefaction can be estimated from laboratory volumetric strain test results, which have been correlated to CPTU field data. Final estimates of post-earthquake settlement depend on site-specific geotechnical information.

STRAIN METHOD

Cyclic shear straining and porewater pressure development of undrained sand is fundamental in the evaluation of seismic liquefaction potential (Ref. 160, 161). The strain method compares earthquake motion-induced cyclic shear strains to threshold cyclic strain. For this method, site-specific laboratory testing and analysis is required. The cyclic shear strains are obtained from dynamic response analysis, and laboratory testing is used to model pore pressure buildup.

1.4.5.4 Evaluation of Soft Zones

Across SRS the soil zone between approximately 30 to 70 meters (100 to 250 feet) below the ground surface is a marine deposit labeled the Santee Formation. Within this interval are areas having locally high concentrations of calcium carbonate. Often found within these sediments, particularly in the upper third of this section, are weak zones interspersed in stronger matrix materials. These weak zones, which vary in thickness and lateral extent, are termed “soft zones”. The existence of soft zones and the potential for settlement is a site-specific characteristic and requires subsurface characterization and engineering evaluation on a site-specific basis.

The soft zones are stable under static conditions. The Santee section, in which the carbonate and soft zones are found, is generally in the saturated zone well below the water table. Here the sediments are in a stable chemical environment, and carbonate dissolution is minimal. The further dissolution and removal of the Santee carbonate (in the engineering sense; i.e., the next 100 years) is a non-issue.

For the types of facilities constructed at the SRS, the increase in load on the soft zone soils is negligible. However, potential load increase due to a seismic event needs consideration even though the geologic record shows that soft zones encountered today have withstood the earthquakes that have occurred since their formation.

A complete summary of the origin, extent and stability of soft zones is presented by Aadland et al. in WSRC-TR-99-4083, "Significance of Soft Zone Sediments at the Savannah River Site." Details on the impact of soft zones for specific facilities can be found in the facility-specific SARs/DSAs.

PREVIOUS STUDIES

Since 1980, several extensive subsurface investigations at scattered site locations within SRS have been completed, yielding more detailed information on the local extent and character of soft zones. In each case, the investigation demonstrated significant variations in subsurface stratigraphy such that the application of general design criteria for soft zone evaluation is not recommended. The investigations have revealed that soft zones within the calcareous materials are found at depths approximately 40 to 52 meters (130 to 170 feet) below natural ground surface and are probably the result of millions of years of carbonate and shell dissolution within the strata. This slow dissolution has resulted in zones of lower density and strength and, consequently, higher compressibility when compared with the surrounding, more intact and sometimes silicified, sandy material. The soft zones behave as local, underconsolidated pockets with overburden stresses arching around the underconsolidated zones. Because the soft zones have formed over a considerable period of time (late Eocene, or about 40 Ma), have survived for millions of years, and have apparently persisted through several historic earthquakes, it is reasonable to assume that the soft zones are of no engineering concern to the dynamic stability of surface or near-surface facilities. However, site-specific evaluations are required.

METHODOLOGIES

Analyses at several SRS facilities, such as K-Area (Ref. 162), assumed that the underconsolidated zones are "arched" by more competent material and that the arch is broken during an earthquake. In those analyses, very conservative subsurface conditions were assumed for the potential width, depth, and extent of the soft zones within the surrounding matrix material. Two basic methods were used to calculate the magnitude of potential surface settlement following a postulated collapse during an earthquake: (1) empirical, using analogies to both soft ground tunneling and coal mining, and (2) numerical modeling. Analyses of the K-Area soft zone suggest that the sandy soil matrix is incapable of arching soft zones larger than about 15 meters (50 feet) in diameter. Thus, zones of larger diameter could not occur. For soft zone widths of about 15 meters (50 feet) and less, the numerical analyses predicted surface settlements of up to approximately 25% of the surface settlement predicted by the empirical approaches. Which analytical methods are used should depend on the facility under evaluation, the design criteria, and the site-specific subsurface conditions.

Numerical analyses of soft zone soils were conducted for the APSF site (Ref. 163). Computed ground settlements after all soft zones are compressed, varied up to approximately 7.6 cm (3 inches), depending on the configuration of soft zones used in the analysis. The results of the settlement analysis are considered in the design.

1.5 NATURAL PHENOMENA THREATS

This section identifies and describes natural phenomena events considered potential accident initiators at specific SRS facilities.

1.5.1 FLOODS

1.5.1.1 Flood History

All the floods represented by the data in this section were the result of excess precipitation runoff and the associated creek or stream flooding. There have been no floods caused by surge, seiche, dam failure, or ice jams. Historical data on the Savannah River is also discussed and referenced in Section Section 1.4 2 of this document.

FLOOD HISTORY OF THE SAVANNAH RIVER

Historical records span from 1796 to 1995. The earliest historical data were determined primarily from high-water marks; flow gauging by the USGS began in 1882. The record historical flood at Augusta, GA, occurred in 1796, with an estimated discharge of 360,000 cfs; the peak flow recorded by the USGS (350,000 cfs) occurred on October 3, 1929. Since Strom Thurmond Dam was constructed, no major flood has occurred at Augusta, GA.

For the 30-year period from 1921 to 1950, before construction of Strom Thurmond Dam, the mean annual maximum flow was 92,600 cfs, the 10-year maximum flow was 211,000 cfs, and the estimated 50-year maximum flow was 362,000 cfs. For the 40-year period from 1956 to 1995, after construction of Strom Thurmond Dam, the mean annual maximum flow, based on mean daily flow rates, was 33,628 cfs, the 10-year maximum flow was 52,913 cfs, and the estimated 50-year maximum flow was 71,182 cfs.

FLOOD HISTORY OF UPPER THREE RUNS CREEK

For Upper Three Runs Creek at Highway 278, the maximum flood recorded was 820 cfs on October 23, 1990, and the corresponding flood stage elevation was 174 feet msl. Similarly, the maximum flow at Road C was 2,040 cfs (132.9 feet msl) on October 12, 1990 and at Road A was more than 2,000 cfs (98 feet msl) on October 12, 1990. No dams are located in the Upper Three Runs Creek watershed.

An analysis of annual maximum floods of the three Upper Three Runs Creek gauging stations, based on mean daily flow rates, was conducted using the Log Pearson Type III distribution.

Records for Upper Three Runs Creek at Highway 278 for water years 1967 through 1995 show the following:

- The mean annual maximum flow was 295 cfs.
- The 10-year maximum flow was 399 cfs.
- The estimated 50-year maximum flow was 501 cfs.

Records for Upper Three Runs Creek at Road C for water years 1975 through 1995 show the following:

- The mean annual maximum flow was 737 cfs.
- The 10-year maximum flow was 1,048 cfs.
- The estimated 50-year maximum flow was 1,590 cfs.

Records for Upper Three Runs Creek at Road A for water years 1976 through 1995 (excluding 1978) show the following:

- The mean annual maximum flow was 789 cfs.
- The 10-year maximum flow was 1,184 cfs.
- The estimated 50-year maximum flow was 1,783 cfs, recorded.

<u>FLOOD HISTORY OF TIMS BRANCH</u>

The maximum flood discharge recorded for Tims Branch was 129 cfs on October 12, 1990, with a corresponding gage height of approximately 145.67 feet msl. Highest flood stage level recorded was approximately 146.71 feet msl on May 29, 1976 (Ref. 32, 39 and 40).

1.5.1.2 <u>Flood Design Considerations</u>

All safety-related structures are located on topographic high points and are well inland from the coast. The only significant impoundments, Par Pond and L Lake, are relatively small and sufficiently lower than any of the safety-related structures that there is no safety threat to safety-related structures from high water.

The calculated Probable Maximum Flood (PMF) water level for the Savannah River at the VEGP site is 118 feet above msl without wave run-up (Ref. 382). With wave run-up, the water may reach as high as 165 feet above msl. Because the minimum plant grade near a structure (L Reactor) is approximately 250 feet above msl, they are all well above the flood stage. If the valley storage effect between Strom Thurmond Dam and VEGP is taken into account, this results in a lower flood peak and lower flood stage.

The PMF for Upper Three Runs Creek, downstream from the point where it is joined by Tinker Creek, is 150,000 cfs. The watershed area at this point is 163 square miles, based on the drainage area at the nearest upstream gauging station (Station 02197300) and the planimetered additional drainage area. The maximum stage corresponding to this flow is 173.5 feet msl, which is well below the minimum site grade at any safety-related structure.

A USGS flow recorder has been maintained since November 1976 at SRS Road A-13.2 on Pen Branch (Station 02197348). From 1976 to 1982, the flow at this station ranged from a minimum of 21 cfs, when K-Reactor was not operating, to a maximum of 950 cfs during simultaneous K-Reactor operation and heavy precipitation. During water year 1995, the mean flow rate at the station was 55.8 cfs.

Before 1951, Pen Branch was a small, single-channel creek meandering through a broad, heavily vegetated floodplain. K-Reactor effluent changed the creek to a wide, multichannel, braided stream system flowing within denuded floodplains. Erosion straightened, widened, and deepened sections of the stream channel immediately below the reactor discharge point. Farther downstream, multiple channels formed across the floodplain to accommodate the increased flow and sediment load.

F-, H-, S-, and Z-Areas are located on relatively elevated regions of the SRS. Therefore, flooding from surface streams is not a credible hazard.

Topographic relief between the M and A-Area boundaries and the base elevation of Tims Branch at its closest approach to M-Area is approximately 120 feet. The maximum gage height recorded on Tims Branch at Station 02197309 is less than 20 feet above the base elevation of the stream. Therefore, flooding is not a credible safety hazard at M or A-Area. Therefore, safety-related equipment and systems to protect the facility against adverse hydrologic consequences are not warranted.

D-Area is located at an elevation slightly above the maximum flood. A flood could submerge pumphouse 5-G and make it inoperative, stopping cooling water flow to the powerhouse.

1.5.1.3 Effects of Local Intense Precipitation

Flood design considerations are described below in reference to specific local facilities. The descriptions are based on available information.

Unusually intense local rainfalls occurred on the SRS on July 25, 1990; August 22, 1990; October 10-12, 1990; and October 22-23, 1990. A report on these unusual rainfalls was prepared by the Environmental Transport Group of SRTC. The report concluded that although over 6 inches of rain fell in a 10 square mile area during the August 22 storm, this amount is just 20% of the greatest possible theoretical depth of precipitation for a given duration and drainage area." (probable maximum precipitation) (PMP) of 31.0 inches (Ref. 21, 383). This rainfall was adjusted to a point PMP of 19 inches in 1 hour, as shown by Hansen et al. (Ref. 384, 385) and used to generate the Probable Maximum Flood (PMF) for SRS. A synthetic hydrograph was used to determine peak flow (Ref. 386).

1.5.1.4 Probable Maximum Flood on Streams and Rivers

RUNOFF MODEL

The PMF values for the Savannah River and for Upper Three Runs Creek were determined using NRC Regulatory Guide 1.59. The PMF of 1,001,000 cfs for the Savannah River at VEGP and thus at SRS, reported in Appendix B of the Regulatory Guide, is slightly greater than the PMF flood discharge of 895,000 cfs determined by Southern Company Services in the VEGP Final SAR (Ref. 382). Procedures outlined in the Regulatory Guide were used to verify the PMF for the Savannah River and to estimate the PMF for Upper Three Runs Creek.

The PMF for McQueen Branch was calculated by first determining the PMP. National Oceanic and Atmospheric Administration Hydrometeorological Reports No. 51 and No. 52 were used to develop PMP envelopes for SRS and for the Savannah River drainage basin upstream of the site (see Section 1.5.1.3) (Ref. 383, 384). The runoff hydrograph was developed using methods developed by the Bureau of Reclamation (Ref. 386).

PROBABLE MAXIMUM FLOOD FLOW

Regulatory Guide 1.59 Appendix B reported the PMF to be 1,001,000 cfs for the Savannah River at VEGP, corresponding to an elevation of 138.5 feet above msl (Ref. 386). The VEGP Final SAR (Ref. 382) estimates a PMF peak discharge of 895,000 cfs, if the effect of valley storage of floodwater is ignored, and a PMF of 540,000 cfs if valley storage upstream from the site is considered. The maximum flood wave elevations determined in the VEGP final SAR were 41.5 feet msl and 38.4 feet msl, respectively.

The PMF determined from Regulatory Guide 1.59 (Ref. 386) for the Savannah River does not consider failure of any upstream dams. All dam failure scenarios are considered in Section 1.5.1.5.

The estimated PMF for Upper Three Runs Creek results in a water level of about 175 feet above msl near F-, H-, and S-Areas. This is about 125 feet below grade at H- and S-Areas, and about 115 feet below grade at F-Area. The PMF for a small unnamed tributary of Upper Three Runs Creek, located about 0.4 miles northwest of F Canyon, corresponds to a peak stage of 225 feet above msl, which is about 75 feet below grade at F Canyon, and about 85 feet below grade at the CIF in H-Area. The PMF for Crouch Branch, which is about 100 feet below the nearest and lowest safety-related structure corresponds to a peak stage of 225 feet above msl. This is about 75 feet below grade at H and S-Areas and 30 feet below the base of the Z-Area vaults..

WATER LEVEL DETERMINATIONS

For the Savannah River, the PMF stage of 138.5 feet above msl computed for this analysis was compared to the PMF stages generated in the VEGP Final SAR and found to be conservative (Ref. 382).

COINCIDENT WIND WAVE ACTIVITY

For the Savannah River and Upper Three Runs Creek, the extent of flooding is far removed from site facilities in both distance and elevation. Thus, it is inconceivable that wind-induced waves would affect safety-related facilities on the site. A small tributary of Upper Three Runs Creek approaches to within 2,200 feet of F Canyon at the PMF stage. The corresponding water surface is at 223 feet above msl or 75 feet below the grade of F Canyon. If a constant 100-mph wind is assumed coincident with the PMF level, the maximum wave is less than 3 feet high. Such a wave would have no effect on facility safety.

1.5.1.5 Potential Dam Failures (Seismically Induced)

RESERVOIR DESCRIPTION

The only significant dams or impoundment structures that could affect the safety of SRS are large dams on the Savannah River and its tributaries upstream of Augusta, GA.. The Stephens Creek Dam is owned by SCE&G. All other dams on the Savannah River are owned by the U.S. Army Corps of Engineers. The dams on the Tugaloo and Tallulah rivers are owned by Georgia Power Company. The dams on the Keowee and Little Rivers are owned by Duke Power Company.

DAM FAILURE PERMUTATIONS

A domino failure of the dams on the Savannah River and its tributaries upstream of VEGP was analyzed in the VEGP Final SAR (Ref. 382). The worst possible case resulted from Jocassee Dam failing during a combined standard project flood and earthquake, with the resulting chain reaction.

Using conservative assumptions, this worst dam failure would yield a peak flow of 2,400,000 cfs at Strom Thurmond Dam. This rate, undiminished in magnitude, was transferred to below Augusta, GA. However, because of the great width of the flood plain, routing of the dam failure surge to the VEGP site (Savannah River Mile 151) resulted in a peak discharge of 980,000 cfs, with a corresponding stage of 141 feet above msl.

UNSTEADY FLOW ANALYSIS OF POTENTIAL DAM FAILURES

No dams are located near SRS Areas. Therefore, this section does not apply.

WATER LEVEL AT FACILITY SITE

The peak water surface elevation of the Savannah River that corresponds to wave run-up of a wind-induced wave, superimposed upon the passage of a flood wave resulting from a sequence of dam failures, is discussed in Section 1.5.1.2.

1.5.1.6 Probable Maximum Surge and Seiche Flooding

No large water bodies exist near the site; therefore, this section does not apply. Run-up of flood waters from the worst combination of wind and waves on the Savannah River is not a hazard at the site because the peak flood elevation is well below minimum plant grade, and the maximum wave under the worst circumstances is less than 3 feet.

1.5.1.7 Ice Flooding

Because of regional climatic conditions, the formation of significant amounts of ice on streams and rivers rarely occurs. The Hartwell, Richard B. Russell, and Strom Thurmond dams moderate water temperature extremes, making ice formation on the Savannah River at SRS unlikely.

No historical ice flooding has been noted, although ice has, on several occasions, been observed in the Savannah River. Because the sites are so much higher than the nearest streams and rivers, it is not considered credible that they could be affected by ice flooding, even if the climatic conditions were conducive to ice formation.

1.5.1.8 Water Canals and Reservoirs

Each reactor has a 25-million-gallon intake basin, which is a concrete structure that is 225 feet wide, 800 feet long, and 20 feet deep with an open top. The basin is divided into three chambers that can be isolated from each other. These basins were used to store cooling water for the reactors and as reservoirs for cooling water to allow the operators to shut down the reactors if needed. These basins were designed as safety-related structures, including withstanding a DBE, and are located well above any PMF (Ref. 387).

1.5.1.9 Channel Diversions

There is no historical record of diversions of streams or rivers in the site area. Outside of precipitation, the only source of water to the site is groundwater. No waterway diversion could flood the sites because the sites are much higher than the surrounding streams and rivers.

1.5.1.10 Flooding Protection Requirements

Because the site is located on a local topographic high, there is no threat to the SRS from flooding, as described in previous sections. Special flooding protection requirements are not necessary to assure the safety of F-, H-, S-, Z-, and M-Areas, and SRTC because they are located at elevations well above the maximum flood. D-Area elevations are higher than the maximum flood; only the pump houses on the river could be flooded and inoperative.

1.5.1.11 Low Water Considerations

LOW FLOW IN RIVERS AND STREAM

Low flow in the Savannah River adjacent to SRS is regulated by Strom Thurmond Dam and the New Savannah Bluff Lock and Dam. A minimum flow of 5,800 cfs is required for navigation in the river downstream from Strom Thurmond Dam. However, it should be noted that a discharge of 6,300 cfs is normal 80% of the time. A minimum required flow of 4,130 cfs is released from New Savannah Bluff Lock and Dam. The Strom Thurmond Dam project is designed for a maximum drawdown of 18 feet from the top of the power pool elevation of 330 feet msl to a minimum pool at 312 feet msl. However, it is not anticipated that the minimum pool will be reached more often than once in every 150 years.

During extreme drought conditions from July 1987 through April 1989, average discharge at Strom Thurmond Dam was cut to 3,600 cfs (Ref. 388). The reduced discharge lasted from April 1988 to April 1989 and was the minimum flow necessary to maintain water quality criteria for the Savannah River downstream of SRS. River flow at Augusta, GA, however, averaged 4,300 cfs weekly from April 1988 to December 1988 due to higher than normal influx downstream of Thurmond Lake. Discharges from Hartwell and Russell Reservoirs, upstream of Thurmond Lake, were also severely restricted. During this drought period, Thurmond Lake conservation pool elevations decreased substantially, reaching a low point of 1 foot above minimum pool level in February 1989.

A low flow stage at SRS corresponding to minimum river flow of 5,800 cfs is 80.4 feet msl at the SRS pumphouse.

Flow records for Augusta, GA, for the periods 1884 through 1906 and 1926 through 1970 were examined. A hypothetical extreme drought flow of 957 cfs was determined by statistical analysis of 1926 through 1950 flow records. During this period, no major dams were built on the river or its tributaries upstream of Augusta. It is concluded that the hypothetical extreme drought would have a stage elevation of 74 feet msl, which is 6 feet below the minimum required to operate any of the river pumping facilities.

From the flow records for the 62 years of examined data from the USGS, it is concluded that a sustained minimum release of 5,800 cfs (the planned operation of Hartwell and Thurmond reservoirs) could have been maintained for this period. A flow of 3,600 cfs at Ellenton Landing is required under present conditions to provide water to the pump intakes.

<u>LOW WATER RESULTING FROM SURGES OR SEICHES</u>

This situation does not apply because SRS does not withdraw water from a large body of water, nor is it located in a region of active seismicity or volcanism, which produce such surges.

<u>HISTORICAL LOW WATER</u>

The available flow records (62 years) for Augusta, GA, for the periods 1884 through 1906 and 1926 through 1970 were examined. The low flow of record for gauging station 02197000, on the Savannah River at New Savannah Bluff Lock and Dam (river mile 189.8) near Augusta, GA, before construction of Strom Thurmond Dam, occurred on September 24, 1939. This was caused by the operation of the gates at New Savannah River Lock and Dam. If the rating curve is extended below 1,400 cfs, an extreme minimum discharge of 648 cfs is reached. This is an extrapolated instantaneous minimum. Water stage recorder graphs and discharge measurements were furnished by the Corps of Engineers. On the day this low flow was recorded, the average daily flow was 2,940 cfs. Examination of the hydrograph for this day indicates that the lowest flow occurred for about 10 hours, the daily flow being over 2,000 cfs. The lowest mean daily flow shown in the Augusta record was 1,040 cfs, which occurred on October 2, 1927.

The minimum mean daily discharge for the period 1963 through 1970 (after the filling of both reservoirs) was 5,130 cfs in 1963. The storage for power and navigation releases (between normal and minimum pool levels) from Hartwell and Thurmond Reservoirs was 2,445,000 acre-feet, which would provide an average release of 3,350 cfs for 1 year assuming no inflow. The total storage (between top of gates and minimum pool level) from both reservoirs was 3,128,000 acre-feet, which would provide an average release of 4,300 cfs for 1 year assuming no inflow.

The Savannah River has been gauged at Augusta, GA, for more than a century. More recently (in 1971), a gauging station was established at Jackson, SC. Upper Three Runs Creek has been gauged since 1966 at Highway 278 near New Ellenton, SC, and near SRS Road A, below F-Area. An additional gauging station on Upper Three Runs Creek was established near SRS Road C in 1974.

The minimum recorded flow for the Savannah River at Augusta, GA, was 1,040 cfs on October 2, 1927. This occurred during a period when the Savannah River was essentially unregulated. Since Strom Thurmond Dam was finished in the early 1950s, the river has been regulated by the Corps of Engineers. A minimum daily flow of 4,000 cfs was recorded October 22, 1991.

The minimum daily flow for Upper Three Runs Creek is 49 cfs at Highway 278; 111 cfs near SRS Road A; and 105 cfs near SRS Road C. Although the period of data recording is short, Upper Three Runs Creek has a smaller range of flow variation than other streams in the area.

Tims Branch has been gauged since March 1974 near its confluence with Upper Three Runs Creek. The minimum daily flow for Tims Branch was 1 cfs. Although the period of data recordings is short, Tims Branch has a smaller range in flow variation than other streams in the area.

1.5.1.12 Future Control

Minimum flow conditions are controlled mainly by upstream dam releases, and no additional users of large amounts of water are anticipated.

1.5.2 EARTHQUAKES

Earthquakes are discussed in Section 1.4.

1.5.3 TORNADOES

Tornadoes are discussed in Section 1.4.

1.6 MAN-MADE EXTERNAL ACCIDENT INITIATORS

This section provides identification of specific external man-made phenomena associated with the site considered to be potential accident initiators, exclusive of sabotage and terrorism.

1.6.1 TRANSPORTATION

Offsite and onsite roadways and the SRS rail network are discussed in this section.

1.6.1.1 Roads and Highways

Various South Carolina state highways lead to the northern, eastern, and southern boundaries of SRS, although public access into SRS is limited (Figure 1.3-2). Northern access to the SRS boundary includes SCR 125 from the town of Jackson and SCR 19 from the towns of Aiken and New Ellenton. Eastern SRS boundary access includes SCR 781 and SCR 39 from the town of Williston, SCR 39 from the town of Elko, SCR 64 from the town of Barnwell, and SCR 125 from the town of Allendale. No access roads exist across the southwestern boundary of SRS, which is the Savannah River. Multi-lane roads leading from SRS include SCR 64 to Barnwell, SCR 125 to Augusta, and SCR 19 to Aiken.

Two major public highways that traverse SRS are SCR 125 and U.S. Route 278. Both highways are patrolled and maintained by the state of South Carolina. Public access into SRS is allowed on U.S. Route 278, SCR 125, SRS Route 1, and a 1/2-mile section of SRS Road 2 leading to SCR 19. Access at the other barricades is restricted to official use only. Plant through-traffic and traffic counts on major public highways is considered to be very light.

Many different vehicles and transport packaging are used for transportation activities for hazardous materials on SRS. Materials transported by truck at SRS include radioactive materials in the form of powders, bulk liquids, samples, solid billets, fabricated components, gases, solid wastes, and contaminated equipment. Nonradioactive hazardous material forms that are transported include bulk liquids, granular solids, liquefied gases, laboratory reagents, and janitorial supplies (Ref. 389). If these materials are involved in an accident onsite, activation of emergency procedures for chemical and/or radiological airborne release is required.

For a detailed analysis of accident consequences and risks resulting from hazardous material transportation at SRS, see the onsite transportation evaluation document (Ref. 389).

Commercial trucks carrying hazardous materials operate on SCR 125. Distances to the nearest facilities are:

- 400-D, approximately 1 mile (1.6 km)
- 700-B, approximately 1 mile (1.6 km)
- K-Area, approximately 1.5 miles (2.4 km)
- 300-M, 700-A, approximately 2.5 miles (4 km)

A detailed analysis of accident consequences and risks resulting from materials transported on Highway 125 (a public transportation corridor) has not been performed, since these shipments are not monitored nor is an inventory kept (Ref. 389). Impacted hazardous materials, delivered to SRS, are evaluated in the onsite transportation evaluation document (Ref. 389).

1.6.1.2 Electrical Grid

The electrical grid on SRS operates at 115 kV and draws power from two transmission lines on separate rights-of-way from the South Carolina Electric and Gas (SCE&G) Urquhart Station and a third line from the 230-kV tie line between the Sumner and Canadys stations of SCE&G. Their three feeders are tapped at SRS stations 504-1G, 504-2G, and 504-3G, respectively. The site 115-kV transmission system contains about 90 miles of power lines which are controlled by SCE&G in Columbia and monitored by a dispatcher in Building 751-A. SRS also has a tie-in line to Vogtle Electric Generating Plant (VEGP).

The removal of several electrical transmission lines is planned. However, SCE&G has not removed any lines to date. DOE has requested that SCE&G notify the site when they are ready to implement.

1.6.1.3 Railroads

CSX Transportation Incorporated operates the line through SRS from Augusta, GA, southeastward through Allendale, SC, to Yemassee, SC (Fig. 1.6-2). CSX operates and maintains the portion of track from the junction with the Augusta, GA-Yemassee, SC track to the Dunbarton Station on SRS and to CNSI near Snelling, SC. In addition, SRS operates and maintains its own railroad system for providing direct rail service to various areas within the site. Close to the site, the Norfolk/Southern Railway owns two tracks that traverse the 5-mile (8-km) area outside the SRS boundary. One track extends east from the Augusta area to Charleston, SC, passing through Aiken, Williston, and Blackville, SC. The other track extends south from Augusta turning eastward at the Burke County line to a point approximately 3 miles (5 km) from SRS and continues south to Savannah, GA (Ref. 390).

The onsite rail system is interfaced with commercial railroads at the Dunbarton Station near the Railroad Classification Yard. The bulk of rail traffic consists of coal and cask car movements. Other cargo, such as tank cars of bulk chemicals, helium, and various other goods, are moved from Dunbarton to areas on the site.

Railcars carrying radioactive materials are handled by specially designated locomotives and are not mixed with cars carrying other cargo. Trains hauling spent fuel casks or equipment contaminated with radioactive materials are operated at speeds of less than 25 mph (40 km/h) and are slowed to less than 15 mph (25 km/h) at railroad-highway crossings that all have signals and cross bars. In the 200-Areas, the cask cars are uncoupled outside the railroad tunnel, and a small battery-powered locomotive is used to position the cars in the railroad tunnel for unloading. Due to shipping container specifications and the administrative procedures, it is unlikely that a transportation accident would have a significant effect except near the accident. Additional information is provided in the referenced evaluation report on transportation (Ref. 389).

Rail traffic on the CSX rail line through SRS includes carriage of some hazardous materials. The distances from SRS facilities to the CSX rail line are:

- 400-D, 0.5 miles (0.8 km)
- 100-K, 3 miles (5 km)
- 700-B, 3 miles (5 km)
- 300-M, 700-A, nearly 5 miles (8 km)

A detailed analysis of accident consequences and risks resulting from an accident involving hazardous materials transported through the SRS on the CSX System (a public transportation corridor) has not been performed, since these shipments are not monitored nor is an inventory kept.

1.6.1.4 Airports and Air Traffic

Bush Field in Augusta, GA, and the Columbia Municipal Airport in Lexington County, South Carolina, are the only two airports within 65 miles of SRS that provide scheduled air passenger services (Fig 1.6-3).

Barnwell County Airport, a small, general aviation facility, is the closest airport to the SRS boundary. Private aircraft, including corporate jets, use the Barnwell County Airport located on U.S. Route 278, 1 mile (1.6 km) west of Barnwell. Two runways are available: a paved and lighted 5,118-foot runway and a paved 5,272-foot runway. Airport traffic is approximately 16,000 flights per 12 month period. Business activity at the airport fluctuates seasonally; fall and spring are usually busier than winter and summer.

Other nearby airports include Aiken Municipal Airport, Allendale County Airport, Bamberg County Airport, Burke County Airport in Waynesboro, and Daniel Field in Augusta (Ref. 391). Figure 1.6-3 shows the location of public airports within 50 miles (80 km) of the SRS center. Numerous private aviation facilities are also located in the area.

The nearest air traffic hub (i.e., as designated by the Federal Aviation Administration, a city or Standard Metropolitan Statistical Area [SMSA] enplaning at least 0.05% of total passengers in all services of U.S. certificated route air carriers) in relation to SRS is Columbia, SC, located 70 miles (113 km) northeast of SRS. Columbia SMSA is classified as a small hub, enplaning approximately 725,000 passengers at Columbia Metropolitan Airport during CY 2005. It had approximately 108,000 total arrivals and departures during that year.

The Augusta metropolitan area, with Bush Field Municipal Airport enplaned approximately 156,000 passengers in CY 2005. Bush Field is located approximately 20 miles (32 km) from SRS, has a lighted runway of 8,000 feet, and is served by commercial airlines. Delta AirLines and US Air are the two major air carriers.

During the history of SRS operations, one single-engine plane emergency landed on an onsite highway. This landing occurred during a period of low traffic density, and the pilot avoided highway vehicles. A security patrol helicopter crashed on the site in September 1985, and did not cause any hazardous substance release (Ref. 389). An Edgerton, Germeshausen, and Grier, Inc. (EG&G) survey helicopter landed in the Solid Waste Disposal Facility area when its engine malfunctioned. In another instance, an amphibious airplane landed on Par Pond when the pilot mistook it for Thurmond Lake (formerly Clarks Hill Reservoir).

In CY 2002, an evaluation determined that the effect of onsite helicopter security flights on aircraft crash probabilities and consequences increased the probability of an event, but did not significantly increase the overall risks (i.e., consequences) associated with aircraft.

1.6.1.5 Airspace Restrictions

The air space restriction over SRS was lifted in 1976. Until that time, the frequency of unauthorized flights over the restricted airspace was about 100 per year. Since 1976, the frequency of flights over the site is estimated to have increased to about 4,000 per year (Ref. 389). Pilots are instructed to avoid flight below 1,200 feet msl in the area over SRS (Ref. 391).

1.6.1.6 Waterborne Transportation

During the 1950s through the mid-1970s, there was navigational traffic on the Savannah River from Augusta to Savannah. By the late 1970s, waterborne commerce was limited to the transportation of oil to Augusta by the Koch Oil Company until the company discontinued shipping operations in 1979. Since then, virtually no commercial shippers have used the river (Ref. 45, 46).

To promote the economic development of Augusta, efforts are being made locally to increase recreational events on the Savannah River. For example, package river tours that cruise the part of the river bounding SRS are available twice daily on certain days of the week. Scull and powerboat races are also held on this river.

1.6.2 MISSILES AND BLAST EFFECTS

The threat from man-made sources capable of generating missiles and blast effects that will impact the functioning of Safety Class items are discussed in facility-specific SARs/DSAs.

1.7 NEARBY FACILITIES

Per DOE-STD-3009 (CN-3), this section is intended to identify nuclear, industrial, and military facilities within a 50-mile (80-km) radius of the SRS center that could be impacted by accidents at SRS. The area within a 50-mile radius includes Edgefield, Aiken, Barnwell, Allendale, Hampton, Bamberg, Orangeburg, Lexington, and Saluda Counties in South Carolina; and Columbia, Richmond, Burke, Jefferson, Jenkins, and Screven Counties in Georgia (see Figure 1.7-1).

In addition, this section is intended to identify any hazardous operations or facilities onsite or offsite that could adversely impact the facility under evaluation.

1.7.1 OFFSITE INDUSTRIAL AND MILITARY FACILITIES

The Georgia Manufacturers Register and the South Carolina Manufacturers Register may be referred to for current, detailed information on all industries located in the two-state area. Most of these businesses are small and would have no impact on SRS facilities. Any events or scenarios resulting from significant area industrial facilities, such as Kimberly Clark, are addressed through the site Emergency Preparedness Program.

1.7.1.1 Non-SRS Nuclear Facilities

Two major non-SRS nuclear facilities are located within 50 miles (80 km) of SRS, their locations being highlighted in Figure 1.7-1. These include:

CHEM NUCLEAR SYSTEMS, INC.

CNSI, a 300-acre site located in Barnwell County, South Carolina, near the eastern SRS boundary, is a commercial facility for the disposal of low-level wastes and hazardous chemicals. CNSI facilities include a burial site, transportation, and maintenance units, and facilities for waste solidification and decontamination. It was licensed for operation in 1971.

VOGTLE ELECTRIC GENERATING PLANT

The VEGP is a two-unit nuclear power plant licensed by NRC and located across the Savannah River from the SRS. It is located in Burke County, Georgia, about 4.5 miles (7.25 km) south-southeast of 400-D Area. Unit 1 was licensed for full-power operation in May 1987. Unit 2 began operation in May 1989. Approximately 890 employees are now at that site.

Based on an analysis of effects from offsite facilities which was conducted as part of the 1990 EIS for continued operations of K-, L-, and P-Reactors (Ref. 94), radiological impacts from the operation of VEGP, a two-unit commercial nuclear electric facility operated by Georgia Power directly across the Savannah River from SRS, are very small. For example, annual latent cancer fatalities are estimated to be $2.9x10^{-5}$; however, the impacts were included in the EIS analysis. The potential radiological impacts from the other nuclear facilities were negligible.

1.7.1.2 Non-SRS, Non-Nuclear Facilities

There are two industrial complexes within fairly close proximity to SRS which are worth mentioning. These are:

- SCE&G's Urquhart Station, a three-unit, 250-MWt, coal- and natural-gas-fired steam electric plant in Beech Island, SC, is located on the Savannah River about 20 river miles (32 river km) north (upstream) of SRS. Because of the distance between the SRS coal-fired power plants and the Urquhart Station and the regional wind direction frequencies, there is little opportunity for any interaction of plant emissions and no significant cumulative impact on air quality (Ref. 91).

- Fort Gordon, the nearest military installation, which is located on 55,000 acres approximately 9 miles (14 km) southwest of Augusta, GA, between U.S. Routes 1 and 78. The 755-bed Dwight David Eisenhower Army Medical Center, located at Fort Gordon, serves as the regional military medical facility for the southeastern United States, Puerto Rico, and the Panama Canal Zone. In 1994, Fort Gordon had an average military population of 13,150 and a civilian population of approximately 5,320. Other military facilities are in Georgia and in South Carolina (see Figure 1.7-2).

1.7.1.3 SRS Nuclear Facilities

This section discusses nuclear facilities on SRS that have safety implications which may affect other SRS facilities.

REACTOR AREAS

Although the 5 production reactor facilities (C, K, L, P, and R) have been shutdown for several years (Ref. 20), significant amounts of moderator and radioactive materials are currently stored in some of the facilities. SRS safety analyses are limited to determination of the impact of individual facility events at the site boundary and the co-located worker and are documented in the individual facility safety bases. Therefore, the on-and off-site impact of events which could occur at the reactor is not required in this document.

H-, S-, AND Z-AREAS

The 5-mile (8-km) area surrounding the H-, S-, and Z-Areas lies entirely within SRS boundaries; therefore, no industrial centers other than onsite SRS facilities are applicable.

The following SRS areas are located within the 5-mile area: 100-C, 100-R, N-Area (Central Shops), 200-E, 200-H, 200-S, 200-Z, 700-B, and 200-F-Areas. The Annual TIER II Inventory Report for the SRS as required by 40 CFR 370 lists the products and materials produced, used, stored, or transported at the 100 and 200-Area facilities. Figure 1.3-4 shows the locations of these facilities.

Nuclear facilities that are in proximity to H-, S-, and Z-Areas and have safety implications for these areas include the following:

- SRS reactor facilities described for F-and E-Areas is applicable to H, S, and Z-Areas.

- F Canyon and FB Line are being decontaminated and decommissioned. The F-Canyon structure and engineered safety features provide an effective radiological confinement system designed to control radionuclide release to the environment. The SAR for F-Canyon and FB Line operations provides estimates of radiological consequences which may occur as a result of F-Canyon and liquid radioactive waste handling accidents. The estimated doses are a small fraction of the annual exposure from natural background. This level of consequence indicates that the facility does not present an undue risk to onsite or offsite populations.

- The reactor materials facilities are located approximately 6 miles (10 km) from H-, S-, and Z-Areas. The impact of the reactor materials facilities on H-, S-, and Z-Areas is the D-Area is no longer in operation. This plant poses no undue risk to facilities in H-, S-, and Z-Areas.

- E-Area is located within one mile of H-Area. It is used for disposal of all SRS radioactive waste and poses no risk to the areas.

<u>H AREA</u>

The H-Canyon structure and engineered safety features provide an effective radiological confinement system designed to control radionuclide release to the environment. Estimates of radiological consequences for personnel in other areas from accidents as a result of H Canyon and liquid radioactive waste handling operations are a small fraction of the annual exposure from natural background, indicating that the facility can be operated without undue risk to onsite or offsite populations.

H-Area also contains tritium facilities that have the potential to release significant quantities of tritium. Risks to the safety of the other site areas due to H-Area operations are minimal except for tritium releases.

The Saltstone Facility is located in Z-Area, approximately 6 miles (10 km) from M-Area and A-Area. See “F and E-Areas” (above) for a discussion of this facility. The Solid Waste Management Facility (SWMF) (E-Area) is located about 5.5 miles (9 km) from the areas. See “H-, S-, and Z-Areas” (above) for a discussion of this area.

H-Canyon and HB Line remain in operation at SRS. H-Canyon is located approximately 6.5 miles (10.5 km) from M-Area and A-Area. H-Area operations are discussed in the previous section, “F- and E-Areas”. F Canyon and FB Line which are located approximately 5 miles (8 km) from M- and A-Areas are shutdown. The estimated doses from accidents in the Separations Areas reaching the vicinity of M- and A-Area would be a small fraction of the annual exposure from natural background. This level of consequence indicates that the facility can be operated without undue risk to onsite or offsite populations.

D-Area is no longer in operation. Currently, the rework unit of the Heavy Water Plant is no longer operating to purify the reactor moderator. This plant poses no undue risk to this area.

M-AREA, A-AREA (SAVANNAH RIVER TECHNOLOGY CENTER)

The status of SRS reactor facilities described for F- and E- Areas is applicable to SRTC, A-Area, and M-Area.

The reactor materials facilities which were once located in M-Area formerly processed aluminum, lithium, uranium, and target materials for SRS reactors. There are no ongoing operations except for decontamination and decommissioning activity which does not pose a significant risk. Most structures in this area have been removed and there are very few personnel in the area.

M-AREA

The facilities are now shutdown with many of the buildings having already been torn down or in other phases of decommissioning. The area poses no significant risk to any other SRS areas.

D-AREA

The distances between D-Area and operating facilities are about 6 miles (10 km) to F-Area, 7.5 miles (12 km) to H-Area, 7 miles (11 km) to E-Area, 8.5 miles 13.5 km) to Z-Area, and about 8 miles (13 km) to S-Area. Because of the distance between D-Area and these other areas, other operating areas pose no risk to D-Area facilities.

A-AREA, M-AREA, AND SAVANNAH RIVER TECHNOLOGY CENTER

There are several small businesses, such as a well drilling service and a welding shop, located in Jackson and New Ellenton, South Carolina. These operations pose no significant risk to the operations in A-Area, M-Area, and SRTC.

D AREA

The only industry within 5 miles (8 km) of D-Area outside of SRS is VEGP. The radiological impacts from the operation of VEGP are very small (Ref. 94). An emergency plan and communications protocol is in place. Details of protective actions, in regards to an accident at VEGP, are in the SRS Emergency Plan described in Chapter 15 of this report. The 100-C and 100-K Areas are the only industrial centers within the 5-mile (8 km) radius of D-Area. Hazardous materials in the 100-Areas are listed in the Annual TIER II Inventory Report for the SRS as required under 40 CFR 370.

1.8 VALIDITY OF EXISTING ENVIRONMENTAL ANALYSES

A review of existing EISs and Environmental Assessments (EAs) that address SRS facilities and/or operations indicates that assumptions concerning site characteristics for these documents are the same as those used in SARs/DSAs. When there is a SAR/DSA for an operation/facility, the EIS or EA focuses on incremental effects of the proposed action compared to those effects identified in the SAR/DSA. The WSRC Environmental Report for 2005 (Ref. 5) discusses the status of environmental compliance and identifies all National Environmental Policy Act documentation and activities for the year.

The Annual Environmental Report for SRS published for each calendar year includes information on sample locations as identified in SCDHEC permits; data for sample collections and measurements of sample contents; and associated permits and activities to comply with EPA regulations and DOE Orders as they apply to SRS. In summary, the Annual Environmental Report for each calendar year:

- Shows results of measurements of releases of radionuclides and nonradionuclide materials from various release points to the environs as identified in EISs, EAs, and SARs/DSAs.
- Identifies noncompliances where the release exceeds radiological or environmental regulations or exceeds state or federal permits.
- Includes a summary description of abnormal or accidental release(s) during the calendar year.
- Documents the estimated consequence of the release(s) to the public and the environment.
- Summarizes the status of environmental compliance activities at SRS for the year.
- Provides a general overview of environmental programs at SRS.
- Provides information on environmental restoration and waste management activities and programs.

EISs and EAs for SRS operations or DOE programmatic activities were prepared over an extended period. The information on site characteristics described in these documents changed as a function of time to reflect findings from continuing studies of the characteristics of climatology, meteorology, geohydrology, and observations of severe weather. Steadily improving state-of-the-art technology, instrumentation, and special techniques such as aerial photography and satellite imagery were employed to study the detailed features of site characteristics and thereby improve the database of those characteristics. Updated information was used as soon as it was reported in referenceable form.

At a particular time, the same set of data for SRS site characteristics was used for any EIS/EA and SAR/DSA activities concurrently in progress. Further, the same methodology and calculational codes were used to calculate the consequences of the postulated release of hazardous materials, via the atmosphere or water routes, to the offsite population. In the SRS annual monitoring reports issued to the public, the consequences from radionuclides measured in samples of effluent air, water in SRS streams, soil, foodstuff, etc., were determined using the methodology and calculational codes employed for EISs/EAs and SARs/DSAs.

The site characteristics (including ecology, geohydrology, meteorology, surface streams receiving cooling water, etc.) were extensively described in the EIS for continued operation of K-, L-, and P-Reactors at SRS (Ref. 51). These brief descriptions were based on Environmental Information Documents (EIDs) specifically developed to provide referenceable information for the EIS. These EIDs and this EIS are often referenced in the approved EAs because they provide a comprehensive description of most site characteristics.

Characteristics of areas surrounding and under waste sites containing hazardous material were documented in 1987 in a series of about 35 EIDs specifically developed to support the EIS for waste management activities for groundwater protection (Ref. 439). Discussions of geohydrology characteristics were included. This group of documents addressed characteristics of the whole site, whereas the EIS for the continued operation of SRS reactors focused on the site streams to which cooling water was discharged.

1.9 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

1. Preparation Guide for U.S. Department of Energy, Nonreactor Nuclear Facility Safety Analysis Reports. DOE-STD-3009-94, Change Notice No. 3, U.S. Department of Energy, Washington, DC, March 2006.

2. Nuclear Safety Management, Code of Federal Regulations, 10 CFR, Part 830, U.S. Government Printing Office, Washington, DC.

3. Standards/Requirements Identification Document. WSRC-RP-94-1268, Washington Savannah River Company, Aiken, SC.

4. Compliance Assurance Manual. WSRC Procedure Manual 8B, Washington Savannah River Company, Aiken, SC.

5. Savannah River Site Environmental Report for 2005. WSRC-TR-2006-00007, Washington Savannah River Company, Aiken, SC.

6. Savannah River Site Emergency Plan. WSRC Procedure Manual SCD-7, Washington Savannah River Company, Aiken, SC.

7. Occupational Radiation Protection. Code of Federal Regulations, 10 CFR, Part 835, U.S. Government Printing Office, Washington, DC.

8. Radiation Protection of the Public and the Environment. DOE Order 5400.5, Change 2, U.S. Department of Energy, Washington, DC, January 1993.

9. Land and Water Use Characteristics in the Vicinity of the Savannah River Site. WSRC-RP-91-17, Washington Savannah River Company, Aiken, SC, March 1991.

10. Agricultural Statistics for Allendale County. South Carolina Agricultural Statistics Service, Department of Agricultural Economics, Clemson University, 1993.

11. Agricultural Statistics for Aiken County. South Carolina Agricultural Statistics Service, Department of Agricultural Economics, Clemson University, 1993.

12. Agricultural Statistics for Barnwell County. South Carolina Agricultural Statistics Service, Department of Agricultural Economics, Clemson University, 1993.

13. Hunter, C. H. A Climatological Description of the Savannah River Site. WSRC-RP-89-313, Washington Savannah River Company, Aiken, SC, May 1990.

14. Hunter, C.H. to Talukdar, B. Updated Meteorological Data for Revision of the SRS Generic Safety Analysis Report. SRT-NTS-970265, WSRC Inter-Office Memorandum, Washington Savannah River Company, Aiken, SC, August 14, 1997.

15. Hunter, C.H. to Howley, J. Meteorological Data for Revision 4 of the SRS Generic Safety Analysis Report. SRT-NTS-99-0043, Washington Savannah River Company, Aiken, SC, March 1, 1999.

16. Local Climatological Data, Annual Summary with Comparative Data, 1991, Augusta, GA. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climate Data Center, Asheville, NC, 1992.

17. Parker, M.J. and Addis, R. P. Meteorological Monitoring Program at the Savannah River Site. WSRC-TR-93-0106, Washington Savannah River Company, Aiken, SC, 1993.

18. Pautz, M.E. Severe Local Storm Occurrences, 1955-1967. Weather Bureau Technical Memorandum, No. 12, U.S. Department of Commerce, Washington, DC, 1969.

19. Marshall, J.L. Lightning Protection. John Wiley and Sons, New York, NY, 1973.

20. 1989-93 Measured Lightning Flash Density. Geomet Data Services Inc., 1994.

21. Addis, R.P. and Kurzeja, R.J. Heavy Rainfall at the SRS in July, August, and October of 1990. WSRC-TR-92-136, Washington Savannah River Company, Aiken, SC.

22. Tattelman, P., et al. Estimated Glaze Ice and Wind Loads at the Earth's Surface for the Contiguous United States. AFCRL-TR-73-0646, U.S. Air Force, October 1973

23. Weber, A.H., et al. Tornado, Maximum Wind Gust, and Extreme Rainfall Event Recurrence Frequencies at the Savannah River Site. WSRC-TR-98-00329, Washington Savannah River Company, Aiken, SC, 1998.

24. Miller, J.F., Two-to-Ten Day Precipitation for Return Periods of Two-to-One Hundred Years in the Contiguous United States. Technical Paper No. 49, U.S. Weather Bureau, U.S. Department of Commerce, Washington, D.C., 1964.

25. Parker, M.J. Savannah River Site Tornado Damage of March 1991. WSRC-RP-91-439, Washington Savannah River Company, Aiken, SC, 1991.

26. Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities. DOE-STD-1020-94, U.S. Department of Energy, Washington, DC, April 1994.

27. Hosler, C.R. "Low-Level Inversion Frequency in the Contiguous United States." Monthly Weather Review. Vol. 89, No. 9, 1961.

28. Pendergast, M.M. Turbulent Diffusion in the Planetary Boundary Layer Over the Savannah River Plant During Periods of Differing Thermal Structure. DP-1412, E.I. du Pont de Nemours and Company, Savannah River Plant, Aiken, SC, 1975.

29. Holzworth, G.C. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. AP-101, U.S. Environmental Protection Agency, Washington, DC, January 1972.

30. Korshover, J. Climatology of Stagnating Anticyclones East of the Rocky Mountains, 1936-65. NOAA Technical Memorandum ERL-ARL-55, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, DC, 1975.

31. Environmental Dose Assessment Manual, WSRC-IM-91-1, Rev. 1, Washington Savannah River Company, Aiken, SC, October 1995.

32. Water Resources Data for South Carolina, Water Year 1987. U.S. Geological Survey Data Report SC-8701, 1988.

33. Kuglar, B.E. State of South Carolina Water Resources Commission Water Use Report. Savannah River Site, 2nd Quarter, 1995.

34. Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site. DOE/EA-1070, U.S. Department of Energy, Savannah River Operations Office, Savannah River Site, Aiken, SC, August 1995.

35. Smith, L.L. “Solution Depressions in Sandy Sediments of the Coastal Plain in South Carolina." Journal of Geology. Vol. 39, 1931.

36. Prouty, W.F. “Carolina Bays and Their Origins." Geological Society of America Bulletin. Vol. 63, 1952.

37. Mackey, H.E. Comprehensive Cooling Water Study Final Report. Volume IV, *Wetlands*. DP-1739-4, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1987.

38. Savannah River Plant Precipitation Summary. E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1986.

39. Water Resources Data for South Carolina, Water Year 1986. U.S. Geological Survey Data Report SC-86-1, U.S. Geological Survey, 1987.

40. Water Resources Data for South Carolina, Water Year 1984. U.S. Geological Survey Data Report SC-84-1, U.S. Geological Survey, 1985.

41. Water Resources Data for South Carolina, Water Year 1988. U.S. Geological Survey Data Report SC-88-1, U.S. Geological Survey, 1989.

42. Root, R.W., Jr. Numerical Simulation of Ground H_2O Flow at Savannah River Plant, South Carolina. Department of Geosciences, Pennsylvania State University, Altoona, PA, 1987.

43. Ashley, et al. Environmental Monitoring at the Savannah River Plant for 1983. DPSPU-84-302, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1984.

44. Ziegler, et al. Environmental Monitoring at the Savannah River Plant for 1984. DPSPU-85-302, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1985.

45. Ziegler, et al. Savannah River Environmental Report for 1985. DPSPU-86-30-1, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1986.

46. Ziegler, et al. Savannah River Plant Environmental Report for 1986. DPSPU-87-30-1, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC 1987.

47. Mikol, et al. U.S. Department of Energy Savannah River Plant Environmental Report for 1987. DPSPU-88-30-1, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1988.

48. Water Resources Data for South Carolina, Water Year 1983. U.S. Geological Survey Data Report SC-83-1, 1984.

49. Water Resources Data for South Carolina, Water Year 1985. U.S. Geological Survey Data Report SC-85-1, U.S. Geological Survey, 1986.

50. Specht, W.L. "Comprehensive Cooling Water Study Final Report." Volume V, Aquatic Ecology. DP-1739-5, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1987.

51. Continued Operation of K-, L-, and P-Reactors, SRS, Aiken, SC, Final Environmental Impact Statement. DOE/EIS-0147, U.S. Department of Energy, Washington, DC, 1990.

52. Langley, T.M. and Marter, W.L. The Savannah River Plant Site. DP-1323, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1973.

53. Paller, M. and Osteen, D.V. Annual Report on the Savannah River Aquatic Ecology Program -- November 1983-August 1984, Volume 1, *Adult Fish*. ECS-SR-17, Environmental and Chemical Science, Inc., Aiken, SC, 1985.

54. Giesy, J.P., Jr. and Briese, L.A. "Trace Metal Transport by Particulates and Organic Carbon in Two South Carolina Steams." Proceedings of the International Association of Theoretical and Applied Limnology. Vol. 20, 1978,

55. Lower, M.W. and Hayes, D.W. "Results of Gamma Spectroscopy Analyses." CCWS Sediment Cores. DPST-86-455, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1986.

56. "Comprehensive Cooling Water Study Final Report." Volume III. Radionuclide and Heavy Metal Transport. DP-1739-3, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, 1987.

57. Lower, M.W. Comprehensive Cooling Water Study Final Report. Volume II: Water Quality. DP-1739-2, E.I. de Pont de Nemours & Co., Savannah River Plant, Aiken, SC, October 1987.

58. Gibbons, J.W. and Sharitz, R.R. "Thermal Alterations of Aquatic Ecosystems." American Scientist. Vol. 62, 1974.

59. Lower, M.W. Compilation of Historic Water Quality Data Base. DPST-84-555, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, June 1984.

60. Rogers, V.A. Soil Survey of Savannah River Plant Area, Parts of Aiken, Barnwell and Allendale Counties, South Carolina. U.S. Department of Agriculture, Soil Conservation Service, Washington, DC, June 1990.

61. Aadland, R.K., et al. Hydrogeologic Framework of West Central South Carolina. Report 5, South Carolina Department of Natural Resources, Water Resources Division, 1995.

62. Aadland, R.K., and Bledsoe, H.W. Classification of Hydrostratigraphic Units at the Savannah River Site, South Carolina. WSRC-RP-90-987, Washington Savannah River Company, Aiken, SC, 1990.

63. Aadland, R.K. and Bledsoe, H.W. "Hydrostratigraphy of the Coastal Plain Sequence, Savannah River Site (SRS), South Carolina." GSA Abstracts with Programs. Vol. 22, No. 7, 1990.

64. Bledsoe, H.W., et al. Baseline Hydrogeologic Investigation - Summary Report. WSRC-RP-90-1010, Washington Savannah River Company, Aiken, SC, 1990.

65. Miller, J.A. and Renkien, R.A. "Nomenclature of Regional Hydrogeologic Units of the Southeastern Coastal Plain Aquifer System." U.S. Geological Survey, Water Resources Investigations Report 874202, 1988j.

66. Poland, J.F., et al. Glossary of Selected Terms Useful in Studies of the Mechanics of Aquifer Systems and Land Subsidence Due to Fluid Withdrawal. U.S. Geological Survey Water Supply Paper 2025, 1972.

67. Bates, R.L. and Jackson, J.A. Glossary of Geology. American Geological Institute, Falls Church, Virginia, 1980.

68. Lohman, S.W., et al. Definitions of Selected Groundwater Terms - Revisions and Conceptual Refinements. U.S. Geological Survey Water-Supply Paper No. 1988, 1972.

69. Florida and in Parts of Georgia, Alabama, and South Carolina. U.S. Geological Survey Professional Paper No. 1403-B, 1986.

70. Meisler, H. Plan of Study for the Northern Atlantic Coastal Plain Regional Aquifer System Analysis. U.S. Geological Survey Water-Resources Investigation Report 80-16, 1980.

71. Grubb, H.F.,Gulf Coast Regional Aquifer System Analysis – A Mississippi Perspective. U.S. Geological Survey – Water Resources Investigations Report 86-4162, U.S. Geological Survey, Denver, CO, 1986.

72. Stringfield, V.T. Artesian Water in Tertiary Limestone in the Southeastern States. U.S. Geological Survey Professional Paper 517, 1966.

73. Krause, R.E. and Randolph, R.B. Hydrology of the Floridan Aquifer System in Southeast Georgia and Adjacent Parts of Florida and South Carolina. U.S. Geological Survey Professional Paper 1403-D, 1989.

74. Krause, R.E. Digital Model Evaluation of the Predevelopment Flow System of the Tertiary Limestone Aquifer, Southeast Georgia, Northeast Florida, and Southern South Carolina. U.S. Geological Survey Water-Resources Investigations Report 82-173, 1982.

75. Evans, E.K. and Parizek, R.R. Characterization of Hydraulic Conductivity Heterogeneity in Tertiary Sediments within the General Separations Area, Savannah River Site, South Carolina. Department of Geosciences, Pennsylvania State University, PA, 1991.

76. Beard, D.C. and Weyl, P.K. "Influence of Texture on Porosity and Permeability of Unconsolidated Sand." American Association of Petroleum Geologists Bulletin. No. 57, 1973.

77. Hydrogeologic Characterization of the MWMF (Mixed Waste Management Facility), SRS. WSRC-RP-92-837, Washington Savannah River Company, Aiken, SC, 1992

78. Walton, C.W. Applied Hydrology. Merrell Publishing, Columbus, OH, 1988.

79. Fetter, W.C. Ground Water Resource Evaluation. McGraw-Hill Book Co., New York, NY, 1988.

80. Fallaw and Price. "Geological Investigations of the Central Savannah River Area, South Carolina, and Georgia." Carolina Geological Society Field Trip Guidebook for 1992. 1992.

81. Aadland, R.K., et al. Geology and Hydrostratigraphy of the A-M Area, Savannah River Site (SRS), South Carolina. WSRC-RP-92-440, Washington Savannah River Company, Aiken, SC, 1992.

82. Clarke, J.S., et al. Hydrogeology of the Dublin and Midville Aquifer Systems of East Central Georgia. Georgia Geological Survey Information Circular 74, 1985.

83. Aucott, W.R., et al. Geohydrologic Framework of the Coastal Plain Aquifers of South Carolina." U.S. Geological Survey Water-Resources Investigations Report 85-4271, 1988.

84. Siple, G.E. “Geology and Ground Water of the Savannah River Plant and Vicinity, South Carolina." Paper No. 1841, United States Geological Survey Water Supply. 1967.

85. Faye, R.E. and Prowell, D.C. Effects of Late Cretaceous and Cenozoic Faulting on the Geology and Hydrology of the Coastal Plain Near the Savannah River, Georgia and South Carolina. U.S. Geological Survey Open File Report 82-156, 1982.

86. GeoTrans, Inc. “Characterization of Ground Water Flow and Transport in General Separations Area, Savannah River Plant.” Effects of Closure Options on Groundwater Flow at the F-Area Seepage Basins. 1988.

87. Stieve, A.L., et al. Pen Branch Fault Program: Consolidated Report on the Seismic Reflection Surveys and the Shallow Drilling. WSRC-TR-91-87, Washington Savannah River Company, Aiken, SC, 1991.

88. Aucott, W.R. and Speiran, G.K. “Ground Water Flow in the Coastal Plain Aquifers of South Carolina.” Journal of Ground Water. Vol. 23, No. 6, 1985a.

89. Benedict, M., et al. Permanent Storage of Radioactive Separations Process Wastes in Bedrock on the Savannah River Plant Site. E.I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC, 1969.

90. Wait, R.L. and Davis, M.E. Configuration and Hydrology of the Pre-Cretaceous Rocks Underlying the Southeastern Coastal Plain Aquifer System. U.S. Geological Survey Water-Resources Investigations Report 86-4010, 1986.

91. Marine, I.W. Hydraulic Correlation of Fracture Zones in Buried Crystalline Rock at the Savannah River Plant Near Aiken, South Carolina. Chapter D, Geological Survey Research 1966. U.S. Geological Survey Professional Paper 550-D, 1966.

92. Marine, I.W. “The Permeability of Fractured Crystalline Rock at the Savannah River Plant Near Aiken, South Carolina." Geological Survey Research 1967, Chapter B, U.S. Geological Survey Professional Paper 575-B, pp. B203-B211, 1967.

93. Marine, I.W. “The Use of Tracer Test to Verify an Estimate of Groundwater Velocity in Fractured Crystalline Rock at the Savannah River Plant Near Aiken, South Carolina." Isotope Techniques in the Hydrologic Cycle. Geophysical Monograph Series, Vol. 11, Washington, DC, American Geophysical Union, 1967.

94. Marine, I.W. “Geohydrology of Buried Triassic Basin at Savannah River Plant, South Carolina.” American Association of Petroleum Geologists Bulletin. Vol. 58, 1974.

95. Webster, D.S., et al. Two-Well Tracer Test in Fractured Crystalline Rock. U.S. Geological Survey Water-Supply Paper 1 544-1, 1970.

96. Wyatt, D.E., et al. A/M-Area Advanced Geological Study, Part 3, “Geologic Interpretation of the Structure and Stratigraphy of the A/M-Area, Savannah River Site, South Carolina.” WSRC-RP-97-0186, Rev. 0, 1997.

97. Aadland, R.K. Tertiary Geology of A/M-Area Savannah River Site, South Carolina. WSRC-RP-97-0505, Rev. 1, Washington Savannah River Company, Aiken, SC, 1997.

98. Strom, R.N. and Kaback, D.S. SRP Baseline Hydrogeologic Investigation: Aquifer Characterization, Groundwater Geochemistry of the Savannah River Site and Vicinity. WSRC-RP-92-450, Washington Savannah River Company, Aiken, SC, 1992.

99. Chappelle, F.J. and Loveley, D.R. “Competitive Exclusion of Sulfate Reduction of Fe-III-Reducing Bacteria: A Mechanism for Producing Discrete Zones of High-Iron Ground Water." Ground Water. Vol. 30, No. 1, 1991.

100. Colquhoun, D.J. and Johnson, Jr., H.S. “Tertiary Sea-Level Fluctuation in South Carolina.” Paleogeography, Paleoclimatology, Paleoecology. Vol. 5, 1968.

101. Colquhoun, D.J., et al. “Surface and Subsurface Stratigraphy, Structure and Aquifers of the South Carolina Coastal Plain.” SCDHEC Report ISBN 0-9613154-0-7, 1983.

102. Cooke, C.W. “Geology of the Coastal Plain of South Carolina.” U.S. Geological Survey Bulletin. No. 867, 1936.

103. Prowell, D.C., et al. “Geologic Section of the Updip Coastal Plain from Central Georgia to Western South Carolina.” Map MF-1737, USGS Miscellaneous Field Studies, 1985.

104. Bollinger, G.A., et al. “Seismicity of the Southeastern United States -- 1968–1986." Decade of Geology. 1987.

105. Visvanathan, T.R. “Earthquakes in South Carolina, 1698—1975,” South Carolina Geological Survey Bulletin, Vol. 40, 1980.

106. Dewy, J.W., “Relocation of Instrumentally Recorded Pre-1974 Earthquakes in South Carolina Region,” in Studies Related to the Charleston, South Carolina Earthquake of 1986 - Tectonics and Seismicity (ed. Gohn, G.S.), US Geological Survey Professional Paper 1313, 1983.

107. Talwani, P., “Crustal Structure of South Carolina,” Second Technical Report to the U.S. Geological Survey, Contract #14-08-0001-14553; 1975.

108. Talwani, P.J., et al. “The Savannah River Plant, South Carolina, Earthquake of June 9, 1985 and its Tectonic Setting.” Earthquake Notes. Vol. 56, No. 4, 1985.

109. Stephenson, D.E., et al. Savannah River Plant Earthquake of June 1985. DPST-85-583, E.I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC, 1985.

110. Stephenson, D.E. Savannah River Plant Earthquake. DPST-88-841, E.I. du Pont de Nemours and Co., Savannah River Laboratory, Aiken, SC, August 1988.

111. National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions for Seismic Regulations for New Buildings and Other Structures. Building Seismic Safety Council, part 1 Provisions (FEMA 302).

112. Lee, R.C. Soil Surface Seismic Hazard and Design Basis Guidelines for Performance Category 1 & 2 SRS Facilities. WSRC-TR-98-00263, Rev. 0, Washington Savannah River Company, Aiken, SC, September 1998.

113. Natural Phenomena Hazards Assessment Criteria. DOE-STD-1023-95, Change Notice No. 1, U.S. Department of Energy, Washington DC, January 1996.

114. Dutton, C.E. "The Charleston Earthquake of August 31, 1886." U.S. Geological Survey Annual Report 1887-1888. Government Printing Office, Washington, DC, 1889.

115. Dutton, C. E. The Charleston Earthquake of August 31, 1886. U.S. Geological Survey, 1890.

116. Talwani, P. The Woodstock Fault is Alive and Ticking Near Charleston, South Carolina. Submitted to the Bulletin of the Seismological Society of America, 1982.

117. Talwani, P. "Seismotectonics of the Charleston Region." Proceedings, National Conference on Earthquake Engineering, 3rd. Earthquake Engineering Research Inst., Vol. 1, 1986.

118. Amick, D.R., et al. Paleoliquefaction Features Along the Atlantic Seaboard. NUREG/CR-5613, U.S. Nuclear Regulatory Commission, Washington, DC, 1990.

119. Obermeier, S.F., et al. Earthquake-Induced Liquefaction Features in the Coastal Setting of South Carolina and in the Fluvial Setting of the New Madrid Seismic Zone. U.S. Geological Survey Professional Paper No. 1504, 1990

120. Geomatrix Consultants, Inc. Ground Motion Following Selection of SRS Design Basis Earthquake and Associated Deterministic Approach. WSRC Subcontract AA2021S, Washington Savannah River Company, Aiken, SC, 1991.

121. Kimball, J.K. "The Use of Site Dependent Spectra." Proceedings of the U.S. Geological Survey Workshop on Site Specific Effects of Soil and Rock on Ground Motions and the Implications for Earthquake-Resistant Design. U.S. Geological Survey Open File Report 83-845, 1983

122. URS/John A. Blume and Associates, Engineers. Update of Seismic Criteria for the Savannah River Plant, Vol. 1 of 2, *Geotechnical.* USR/JAB8144, San Francisco, CA. Prepared for E.I. du Pont de Nemours and Company as DPE-3699, Savannah River Plant, Aiken, SC, 1982.

123. Lee, R.C. Update of H-Area Seismic Design Basis. WSRC-TR-94-0528, Rev. 1, Washington Savannah River Company, Aiken, SC.

124. Lee, R.C., et al. Savannah River Site Seismic Response Analysis and Design Basis Guidelines. WSRC-TR-97-0085, Rev. 0, Washington Savannah River Company, Aiken, SC, March 1997.

125. National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions for Seismic Regulations for New Buildings and Other Structures. Building Seismic Safety Council, part 1 Provisions (FEMA 302).

126. Hanks, T.C. and McGuire, R.K. "The Character of High-Frequency Strong Ground Motion." Bulletin of the Seismological Society of America. Vol. 71, No. 6, 1981.

127. Boore, D.M. "Stochastic Simulation of High-Frequency Ground Motions Based on Seismological Models of the Radiated Spectra." Bulletin of the Seismological Society of America. Vol. 73, 1983.

128. Guidelines for Determining Design Basis Ground Motions. EPRI TR-102293, Electric Power Research Institute, Palo Alto, CA, November 1993.

129. Somerville, P.G., et al. Comparison of Source Scaling Relation of Eastern and Western North American Earthquakes. BSSA, 77, #2, 322-346. 1987

130. Ou, G.B. and Herrmann, R.B. "A Statistical Model for Ground Motion Produced by Earthquakes at Local and Regional Distances." Bulletin of the Seismological Society of America. Vol. 80, No. 6, 1990.

131. Guidelines for Determining Design Basis Ground Motions. EPRI TR-102293, Electric Power Research Institute, Palo Alto, CA, November 1993.

132. Stokoe, K.H., et al. Correlation Study of Nonlinear Dynamic Soil Properties: Savannah River Site, Aiken, South Carolina. Rev. 0, File No. SRS-RF-CDP-95, University of Texas at Austin, Department Civil Engineering, September 13, 1995.

133. Lee, R.C. Investigations of Nonlinear Dynamic Soil Properties at the Savannah River Site. WSRC-TR-96-0062, Rev. 0, Washington Savannah River Company, Aiken, SC, March 1996.

134. Gutierrez, B.J. "Revised Envelope of the Site-Specific PC3 Surface Ground Motion," letter from DOE to L.A. Salamone and F. Loceff, September 9, 1999.

135. SRS Engineering Practices Manual. WSRC-IM-95-58, Rev. 0, Guide No. 02224-G, "Excavation Backfill, and Grading," Washington Savannah River Company, Aiken, SC, March 1997.

136. Deleted

137. Technical Engineering and Design Guides Adapted from the US Army Corps of Engineers, No. 9, "Settlement Analysis," American Society of Civil Engineers Press, New York, NY, 1994.

138. Soil Analysis. NAVFAC DM-7.01, Department of the Navy, Washington, DC, September 1986.

139. Hasek, M.J. Settlement of H-Area Waste Storage Tanks and Structures. K-ESR-H-00011, Washington Savannah River Company, Aiken, SC, October 1999.

140. Li, W.T. Settlement of Defense Waste Processing Facility. K-ESR-S-00003, Rev. 0, Washington Savannah River Company, Aiken, SC, September 1999.

141 APSF Liquefaction Settlement Analysis. K-CLC-F-00033, Rev. 0, Washington Savannah River Company, Aiken, SC, June 1998.

142. Geotechnical Summary Report for the Consolidated Incineration Facility. K-ESR-H-00004, Rev. 0, Washington Savannah River Company, Aiken, SC, 1994.

143. In Tank Precipitation Facility (ITP) H-Tank Farm (HTF) Geotechnical Report. WSRC-TR-95-0057, Rev. 0, Washington Savannah River Company, Aiken, SC, 1995.

144. Commercial Light Water Reactor Tritium Extraction Facility Geotechnical Summary Report. K-ESR-H-00010, Rev. 1, Washington Savannah River Company, Aiken, SC, June 1999.

145. F-Area Geotechnical Characterization Report. WSRC-TR-96-0069, Rev. 0, Washington Savannah River Company, Aiken, SC, September 1996.

146. Savannah River Site, Replacement Tritium Facility (233-H) Geotechnical Investigation. Volume 1, WSRC-RP-93-606, Bechtel Savannah River Incorporated, Savannah River Site, Aiken, SC, 1993.

147. Wang, W. Some Findings in Liquefaction. Water Conservancy and Hydroelectric Power Scientific Research Institute, Beijing, China, August 1979.

148. Koester, J.P. and Franklin, A.G. Current Methodologies for Assessing the Potential for Earthquake-Induced Liquefaction in Soils. NUREG/CR-430, U.S. Nuclear Regulatory Commission, Washington, DC, 1985.

149. Seed, H.B., et al. "Evaluation of Liquefaction Potential Using Field Performance Data." Journal of Geotechnical Engineering Division. Volume 109, No. 3, American Society of Civil Engineers, 1983.

150. Youd, T.L. and Idriss, I.M. Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Technical Report NCEER-97-0022, Buffalo, NY, December 31, 1997.

151. Savannah River Site, Replacement Tritium Facility (233-H) Geotechnical Investigation. WSRC-RP-93-606, Vol. I, Bechtel Savannah River Incorporated, Savannah River Site, Aiken, SC, 1993.

152. Youd, T.L. and Hoose, S.N. "Liquefaction Susceptibility and Geologic Setting." Proceedings, 6th World Conference on Earthquake Engineering. New Delhi, India, Vol. III, 1977.

153. Seed, H.B. "Soil Liquefaction and Cyclic Mobility Evaluation for Level Ground During Earthquakes." Journal of Geotechnical Engineering Division. Vol. 105, No. 2, American Society of Civil Engineers, February 1979.

154. Mitchell, J.K. and Solymar, Z.V. "Time Dependent Strength Gain in Freshly Deposited or Densified Sand," Journal of Geotechnical Engineering Division, Vol. 110, No. 11, American Society of Civil Engineers, November 1984.

155. Mitchell, J.K. "Practical Problems from Surprising Soil Behavior," The 20th Terzaghi Lecture, Journal of Geotechnical Engineering Division, Vol. 112, No. 3, American Society of Civil Engineers, March 1986.

156. Skempton, A.W. "Standard Penetration Test Procedures and the Effects in Sands of Overburden Pressure, Relative Density, Particle Size, Aging and Overconsolidation," Geotechnique, Vol. 36, No. 3, 1986.

157. Schmertmann, J.H. "The Mechanical Aging of Soils," The 25th Terzaghi Lecture, Journal of Geotechnical Engineering, Vol. 117, No. 9, American Society of Civil Engineers, September 1991.

158. Schmertmann, J.H. "Update on the Mechanical Aging of Soils," for the symposium *Sobre Envejecimiento de Suelos,* The Mexican Society of Soil Mechanics, Mexico City, Mexico, August 1993.

159. Lewis, M.R., et al. "Liquefaction Resistance of Old Sand Deposits," Proceedings of the XI Panamerican Conference on Soil Mechanics and Geotechnical Engineering. Foz do Iguassu, Brazil, August 1999.

160. Dobry, R., et al. Predication of Pore Water Pressure Buildup and Liquefaction of Sands During Earthquakes by the Cyclic Strain Method. National Bureau of Standards Building Science Series 138, 1982.

161. Martin, G.R., et al. "Fundamentals of Liquefaction Under Cyclic Loading." Journal of the Geotechnical Engineering Division. Proceedings Paper 11284, ASCE, Vol. 101, No. 5, May 1975.

162. K-Area Soil Stabilization Program Geotechnical Evaluation. WSRC-TR-92-299, Washington Savannah River Company, Aiken, SC, July 1992.

163. APSF Soft Zone Settlement Analysis. K-CLC-F-00034, Rev. 0, Washington Savannah River Company, Aiken, SC, June 1998,

164. Siple, G.E. Geology and Ground Water of the Savannah River Plant and Vicinity, South Carolina. U.S. Geological Survey Water-Supply Paper 1841, 1967.

165. Geologic-Engineering Investigations, Savannah River Plant. DPWR-52, E.I. du Pont de Nemours and Company, Savannah River Plant, Aiken, SC, 1952.

166. Anderson, E.E. The Seismotectonics of the Savannah River Site: The Results of a Detailed Gravity Survey (M.S. Thesis). University of South Carolina, Columbia, SC, 1990.

167. Hatcher, R.D., et al. Continent-Ocean Transect E5 Cumberland Plateau (North American Craton) to Blake Plateau Basin. The Decade of North American Geology Project, Geological Society of America, Boulder, CO, 1994.

168. Hatcher, R.D., Jr., et al. "Tectonic Map of the U.S. Appalachian, Plate 1, the Appalachian-Ouachita Orogen in the United States." The Geology of North America. Vol. F-2. Geological Society of America, Boulder, CO, 1990.

169. Dillon, W.P. and Popenoe, P. "The Blake Plateau Basin and Carolina Trough." The Geology of North America. V I-2, The Atlantic Continental Margin. DNAG Publication, Geological Society of America, Boulder, CO, 1988.

170. Klitgord, K.D., et al. "US Atlantic Continental Margin: Structural and Tectonic Framework." The Geology of North America. V I-2, The Atlantic Continental Margin. DNAG Publication, Geological Society of America, Boulder, CO, 1988.

171. Poag, C.W. and Valentine, P.C. "Mesozoic and Cenozoic Stratigraphy of the US Atlantic Continental Shelf and Slope." The Geology of North America. V I-3, The Atlantic Continental Margin. DNAG Publication, Geological Society of America, Boulder, CO, 1988.

172. Hatcher, R.D., Jr. and Goldberg, S.A. "The Blue Ridge Geologic Province." The Geology of the Carolinas. Carolina Geological Society 50th Anniversary Volume, 1991.

173. Hatcher, R.D., Jr. and Butler, J.R. Guidebook for Southern Appalachian Field Trip in the Carolinas, Tennessee, and Northeastern Georgia. International Geologic Correlation Program Project 27, University of North Carolina, Chapel Hill, NC, 1979.

174. King, P.B. "A Geologic Cross Section Across the Southern Appalachians, An Outline of the Geology in the Segment in Tennessee, North Carolina, and South Carolina." Guides to Southeastern Geology. Geological Society of America Annual Meeting, 1955.

175. Hopson, J.R. "Structure, Stratigraphy, and Petrogenesis of the Lake Burton Mafic-Ultramafic Complex." Georgia Geological Society Guidebook. Vol. 9, 1989.

176. Hatcher, R.D., Jr. “Tectonics of the Western Piedmont and Blue Ridge, Southern Appalachians: Review and Speculation." American Journal of Science. Vol. 278, 1978.

177. Hatcher, R.D., et al. “The Smokies Foothills Duplex and Possible Significance of the Guess Creek Fault, A Corollary to the Mapping of King and Neuman.” Geological Society of America Abstracts with Programs. Vol. 18, 1986a.

178. Hatcher, R.D., Jr. “Developmental Model for the Southern Appalachians.” Geological Society of America Bulletin. Vol. 83, 1972.

179. Nelson, K.D., et al. “New COCORP Profiling in the Southeastern United States: Part I: Late Paleozoic Suture and Mesozoic Rift Basin.” Geology. Vol. 13, 1985.

180. Coruh, C., et al. “Results from Regional Vibroseis Profiling: Appalachian Ultradeep Core Hole Site Study.” Geophysical Journal of the Royal Astronomical Society. Vol. 89, 1987.

181. Cook, F.A., et al. “Thin-skinned Tectonics in the Crystalline Southern Appalachians: COCORP Seismic Reflection Profiling of the Blue Ridge and Piedmont.” Geology. Vol. 7, 1979.

182. Neuman, R.B. and Nelson, W.H. Geology of the Western Great Smoky Mountains, Tennessee. U.S. Geological Survey Professional Paper 349-D, 1965.

183. King, P.B., et al. Geology of the Great Smoky Mountains National Park, Tennessee and North Carolina. U.S. Geological Survey Professional Paper 587.

184. Fullagar, P.D., et al. “1200 m.y.-Old Gneisses in the Blue Ridge Province of North and South Carolina.” Southeastern Geology. Vol. 20, 1979.

185. Fullagar, P.D. and Bartholomew, M.J. “Rubidium-Strontium Ages of the Watauga River Cranberry, and Crossing Knob Gneisses, Northwestern North Carolina." Geological Investigations in the Blue Ridge of Northwestern North Carolina: 1983 Guidebook for the Carolinas. Geological Society, North Carolina Division of Land Resources, Article 11, 1983.

186. Fullagar, P.D. and Odom, A.L. “Geochronology of Precambrian Gneisses in the Blue Ridge Province of Northwestern North Carolina and Adjacent Parts of Virginia and Tennessee.” Geological Society of America Bulletin. Vol. 84, 1973.

187. Wehr, F. and Glover, L., III. “Stratigraphy and Tectonics of the Virginia-North Carolina Blue Ridge: Evolution of a Late Proterozoic-Early Paleozoic Hinge Zone." Geological Society of America Bulletin. Vol. 96, 1985.

188. Rast, N. and Kohles, K.M. “The Origin of the Ocoee Supergroup.” American Journal of Science. V. 286, 1986.

189. Hopson, J.L., et al. “Geology of the Eastern Blue Ridge of Northeast Georgia and the Adjacent Carolinas." Georgia Geological Society Guidebook. Vol. 9, 1989.

190. Horton, J.W., Jr. and McConnell, K.I. “The Western Piedmont.” The Geology of the Carolinas. Carolina Geological Society 50th Anniversary Volume, 1991.

191. Nelson, A.E., et al. “Generalized Tectonic Map of the Greenville 1x2 Quadrangle, Georgia, South Carolina, and North Carolina.” U.S. Geological Survey Miscellaneous Field Studies Map MF-1898, Scale 1:250,000, 1987.

192. Goldsmith, R., et al. “Geologic Map of the Charlotte 1x2 Quadrangle, North Carolina and South Carolina.” U.S. Geological Survey Miscellaneous Investigations Series Map I-1251-E, Scale 1:250,000, 1988.

193. Mitwede, S.K., et al. “Major Chemical Characteristics of the Hammett Grove Meta-Igneous Suite, Northeastern South Carolina.” Southeastern Geology. Vol. 28, No. 1, 1987.

194. Hatcher, R.D., Jr., et al. “Detailed Geologic Map of the Appalachian Ultradeep Core Hole (ADCOH) Region.” New Constraints on the Structure of the Southern Appalachian Internides. Geological Society of America Abstracts with Programs, Vol. 18, 1986b.

195. Secor, D.T., Jr., et al. “Confirmation of Carolina Slate Belt as an Exotic Terrane.” Science. Vol. 221, 1983.

196. Samson, S., et al. “Biogeographical Significance of Cambrian Trilobites from the Carolina Slate Belt.” Geological Society of America Bulletin. Vol. 102, 1990.

197. Vick, H.K., et al. “Ordovician Docking of the Carolina Slate Belt.” Paleomagnetic Data: Tectonics. Vol. 6, 1987.

198. Noel, J.R., et al. “Paleomagnetism and 40 Ar/39 Ar Ages from the Carolina Slate Belt, North Carolina: Implications for Terrane Amalgamation.” Geology. Vol. 16, 1988.

199. Hatcher, R.D., Jr., et al. “Geometric and Time Relations of Thrusts in the Crystalline Southern Appalachians.” Geometry and Mechanisms of Appalachian Thrusting, with Special Reference to the Appalachians. Geological Society of America Special Paper 222, 1988.

200. Hooper, R.J. and Hatcher, R.D., Jr. “The Pine Mountain Terrane, a Complex Window in the Georgia and Alabama Piedmont-Evidence from the Eastern Termination.” Geology. Vol. 16, 1988.

201. Steltenpohl, M.G. “Kinematics of the Towaliga, Bartletts Ferry, and Goat Rock Fault Zones, Alabama: The Late Paleozoic Dextral Shear System in the Southernmost Appalachians.” Geology. Vol. 16, 1988.

202. Griffin, V.S., Jr. “Geology of the Abbeville East, Abbeville West, Latimer and Lowndesville Quadrangles, South Carolina." South Carolina Geological Survey MS-24. 1979.

203. Davis, G.J. The Southwestern extension of the Middleton-Lowndesville Cataclastic Zone in the Greensboro, Georgia, Area and its Regional Implications (M. S. Thesis). University of Georgia, Athens, Georgia, 1980.

204. Rozen, R.W. "The Middleton-Lowndesville Cataclastic Zone in the Elberton East Quadrangle, Georgia." Geological Investigations of the Kings Mountain Belt and Adjacent Areas in the Carolinas. Carolina Geological Society Guidebook, 1981.

205. Horton, J.W., Jr. "Shear Zone Between the Inner Piedmont and Kings Mountain Belts in the Carolinas." Geology. Vol. 9, 1981.

206. Heyn, T. "Geology of the Hinge Zone of the Sauratown Mountains Anticlinorium, North Carolina: Structure of the Sauratown Mountains Window, North Carolina." Carolina Geological Society Guidebook. 1988.

207. McConnell, K.I. "Geology of the Sauratown Mountains Anticlinorium; Vienna and Pinnacle 7.5 Minute Quadrangles: Structure of the Sauratown Mountains Window, North Carolina." Carolina Geological Society Guidebook. 1988.

208. Bobyarchick, A.R. "The Eastern Piedmont Fault System and Its Relationship to Alleghanian Tectonics in the Southern Appalachians." Journal of Geology. Vol. 89, 1981.

209. Secor, D.T., Jr. et al. "Character of the Alleghanian Orogeny in the Southern Appalachians, Part I: Alleghanian Deformation in the Eastern Piedmont of South Carolina." Geological Society of America Bulletin. Vol. 97, 1986a.

210. Secor, D.T., Jr., et al. "Character of the Alleghanian Orogeny in the Southern Appalachians: Part III, Regional Tectonic Relations." Geological Society of America Bulletin. Vol. 97, 1986b.

211. Hatcher, R.D., Jr. and Edelman, S.H. "Macro-Scale Partitioning in the Southern and Central Appalachians: Thrusting and Strike-Slip as Products of Alleghanian Collision." Geological Society of America Abstracts with Programs. Vol. 19, 1987.

212. Dennis, A.J. "Is the Central Piedmont Suture a Low-Angle Normal Fault?" Geology. Vol. 19, 1991.

213. Maher, H.D., et al. "40Ar/39Ar Constraints on Chronology of Augusta Fault Zone Movement and Late Alleghanian Extension, Southern Appalachian Piedmont, South Carolina and Georgia." American Journal of Science. Vol. 294, 1994.

214. Maher, H.D., et al. "The Eastern Piedmont of South Carolina." The Geology of the Carolinas. University of Tennessee Press, Knoxville, 1991.

215. Snoke, A.W., et al. "Deformed Hercynian Granitic Rocks from the Piedmont of South Carolina." American Journal of Science. Vol. 280, 1980.

216. Secor, D.T., Jr. "Regional Overview, Anatomy of the Alleghanian Orogeny as Seen from the Piedmont of South Carolina and Georgia." Carolina Geological Society Field Trip Guidebook. South Carolina Geological Survey, 1987.

217. Bramlett, K.W. Geology of the Johnston-Edgefield Area, South Carolina, and its Regional Implications. (M.S. Thesis). University of South Carolina, Columbia, SC, 1989.

218. Maher, H.D., Jr. Stratigraphy, Metamorphism, and Structure of the Kiokee and Belair Belts Near Augusta, Georgia (MS Thesis). University of South Carolina, Columbia, SC, 1979.

219. Snoke, A.W. and Frost, B.R. "Exhumation of High Pressure Pelitic Schist, Lake Murray Spillway, South Carolina: Evidence for Crustal Extension During Alleghanian Strike-Slip Faulting." American Journal of Science. Vol. 280, 1990.

220. Dallmeyer, R.D., et al. "Character of the Alleghanian Orogeny in the Southern Appalachians: Part II, Geochronological Constraints on the Tectonothermal Evolutions of the Eastern Piedmont in South Carolina." Geological Society of America Bulletin. Vol. 97, 1986.

221. Long, L.T. "The Carolina Slate Belt-Evidence of a Continental Rift Zone." Geology. Vol. 7, 1979.

222. Maher, H.D. "Stratigraphy and Structure of the Belair and Kiokee Belts near Augusta, Georgia, Geological Investigations of the Eastern Piedmont, Southern Appalachians." Carolina Geological Society Field Trip Guidebook. South Carolina Geological Survey, 1978.

223. Bramlett, K.W., et al. "The Belair Fault: A Cenozoic Reactivation Structure in the Eastern Piedmont." Geological Society of America Bulletin. Vol. 93, 1982.

224. Maher, H.D., Jr. "Kinematic History of Mylonitic Rocks from the Augusta Fault Zone, South Carolina and Georgia." American Journal of Science. Vol. 287, 1987.

225. Hatcher, R.D., Jr., et al. "Eastern Piedmont Fault System: Speculations on its Extent." Geology. Vol. 5, 1977.

226. Prowell, D.C and O'Connor, B.J. "Belair Fault Zone: Evidence of Tertiary Fault Displacement in Eastern Georgia." Geology. Vol. 6, 1978.

227. Prowell, D.C. "Cretaceous and Cenozoic Tectonism on the Atlantic Coastal Margin, the Geology of North America, the Atlantic Continental Margin." Geological Society of America. Vol. I-2, 1988.

228. O'Connor, B.J. and Prowell, D.C. "The Geology of the Belair Fault Zone and Basement Rocks of the Augusta, Georgia Area." Georgia Geological Society Guidebook 16. 1976.

229. Daniels, D.L. “Geologic Interpretation of Geophysical Maps, Central Savannah River Area, South Carolina and Georgia." Geophysical Investigation Map GP-893, U.S. Geological Survey, 1974.

230. Manspeizer, W., et al. “Separation of Morrocco and Eastern North America: A Triassic-Liassic Stratigraphic Record." Geological Society of America Bulletin. Vol. 89, 1978.

231. Petersen, T.A., et al. “Structure of the Riddleville Basin from COCORP Seismic Data and Implications for Reactivation Tectonics." Journal of Geology. Vol. 92.

232. Ratcliffe, N.E. “The Ramapo Fault System in New York and Adjacent Northern New Jersey: A Case of Tectonic Heredity." Geological Society of America Bulletin. Vol. 82, 1971.

233. Lindholm, R.C. “Triassic-Jurassic Faulting in Eastern Northern America - A Model Based on Pre-Triassic Structures." Geology. Vol. 6, 1978.

234. Glover, L., III, et al. “Diachronous Paleozoic Mylonites and Structural Heredity of Triassic-Jurassic Basins in Virginia." Geological Society of America Abstracts with Programs. Vol. 12, 1980.

235. Olsen, P.E., et al. “Rift Basins of Early Mesozoic Age." The Geology of the Carolinas. University of Tennessee Press, Knoxville, 1991.

236. King, P.B. Systematic Pattern of Triassic Dikes in the Appalachian Region, Second Report. U.S. Geological Survey Professional Paper 759-D, 1971.

237. Olsen, P.E. “On the Use of the Term Newark for Triassic and Early Jurassic Rocks of Eastern North America.” Newsletters on Stratigraphy. Vol. 7, 1978.

238. Smoot, J.P. “The Closed-Basin Hypothesis and Its Use in Facies Analysis of the Newark Supergroup.” Proceedings of the Second U.S. Geological Survey Workshop on the Early Mesozoic Basins of the Eastern United States. U.S. Geological Survey Circular 946, 1985.

239. Gore, P.J.W. “Depositional Framework of a Triassic Rift Basin: The Durham and Sanford Sub-basins of the Deep River Basin, North Carolina." Society of Economic Paleontologists and Mineralogists Field Guidebook. Third Annual Midyear Meeting, Raleigh, NC, 1986.

240. Olsen, P.E. and Schlische, R.W. “Unraveling the Rules of Rift Basins.” Geological Society of America Abstracts with Programs. Vol. 20, 1988.

241. Schlische, R.W. and Olsen, P.E. “Quantitative Filling Model for Continental Extensional Basins with Application to the Early Mesozoic Rifts of Eastern North America.” Journal of Geology. 1992.

242. Stieve, A.L. and Stephenson, D.E. "Geophysical Evidence for Post Late Cretaceous Reactivation of Basement Structures in the Central Savannah River Area." Southeastern Geology. Vol. 35, No. 1, 1995.

243. McBride, J.H. "Constraints on the Structure and Tectonic Development of the Early Mesozoic South Georgia Rift, Southeastern United States; Seismic Reflection Data Processing and Interpretation." Tectonics. Vol. 10, No. 5, 1991.

244. Prowell, D.C., et al. "Geologic Section of the Updip Coastal Plain from Central Georgia to Western South Carolina." U.S. Geological Survey Miscellaneous Field Studies Map MF-1737, 1985a.

245. Logan, W.R. and Euler, G.M. Geology and Groundwater Resources of, Bamberg, and Barnwell Counties as Part of Aiken County, SC. South Carolina Water Resources Commission Report 155, 1989.

246. Swift, D. J. and Heron, S.D. "Stratigraphy of the Carolina Cretaceous." Southeastern Geology. Vol. 10, 1969.

247. Nystrom, P.G. and Willoughby, R.H. "Geological Investigations Related to the Stratigraphy in the Kaolin Mining District, Aiken County, South Carolina." 1982 Carolina Geological Society Field Trip Guidebook. South Carolina Geological Survey, 1982.

248. Christopher, R.A. "Quantitative Palynologic Correlation of Three Campanian and MaeStrichtian Sections Upper Cretaceous from the Atlantic Coastal Plain." Palynology. Vol. 2, 1978.

249. Sohl, N.F. and Christopher, R.A., the Black Creek-Peedee Formational Contact (Upper Cretaceous) in the Cape fear River Region of North Carolina. U.S. Geological Survey Professional Paper 1285, 1983.

250. Klitgord, K.D. and Behrendt, J.C. Basin Structure of the U.S. Atlantic Margin, Geological and Geophysical Investigations of Continental Margins. American Association of Petroleum Geologists, Memoir 29, 1979.

251. Heron, S.D. "History of Terminology and Correlations of the Basal Cretaceous Formations of the Carolinas." South Carolina State Development Board, Division of Geology, Geologic Notes. Vol. 2, 1958.

252. Aadland, R.K. Geology of A/M-Area, Savannah River Site South Carolina. WSRC-RP-96-0505, Rev. 0, Washington Savannah River Company, Aiken, SC, 1996.

253. Gohn, F.S., et al. "The Fishburne Formation (Lower Eocene), a Newly Defined Subsurface Unit in the South Carolina Coastal Plain." U.S. Geological Survey Bulletin. No. 1537-C, 1983.

254. Fallaw, W.C. and Price, Van. "Stratigraphy of the Savannah River Site and Vicinity." Southeastern Geology. Vol. 35, No. 1, 1995.

255. Herrick, S.M. and Vorhis, R.C. Subsurface Geology of the Georgia Coastal Plain. Georgia Department of Natural Resources, Division of Mines, Mining, and Geology, Information Circular 25, 1963.

256. Fallaw, W.C., et al. "Effects of Varying Degrees of Marine Influence on Tertiary Sediments in Southwestern South Carolina." Geological Society of America Abstracts with Programs. Vol. 22, No 7, 1990.

257. Clarke, J.S., et al. "Geology and Ground-Water Resources of the Coastal Area of Georgia." Georgia Geological Survey Bulletin. No. 113, 1990.

258. Aadland, R.K., et al. Significance of Soft Zone Sediments at the Savannah River Site, Historical Review of Significant Investigations and Current Understanding of Soft Zone Origin, Extent, and Stability. WSRC-TR-99-4083, Rev. 0, Washington Savannah River Company, Aiken, SC, September 1999.

259. Huddleston, P.F. and Hetrick, J.H. "Upper Eocene Stratigraphy of Central and Eastern Georgia." Georgia Geologic Survey Bulletin. No. 95, 1985.

260. Nystrom, P.G., Jr., et al. "Cretaceous-Tertiary Stratigraphy of the Upper Edge of the Coastal Plain between North Augusta and Lexington South Carolina." in Carolina Geological Society Field Trip Guidebook. South Carolina Geological Survey, 1986.

261. Colquhoun, D.J. et al. Sedimentology and Stratigraphy of the Upland Unit: Final Report under SCUREF Cooperation Agreement with DOE. Task 119 AA009OOT to DOE. Geological Sciences Department, Earth Sciences and Resources Institute, University of South Carolina, Columbia, SC, 1994.

262. Hanson, K.L., et al. "Applications of Quaternary Stratigraphic, Soil-Geomorphic, and Quantitative Geomorphic Analyses to the Evaluation of Tectonic Activity and Landscape Evolution in the Upper Coastal Plain, South Carolina." Proceedings, 4th DOE Natural Phenomena Hazards Mitigation Conference. Vol. 2, Atlanta, Georgia, 1993.

263. Preliminary Quaternary and Neotectonic Studies. Geomatrix, Savannah River Site, Aiken, SC, 1993.

264. Markewich, H.W. and Christopher, R.A. "Pleistocene and Holocene Fluvial History of Uphapee Creek, Macon County, Alabama," U.S. Geological Survey Bulletin. No. 1522, 1982.

265. Coleman, S.M. "Progressive Changes in the Morphology of Fluvial Terraces and Scarps Along the Rappahannock River, Virginia." Earth Surface Processes and Land Forms. Vol. 8, 1983.

266. Mixon, R.B., et al. "Geologic Map of the Coastal Plain and Adjacent Parts of the Piedmont, Virginia." U.S. Geological Survey Miscellaneous Investigations Map I-2033, 2 Pls., scale 1:250,000, 1989.

267. Markewich, H.W. "Geomorphic Evidence for Pliocene-Pleistocene Uplift in the Area of Cape Fear Arch, North Carolina, Tectonic Geomorphology." Proceedings of the 15th Annual Binghampton Geomorphology Symposium. Allen & Unwin, Boston, MA, 1985.

268. Soller, D.R. Geology and Tectonic History of the Lower Cape Fear River Valley, Southeastern North Carolina. U.S. Geological Survey Professional Paper 1466-A, 1988.

269. Brooks, M.J. and Sassaman, K.E. "Point Bar Geoarchaeology in the Upper Coastal Plain of the Savannah River Valley, South Carolina: A Case Study." Archaeological Geology of North America. Geological Society of America Centennial Special Publications No. 4, 1990.

270. Soller, D.R. and Mills, H.H. "Surficial Geology and Geomorphology." The Geology of the Carolinas. Carolina Geological Society Fiftieth Anniversary Volume, University of Tennessee Press, Knoxville, 1991.

271. Johnson, D.W. The Origins of Carolina Bays. Columbia University Press, New York, NY, 1942.

272. Gamble, E.E., et al. "The Goldsboro Ridge, an Enigma." Southeastern Geology, Vol. 12, 1977.

273. Cooke, C.W. Carolina Bays and the Shapes of Eddies. U.S. Geological Survey Professional Paper 254-I, 1953.

274. Melton, I.A. and Schriever, W. "The Carolina 'Bays' - Are They Meteorite Scars?" Journal of Geology. Vol. 41, 1933.

275. Thom, B.G. "Carolina Bays in Horry and Marion Counties, South Carolina." Geological Society of America Bulletin. Vol. 18, 1970.

276. Kaczorowksi, R.T. "Origin of the Carolina Bays." Terrigenous Clastic Depositional Environments. Technical Report No. 11-CRD, Coastal Research Division, Department of Geology, University of South Carolina, Columbia, 1976.

277. Savage, H., Jr. The Mysterious Carolina Bays. Columbia University Press 1982.

278. Rankin, D.W. Studies Related to the Charleston, South Carolina, Earthquake of 1886 -- Introduction and Discussion, Studies Related to the Charleston, South Carolina, Earthquake of 1886--A Preliminary Report. U.S. Geological Survey Professional Paper 1028, 1977.

279. Colquhoun, D.J. and Steele, K.B. Chronostratigraphy and Hydrostatigraphy of the Northwestern South Carolina Coastal Plain. Annual Cooperative Grant Agreement No. 13040 R-83-591, Project No. G868-05, Interim Technical Report to Water Resources Research Institute, Clemson University, Clemson, South Carolina, 1985.

280. Prowell, D.C., et al. "The Ellenton Formation in South Carolina: A Revised Age Designation from Cretaceous to Paleocene." U.S. Geological Survey Bulletin. No. 1605-A, 1985.

281. Dennehy, K.F., et al. "Geohydrology of the Defense Waste Processing Facility and Vicinity, Savannah River Plant, South Carolina." U.S. Geological Survey Water Resources Investigation, WRI 88-4221, 1988.

282. Nystrom, P.G., et al. "Clainbornian Stratigraphy of the Savannah River Site and Surrounding Area, 1990, Savannah River Region: Transition Between the Gulf and Atlantic Coastal Plains." Proceedings of the Second Bald Head Island Conference on Coastal Plains Geology. Hilton Head Island, November 6-11, 1990.

283. Marine, I.W. Geohydrology of the Buried Triassic Basin at the Savannah River Plant Groundwater. Vol. 2, 1974.

284. Marine, I.W. "Geohydrology of Buried Triassic Basin at the Savannah River Plant, South Carolina." American Association of Petroleum Geologists Bulletin, Vol. 58, 1974.

285. Marine, I.W. and Siple, G.E. "Buried Triassic Basin in the Central Savannah River Area, South Carolina and Georgia." Geological Society of America Bulletin. Vol. 85, 1974.

286. Snipes, D. S., et al. "The Pen Branch Fault: Documentation of Late Cretaceous-Tertiary Faulting in the Coastal Plain of South Carolina." Southeastern Geology. Vol. 33, No. 4, 1993.

287. Chowns, T.M., et al. Investigation of Triassic Basin Sediments – Savannah River Site. Task #52, Final Report prepared for Washington Savannah River Company, Aiken, SC, 1996.

288. Domoracki, W. A Geophysical Investigation of Geologic Structure and Regional Tectonic Setting at the Savannah River Site, South Carolina. Ph.D. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 1995.

289. Cumbest, R.J., et al. Basement Surface Faulting for Savannah River Site and Vicinity. WSRC TR-98-00346, Washington Savannah River Company, Aiken, SC, 1998.

290. Stephenson, D.E. and Stieve, A. Structural Model of the Basement Based on Geophysical Data in the Central Savannah River Area, South Carolina and Georgia. WSRC-TR-92-120, Washington Savannah River Company, Aiken, SC, 1992.

291. Cumbest, R.J., et al. "Gravity and Magnetic Modeling of the Dunbarton Triassic Basin, South Carolina." Southeastern Geology. Vol. 33, No. 1, 1992.

292. Latour, T.E., et al. Crystalline Basement Core – Savannah River Site. Final Report, ERDA Task 53, 1995.

293. Shervais, J.W., Mauldin, J., Dennis, A.J. Petrology and Geochemistry of Neo-Proterozoic Arc Plutons beneath the Atlantic Coastal Plain: Savannah River Site, South Carolina. Report submitted for SCURF, Task 170, 1996.

294. Mauldin, J., Shervais, J.W., Dennis, A.J. Petrology and Geochemistry of Metavolcanic Rocks from a Neoproterozoic Volcanic Arc, Savannah River Site, South Carolina. Report submitted for SCURF, Task 170, 1996.

295. Dennis, A.J., et al. Repeated Phanerozoic Reactivation of a Southern Appalachian Fault Zone Beneath the Up-Dip Coastal Plain of South Carolina. Report submitted for SCURF, Task 170, 1996.

296. Hall, M.H. Heavy Mineral Provinence of Triassic Dunbarton Basin Deposits, South Carolina. M.S. thesis, University of North Carolina, Wilmington, NC, 1997.

297. Chapman, W.L. and DiStefano, M.P. Savannah River Plant Seismic Survey, 1987-88. Research Report 1809-005-006-1-89, Conoco, Inc., Seismic Acquisition Section, 1989.

298. Leutgert et al. "Crystal Structure Beneath the Atlantic Coast Plain of South Carolina." Seismological Research Letters. Vol. 65, No. 2, 1994.

299. Madabhushi, S. and Talwani, P. "Fault Plane Solution and Relocations of Recent Earthquakes in Middleton Place Summerville Seismic Zone Near Charleston South Carolina." Bulletin of the Seismological Society of America. Vol. 83, No. 5, 1993.

300. Parsons, et al. Bedrock Waste Storage Project, Triassic Basin Fault Probing Program Report. E. I. du Pont de Nemours and Co., Savannah River Plant, Aiken, SC, 1973.

301. Prowell, D.C. Preliminary Geologic Map of the Barnwell 30' x 60' Quadrangle, South Carolina and Georgia. Open File Report 94-673, U.S. Geological Survey, Atlanta, GA, 1994

302. Stieve, A.L. et al. Confirmatory Drilling Project Final Report. WSRC-RP-94-0136, Washington Savannah River Company, Aiken, SC, 1994.

303. Grow, J.A., et al. "Structure and Evolution of Baltimore Canyon Trough." The Geology of North America. Vol. I-1, *The Atlantic Continental Margin*. DNAG Publication, Geological Society of America, Boulder, CO, 1988.

304. Sheridan, R.E. and Grow, J.A. "The Geology of North America." The Atlantic Continental Margin. Vol. I-1 and I-2, DNAG Publication, Geological Society of America, Boulder, CO, 1988.

305. Maher, H.D., Jr., et al. "Magmatic Softening in the Orogenic Hinterlands Southern Appalachian Piedmont, Georgia." Geological Society of America Abstracts with Programs. Vol. 24, No. 2, 1992.

306. Farrar, S.S. “Tectonic Evolution of the Eastern-Most Piedmont, North Carolina." Geological Society of America Bulletin. Vol. 96, 1985.

307. Sacks, P.E. and Dennis, A.J. “The Modoc Zone-D_2 (Early Alleghanian) in the Eastern Appalachian Piedmont, South Carolina and Georgia, Anatomy of the Alleghanian Orogeny as Seen from the Piedmont of South Carolina and Georgia.” Carolina Geological Society Field Trip Guidebook. South Carolina Geological Survey, 1987

308. Cook, F.A., et al. “COCORP Seismic Profiling of the Appalachian Orogen Beneath the Coastal Plain of Georgia.” Geological Society of America Bulletin. Vol. 92, No. 10, 1981.

309. Sen, A.K. and Coruh, C., Removing Near-Surface Effects in Seismic Data: Application for Determination of Faults in the Coastal Plain Sediments. WSRC-TR-92-169, Washington Savannah River Company, Aiken, SC, 1992.

310. Kanter, L.R. Tectonic Interpretation of Stable Continental Crust in: The Earthquakes of Stable Continental Regions. Electric Power Research Institute, Palo Alto, CA, 1994.

311. Keen, C.E. and Haworth, R.T. “DNAG Transect D-3: Rifted Continental Margin Off Nova Scotia: Offshore Eastern Canada.” Geological Society of America, Centennial Continent/Ocean Transect #4. Boulder, CO, 1985.

312. Hutchinson, D.R. and Klitgord, K.D. “Evolution of Rift Basins on the Continental Margin Off Southern New England: Triassic-Jurassic Rifting: North America and Africa.” American Association of Petroleum Geologists Memoir, 1986.

313. Price, V., et al. Pen Branch Fault Investigation Program Plan. ESS-SRL-89-395, 1989.

314. Klitgord, K.D. and Schouten, H. “Plate Kinematics of the Central Atlantic.” The Geology of North America. Vol. M, The Western North Atlantic Region. DNAG Publication, Geological Society of America, Boulder, CO, 1986.

315. Zoback, M.D. and Zoback, M.L. Tectonic Stress Field of North America and Relative Plate Motions in Neotectonics of North America. Vol. I, Decade Map, Geological Society of America, Boulder, CO, 1991.

316. Gohn, G.S. “Late Mesozoic and Early Cretaceous Geology of the Atlantic Coastal Plain: North Carolina to Florida.” The Geology of North America. Vol. I-2, The Atlantic Continental Margin, pp. 107-130, DNAG Publication, Geological Society of America, Boulder, CO.

317. Steckler, M.S., et al. “Subsidence and Basin Modeling at the U.S. Atlantic Passive Margin." The Geology of North America. Vol. I-2, The Atlantic Continental Margin. DNAG Publication, Geological Society of America, Boulder, CO, 1988.

318. Sawyer, D.S. “Thermal Evolution." The Geology of North America. Vol. I-2, The Atlantic Continental Margin. DNAG Publication, Geological Society of America, Boulder, CO, 1988.

319. Brown, P.M., et al. Structural and Stratigraphic Framework, and Spatial Distribution of Permeability of the Atlantic Coastal Plain, North Carolina to New York. U.S. Geological Survey Professional Paper 796, 1972.

320. Heller, P.L., et al. “Episodic Post-Rift Subsidence of the United States Atlantic Margin.” Geological Society of America Bulletin. Vol. 93, No. 5, 1982.

321. Winkler, C.D. and Howard, J.D. “Correlation of Tectonically Deformed Shorelines on the Southern Atlantic Coastal Plain.” Geology. Vol. 5, 1977.

322. Baum, G.R., et al. “Structural and Stratigraphic Framework for the Coastal Plain of North Carolina.” Field Trip Guidebook for Carolina Geological Society and Atlantic Coastal Plain Geological Society. North Carolina Department of Natural Resources and Development, 1979.

323. Prowell, D.C. and Obermeier, S.F. “Evidence of Cenozoic Tectonism.” The Geology of the Carolinas. University of Tennessee Press, Knoxville, TN, 1991.

324. Cumbest, R.J., Comparison of the Cenozoic Tectonic Setting of Savannah River Site to the Atlantic Coast Fault Province with Implications Concerning Seismic Hazard, WSRC-TR-2000-00310, 2000.

325. Prowell, D.C. Index of Faults of Cretaceous and Cenozoic Age in the Eastern United States. U.S. Geological Survey Miscellaneous Field Studies Map MF-1269, 1983.

326. Moos, D. and Zoback, M.D. In Situ Stress Measurements in the NPR Hole, Savannah River Site, South Carolina: Final Report to Washington Savannah River Co., Vol. 1, Results and Interpretations. Subcontract AA00925P, Science Applications International Corporation, Augusta, GA, 1992.

327. Moos, D. and Zoback, M.D. Near Surface “Thin Skin” Reverse Faulting Stresses in the Southeastern United States. Vol. 30, No. 7, 1993.

328. Talwani, P., et al. Induced Seismicity and Earthquake Prediction Studies in South Carolina. Tenth Technical Report to the USGS, Contract 14-08-001-17670.1980.

329. Stephenson, D.S. and Chapman, W.L. “Structure Associated with the Buried Dunbarton Basin, South Carolina from Recent Seismic Data.” Geological Society of America, Southeastern Section Abstracts with Programs. Vol. 20, 1988.

330. Seismograph Services Corporation. Gravity and Magnetic Survey, Savannah River Plant, South Carolina. Unpublished report prepared for E.I. du Pont de Nemours and Co., Inc., Engineering Department, Wilmington, DE, 1972.

331. Stieve, A.L. Pen Branch Fault Program: Interim Report on the High Resolution, Shallow Seismic Reflection Surveys. WSRC-TR-91-30, Washington Savannah River Company, Aiken, SC, 1991.

332. Berkman, E. High Resolution Seismic Survey, Pen Branch Fault, Savannah River Site, South Carolina. WSRC-TR-91-38, Washington Savannah River Company, Aiken, SC, 1991.

333. Pen Branch Fault Basement Drilling. Washington Environmental and Geotechnical Services, 1991.

334. O'Connor, et al. "Recently Discovered Faults in the Central Savannah River Area." abstract, Georgia Academy of Science Bulletin. Vol. 32, 1974.

335. Prowell, D.C., et al. Preliminary Evidence for Holocene Movement Along the Belair Fault Zone Near Augusta, Georgia. Open File Report 75-680, U.S. Geological Survey, Atlanta, GA, 1976.

336. Wentworth, C.M. and Mergener, K.M. "Regenerate Faults of the Southeastern United States." Studies Related to the Charleston, South Carolina, Earthquake of 1886, Tectonics and Seismicity. U.S. Geological Survey Professional Paper 1313, 1983.

337. Gohn, G.S. Studies Related to the Charleston Earthquake of 1886: Tectonics and Seismicity. U.S. Geological Survey Professional Paper 1313, 1983.

338. Talwani, P. "Current Thoughts on the Cause of the Charleston, South Carolina Earthquakes." South Carolina Geology. Vol. 29, 1985.

339. Zoback, M.L. and Zoback, M.D. "State of Stress in the Conterminous United States." Journal of Geophysical Research. Vol. 85, 1980.

340. Long, L.T. and Chapman, J.W., Jr. "Bouguer Gravity Map of the Summerville-Charleston, South Carolina Epicentral Zone and Tectonic Implications." Studies Related to the Charleston, South Carolina Earthquake of 1886--A Preliminary Report. U.S. Geological Survey Professional Paper 1028, 1977.

341. Barstow, N.L., et al. An Approach to Seismic Zonation for Siting Nuclear Electric Power Generation Facilities in the Eastern United States. NUREG/CR-1577, U.S. Nuclear Regulatory Commission, Washington, DC, 1981.

342. Tarr, A.C., et al. "Results of Recent South Carolina Seismological Studies." Bulletin of the Seismological Society of America. Vol. 71, 1981.

343. Talwani, P. and Cox, S. "An Internally Consistent Pattern of Seismicity Near Charleston, South Carolina." Geology. Vol. 10, 1985.

344. Youd, T.L. "Liquefaction, Flow and Associated Ground Failure." U.S. Geological Survey Circular. No. 688, 1973.

345. Dutton, C.E. "The Charleston Earthquake of August 31, 1886." U.S. Geological Survey Annual Report 1887-1888. Government Printing Office, Washington, DC, 1889.

346. Cox, J. and Talwani, P. "Paleoseismic Studies in the 1886 Charleston Earthquake Meizoseismal Area." Geological Society of America, Abstracts with Programs. No. 16, 1983.

347. Talwani, P. and Cox, S. "Paleoseismic Evidence for Recurrence of Earthquakes near Charleston, South Carolina." American Association for the Advancement of Science. Vol. 229, July 1985.

348. Gohn, G.S., et al. "Field Studies of Earthquakes Induced Liquefaction-Flowage Features in the Charleston, South Carolina, Area Preliminary Report". U.S. Geological Survey Open-File Report 84-670, 1984.

349. Obermeier, S.F., et al. "Geologic Evidence for Recurrent Moderate to Large Earthquakes near Charleston, South Carolina." Science. Vol. 227, 1985.

350. Amick, D. and Gelinas, R. "The Search for Evidence of Large Prehistoric Earthquakes along the Atlantic Seaboard." American Association for the Advancement of Science, February 1991. Vol. 251, 1991.

351. Sibol, M.S. and Bollinger, G.A. Earthquake Catalog for the Southeastern United States, 1698-1989. Virginia Polytechnic Institute and State University Seismological Observatory Computer File, Blacksburg, VA, 1990.

352. Bollinger, G.A. "Specification of Source Zones, Recurrence Rates, Focal Depths, and Maximum Magnitudes for Earthquakes Affecting the Savannah River Site in South Carolina." U.S. Geological Survey Bulletin. No. 2017, 1992.

353. Lahr, J.C. "HYPOELLIPSE: A Computer Program for Determining Local Earthquake Hypocentral Parameters, Magnitude, and First Motion Pattern," U.S. Geological Survey Open File Report 84-519, 1984.

354. Bollinger, G.A. "Seismicity of the Southeastern United States." Bulletin of the Seismological Society of America. Vol. 63, No. 5, 1973.

355. Bollinger, G.A., et al. "Seismicity of the Southeastern United States: 1698-1986." Neotectonics of North America. Geological Society of America DNAG Map Vol. 1, 1991.

356. Domoracki, W.J., et al. "Seismotectonic Structures Along the Savannah River Corridor, South Carolina, USA." Journal of Geodynamics. 1997.

357. Phinney, R.A. and Roy-Chowdhury, K. Reflection Seismic Studies of Crustal Structure in the Eastern United States: Geophysical Framework of the Continental United States. Geological Society of America Mem. 172, 1989.

358. Coruh, C., et al. "Seismogenic Structures in the Central Virginia Seismic Zone." Geology. Vol. 16, 1988.

359. Bollinger, G.A., et al. “An Analysis of Earthquake Focal Depths in the Southeastern United States." Geophysical Research Letters. Vol. 12, 1985.

360. Sibson, R.H. “Frictional Constraints to Thrust, Wrench, and Normal Faults.” Nature. Vol. 249, 1984.

361. Sibson, R.H. “Earthquakes and Rock Deformation in Crustal Fault Zones.” Annual Review of Earth Planet Sciences. Vol. 14, 1986.

362. Scholz, C.H. The Mechanics of Earthquakes and Faulting. Cambridge University Press, 1990.

363. Reactor Site Criteria. 10 CFR 100, Washington, DC, November 15, 1983.

364. Housner, G.W. Earthquake Criteria for the Savannah River Plant. DPE-2383, E.I. du Pont de Nemours and Company, Savannah River Plant, Aiken, SC, 1968.

365. Stephenson, D.E. Review of Seismicity and Ground Motion Studies Related to the Development of Seismic Design Criteria at SRS. WSRC-TR-90-0284, Washington Savannah River Company, Aiken, SC, 1990.

366. Bollinger, G.A. “Reinterpretation of the Intensity Data for the 1886 Charleston, South Carolina Earthquake.” Studies Related to the Charleston, South Carolina, Earthquake of 1886--A Preliminary Report. U.S. Geological Society Professional Paper 1028, 1977.

367. 121. Kimball, J.K. “The Use of Site Dependent Spectra.” Proceedings of the U.S. Geological Survey Workshop on Site Specific Effects of Soil and Rock on Ground Motions and the Implications for Earthquake-Resistant Design. U.S. Geological Survey Open File Report 83-845, 1983.

368. Stephenson, D.E., et al. “Savannah River Site Disaggregated Seismic Spectra.” Fourth DOE Natural Phenomena Hazards Mitigation Conference. U.S. Department of Energy, Washington, DC, 1993.

369. Quality Assurance. WSRC Procedure Manual 1Q, Washington Savannah River Company, Aiken, SC.

370. Engineering Standards Manual, Structural Design Criteria Standard No 01060. Washington Savannah River Company, Aiken, SC, 1999.

371. Seismic Siting Decision Process, Nuclear Energy Institute, Washington, DC, May 24, 1994

372. Bernreuter, D.L., “Fission Energy and Systems Safety Program,” NTFS97-123, letter report to Jeff Kimball, DOE, Lawrence Livermore National Laboratory, May 15, 1997.

373. Savy, J.B., “Fission Energy and Systems Safety Program,” SANT96-147JBS, letter to Jeff Kimball, DOE, April 24, 1996.

374. Lee, R.C., Computation of USGS Soil UHS and Comparison to NEHRP and PC1 Seismic Response Spectra for the Savannah River Site.. WSRC-TR-99-00271, Rev. 0, Washington Savannah River Company, Aiken, SC, September 1999.

375. Frankel et al., National Seismic Hazard Maps, U.S. Geological Survey, Denver, CO, June 1996.

376. Cornell, C.A. and Bazzurro, P., Efficient Probabilistic Hazard Analysis for Non-Linear Soil Sites with Uncertain Properties, 1997

377. Coats, D.W. and Murray, R.C., Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites, UCRL-53582, Rev. 1, Lawrence Livermore National Laboratory, 1984.

378. Wingo, H.E., Development of Probabilistic Seismic Hazard Curve for DWPF at Savannah River Site. WSRC-TR-93-317, Rev. 1, Washington Savannah River Company, Aiken, SC, 1994

379. Standard Engineering Specifications, Civil Sections. E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, November 1988.

380. Engineering Requirement Document 02224-01-R, Rev. 1. Washington Savannah River Company, Aiken, SC, August 19, 1994.

381. Cumbest, R.J., Comparison of the Cenozoic Tectonic Setting of Savannah River Site to the Atlantic Coast Fault Province with Implications Concerning Seismic Hazard,

382. Alvin W. Vogtle Electric Generating Plant, Unit 1 and Unit 2, Final Safety Analysis Report. Vol. 1-34, Georgia Power Company, 1987.

383. Schreiner, L. C., and Riedel, J. T. Probable Maximum Precipitation Estimates, United States East of the 105th Meridian. National Oceanic and Atmospheric Administration (NOAA) Hydrometeorological Report No. 51, U.S. Department of Commerce, Washington, DC, 1978.

384. Hansen, E. M., Schreiner, L. C., and Miller, J. F. Application of Probable Maximum Precipitation Estimates -- United States East of the 105th Meridian. National Oceanic and Atmospheric Administration (NOAA) Hydrometeorological Report No. 52, U.S. Department of Commerce, Washington, DC, 1982.

385. Probable Maximum and TVA Precipitation for Tennessee River Basins up to 3,000 Square Miles in Area and Durations of 72 Hours. Hydrometeorological Report No. 45, National Weather Service, Silver Springs, MD, 1969.

386. Design Basis Floods for Nuclear Power Plants. NUREG 1.59, U.S. Nuclear Regulatory Commission, Washington, DC, 1977.

387. Savannah River Site Production Reactor Safety Analysis Report. WSRC-SA-10003, Washington Savannah River Company, Aiken, SC, 1990.

388. Water Resources: Corps of Engineers' Drought Management of Savannah River Projects. GAO/RCED-89-169, United States General Accounting Office, Washington, DC, June 1989.

389. Evaluation of Accident Risks in the Transportation of Hazardous Materials by Truck and Rail at the Savannah River Plant. WSRC-RP-89-715, Rev. 1, Washington Savannah River Company, Aiken, SC, September1992.

390. Map of the South Carolina Railroad System. South Carolina Public Service Commission, Transportation Division, Columbia, SC, 1986.

391. South Carolina Aeronautical Chart, 1988/89. South Carolina Aeronautics Commission, Columbia, SC, 1988.

1.10 TABLES

Table 1.4-1

Monthly Average and Extreme Temperatures for SRS

	Average Daily Temperature, °F [a]			Extreme Temperature, °F [b]	
Month	Maximum	Minimum	Month	Maximum (Yr)	Minimum (Yr)
January	55.9	36.0	45.8	86 (1975)	-3 (1985)
February	60.0	38.3	49.1	86 (1989)	10 (1996)
March	68.6	45.4	57.0	91 (1974)	11 (1980)
April	77.1	52.5	64.8	99 (1986)	29 (1983)
May	83.5	60.7	72.1	102 (1963)	38 (1989)
June	89.6	68.0	78.8	105 (1985)	48 (1984)
July	92.1	71.5	81.7	107 (1986)	56 (1963)
August	90.1	69.6	80.3	107 (1983)	56 (1986)
September	85.4	65.6	75.4	104 (1990)	41 (1967)
October	76.6	54.6	65.6	96 (1986)	28 (1976)
November	67.0	45.2	56.2	89 (1974)	18 (1970)
December	59.3	39.1	49.1	82 (1984)	5 (1962)
Annual	75.5	54.0	64.7	107 (1986)	-3 (1985)

[a] Period of record: 1967-1996.
[b] Period of record: 1961-1996.

Source: Hunter, C. H., Updated Meteorological and Hydrological Data for Revision 2 of the SRS Generic Safety Analysis Report, SRT-NTS-970265.

Table 1.4-2

Average Relative and Absolute Humidity at SRS.

Month	Relative Humidity (%)a			Absolute Humidity (g/m^3)b		
	Min	Max	Avg	Min	Max	Avg
January	51	86	70	2.3	13.2	6.0
February	44	84	65	2.9	11.3	6.6
March	40	86	61	3.4	11.8	7.0
April	36	88	56	3.7	13.3	8.4
May	40	93	63	6.2	17.6	12.7
June	44	95	75	10.2	19.2	15.6
July	47	96	75	13.0	20.6	18.4
August	50	97	78	11.1	21.3	18.3
September	48	96	78	9.8	19.1	15.4
October	45	93	74	5.8	17.6	11.3
November	46	90	70	3.4	15.8	7.3
December	48	87	70	2.3	12.4	6.0
Average	45	91	70			11.1

a Period of record: 1967-1996.
b Period of record: 1995-1996.

Source: Hunter, C. H. to B. Talukdar, Updated Meteorological, and Hydrological Data for Revision 2 of the SRS Generic Safety Analysis Report, SRT-NTS-970265

Table 1.4-3

Average and Extreme Precipitation at SRS (Water Equivalent), in Inches

Month	Average[a]	Maximum (Year)[b]	Minimum (Year)[b]
January	4.44	10.02 (1978)	0.89 (1981)
February	4.25	7.97 (1995)	0.94 (1968)
March	4.83	10.96 (1980)	0.91 (1995)
April	3.02	8.20 (1961)	0.57 (1972)
May	3.86	10.90 (1976)	1.33 (1965)
June	4.53	10.98 (1973)	0.89 (1990)
July	5.57	11.48 (1982)	0.90 (1980)
August	5.44	12.34 (1964)	1.04 (1963)
September	3.63	8.71 (1959)	0.49 (1985)
October	3.40	19.62 (1990)	0.00 (1963)
November	2.89	7.78 (1992)	0.21 (1958)
December	3.59	9.55 (1981)	0.46 (1955)
Year	49.46	73.47 (1964)	28.82 (1954)

[a] Period of record: 1967-1996.
[b] Period of record: 1952-1996.

Source: Hunter, C. H., Updated Meteorological, and Hydrological Data for Revision 2 of the SRS Generic Safety Analysis Report, SRT-NTS-970265.

Table 1.4-4

Average Number of Thunderstorm Days, Augusta, Georgia, 1951-1995

Month	Thunderstorm Days
January	0.8
February	1.7
March	2.6
April	3.9
May	6.3
June	9.7
July	13.1
August	10.0
September	3.5
October	1.3
November	0.8
December	0.7
Annual	54.4

Period of record, 1951-1995.

Source: Local Climatological Data, Annual Summary with Comparative Data, 1995, Augusta, Georgia. National Oceanic and Atmospheric Administration, National Climate Data Center, Asheville, NC (1996).

Table 1.4-5

Estimated Ice Accumulation for Various Recurrence Intervals for the Gulf Coast States

Recurrence Interval (yr)	Accumulation (in.)
2	0
5	0.24
10	0.39
25	0.51
50	0.59
100	0.66

Source: Tattelman, P., et al. Estimated Glaze Ice and Wind Loads at the Earth's Surface for the Contiguous United States. AFCRL-TR-73-0640, U.S. Air Force (1973).

Table 1.4-6

Extreme Total Rainfall for SRS Region (August 1948-December 1995)

Period Hours	Period Days	Inches/ Period	Begin Time	Begin Date
Augusta Bush Field				
1		3.14	1300	7/24/86
3		4.25	1900	9/20/75
6		4.50	1900	9/20/75
12		7.62	2100	10/11/90
24		8.57	1300	10/11/90
	3	12.24		10/10/90
	7	12.24		10/10/90
	10	12.24		10/10/90
	14	14.56		10/10/90
	30	15.47		9/30/90
	60	19.84		7/15/64
	90	25.88		7/18/64
Columbia Airport				
1		3.80	2000	8/18/65
3		5.03	1900	8/18/65
6		5.29	1700	6/15/73
12		7.03	2200	8/16/49
24		7.66	1600	8/16/49
	3	8.41		8/14/90
	7	10.22		6/15/73
	10	10.29		6/13/73
	14	14.71		8/14/49
	30	19.30		7/29/49
	60	25.64		6/18/71
	90	33.69		7/18/64

Source: C. H. Hunter to J. Howley, Updated Metereology for Revision 4 of the SRS Generic Safety Analysis Report, SRT-NTS-99-0043.

Table 1.4-7

Extreme Precipitation Recurrence Estimates by Accumulation Period.

Recurrence Interval (years)	15 min	1 hr	3 hr	6 hr	24 hr	48 hr
10	1.5	2.7	3.3	3.6	5.0	6.5
						7.39[b]
25	1.8	3.2	4.0	4.4	6.1	7.9
50	2.0	3.5	4.6	5.0	6.9	8.6
					(7.39)[b]	
100	2.1	3.9	5.1	5.7	7.8	9.4
			(5.2)[a]	(5.8)[b]		(10.2)[c]
						(11.15)[d]
1000	2.7	5.0	7.4	8.3	11.5	N/A
10,000	3.3	6.2	10.3	11.8	16.3	N/A
100,000	3.9	7.4	14.1	16.7	22.7	N/A

[a] July 25 rainfall at the 700-Area

[b] August 22 rainfall at the Climatology Site

[c] October 11-12 rainfall at the 773-A Area

[d] October 11-12 rainfall at Bush Field

Sources: A.H. Weber, et al., “Tornado, Maximum Wind Gust, and Extreme rainfall Event Recurrence Frequencies at the Savannah River Site”, WSRC-TR-98-00329, Washington Savannah River Company, Aiken, SC (1998).

J. F. Miller, "Two-To-Ten Day Precipitation for Return Periods of Two-to-One Hundred Years in the Contiguous United States," Technical Paper No. 49, U.S. Weather Bureau, USDOC (1964).

Addis, R. P. and Kurzeja, R. J. Heavy Rainfall at the SRS in July, August, and October of 1990.

Table 1.4-8

Number of Tornadoes Reported Between 1951 and 1996 by Month and F-Scale in a Two-Degree Square Centered at SRS

Month	F-0	F-1	F-2	F-3	F-4	F-5	Total	Percent
January	3	8	2	1	0	0	14	7.0
February	4	12	1	0	0	0	17	8.5
March	1	10	9	0	1	0	21	10.5
April	4	17	4	1	0	0	26	13.0
May	3	18	6	0	0	0	27	13.5
June	4	10	0	0	0	0	14	7.0
July	2	8	3	0	0	0	13	6.5
August	4	7	5	2	0	0	18	9.0
September	0	5	3	0	0	0	8	4.0
October	1	2	4	0	0	0	7	3.5
November	10	8	7	2	0	0	27	13.5
December	1	2	2	2	1	0	8	4.0
Total	37	107	46	8	2	0	200	100.0

Source: C.H. Hunter to J. Howley, Meteorological Data for Revision 4 to SRS Generic Safety Analysis Report, SRT-NTS-99043, March 1, 1999.

Table 1.4-9

Fujita Scale for Damaging Tornado Winds

Scale	Rotational Wind Speed	Expected Damage
F-0	40 - 72	Light damage
F-1	73 - 112	Moderate damage
F-2	113 - 157	Considerable damage
F-3	158 - 206	Severe damage
F-4	207 - 260	Devastating damage
F-5	261 - 318	Incredible damage

Source: Hunter, C. H., A Climatological Description of the Savannah River Site, WSRC-RP-89-313, Washington Savannah River Company, Savannah River Site, Aiken, SC, May 1990.

Table 1.4-10

Estimated Maximum Three-Second Wind Speeds for Tornadoes and “Straight-Line” Winds

Recurrence Interval, years	Probability events/year	Estimated Maximum 3-Sec Wind Speed, mph	
		Tornadoes	“Straight-Line” Winds
10	1×10^{-1}	---	69
50	2×10^{-2}	---	83
100	1×10^{-2}	---	88
200	5×10^{-3}	---	94
500	2×10^{-3}	---	102
1,000	1×10^{-3}	---	107
5,000	2×10^{-4}	45	120
10,000	1×10^{-4}	78	126
100,000	1×10^{-5}	170	145
500,000	1×10^{-5}	215	---
1,000,000	1×10^{-6}	230	---

Source: A. H. Weber, et al., “Tornado, Maximum Wind Gust, and Extreme Rainfall Event Recurrence Frequencies at the Savannah River Site”, WSRC-TR-98-00329, Washington Savannah River Comapany, Aiken, SC (1998).

Table 1.4-11

Total Occurrences of Hurricanes in South Carolina by Month, 1700-1992

Month	Number	Percent of Total
June	1	2.8
July	2	5.6
August	11	30.5
September	18	50.0
October	4	11.1

Table 1.4-12

Observed Annual Fastest 1-Minute Wind Speeds for SRS

Year	Wind Speed (mph)[c]	Direction	Date
1967	52	W	5/8
1968	43	NW	7/16
1969	43	NE	7/8
1970	52	NW	7/16
1971	34	SW	7/11
1972	56	SW	3/2
1973	37	NW	11/21
1974	49	W	3/21
1975	37	W	7/6*
1976	32	NW	3/9
1977	43	S	10/2
1978	39	SW	1/26
1979	30	W	5/12
1980	32	S	7/9
1981	33	NW	3/16
1982	40	NW	2/16
1983	32	NW	12/31
1984	32	SW	3/28
1985	35	W	2/11
1986	32	NW	7/2
1987	35	NNW	7/24
1988	32	WNW	5/24
1989	39	NW	6/22
1990	28	WSW	1/29
1991	29	NW	2/15
1992	29	SW	7/1
1993	33	W	3/13
1994	34	SE	7/10
1995	38	W	11/11
1996	35	W	2/12

Maximum 1-minute wind since 1950: 83 mph on 5/28/50

[a] Data for 1967-1994 from National Weather Service Office, Bush Field, Augusta, Georgia.
Source: Local Climatological Data, Annual Summary with Comparative Data, 1995, Augusta, Georgia. National Oceanic and Atmospheric Administration, National Climate Data Center, Asheville, NC (1996).

[b] Data for 1995-1996 from SRS Central Climatology Facility.
Source: Hunter, C. H., Updated Meteorological Data for Revision 2 of the SRS Generic Safety Analysis Report, SRT-NTS-970265.

[c] Values interpolated to a 10 m anemometer height.

Table 1.4-13

Percent Occurrence of Atmospheric Stability Class for SRS Meteorological Towers

Stability Class	Percent Occurrence Per Year							
	A-Area	C-Area	D-Area	F-Area	H-Area	K-Area	L-Area	P-Area
A	17.5	15.6	20.5	13.3	25.9	15.4	16.8	14.9
B	10.6	8.8	11.9		8.3	13.2	9.8	10.2
	9.4							
C	17.6	15.7	19.4		15.2	20.1	17.0	18.0
16.4								
D	26.6	27.1	24.9		28.6	22.1	25.4	25.1
	26.5							
E	19.6	20.6	17.4		24.9	15.5	21.2	18.7
	21.1							
F/G	8.0	12.1	6.0	10.6	3.2	11.1	11.1	11.8

Period of record: 1992-1996.

Source: Hunter, C. H. to J. Howley, Updated Meteorological Data for Revision 4 of the SRS Generic Safety Analysis Report, SRT-NTS-990043.

Table 1.4-14 Flow Summary for the Savannah River and Savannah River Site Streams (values in ft^3/second)

	Mean	STD Dev.	7Q10	7-Day Low Flow
Savannah River				
at Augusta, GA	9493	2611	4332	3746
at SRS Boat Dock	----	----	4293	3773
at Hwy 301 [a]	10397	2830	4411	3991
at Clyo	12019	3687	5211	4513
Upper Three Runs				
at Hwy 278	105	8	56	55
at SRS Road C	211	30	100	86
at SRS Road A	245	41	100	84
Beaver Dam Creek				
at 400D	81.5	8.7	0.01	18
Fourmile Branch				
at SRS Site 7	17.8	5.4	0.58	3.2
Pen Branch				
at SRS Road B	7.5	8.2	0.27	0.22
at SRS Road A-13	210	45	5.5	8.8
Steel Creek				
at Hattiesville Bridge	160	12.3	12.9	12.0
Lower Three Runs				
below Par Pond	38.4	10.4	1.2	0.9
near Snelling, SC	85.8	27.9	16	15

[a] Eleven years are missing between 1971 and 1982.

Source: Hunter, C. H., Updated Meteorological, and Hydrological Data for Revision 2 of the SRS Generic Safety Analysis Report, SRT-NTS-970265.
Chen, Kou-fu, 7Q10 Flows for SRS Streams, WSRC-RP-96-340, Washington Savannah River Co., Aiken, SC, 1996.

NOTE: The flow data used for computing statistics for the Savannah River and Savannah River Site Streams were based on U. S. Geological Survey stream gage measurements after construction of Thurmond Dam. Values listed for 7-day low flow, ten year recurrence (7Q10) are based on adjusted "natural" flows, i.e. without the effects of cooling water discharges from Savannah River Site reactors.

Table 1.4-15

Significant Earthquakes Within 200 Miles of SRS (Intensity > 4 or Magnitude > 3)

DATE yr/mm/dd	Latitude Deg. N	Longitude Deg. W	Depth mi.	Magnitude(s)*	Intensity	Distance mi.
1776/11/05	35.2	83			IV	154
1799/04/04	32.9	80			V	96
1799/04/11	32.9	80			V	96
1799/04/11	32.9	80			V	96
1817/01/08	32.9	80			V	96
1820/09/03	33.4	79.3			IV	133
1827/05/11	36.1	81.2			IV	195
1851/08/11	35.6	82.6			V	170
1853/05/20	34	81.2			VI	56
1857/12/19	32.9	80			V	96
1860/01/19	32.9	80			V	96
1861/08/31	36.1	81.1			VI	195
1869	32.9	80			IV	96
1872/06/17	33.1	83.3			V	98
1874/02/10	35.7	82.1			V	170
1874/02/22	35.7	82.1			IV	170
1874/03/17	35.7	82.1			IV	170
1874/03/26	35.7	82.1			IV	170
1874/04/14	35.7	82.1			IV	170
1874/04/17	35.7	82.1			IV	170
1875/11/02	33.8	82.5			VI	62
1876/12/12	32.9	80			IV	96
1879/12/13	35.2	80.8			IV	141
1885/08/06	36.2	81.6			V	200
1885/10/17	33	83			IV	82
1886/08/27	32.9	80			V	96
1886/08/28	32.9	80			VI	96
1886/08/28	32.9	80			IV	96
1886/08/28	32.9	80			IV	96
1886/09/01	30.4	81.7			IV	197
1886/09/01	32.9	80		6.9F	X	96
1886/09/01	32.9	80			V	96
1886/09/02	32.9	80			V	96
1886/09/03	30.4	81.7			IV	197
1886/09/04	32.9	80			V	96
1886/09/04	30.4	81.7			IV	197
1886/09/05	30.4	81.7			IV	197
1886/09/06	32.9	80			V	96
1886/09/06	32.9	80			IV	96
1886/09/08	30.4	81.7			IV	197
1886/09/09	30.4	81.7			IV	197
1886/09/17	32.9	80			VI	96
1886/09/21	32.9	80			VI	96
1886/09/21	32.9	80			V	96
1886/09/27	32.9	80			VI	96
1886/09/27	32.9	80			V	96
1886/10/09	32.9	80			IV	96

Table 1.4-15

Significant Earthquakes Within 200 Miles of SRS (Intensity > 4 or Magnitude > 3) (Continued)

DATE yr/mm/dd	Latitude Deg. N	Longitude Deg. W	Depth mi.	Magnitude(s)*	Intensity	Distance mi.
1886/10/09	32.9	80			IV	96
1886/10/09	32.9	80			V	96
1886/10/22	32.9	80			VI	96
1886/10/22	32.9	80			VII	96
1886/10/23	32.9	80			IV	96
1886/11/05	32.9	80			VI	96
1886/11/28	32.9	80			IV	96
1887/01/04	32.9	80			V	96
1887/03/04	32.9	80			IV	96
1887/03/17	32.9	80			V	96
1887/03/18	32.9	80			IV	96
1887/03/19	32.9	80			IV	96
1887/03/24	32.9	80			IV	96
1887/03/24	32.9	80			IV	96
1887/03/28	32.9	80			IV	96
1887/04/07	32.9	80			IV	96
1887/04/08	32.9	80			IV	96
1887/04/10	32.9	80			IV	96
1887/04/14	32.9	80			IV	96
1887/04/26	32.9	80			IV	96
1887/04/28	32.9	80			V	96
1887/05/06	32.9	80			IV	96
1887/06/03	32.9	80			IV	96
1887/07/10	32.9	80			IV	96
1887/08/27	32.9	80			V	96
1887/08/27	32.9	80			IV	96
1888/01/12	32.9	80			VI	96
1888/01/16	32.9	80			IV	96
1888/02/29	32.9	80			V	96
1888/03/03	32.9	80			IV	96
1888/03/03	32.9	80			IV	96
1888/03/04	32.9	80			IV	96
1888/03/14	32.9	80			V	96
1888/03/20	32.9	80			IV	96
1888/03/25	32.9	80			IV	96
1888/04/16	32.9	80			IV	96
1888/04/16	32.9	80			IV	96
1888/05/02	32.9	80			IV	96
1889/02/10	32.9	80			IV	96
1889/07/12	32.9	80			IV	96
1891/10/13	32.9	80			IV	96
1893/06/21	32.9	80			V	96
1893/06/21	30.4	81.7			IV	197
1893/07/05	32.9	80			IV	96

Table 1.4-15

Significant Earthquakes Within 200 Miles of SRS (Intensity > 4 or Magnitude > 3) (Continued)

DATE yr/mm/dd	Latitude Deg. N	Longitude Deg. W	Depth mi.	Magnitude(s)*	Intensity	Distance mi.
1893/07/06	32.9	80			IV	96
1893/07/08	32.9	80			IV	96
1893/07/08	32.9	80			IV	96
1893/09/19	32.9	80			IV	96
1893/09/19	32.9	80			IV	96
1893/09/19	32.9	80			IV	96
1893/11/08	32.9	80			IV	96
1893/11/08	32.9	80			IV	96
1893/12/27	32.9	80			IV	96
1893/12/27	32.9	80			IV	96
1893/12/27	32.9	80			IV	96
1893/12/27	32.9	80			IV	96
1893/12/28	32.9	80			IV	96
1894/01/10	32.9	80			IV	96
1894/01/10	32.9	80			IV	96
1894/01/10	32.9	80			IV	96
1894/01/30	32.9	80			IV	96
1894/02/01	32.9	80			IV	96
1894/06/16	32.9	80			IV	96
1894/12/11	32.9	80			IV	96
1895/01/08	32.9	80			IV	96
1895/01/08	32.9	80			IV	96
1895/01/08	32.9	80			IV	96
1895/04/27	32.9	80			IV	96
1895/07/25	32.9	80			IV	96
1895/10/06	32.9	80			IV	96
1895/10/20	32.9	80			IV	96
1895/11/12	32.9	80			IV	96
1896/03/19	32.9	80			IV	96
1896/08/11	32.9	80			IV	96
1896/08/11	32.9	80			IV	96
1896/08/11	32.9	80			IV	96
1896/08/11	32.9	80			IV	96
1896/08/12	32.9	80			IV	96
1896/08/14	32.9	80			IV	96
1896/08/30	32.9	80			IV	96
1896/09/08	32.9	80			IV	96
1896/11/14	32.9	80			IV	96
1899/03/10	32.9	80			IV	96
1899/12/04	32.9	80			IV	96
1900/10/31	30.4	81.7			V	197
1901/12/02	32.9	80			IV	96
1903/01/24	32.9	80			IV	96
1903/01/24	32.1	81.1			VI	85
1903/01/31	32.9	80			IV	96
1907/04/19	32.9	80			V	96
1911/04/20	35.1	82.7			V	141

Table 1.4-15

Significant Earthquakes Within 200 Miles of SRS (Intensity > 4 or Magnitude > 3) (Continued)

DATE yr/mm/dd	Latitude Deg. N	Longitude Deg. W	Depth mi.	Magnitude(s)*	Intensity	Distance mi.
1903/02/03	32.9	80			IV	96
1904/03/05	35.7	83.5		4.0F	V	198
1912/06/12	32.9	80			VII	96
1912/06/20	32	81			V	94
1912/09/29	32.9	80			IV	96
1912/10/23	32.7	83.5			IV	115
1912/11/17	32.9	80			IV	96
1912/12/07	34.7	81.7			IV	98
1913/01/01	34.7	81.7			VII	98
1913/04/17	35.3	84.2		3.9F	V	203
1914/03/05	33.5	83.5			VI	109
1914/03/07	34.2	79.8			IV	122
1914/07/14	32.9	80			IV	96
1914/09/22	32.9	80			V	96
1915/10/29	35.8	82.7			IV	184
1915/10/29	35.8	82.7			V	184
1916/02/21	35.5	82.5			VII	162
1916/03/02	34.5	82.7			IV	104
1916/08/26	36	81			V	190
1924/01/01	34.8	82.5			IV	117
1924/10/20	35	82.6			V	131
1926/07/08	35.9	82.1			VII	182
1928/11/03	36.112	82.828	3.1	4.5N	VI	206
1928/11/20	35.8	82.3			IV	178
1928/12/23	35.3	80.3			IV	158
1929/01/03	33.9	80.3			IV	88
1929/10/28	34.3	82.4			IV	83
1930/12/10	34.3	82.4			IV	83
1930/12/26	34.5	80.3			IV	114
1931/05/06	34.3	82.4			IV	83
1933/12/19	32.9	80			IV	96
1933/12/23	32.9	80			V	96
1933/12/23	32.9	80			IV	96
1934/12/09	32.9	80			IV	96
1935/01/01	35.1	83.6			V	170
1938/03/31	35.6	83.6			IV	195
1940/12/25	35.9	82.9			IV	195
1941/05/10	35.6	82.6			IV	170
1943/12/28	32.9	80			IV	96
1944/01/28	32.9	80			IV	96
1945/01/30	32.9	80			IV	96
1945/07/26	33.75	81.376	3.1	4.4F	VI	35
1947/11/02	32.9	80			IV	96
1949/02/02	32.9	80			IV	96
1952/11/19	32.9	80			V	96
1956/01/05	34.3	82.4			IV	83
1956/01/05	34.3	82.4			IV	83

Table 1.4-15

Significant Earthquakes Within 200 Miles of SRS (Intensity > 4 or Magnitude > 3) (Continued)

DATE	Latitude Longitude		Depth	Magnitude(s)*		Intensity	Distance	
yr/mm/dd	Deg. N	Deg. W		mi.				mi.
1949/06/27	32.9	80					IV	96
1951/03/04	32.9	80					IV	96
1951/12/30	32.9	80					IV	96
1956/05/19	34.3	82.4					IV	83
1956/05/27	34.3	82.4					IV	83
1956/09/07	35.5	84				4.1F	V	203
1957/05/13	35.799	82.142		3.1		4.1F	VI	176
1957/07/02	35.6	82.7		4.4			VI	171
1957/11/24	35	83.5				4.0F	VI	160
1958/05/16	35.6	82.6					IV	170
1958/10/20	34.5	82.7					V	104
1959/08/03	33.054	80.126		0.6		4.4F	VI	88
1959/10/27	34.5	80.2					VI	117
1960/01/03	35.9	82.1					IV	182
1960/03/12	33.072	80.121		5.6		4.0F	V	88
1960/07/24	32.9	80					V	96
1963/04/11	34.9	82.4					IV	120
1963/05/04	32.972	80.193		3.1		3.3M	IV	85
1963/10/08	33.9	82.5				3.2M		67
1964/01/20	35.9	82.3					IV	184
1964/03/07	33.724	82.391		3.1		3.3M		54
1964/03/13	33.193	83.309		0.6	4.4P	3.9M	V	98
1964/04/20	33.842	81.096		1.9		3.5M	V	50
1965/09/09	34.7	81.2				3.9M		101
1965/09/10	34.7	81.2				3.0M		101
1965/11/08	33.2	83.2				3.3M		91
1967/10/23	32.802	80.221		11.8	3.8P	3.4N	V	86
1968/07/12	32.8	79.7					IV	115
1968/09/22	34.111	81.484		0.6	3.7P	3.5M	IV	58
1969/05/09	33.95	82.58				3.3N		72
1969/05/18	33.95	82.58			3.5N			72
1969/12/13	35.036	82.84	6	3.7		3.7M	IV	141
1970/09/10	36.02	81.421		0.6		3.1N	V	189
1971/05/19	33.359	80.655		0.6	3.4P	3.7N	V	56
1971/07/13	34.76	82.98			3.8N		VI	128
1971/07/13	34.7	82.9			3.0M			122
1971/07/31	33.341	80.631		2.5	3.8N		III	56
1971/08/11	33.4	80.7			3.5N			54
1971/10/09	35.795	83.371	5	3.4P	3.7N		V	200
1971/10/22	36	83			3.3M			203
1972/02/03	33.306	80.582		1.2	4.5P	4.5N	V	59
1972/02/07	33.46	80.58			3.2M		III	61
1972/02/07	33.46	80.58			3.2M		III	61
1972/08/14	33.2	81.4				3.0L	III	14
1973/12/19	32.974	80.274		3.7		3.0M	III	80
1974/10/28	33.79	81.92				3.0L	IV	40
1974/11/05	33.73	82.22				3.7L	II	46

Table 1.4-15

Significant Earthquakes Within 200 Miles of SRS (Intensity > 4 or Magnitude > 3) (Continued)

DATE yr/mm/dd	Latitude Deg. N	Longitude Deg. W	Depth mi.	Magnitude(s)*		Intensity	Distance mi.
1974/08/02	33.908	82.534	2.5	4.3P	4.1N	V	69
1974/10/08	33.9	82.4	3.1P			III	62
1974/11/22	32.926	80.159	3.7	4.7P	4.3N	VI	88
1974/12/03	33.95	82.5			3.6L	IV	69
1975/04/01	33.2	83.2			3.9M		91
1975/04/28	33	80.22	6.2		3.0N	IV	83
1975/10/18	34.9	83				IV	136
1975/11/25	34.943	82.896	6.2		3.2N	IV	136
1976/12/27	32.06	82.504	8.7		3.7N	V	98
1977/01/18	33.058	80.173	0.6		3.0N	VI	85
1977/03/30	32.95	80.18	5		2.9D	V	85
1977/08/04	33.369	80.699	5.6		3.1N		54
1977/08/25	33.369	80.698	2.1	3.1N	2.8D	IV	54
1977/12/15	32.944	80.167	4.7	3.0N	2.6D	V	86
1978/09/07	33.063	80.21	6.2	2.7N	2.6D	IV	83
1979/08/13	35.2	84.353	13.8	3.7N	3.7D	V	203
1979/08/13	33.9	82.54	14.3		4.1D		69
1979/09/06	35.298	83.241	6.2		3.2D		166
1979/09/12	35.579	83.941	16.8	3.2N	3.1D	V	206
1979/12/07	33.008	80.163	3.1	2.8N	2.8D	IV	85
1980/06/10	35.458	82.815	0.4	3.0N	2.5D		165
1980/09/01	32.978	80.186	4.4	2.7N	2.9D	IV	85
1981/03/04	35.81	79.737	0.6	2.8N	2.2D	IV	203
1981/04/09	35.514	82.051	0.1	3.0N	3.3D	V	157
1981/05/05	35.327	82.422	6.3	3.5N	3.1D	V	149
1982/01/28	32.982	81.393	4.4	3.4N	2.4D		24
1982/03/01	32.936	80.138	4.2	3.0N	2.8D	IV	88
1982/07/16	34.32	81.55	1.2		3.1D	III	72
1982/10/31	32.671	84.873		2.9N	3.0D	V	192
1982/10/31	32.644	84.894		3.1N	3.1D		194
1982/12/11	32.853	83.532			3.0D		114
1983/01/26	32.853	83.558		3.5N	3.5D		115
1983/03/25	35.333	82.46	7.1	3.2N	3.3D	V	149
1983/11/06	32.937	80.159	6		3.3D	V	88
1985/12/22	35.701	83.72	8.3		3.3D		205
1986/03/13	33.229	83.226	3.1		2.4D	IV	93
1986/09/17	32.931	80.159	4.2		2.6D	IV	88
1987/03/16	34.56	80.948	1.9		3.1D		96
1988/01/09	35.279	84.199	7.6		3.2D	IV	200
1988/01/23	32.935	80.157	4.6		3.3D	V	88
1988/02/18	35.346	83.837	1.5	3.5N	3.3D	IV	190
1989/06/02	32.934	80.166	3.6		2.0D	IV	86
1990/11/13	32.947	80.136	2.1	3.5N	3.2D	V	88
1991/06/02	32.98	80.214	3.1		1.7D	V	83

Table 1.4-15

Significant Earthquakes Within 200 Miles of SRS (Intensity > 4 or Magnitude > 3) (Continued)

DATE yr/mm/dd	Latitude Deg. N	Longitude Deg. W	Depth mi.	Magnitude(s)*		Intensity	Distance mi.
1992/01/03	33.981	82.421	2.1		3.4D	V	67
1992/08/21	32.985	80.163	4	4.1N	4.1D	VI	86
1993/01/01	35.878	82.086	1.4		3.0D		181
1993/08/08	33.597	81.591	5.3	3.2N	2.9D	V	22

Source: SEUSSN Bulletins, Va. Tech Publications, Complete through 1/95)
* MAGNITUDE TYPE CODES (FOLLOWS MAGNITUDE VALUE)
" D - Md from duration or coda length"
" F - mb from felt area or attenuation data"
" L - ML (Richter, 1958)"
" M - mb determined from modified instruments/formuli"
" N - mb from Lg wave data (Nuttli, 1973)"
" P - mb from P wave data (Gutenberg and Richter (1956)"

Table 1.4-16

Modified Mercalli Intensity Scale of 1931

Level	Definition
I.	Not felt except by a very few under especially favorable circumstances (I Rossi-Forel Scale).
II.	Felt by only a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing (I and II, Rossi-Forel Scale).
III.	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing truck. Duration estimated (III Rossi-Forel Scale).
IV.	During the day felt indoors by many; outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably (IV to V Rossi-Forel Scale).
V.	Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken, a few instances of cracked plaster, unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop (V to VI Rossi-Forel Scale).
VI.	Felt by all; many are frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight (VI to VII Rossi-Forel Scale).
VII.	Everybody runs outdoors. Damage negligible in buildings of good structures; considerable in poorly built or badly designed structures; some chimneys are broken. Noticed by persons driving motor cars (VIII Rossi-Forel Scale).
VIII.	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbs persons driving motor cars (VIII+ to IX Rossi-Forel Scale).
IX.	Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken (IX+ Rossi-Forel Scale).
X	Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundations, ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks (X Rossi-Forel Scale).
XI.	Few, if any, masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII.	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

Source: Earthquake Intensity and Ground Motion, pp 7-8, by Frank Neumann, University of Washington Press, Seattle, WA (1954).

Table 1.4-17

Historic Earthquakes Recorded Within 50 Miles of SRS (through December 1999)

Date	Latitude	Longitude	Depth (km)	Magnitude
05/06/1897	33.3000	-81.2000		Felt
05/09/1897	33.9000	-81.6000		Felt
05/24/1897	33.3000	-81.2000		Felt
05/27/1897	33.3000	-81.2000		Felt
8/14/1972	33.2000	-81.4000		3.20
10/28/1974	33.7900	-81.9200		3.00
11/5/1974	33.7300	-82.2200		3.70
9/15/1976	33.1440	-81.4130	4.50	2.40
6/5/977	33.0520	-81.4120	3.50	2.70
2/21/1981	33.5933	-81.1476	6.61	2.00
1/28/1982	32.9800	-81.3900	7.00	3.40
6/9/1985	33.2225	-81.6842	5.81	2.70
2/17/1988	33.5113	-81.6966	11.73	2.50
8/5/1988	33.1873	-81.6290	2.26	2.20
7/13/1992	33.4798	-81.1920	7.60	1.90
10/2/1992	33.4990	-81.2020	3.00	2.40
12/12/1992	33.2798	-81.8328	11.80	1.20
6/29/1993	33.4652	-81.2210	4.90	2.20
8/8/1993	33.5893	-81.5852	10.18	3.20
8/8/1993	33.5885	-81.5812	9.22	1.60
9/18/1996	33.6915	-82.1248	2.38	2.80
5/17/1997	33.2118	-81.6765	5.44	2.50

Source: SEUSSN Bulletins, Virginia Tech Publication; complete through 12/99)

Table 1.4-18

Blume (1982) Estimated Site Motions for Postulated Maximum Events

Location	Epicentral Intensity (MMI)	R (km)	Site Intensity (MMI)	Site PGA (%g)
Local	VII	0-10	VII	0.10
Fall Line	VIII	45	VI	0.06
Bowman	X	95	VII	0.10
Middleton	X	145	VI-VII	0.075

Source: URS/John A. Blume and Associates, Engineers. Update of Seismic Criteria for the Savannah River Plant, Vol. 1 of 2, *Geotechnical*. USR/JAB 8144, San Francisco, CA. Prepared for E.I. du Pont de Nemours and Company, as DPE-3699, Savannah River Plant, Aiken, SC, 1982.

Table 1.4-19

Geomatrix Estimated Site Motions for Postulated Maximum Events

Location	Magnitude (Mw)	R (km)	Site PGA[a] (%g median, horizontal)
Local	5.0	<25	0.18
Bowman	6.0	80	0.06
Charleston	7.5	110	0.11

[a] 25 Hz

Source: Geomatrix Consultants, Inc., Ground Motion Following Selection of SRS Design Basis Earthquake and Associated Deterministic Approach, WSRC Subcontract AA2021S, Washington Savannah River Company, Savannah River Site, Aiken, SC, 1991.

1.11 FIGURES

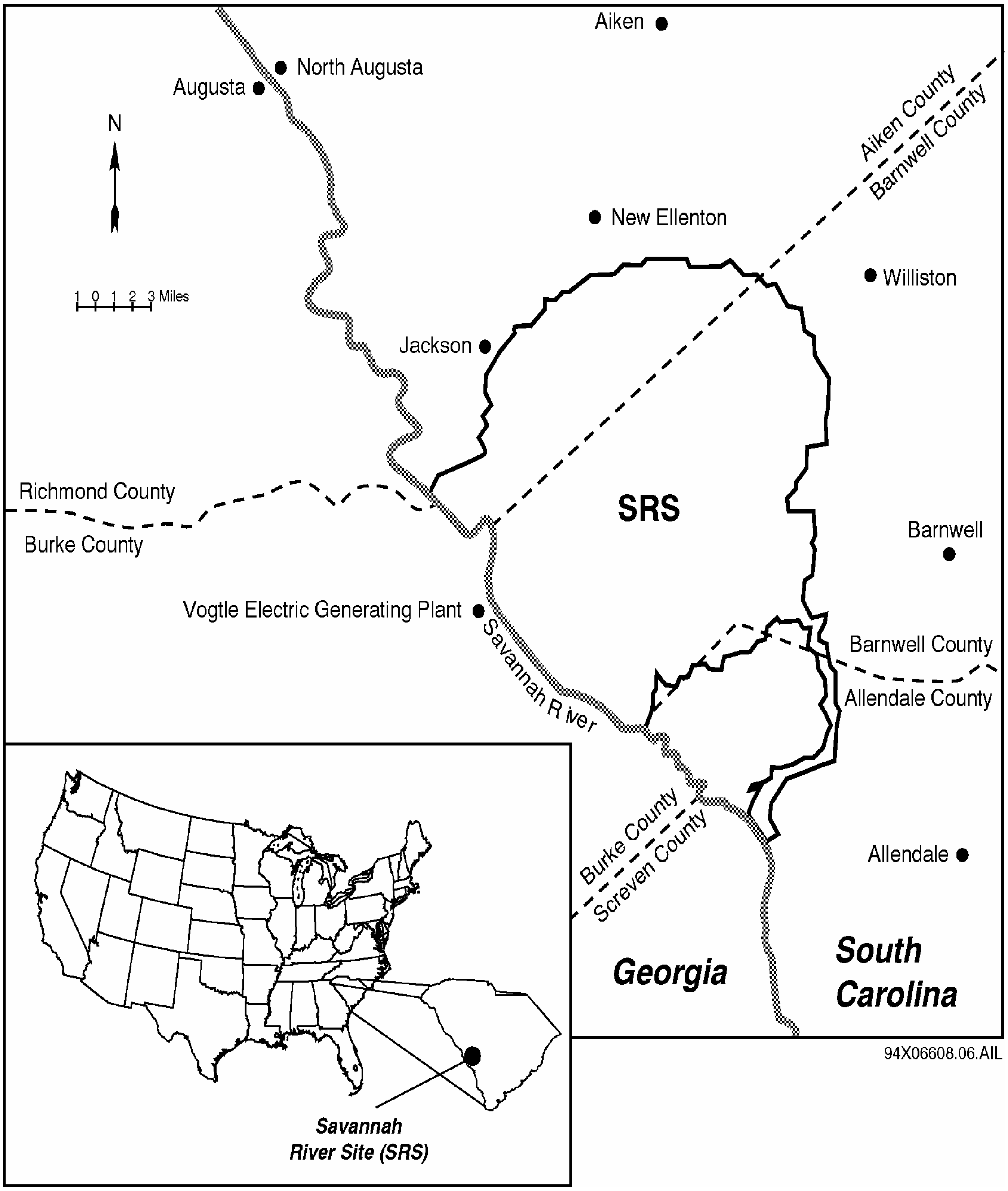


Figure 1.3-1 Savannah River Site Map (Sheet 1 of 2)

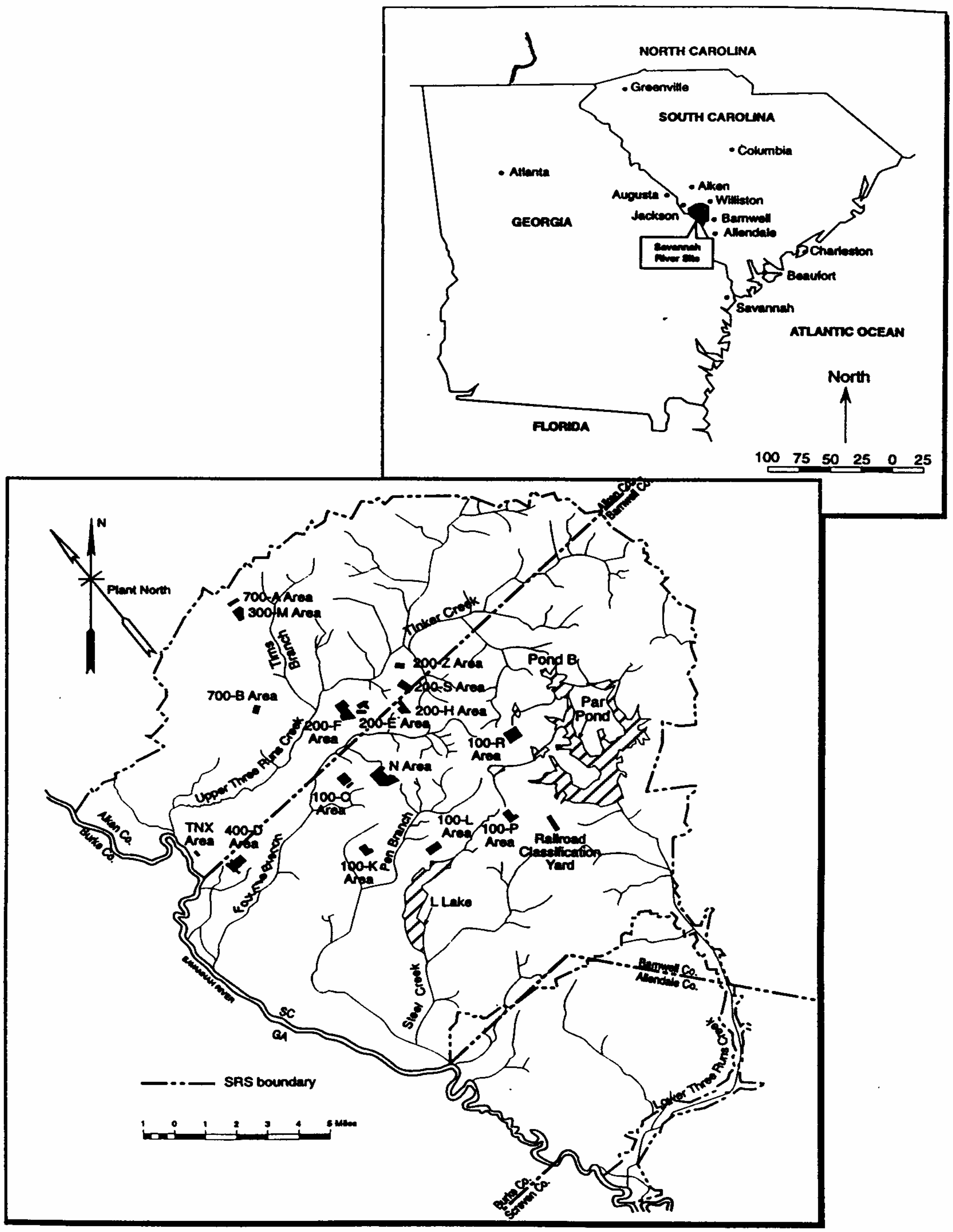


Figure 1.3-1 Savannah River Site Map (Sheet 2 of 2)

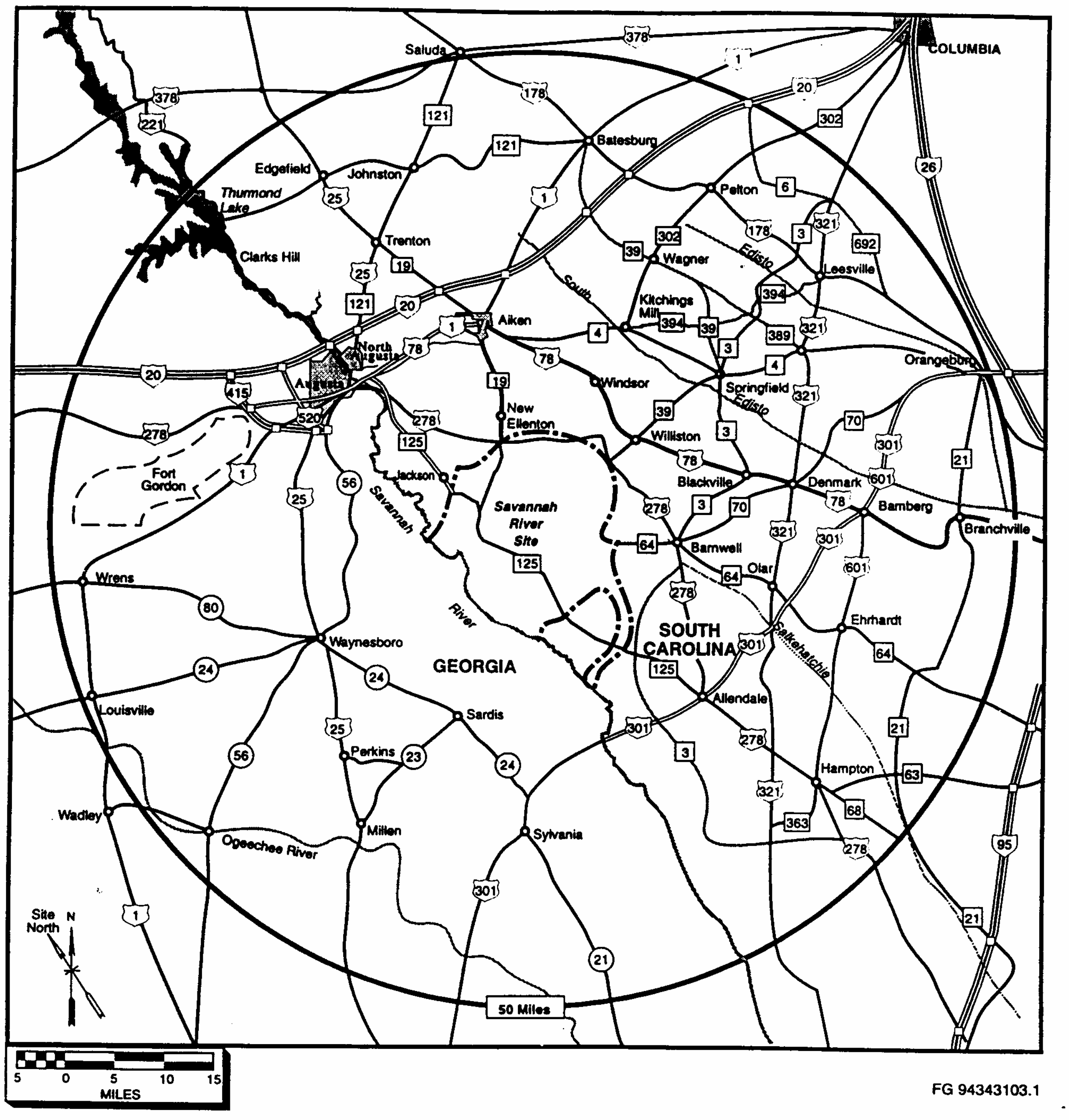


Figure 1.3-2 50-Mile Vicinity of SRS

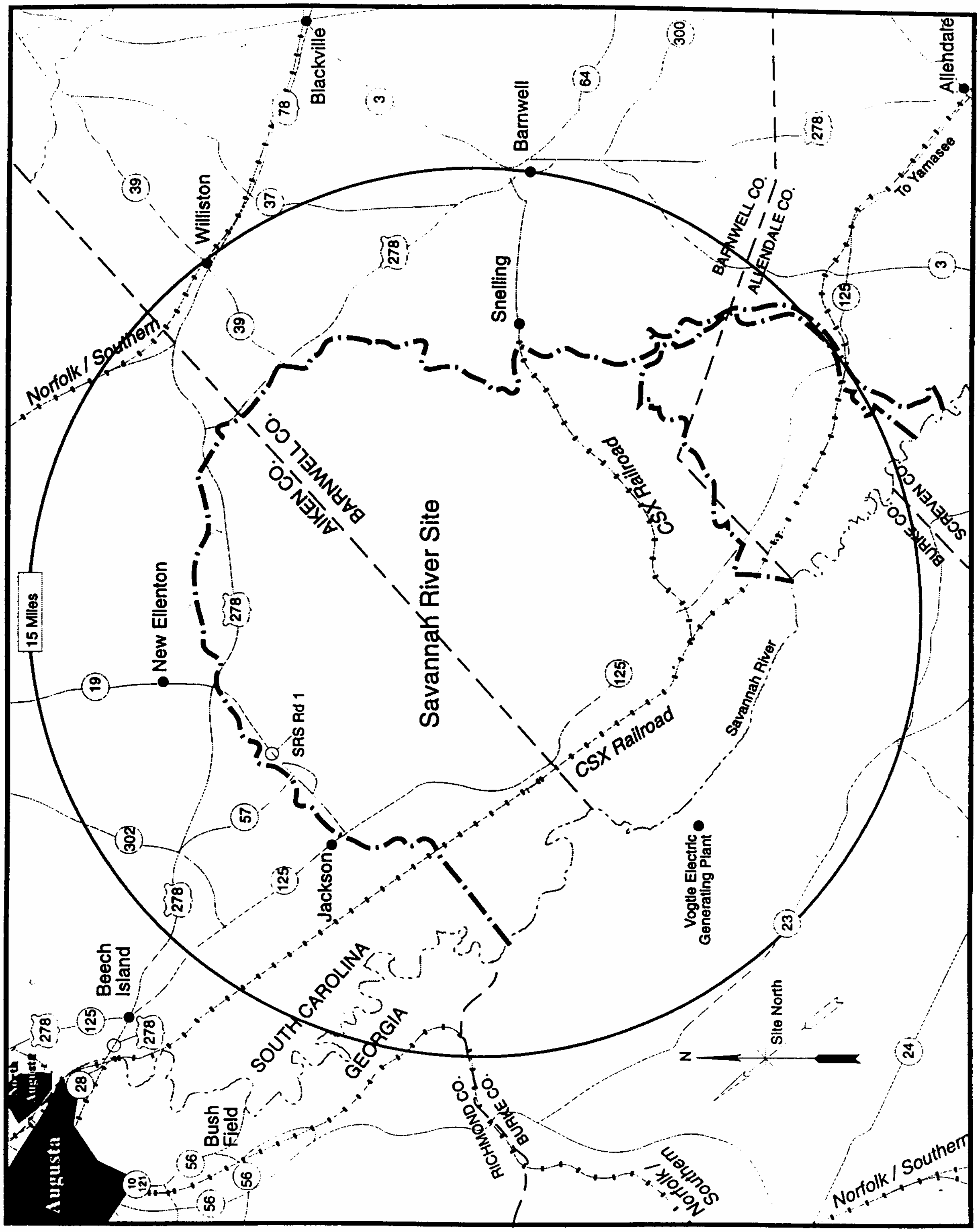
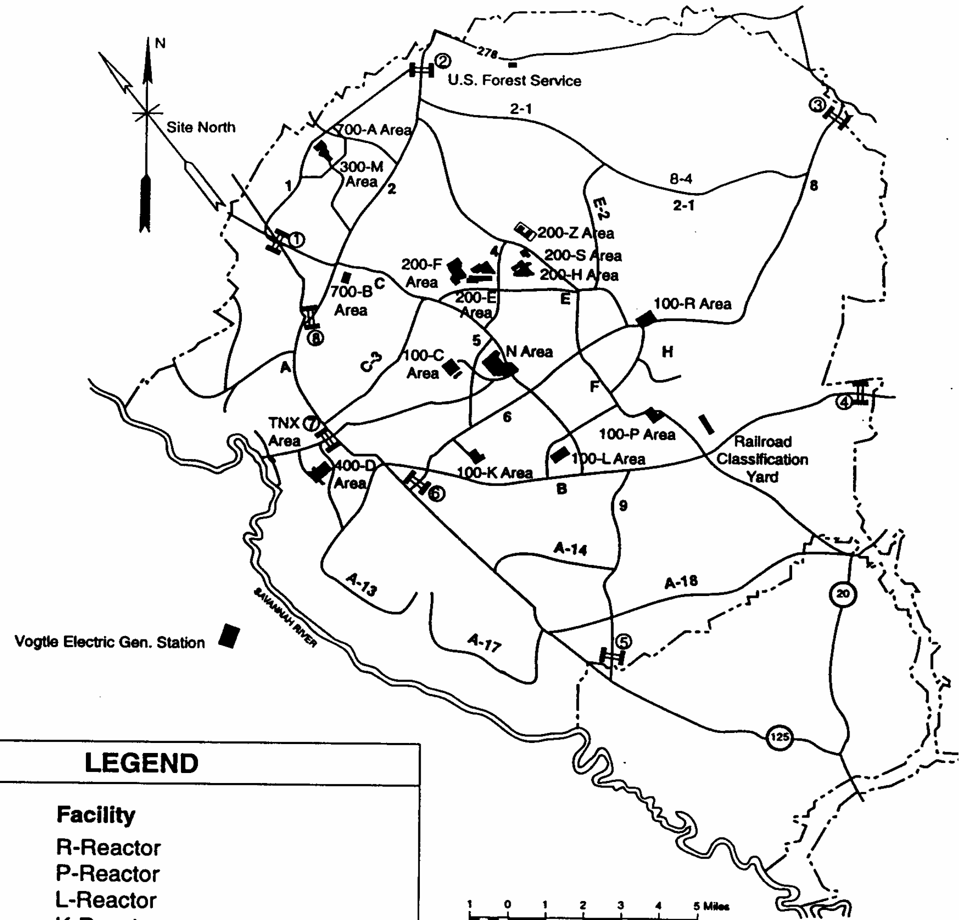


Figure 1.3-3 Map Showing 15-Mile Radius from SRS Center



LEGEND

Area	Facility
R-Area	R-Reactor
P-Area	P-Reactor
L-Area	L-Reactor
K-Area	K-Reactor
C-Area	C-Reactor
F-Area	F-Canyon, FB Line, 235-F
H-Area	H-Canyon, HB Line, Tritium Facility
S-Area	DWPF Ops.
Z-Area	Saltstone Ops.
N-Area	Central Shops
M-Area	Reactor Materials Facilities
D-Area	Heavy Water Purification
A-Area	DOE/WSRC Administration, SRTC
B-Area	WSI Headquarters
Offsite	Vogtle Electric Gen. Station
⊢⊣	Barricades

FG 94343105.1

Figure 1.3-4 SRS Map Showing Key Facilities

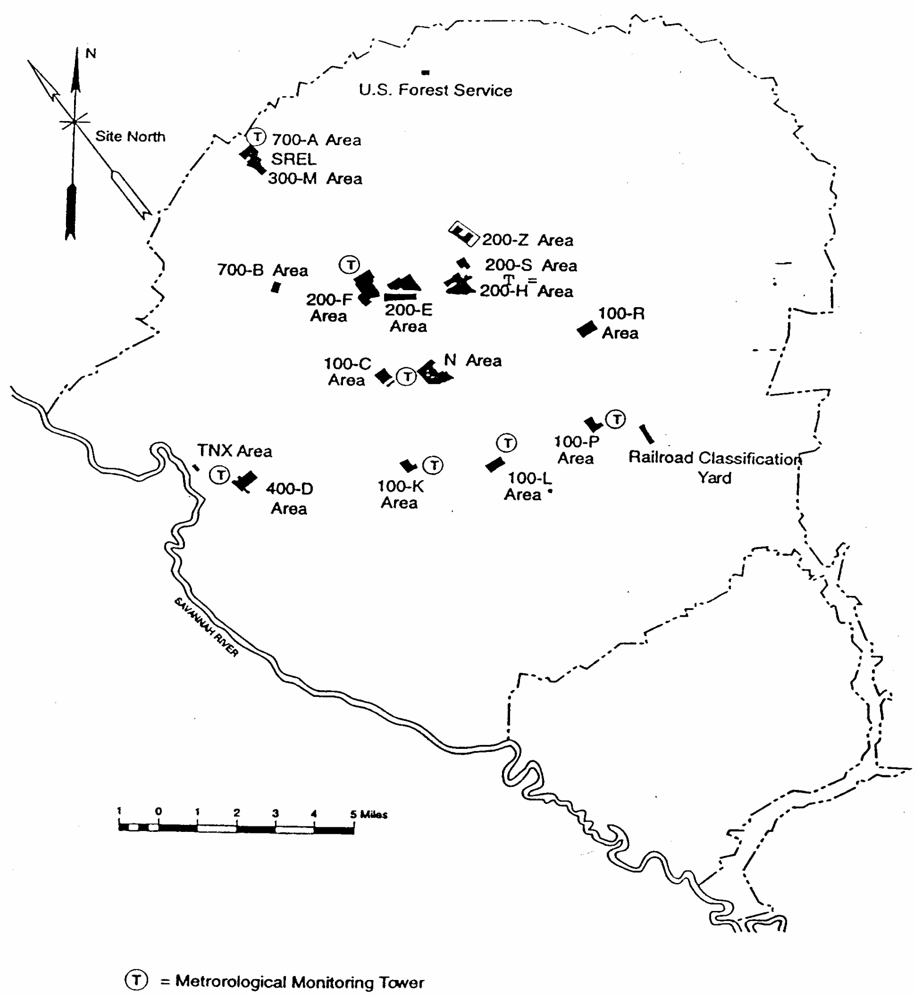


Figure 1.4-1 Locations of SRS Meteorological Monitoring Towers

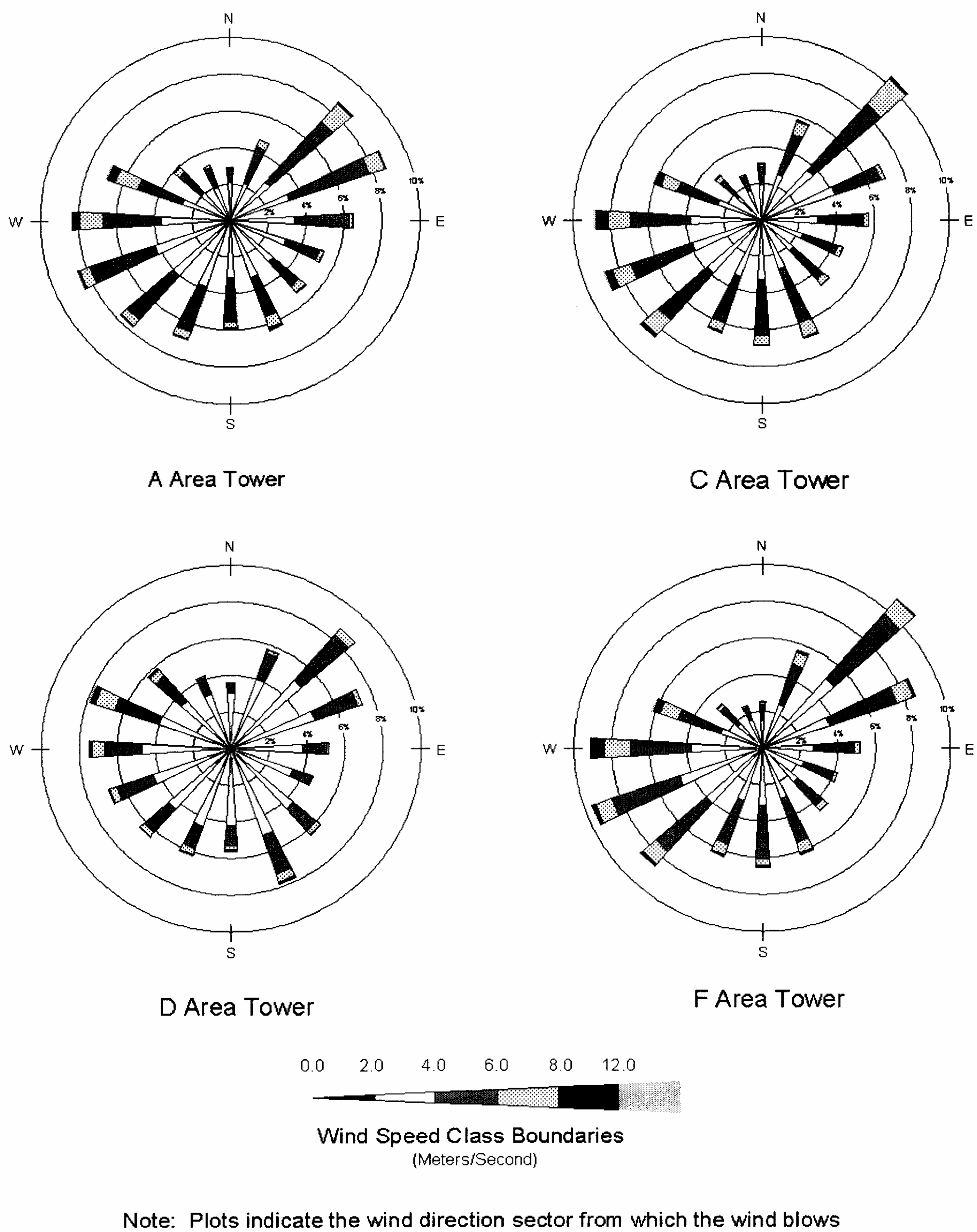


Figure 1.4-2 Wind Rose Plots for A, C, D, F, H, K, L, and P Areas, 1992-1996 (Sheet 1 of 2)

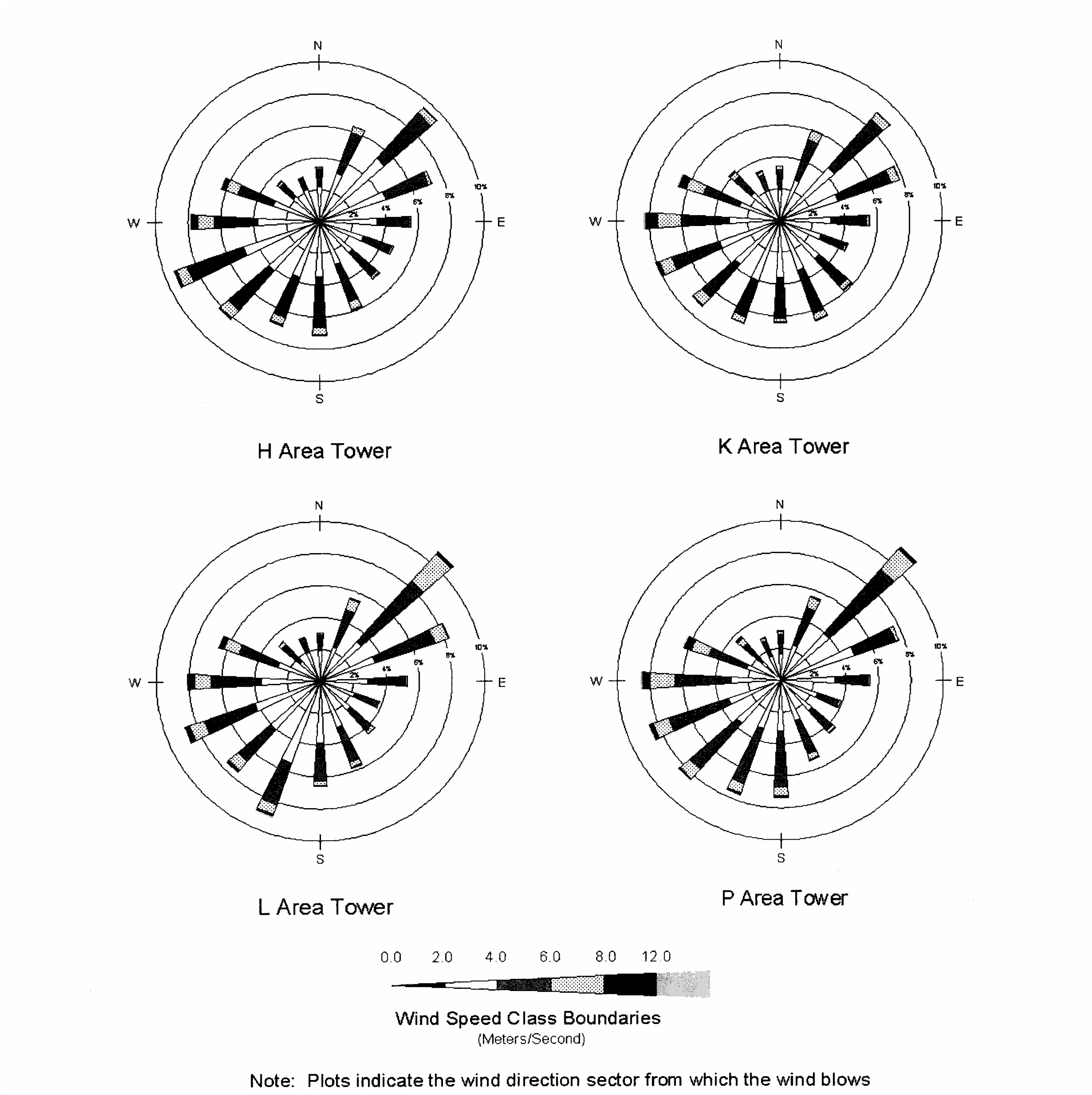
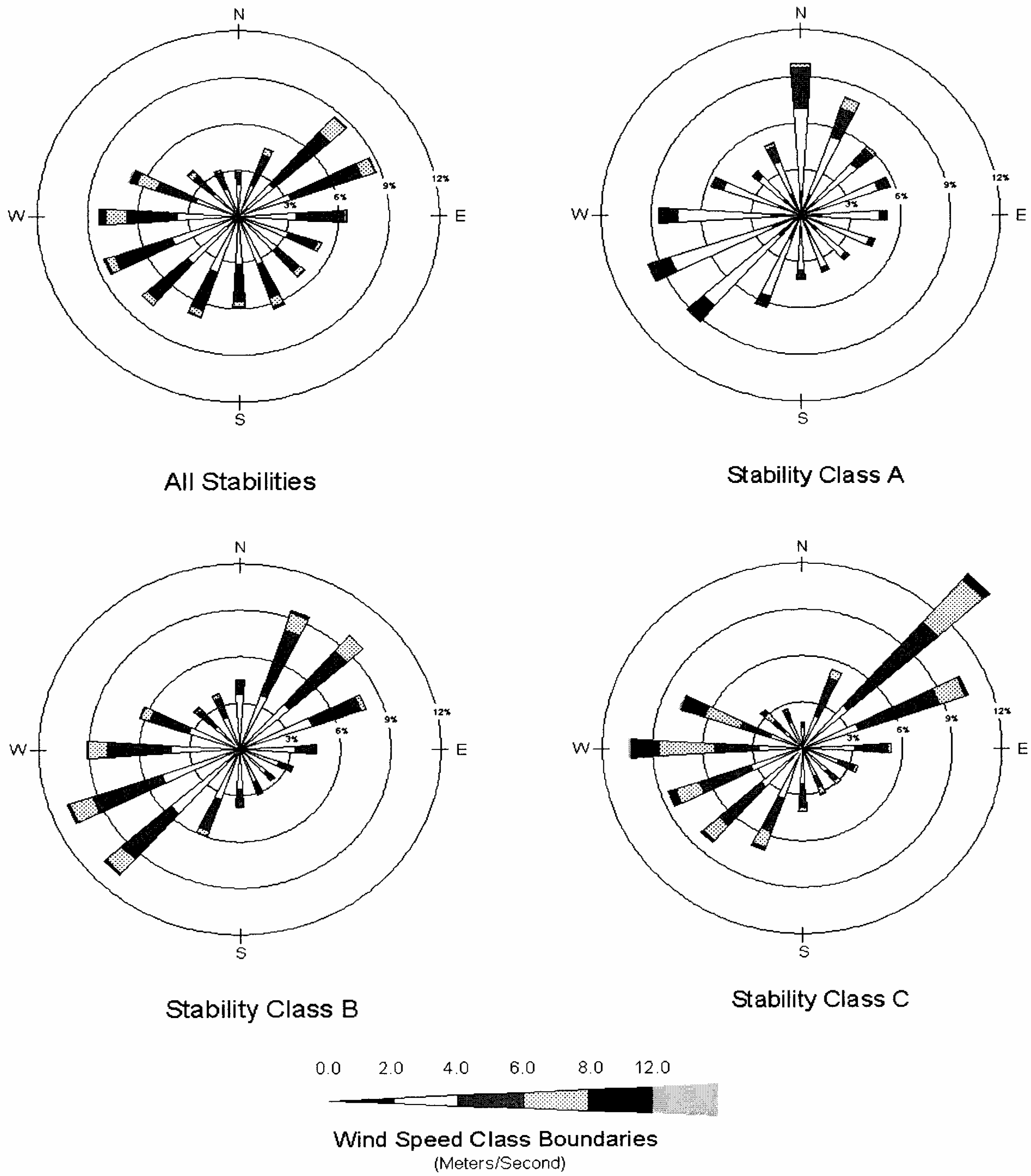


Figure 1.4-2 Wind Rose Plots for A, C, D, F, H, K, L, and P Areas, 1992-1996 (Sheet 2 of 2)



Note: plots indicate the wind direction sector from which the wind blows

Figure 1.4-3 Wind Rose Plots by Stability Class - A Area Tower, 1992-1996 (Sheet 1 of 2)

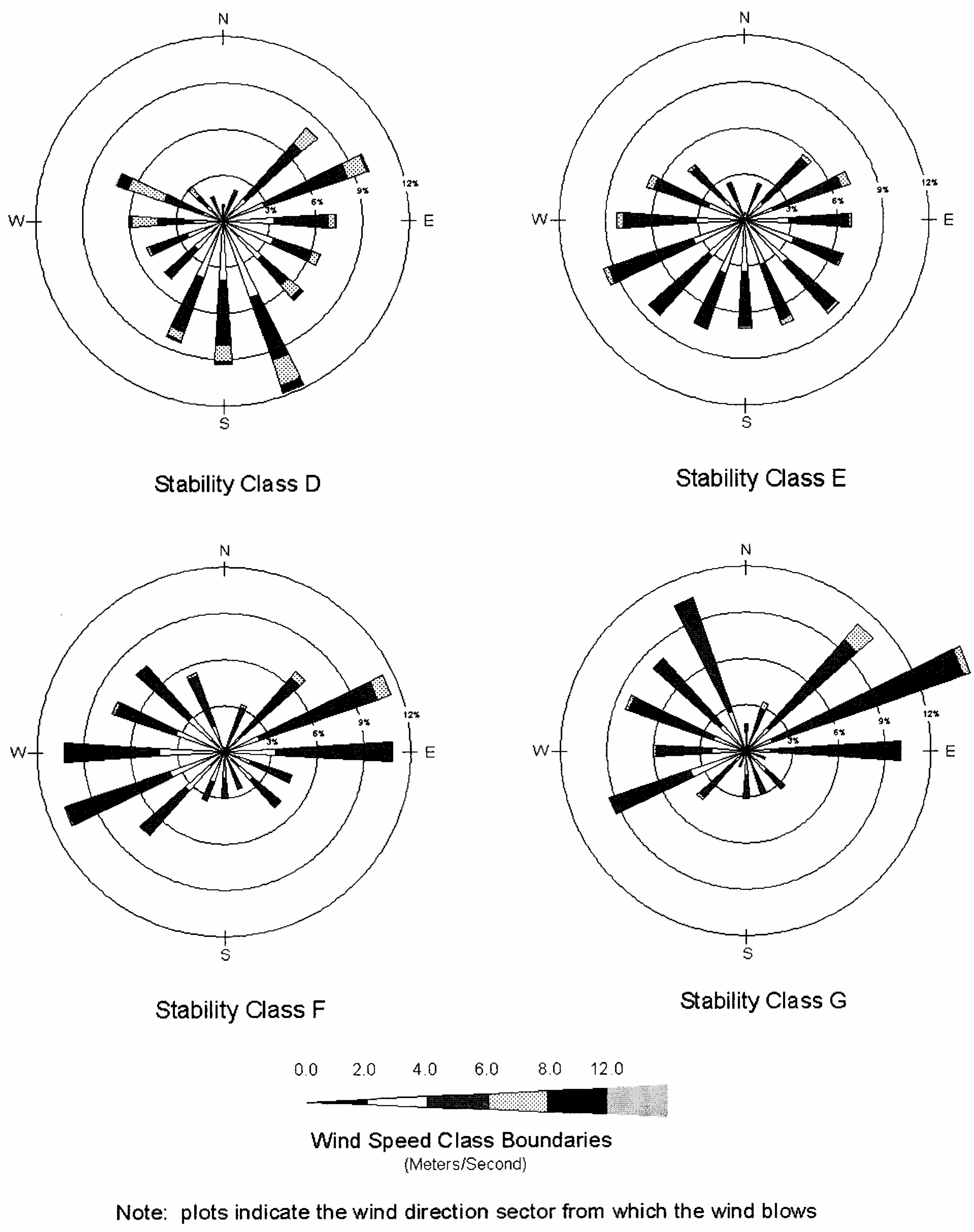
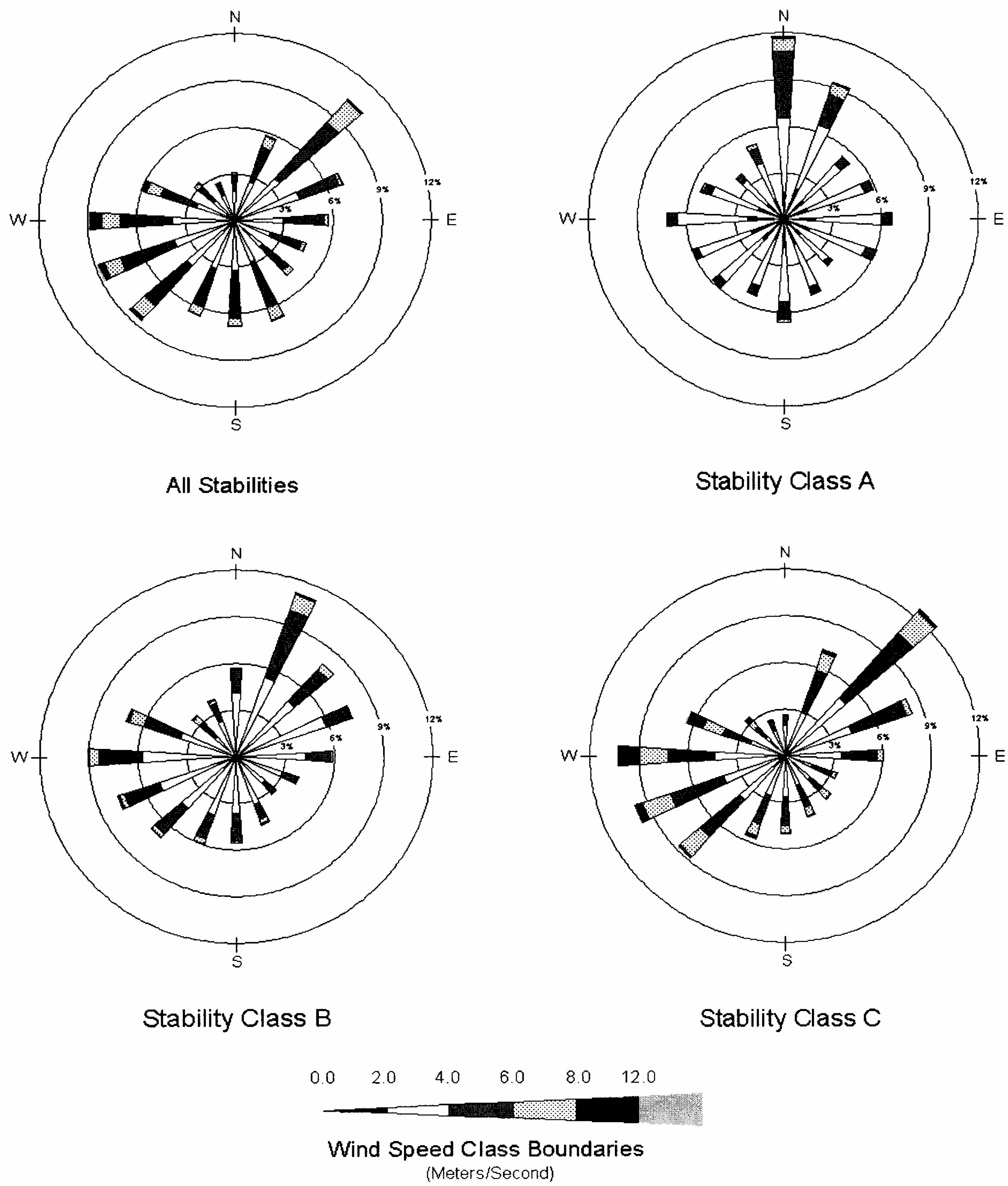


Figure 1.4-3 Wind Rose Plots by Stability Class - A Area Tower, 1992-1996 (Sheet 2 of 2)



Note: plots indicate the wind direction sector from which the wind blows

Figure 1.4-4 Wind Rose Plots by Stability Class - C Area Tower, 1992-1996 (Sheet 1 of 2)

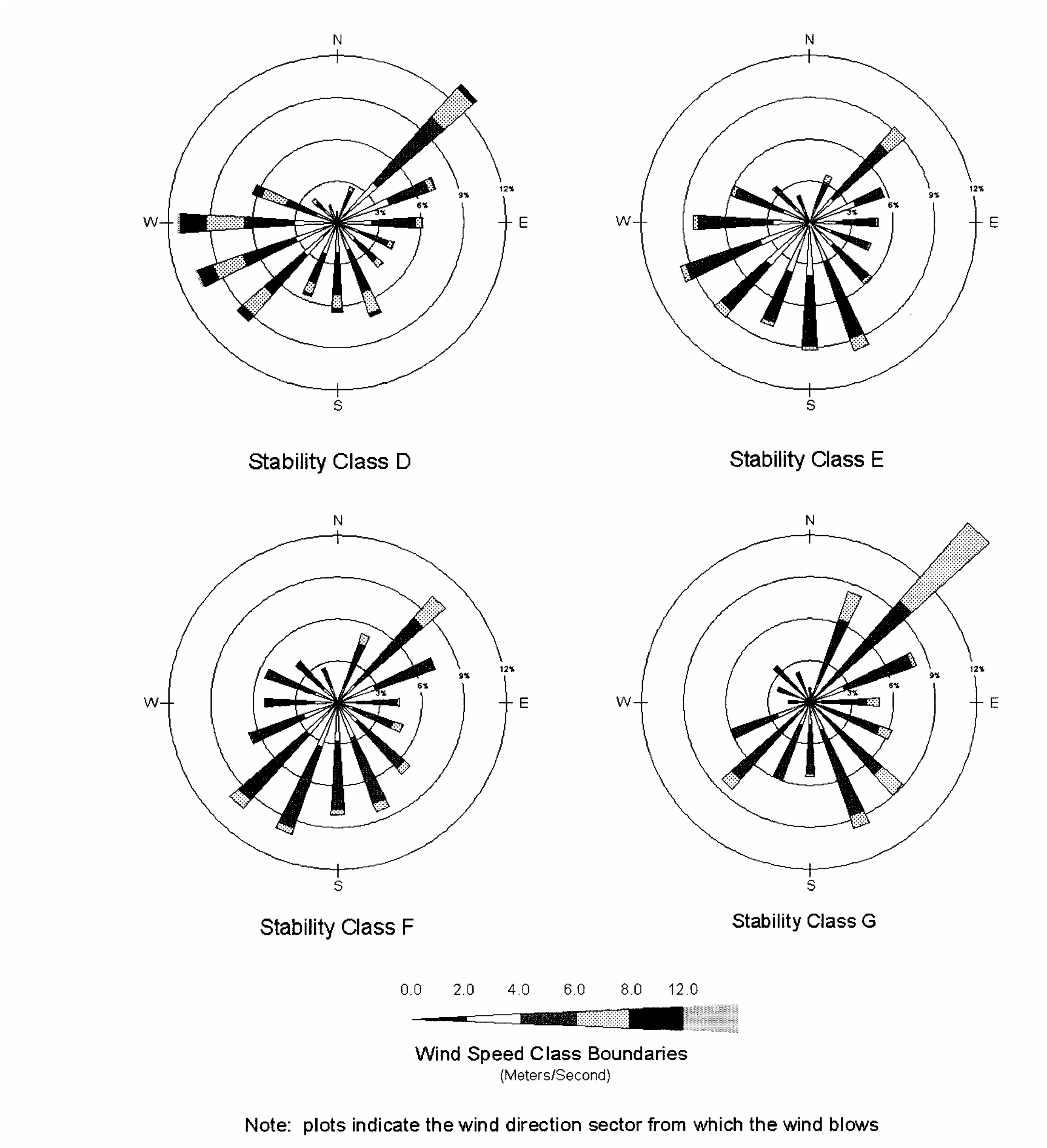


Figure 1.4-4 Wind Rose Plots by Stability Class - C Area Tower, 1992-1996 (Sheet 2 of 2)

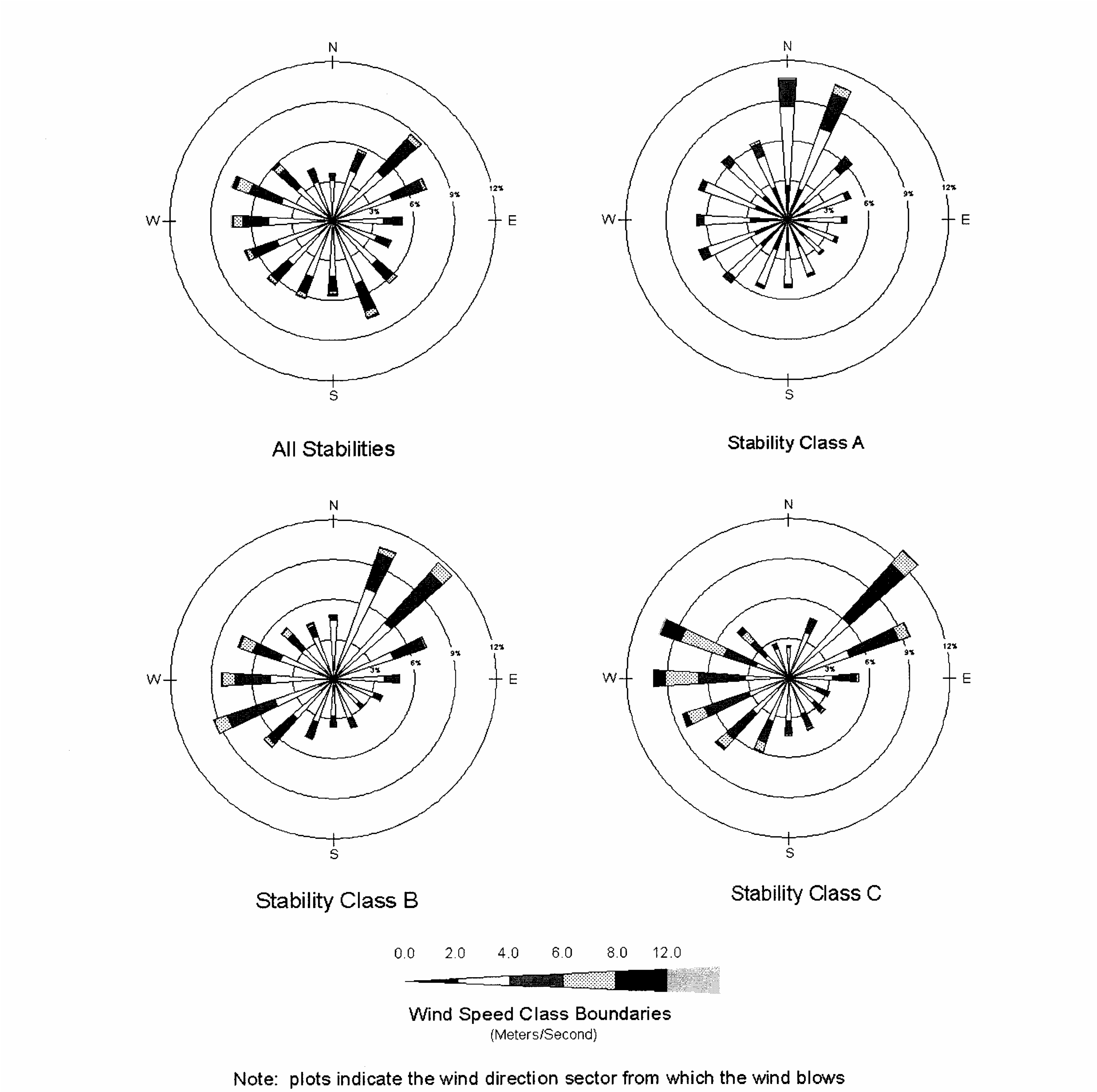


Figure 1.4-5 Wind Rose Plots by Stability Class - D Area Tower, 1992-1996 (Sheet 1 of 2)

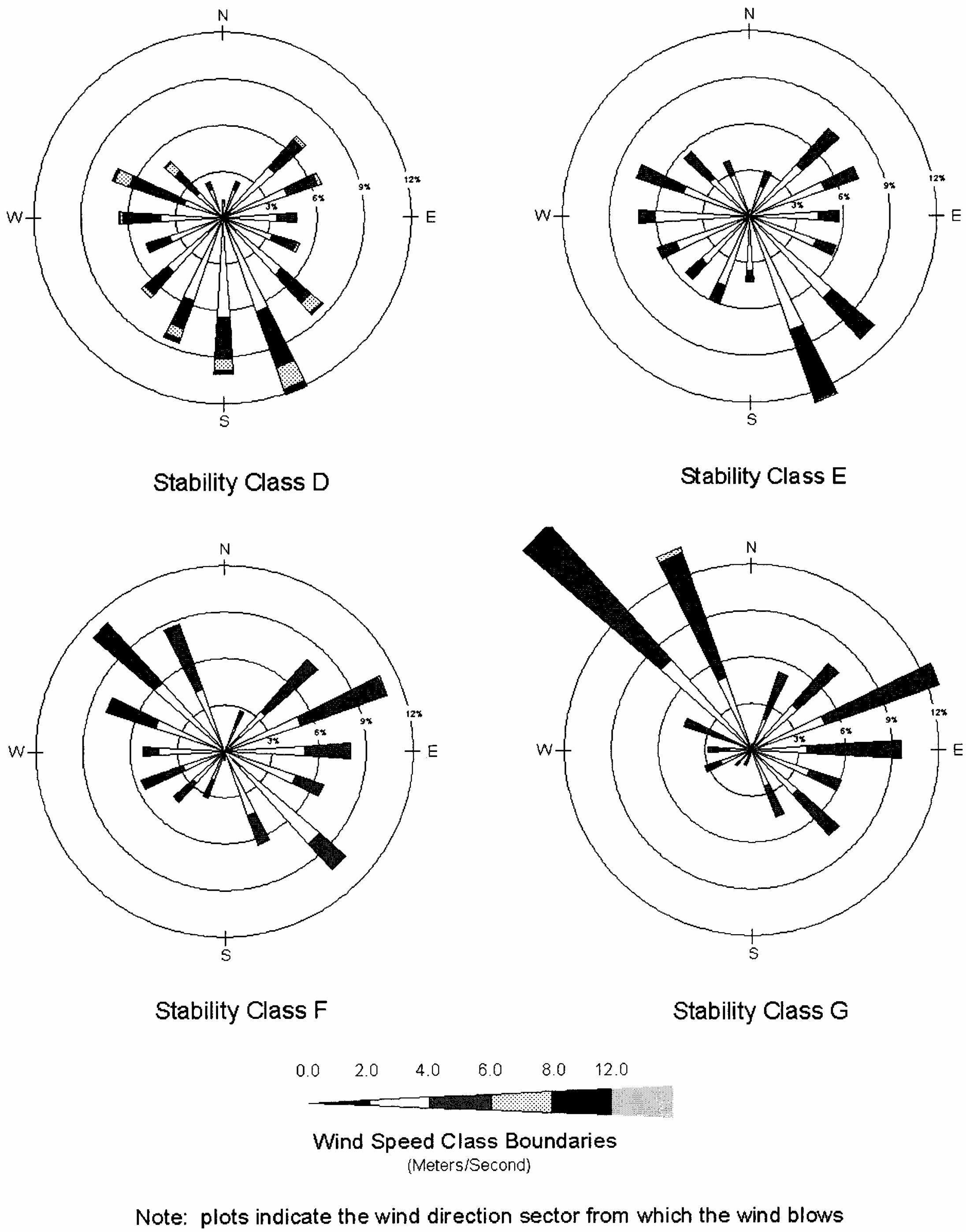


Figure 1.4-5 Wind Rose Plots by Stability Class - D Area Tower, 1992-1996 (Sheet 2 of 2)

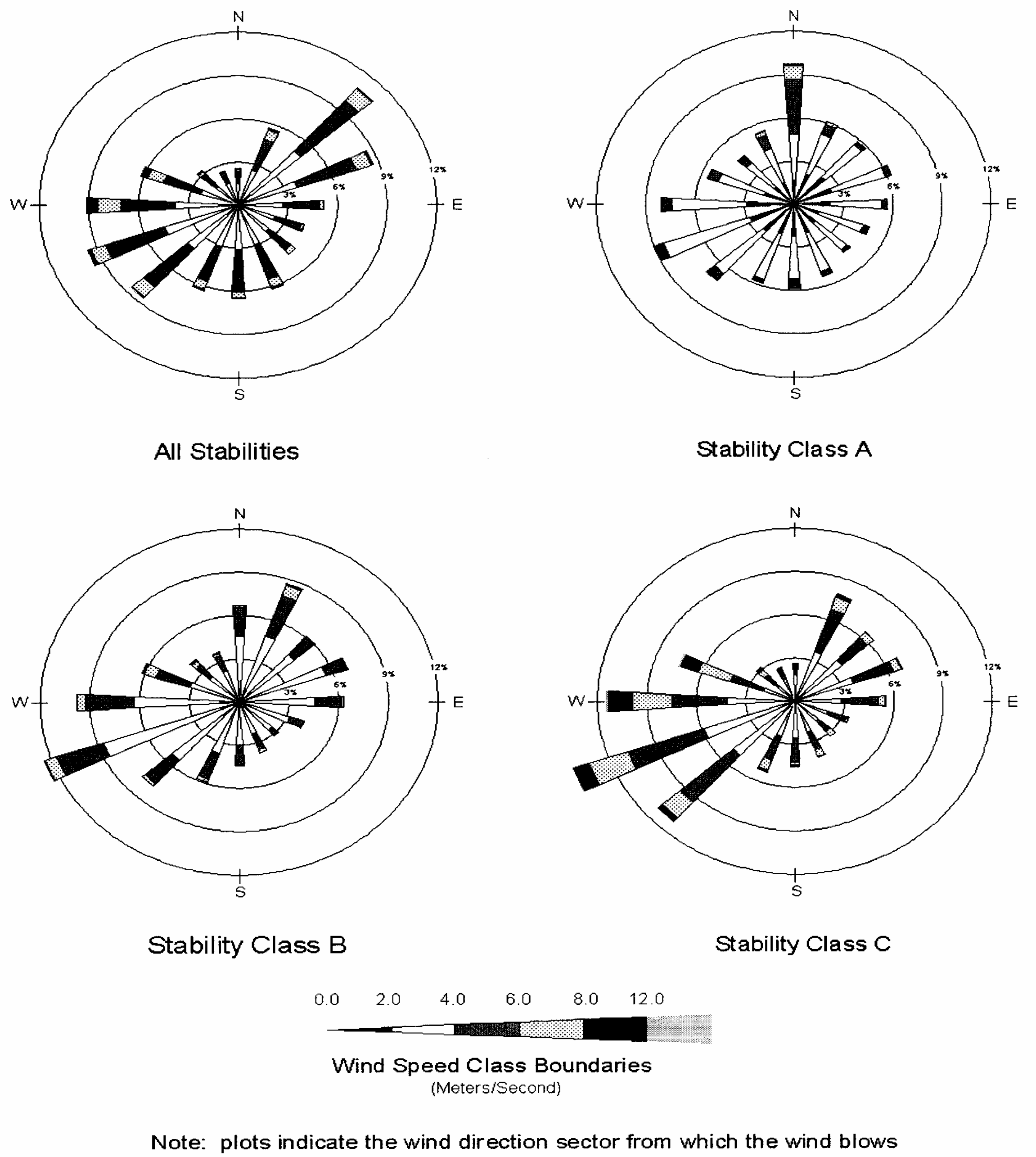
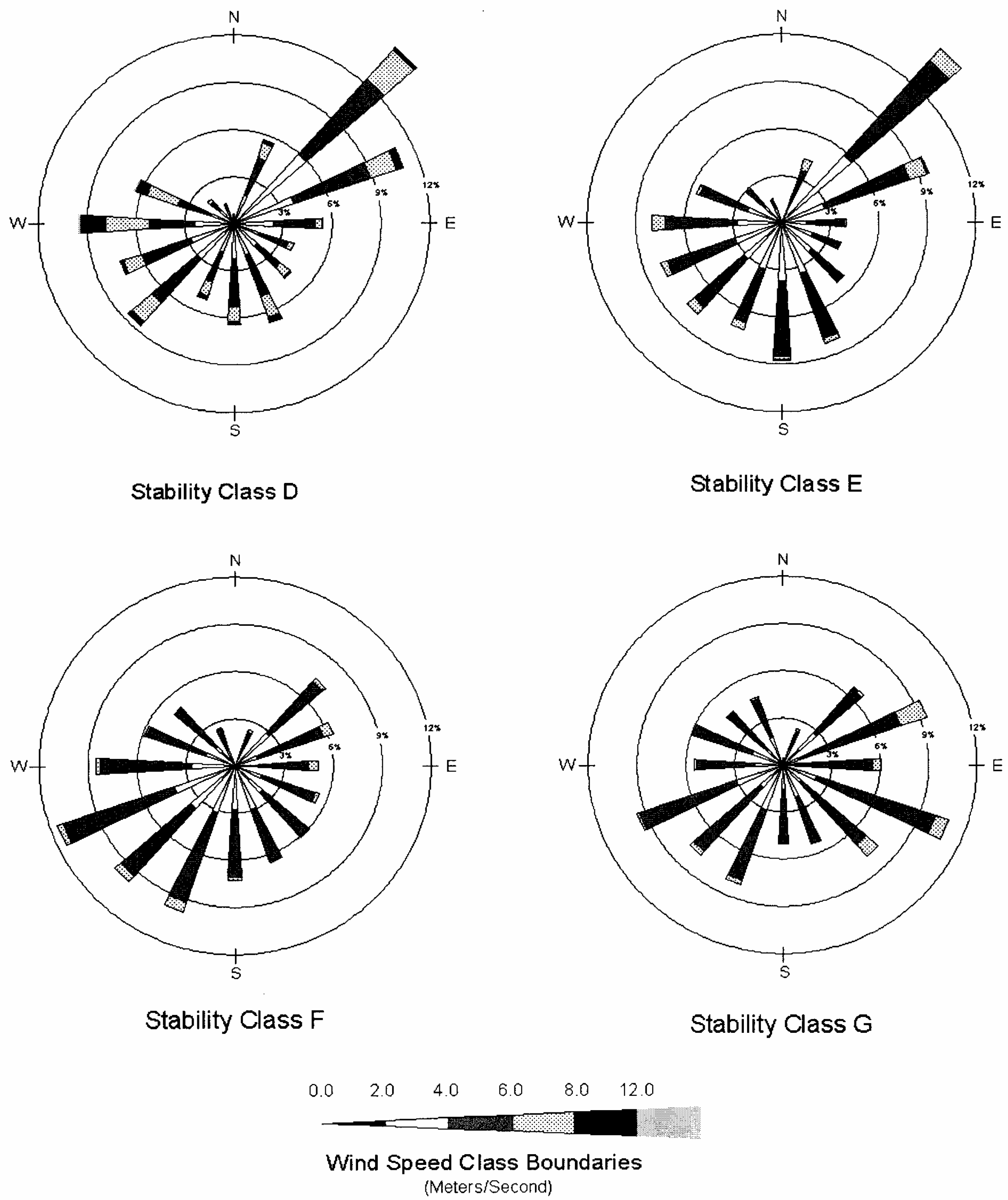


Figure 1.4-6 Wind Rose Plots by Stability Class - F Area Tower, 1992-1996 (Sheet 1 of 2)



Note: plots indicate the wind direction sector from which the wind blows

Figure 1.4-6 Wind Rose Plots by Stability Class - F Area Tower, 1992-1996 (Sheet 2 of 2)

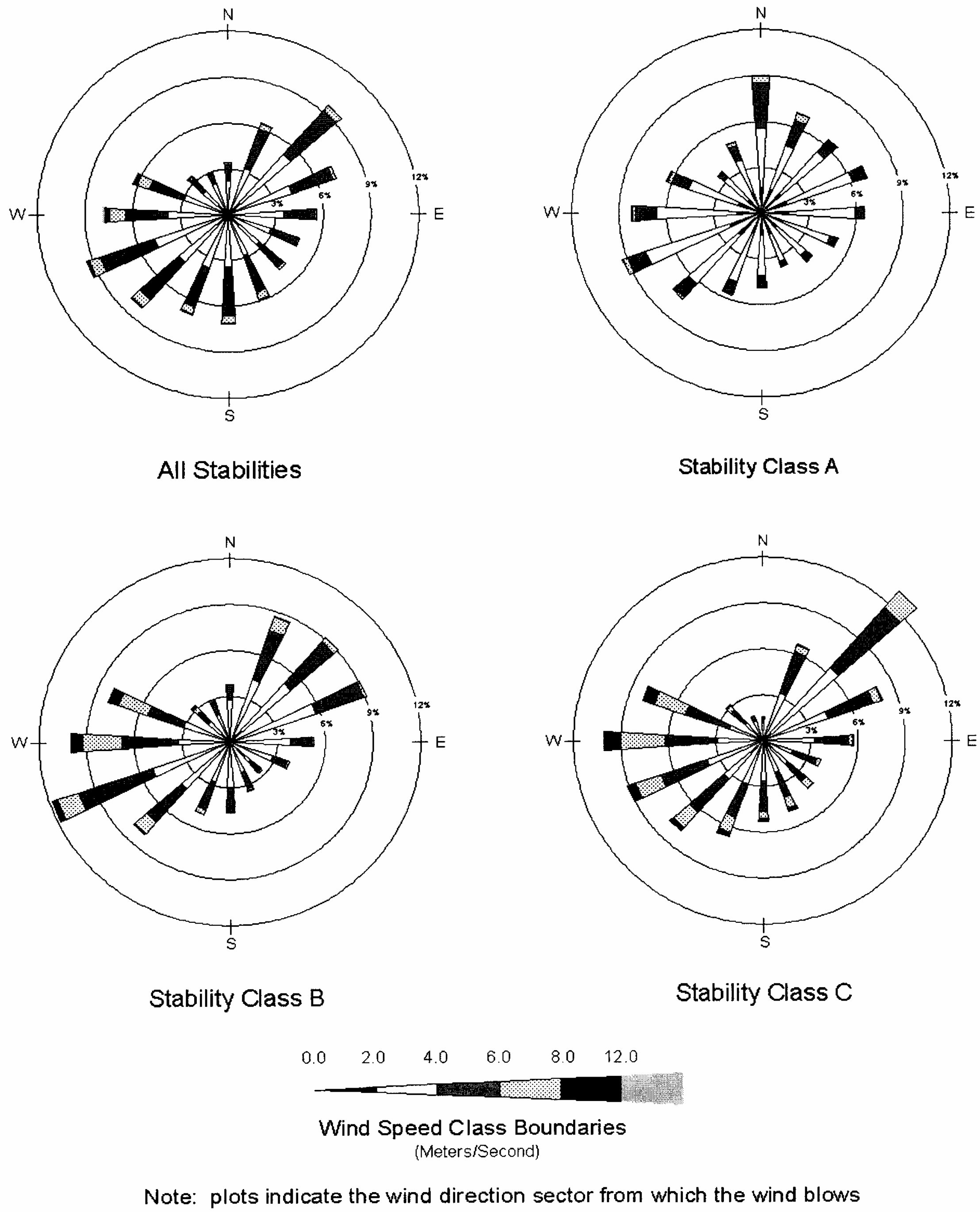
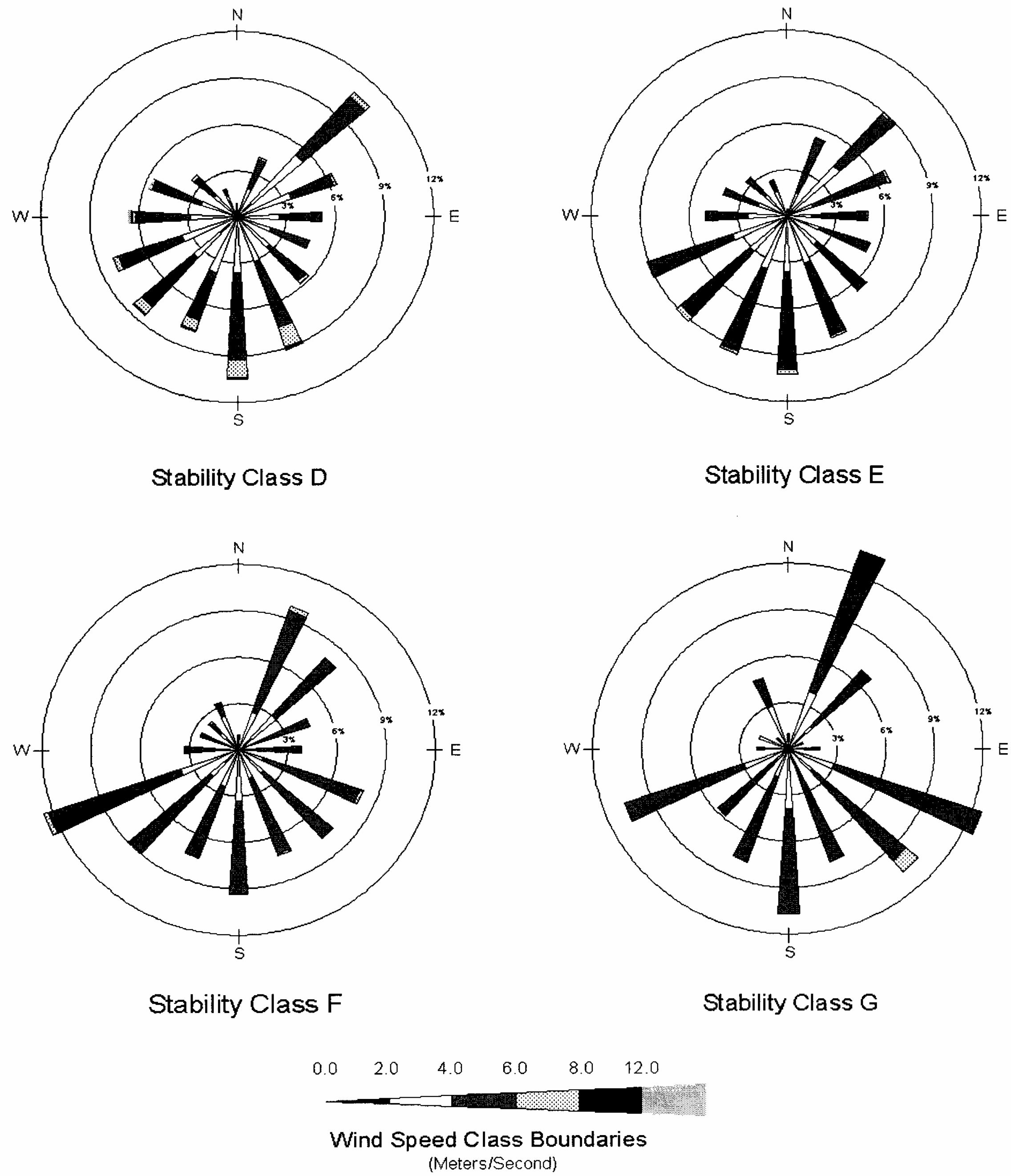


Figure 1.4-7 Wind Rose Plots by Stability Class - H Area Tower, 1992-1996 (Sheet 1 of 2)



Note: plots indicate the wind direction sector from which the wind blows

Figure 1.4-7 Wind Rose Plots by Stability Class - H Area Tower, 1992-1996 (Sheet 2 of 2)

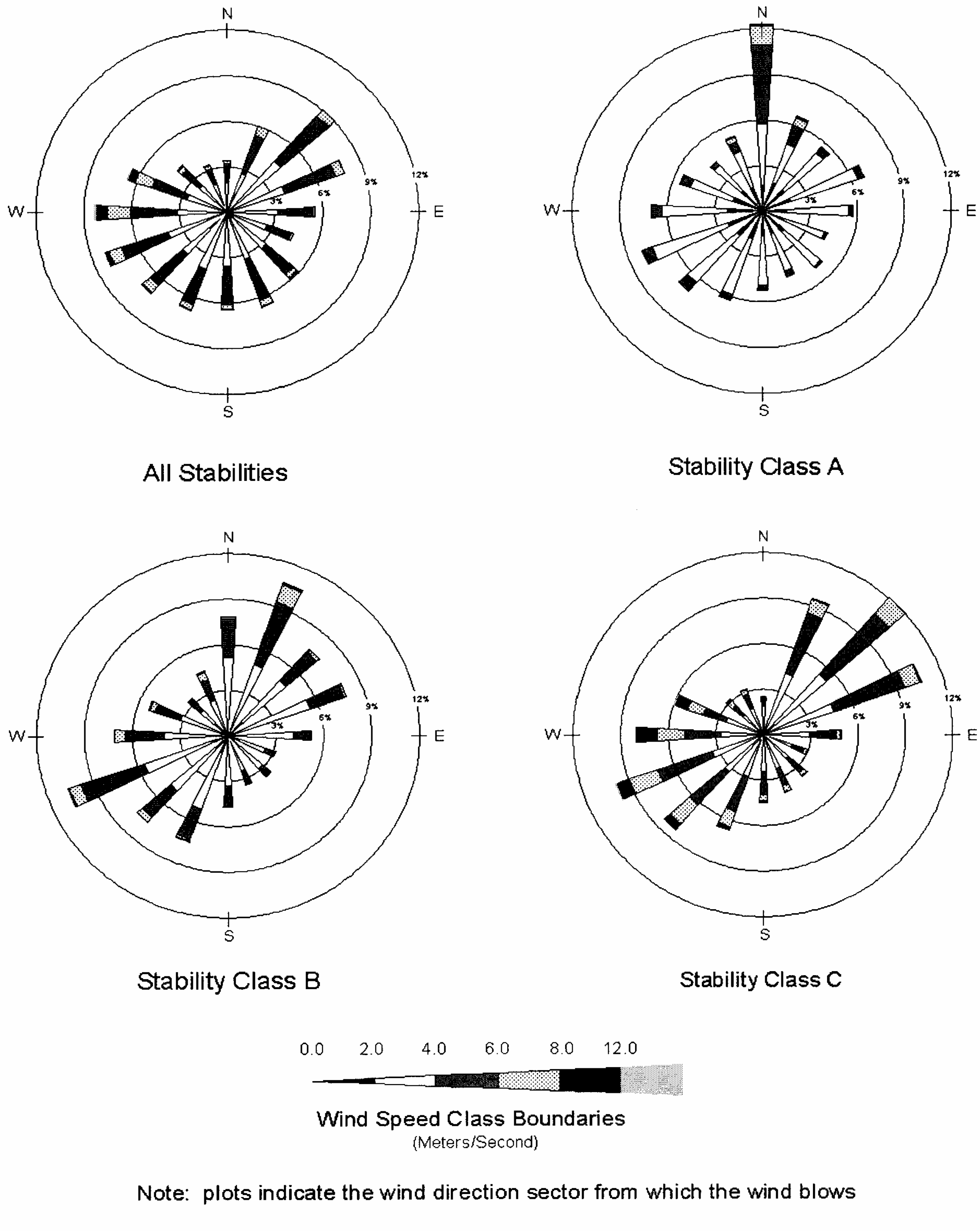


Figure 1.4-8 Wind Rose Plots by Stability Class - K Area Tower, 1992-1996 (Sheet 1 of 2)

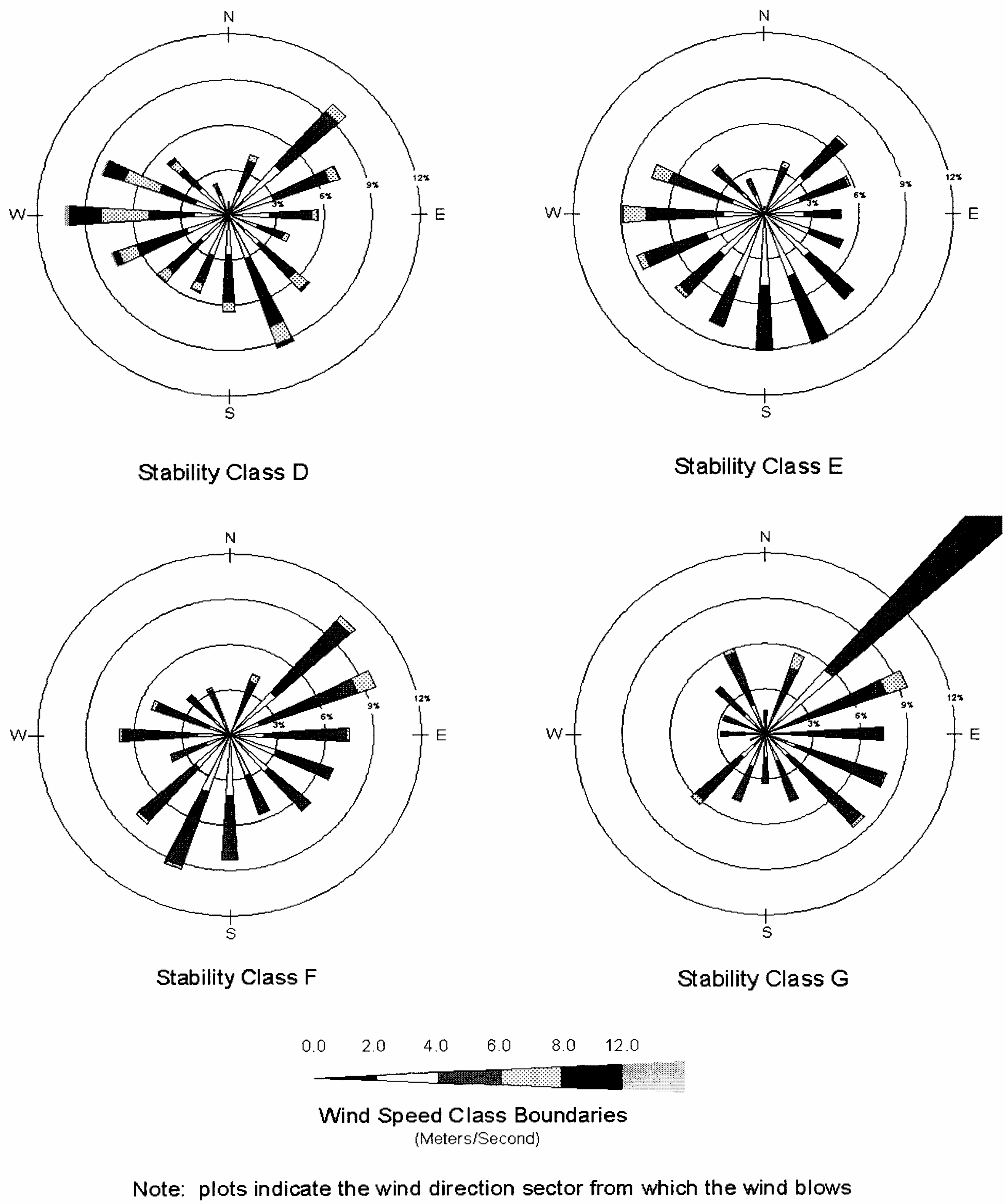


Figure 1.4-8 Wind Rose Plots by Stability Class - K Area Tower, 1992-1996 (Sheet 2 of 2)

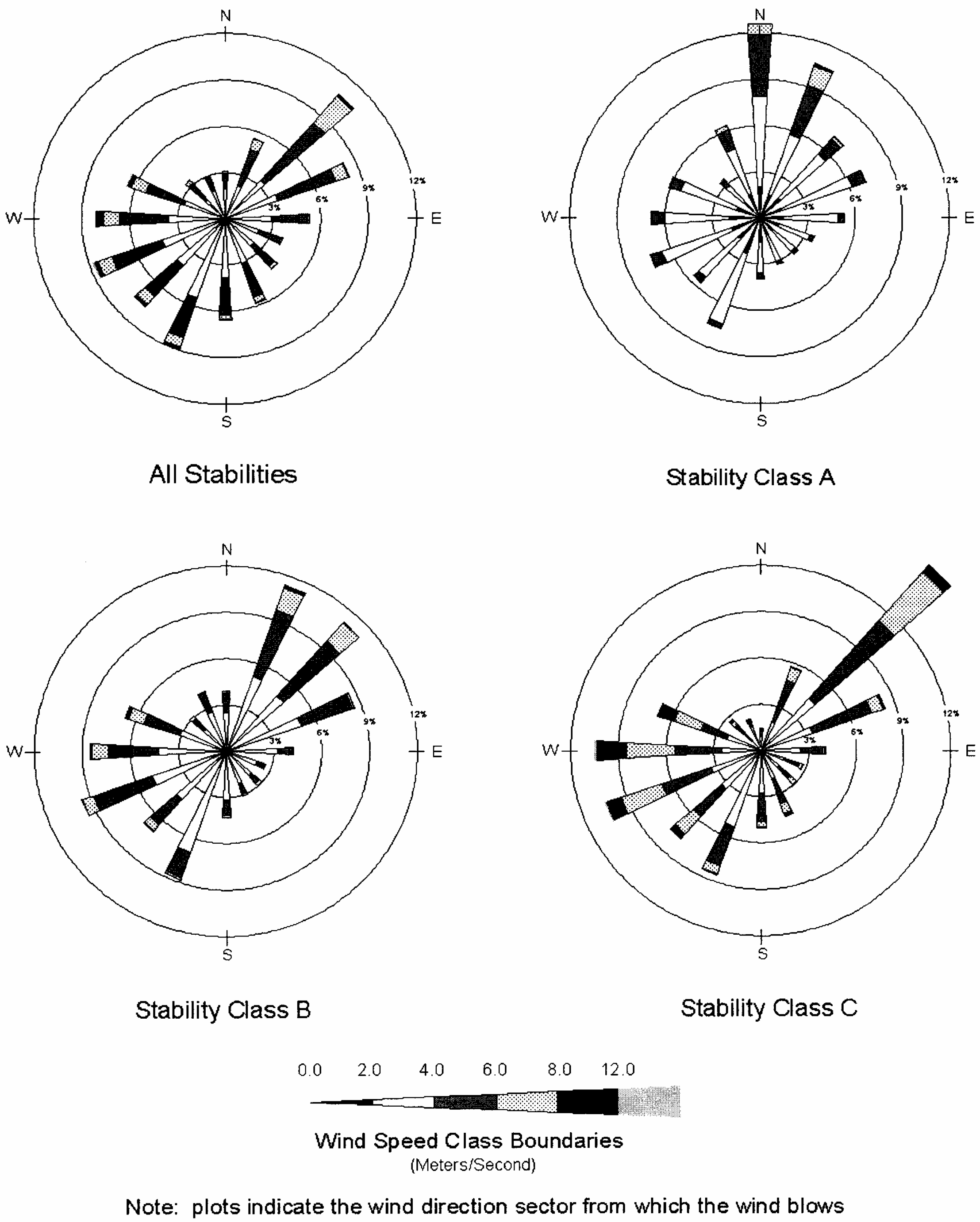


Figure 1.4-9 Wind Rose Plots by Stability Class - L Area, 1992-1996 (Sheet 1 of 2)

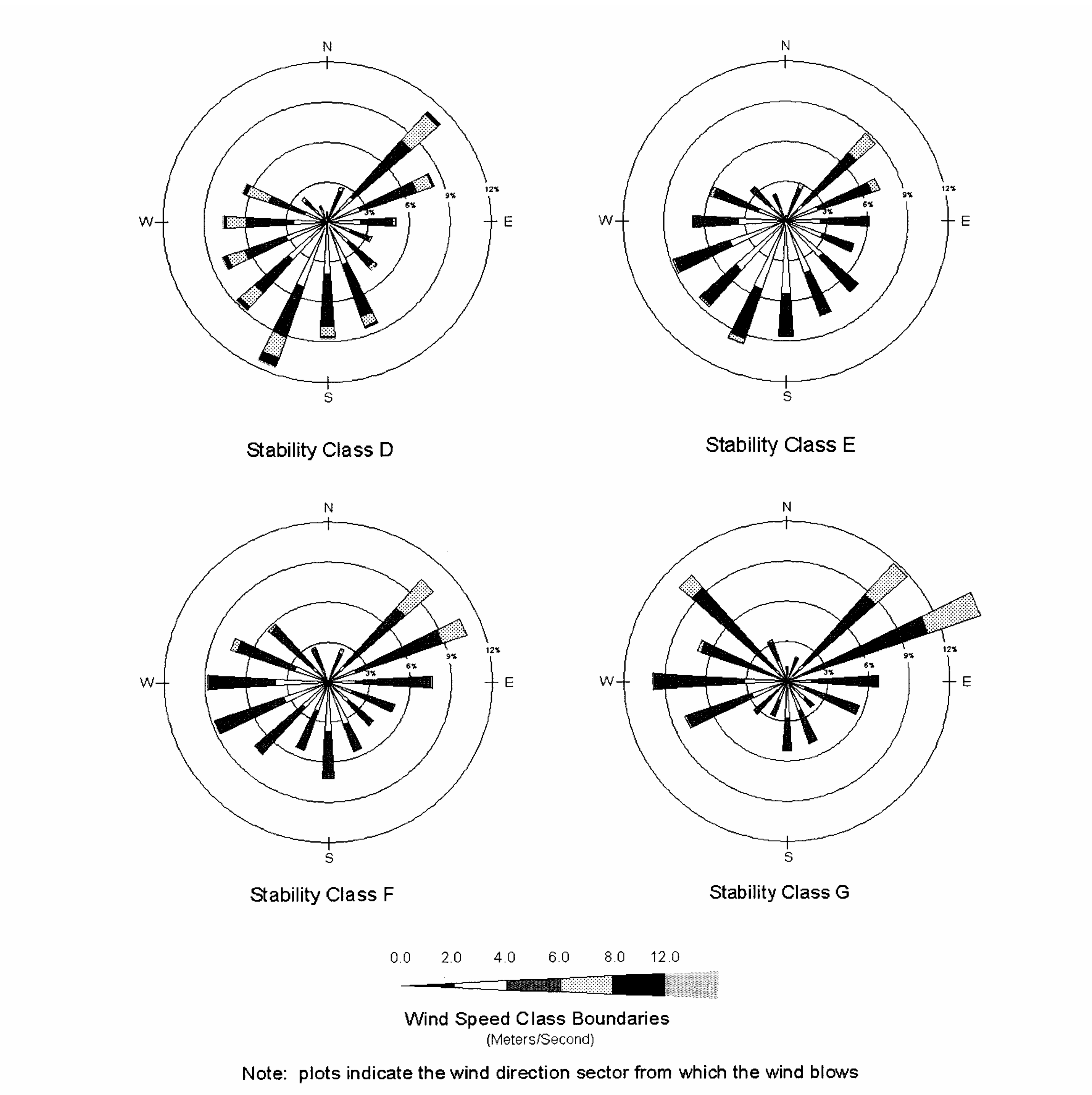


Figure 1.4-9 Wind Rose Plots by Stability Class - L Area, 1992-1996 (Sheet 2 of 2)

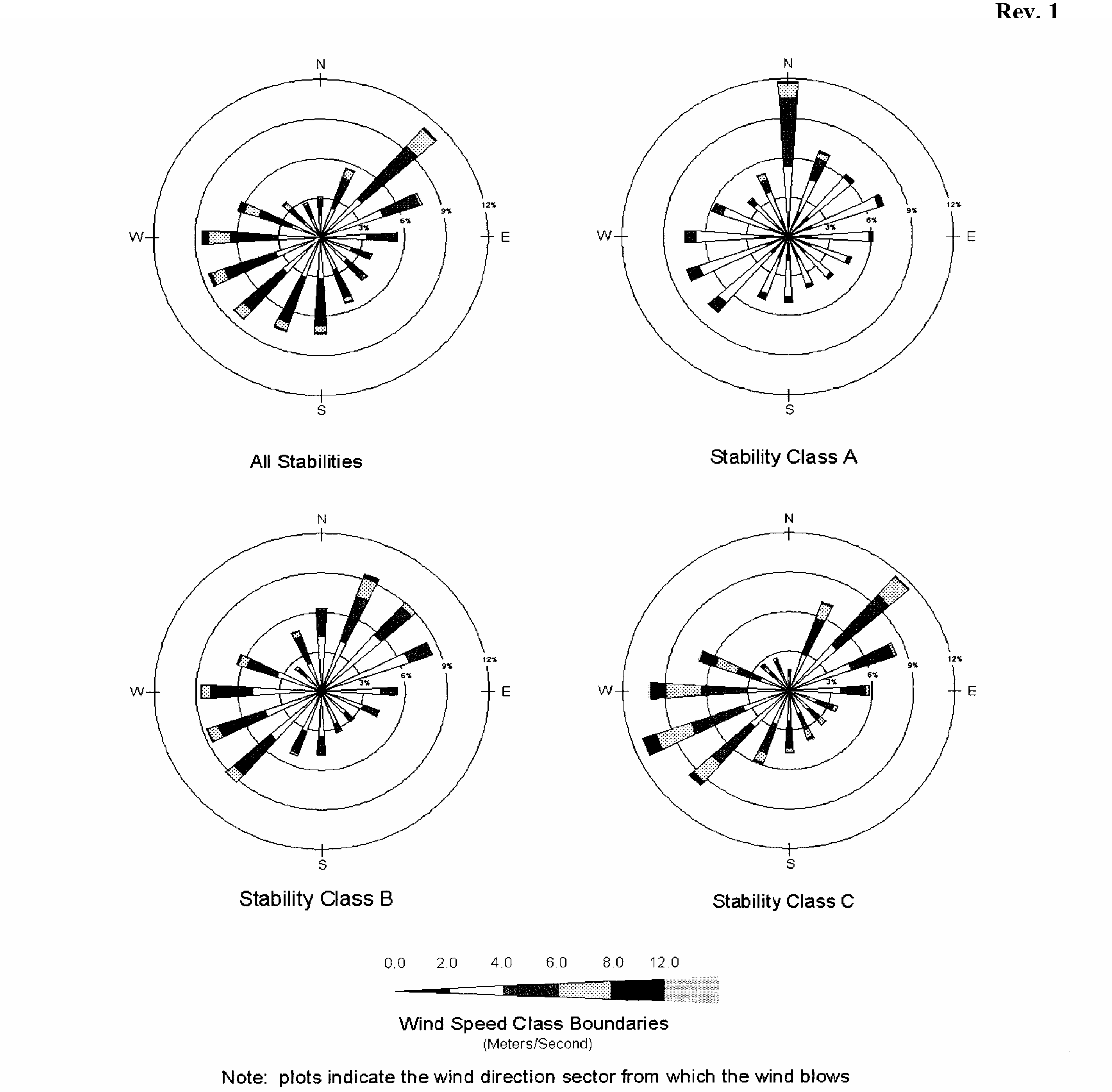


Figure 1.4-10 Wind Rose Plots by Stability Class- P Area, 1992-1996 (Sheet 1 of 2)

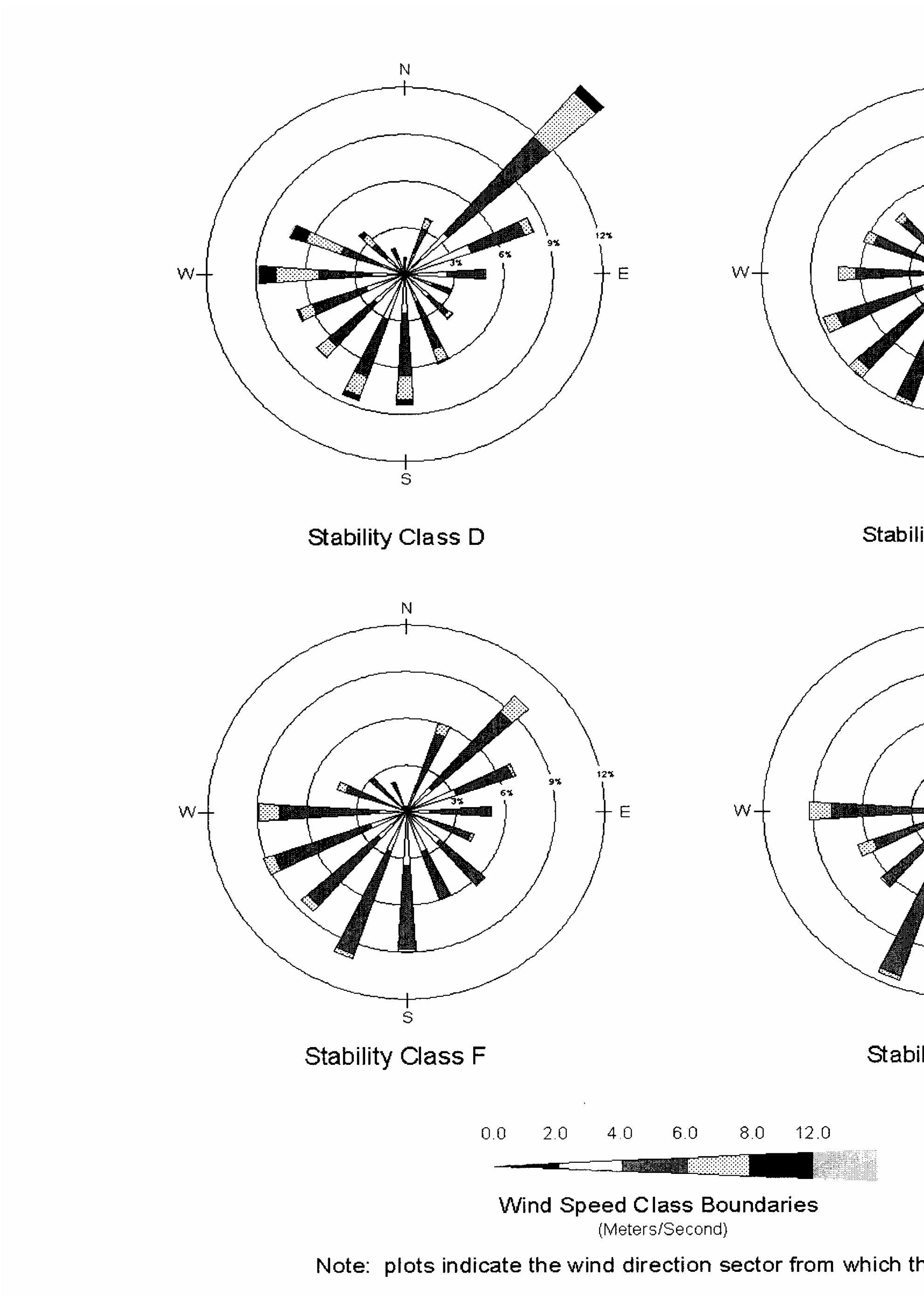


Figure 1.4-10 Wind Rose Plots by Stability Class- P Area, 1992-1996 (Sheet 2 of 2)

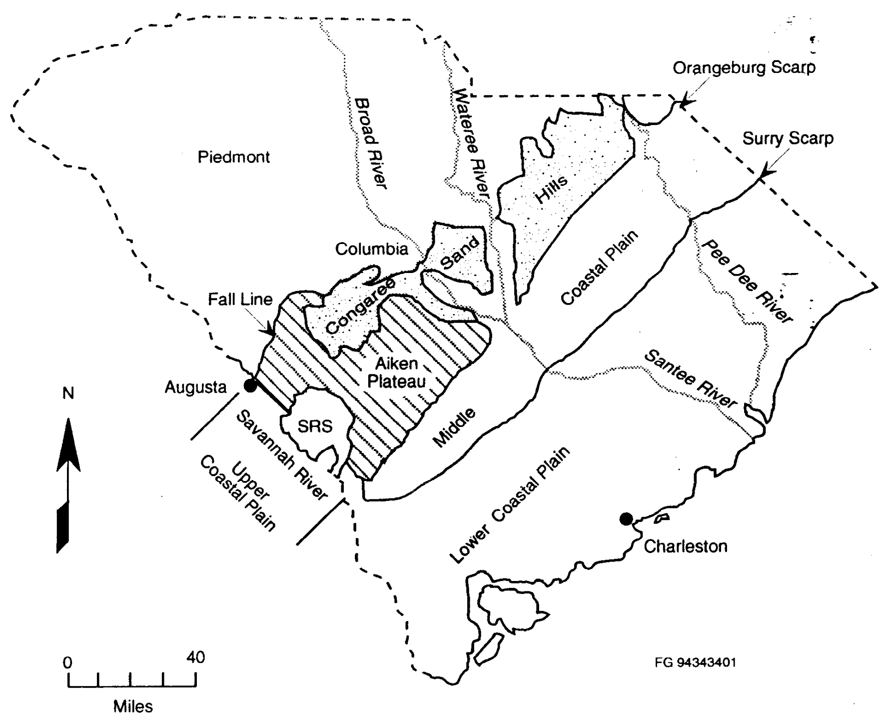


Figure 1.4-11 Physiography of the SRS Area

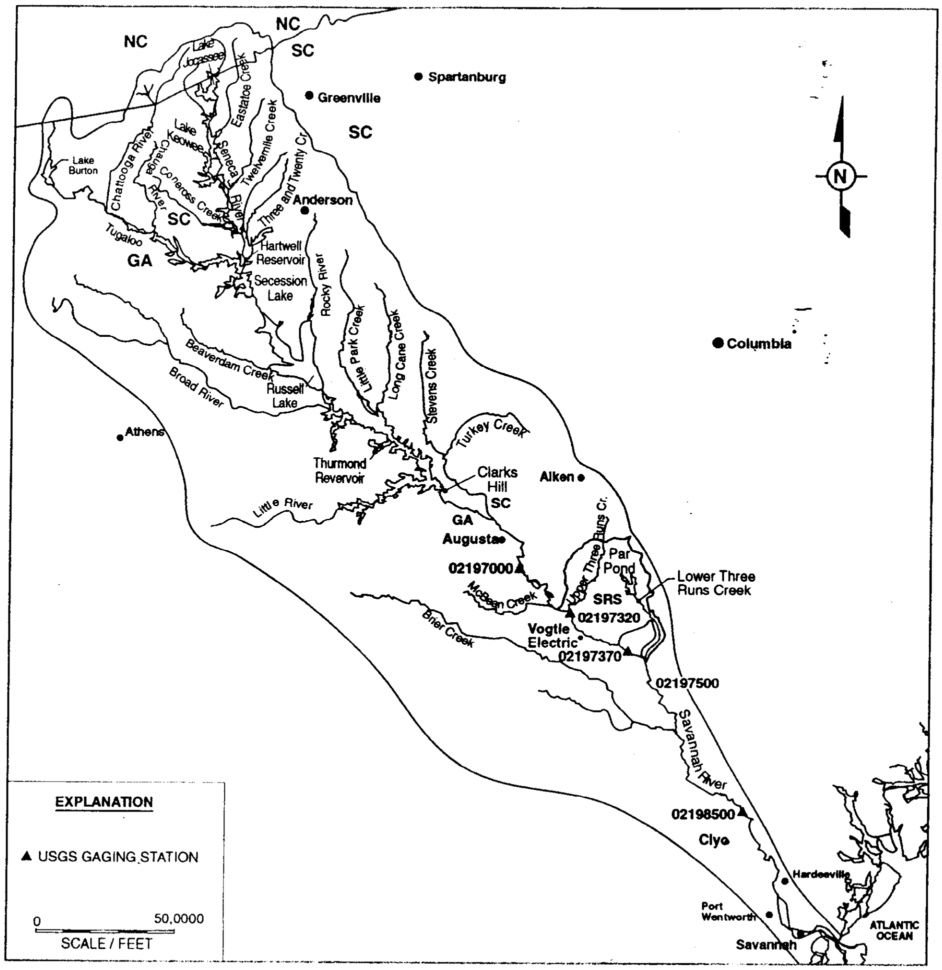


Figure 1.4-12 Savannah River Basin

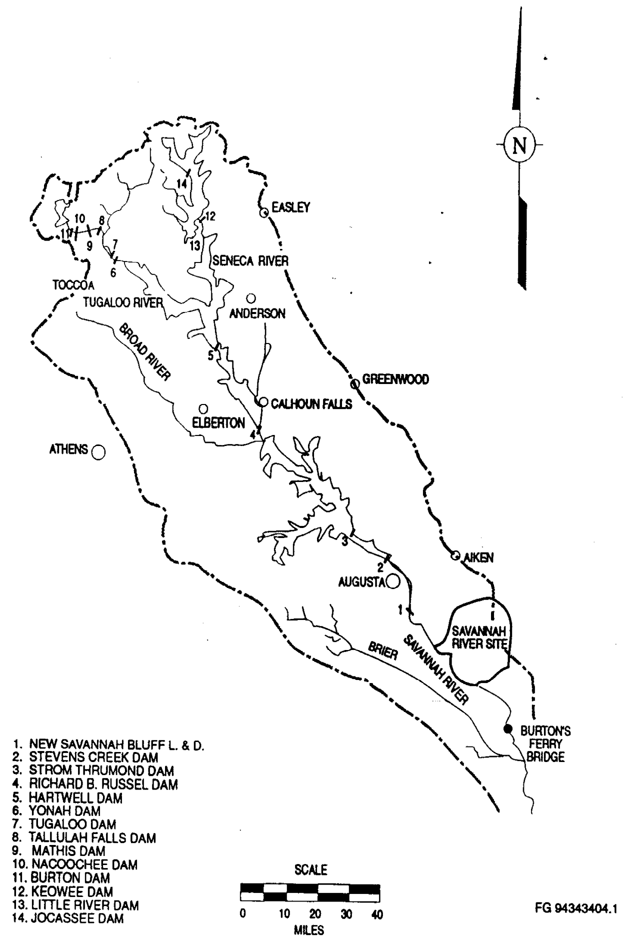


Figure 1.4-13 Savannah River Basin Dams Upstream of SRS

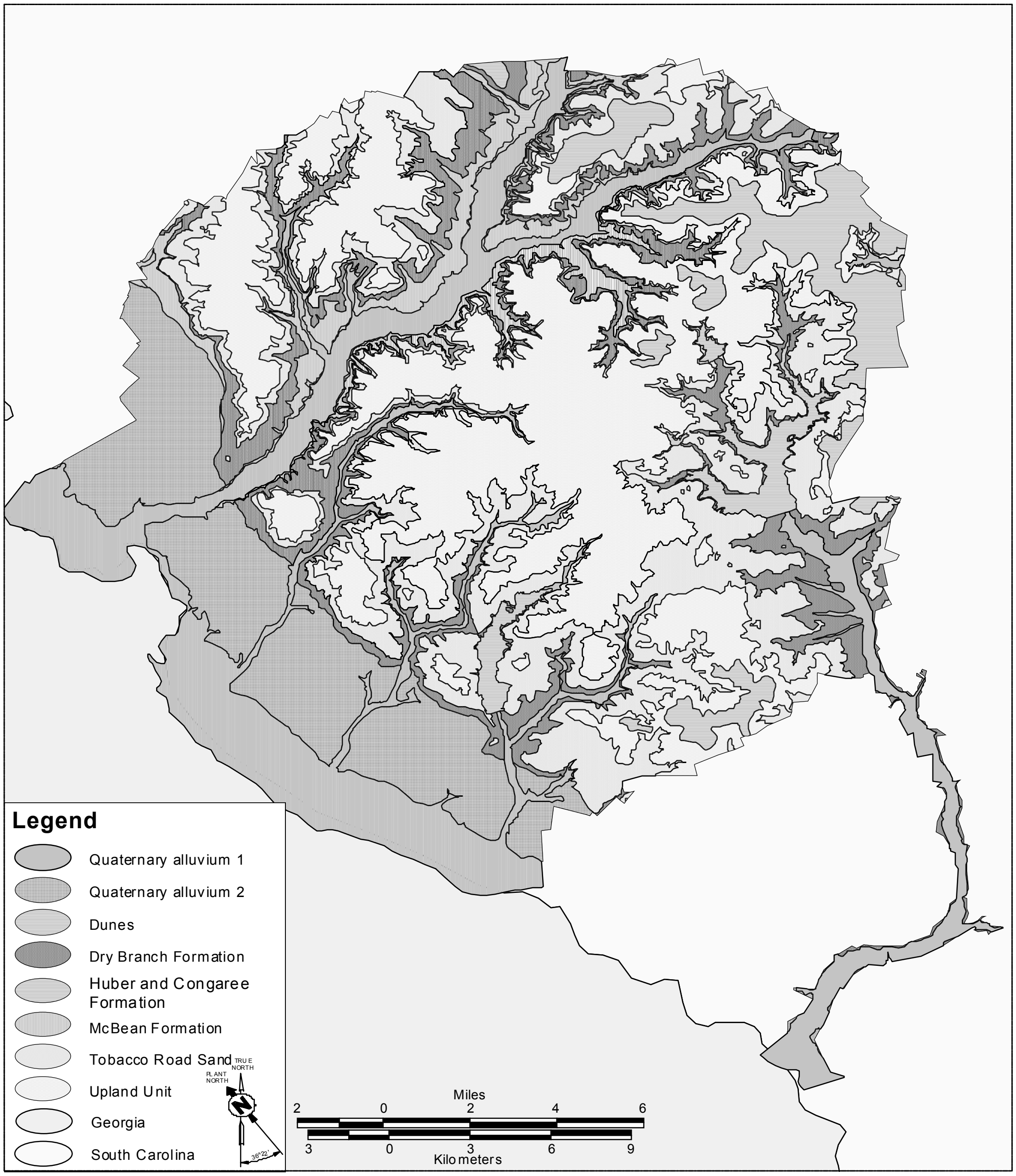


Figure 1.4-14 Geologic Map of the SRS

2.0 FACILITY DESCRIPTION

This chapter does not contain information generic to the Savannah River Site. For detailed information on Facility Descriptions, refer to Chapter 2 of the facility-specific SARs/DSAs.

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WSRC-IM-2004-00008
Rev. 1

DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

Formerly the
GENERIC SAFETY ANALYSIS REPORT

CHAPTER 3

HAZARD AND ACCIDENT ANALYSIS (U)

January 2007

Washington Savannah River Company
Aiken, SC 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

CONTENTS

ACRONYMS AND ABBREVIATIONS

AA	Accident Analysis
BIO	Basis for Interim Operation
CHAP	Consolidated Hazard Analysis Process
DBA	Design Basis Accident
DID	Defense-in-Depth
DOE	Department of Energy
DSA	Documented Safety Analysis
HA	Hazard Analysis
HC	Hazard Classification
HE	Hazard Evaluation
PHA	Preliminary Hazard Analysis
PHR	Process Hazard Review
SRS	Savannah River Site
SSC	Structure, System, and Component
TEDE	Total Effective Dose Equivalent
TSR	Technical Safety Requirement
WSRC	Washington Savannah River Company

3.0 HAZARD AND ACCIDENT ANALYSIS

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document, the user will default to the Site Program Manuals.

3.1 HAZARD ANALYSIS

HA is the process by which hazards associated with nuclear facilities and processes are analyzed, and by which preventive and mitigative controls are identified. DOE Orders require that a HA be performed for SRS facilities to characterize the hazards associated with operation of the individual facilities. The HA performs the following functions:

- Provides the basis for hazard classification of the facility (Ref. 1)
- Identifies and assesses the hazards that are present within the facility
- Evaluates the potential for hazards to develop into accidents
- Identifies the lines of defense within the facility that form the basis for Defense-in-Depth (DID) against adverse consequences to the workers and public from accidents

Additionally, the HA postulates bounding accident scenarios resulting from these hazards, evaluates their frequencies of occurrence and consequences in a qualitative, conservative manner. These scenarios are binned into one of twelve risk categories according to the frequency of occurrence and the severity of consequence. Analyses that are more rigorous are performed for accidents with the potential to subject the public to unacceptable combinations of frequency and consequence.

3.2 HAZARD ANALYSIS METHODOLOGY

This section describes the methodology used to identify and characterize hazards and to perform a systematic evaluation of basic accidents.

The WSRC Hazard Analysis (HA) program has been developed in accordance with DOE's Integrated Safety Management System which is a basic and powerful approach to performing work safely (Ref. 7). The program is implemented through the Consolidated Hazards Analysis process (Ref. 1). The Consolidated Hazards Analysis Process (CHAP) is a comprehensive, cost effective process that is applied throughout all phases of a facility, project, modification, or activity life cycle. CHAP is a a team approach directed at the formal identification of process hazards, evaluation of the unmitigated frequency and consequence of hazardous events, identification, and functional classification of controls to reduce the frequency and/or consequence of hazardous events to acceptable levels, and identification of candidate design basis accidents. The process provides the design team with the detailed understanding of the overall scope of safety functions needed to define the design of safety controls and specify associated standards analyses (e.g., fire hazard analysis, emergency protection hazards analysis, nuclear criticality safety evaluations).

CHAP consolidates several historical types of hazard analyses into a single platform. The CHA replaces Process Hazards Reviews (PHRs), serves as the Preliminary Hazards Analyses (PHAs) required for Bases for Interim Operation (BIOs), and serves as the Hazards Assessments (HA) for SARs/DSAs. Any activity that previously required a PHR, PHA, Hazards Assessment, or PrHA now requires application of the CHAP.

3.3 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document, then the user will default to the Site Program Manuals.

1. Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Rule 10 Code of Federal Regulations (CFR) Part 830, Nuclear Safety Management: DOE-STD-1027-92, Change 1, U.S. Department of Energy, Washington, DC, September 1997.

2. WSRC-RP-94-1268, Integrated Safety Management System Description (U).

3. WSRC Manual SCD-11, Consolidated Hazard Analysis Process Program and Methods Manual.

4.0 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

This chapter does not contain information generic to the Savannah River Site. For more detailed information on Safety Structures, Systems, and Components refer to Chapter 4 of the facility-specific Safety Analysis Reports/Documented Safety Analysis.

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5.0 DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

This chapter does not contain information generic to the Savannah River Site. For more detailed information on Derivation of Technical Safety Requirements, refer to Chapter 5 of the facility-specific Safety Analysis Reports/Documented Safety Analysis.

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DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

Formerly the
GENERIC SAFETY ANALYSIS REPORT

CHAPTER 6

CRITICALITY SAFETY PROGRAM

January 2007

Westinghouse Savannah River Company
Aiken, SC 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

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ACRONYMS AND ABBREVIATIONS

ANS	American Nuclear Society
ANSI	American National Standards Institute
CSC	Criticality Safety Committee
DOE	Department of Energy
MP	Management Policy
NCSA	Nuclear Criticality Safety Analysis
NCSASR	Nuclear Criticality Safety Analysis Summary Report
NCSE	Nuclear Criticality Safety Evaluation
NCSRC	Nuclear Criticality Safety Review Committee
NCSS	Nuclear Criticality Safety Supplement
NIM	Nuclear Incident Monitor
NSDS	Nuclear Safety Data Sheet
ORR	Operational Readiness Review
RPD	Radiological Protection Department
S/RID	Standards/Requirements Identification Document
SAR	Safety Analysis Report
SRS	Savannah River Site
SRNL	Savannah River National Laboratory
TSR	Technical Safety Requirement
WSMS	Washington Safety Management Solutions, LLC
WSRC	Westinghouse Savannah River Company

6.0 CRITICALITY SAFETY PROGRAM

6.1 INTRODUCTION

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

Washington Savannah River Company (WSRC) Manual WSRC-1-01, Management Policy (MP) 4.5 establishes the criticality safety program for the WSRC (Ref. 1). MP 4.5 states that the nuclear criticality safety program is established, maintained, and applied to any process, structure, system, or component that requires the control of one, or more, parameters for criticality safety purposes. The requirements applicable to, and features of, the criticality safety program are implemented in WSRC-SCD-3 (Ref. 2). The nuclear criticality safety program in WSRC-SCD-3 satisfies the Department of Energy (DOE) and ANS-8 requirements as referenced in Standards/Requirements Identification Documents (S/RIDs) (Ref. 5).

This chapter is not to be used as the vehicle for review and approval of the nuclear criticality safety program.

6.1.1 OBJECTIVES

This document describes the criticality prevention provisions for Savannah River Site (SRS) nuclear facilities and their operations and summarizes the WSRC Criticality Safety Program as established by WSRC-1-01, MP 4.5 and as implemented through WSRC-SCD-3 (Refs. 1, 2). The format of this document is patterned after DOE-STD-3009-94, Chapter 6 (Ref. 3), and contains:

A summary of the overall SRS nuclear criticality safety policy and program

A description of the general basis and analytical approach used for deriving operational criticality limits

A summary of the design and administrative controls used by the nuclear criticality safety program

6.1.2 SCOPE

The following three hazard categories are defined for classifying nuclear facilities that handle, process, or store inventories of radioactive materials and are listed in order of decreasing hazard severity (Ref. 4):

- Hazard Category 1 - potential for significant offsite consequences
- Hazard Category 2 - potential for significant onsite consequences
- Hazard Category 3 - potential for only significant localized consequences

SRS has no Hazard Category 1 facilities. Hazard Category 2 facilities can handle, process, or store inventories of fissionable materials sufficient to present a criticality hazard. Hazard Category 3 facilities, by definition, do not have sufficient material to present a criticality hazard, but may require inventory limits. Regardless of facility hazard category, this document is applicable, in whole or in part, to any facility that requires an NCSE.

6.2 REQUIREMENTS

S/RIDs stipulate the regulations, orders, codes, and standards that govern the SRS policies and programs for prevention of criticality (Ref. 5). Programmatic compliance assessment has been performed against the S/RIDs and documented as specified in WSRC Procedure Manual 8B (Ref. 6). The Regulatory Services Section of T&QS/LWO maintains records of the programmatic compliance assessments.

6.3 CRITICALITY CONCERNS

SRS contains several facilities that handle, process, or store fissionable material, including the following:

- Nuclear Chemical Processing Facilities (H-Canyon, HB-Line)
- Nuclear Material Packaging and Storage Facilities (K-Area Complex)
- Irradiated Reactor Fuel Storage (L-Reactor)
- Solid Waste Handling and Storage and Disposal Facilities (SWMF)
- Liquid Waste Processing and Storage (DWPF, F-Area Tank Farm, H-Area Tank Farm West, H-Area Tank Farm East)
- Experimental and analytical laboratories (F/H Lab, SRNL)

In addition, several facilities have been shutdown and substantially de-inventoried of fissionable material, but still contain fissionable material in identified hold-up areas (e.g., FB-Line, F-Canyon, FAMS).

Fissionable materials of primary concern at SRS are U-235 and Pu-239; however, Pu-238 is present in small quantities and Np-237 is being processed. Other isotopes such as Am and Cm are present in the HLW tanks and in small quantities in lab facilities. The forms of fissionable materials at SRS include metals, oxides, solutions, alloys, and various forms of scrap. Uranium enrichment varies from depleted U-235 to highly enriched U-235. Plutonium isotopic composition varies.

6.4 CRITICALITY CONTROLS

Criticality control is achieved through process designs and operations ensuring that criticality safety parameters are maintained within safe ranges. The three basic means of control are passive engineered control, active engineered control, and administrative control. Passive engineered control is preferred over active engineered control, and active engineered control is preferred over administrative control (Ref. 2). Facilities in which criticality is a concern can be divided into three general categories:

- Facilities that, because of the quantity of fissionable material(s) and the processes and operations involved require controls to prevent criticality accidents and reduce the probability of a criticality accident to a level judged acceptable, although still credible, in the Safety Analysis Report (SAR)/Documented Safety Analysis (DSA).

- Facilities that, because of the quantity of fissionable material(s) and the processes and operations involved require controls to prevent criticality accidents, but, by implementing such controls, reduce the probability of a criticality accident to a level judged incredible.

- Facilities in which, based on documented engineering judgment or comprehensive analysis, a criticality accident is determined to be incredible and controls are not required, but the as designed process conditions and assumptions upon which incredibility is based must be maintained. Training, procedures, change control and periodic assessments are all important in maintaining the as-required process conditions and assumptions.

Some facilities meet more than one category because of the diversity of operations taking place within the facility. If a criticality accident is evaluated to be inherently incredible based on the quantity of fissile material, form of the material, or the inherent physical or chemical nature of the process, then application of criticality safety controls is not required. However, for facilities having more than, or the credible potential for more than, 450 grams of Pu-239 or 700 grams of U-235 due to normal or upset conditions, a determination of inherent incredibility/nature of process shall be documented to include concurrence by a criticality safety engineer. Reviews of facility or process changes involving fissionable materials evaluate the need for criticality safety engineer review and the need for criticality safety requirements.

6.4.1 ENGINEERING CONTROLS

The two means of engineered controls are defined as follows:

Passive engineered controls are fixed design features, or devices, that rely on natural forces, or properties of material to limit, or prevent, a nuclear criticality. Passive engineered controls are devices or features, such as fixed geometry, fixed spacing, fixed size, volume, siphon breaks, etc., which serve to maintain criticality safety.

Active engineered controls are engineered devices, which sense a given parameter and act for the purpose of maintaining criticality safety. These devices monitor parameters important to criticality safety and automatically initiate action to secure the system to a safe condition without human intervention. An example of an active engineered control is a colorimeter that monitors solution concentrations and is hardwired to an interlock to stop flow if the concentration of fissile material exceeds a preset value.

6.4.2 ADMINISTRATIVE CONTROLS

Administrative controls are controls that rely on the repetitive actions, judgement, and responsibility of people for their implementation. Because administrative controls are human-based, and therefore subject to error in application, they are less desirable than engineered controls. These controls are sometimes accompanied or enhanced by equipment items or analyses that alert an operator to take action. They may also include procedural requirements for handling, storing, and transporting fissionable materials; action, caution, or verification steps in a procedure; or steps in a surveillance program that rely on the judgment, training, and responsibility of personnel for implementation.

6.4.3 APPLICATION OF DOUBLE-CONTINGENCY PRINCIPLE

Up through the end of FY'06, the double contingency principle as stated in DOE O 420.1A was followed (Ref. 7). It stated:

"Process designs shall incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible. Protection shall be provided by either (i) the control of two independent process parameters (which is the preferred approach, when practical, to prevent common mode failure), or (ii) a system of multiple controls on a single process parameter. The number of controls required upon a single controlled process parameter shall be based upon control reliability and any features that mitigate the consequences of control failure. In all cases, no single credible event or failure shall result in the potential for a criticality accident, except as referenced in the paragraph that follows. At SRS, there are accident scenarios that implement the DOE O 420.1A double contingency requirement using two-parameter control and scenarios that implement the double contingency requirement using single-parameter control.

DOE O 420.1B (Ref. 13) superseded DOE O 420.1A in December 2005. The double contingency principle, as stated in DOE-O 420.1B is:

> "The double contingency principle defined in ANSI/ANS-8.1, Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors, is a requirement that must be implemented for all fissionable material processes, operations, and facility designs within the scope of this chapter unless the deviation is documented, justified, and approved by DOE."

In FY'07, the DOE O 420.1B criticality safety requirements will be incorporated into the S/RID. Since the DOE O 420.1B double contingency requirement specifies two-parameter control unless a deviation is obtained for single parameter control, a Program Plan will be developed to group all credible scenarios that use single parameter control into three categories: 1.) credible scenarios in facilities that have a short remaining operational life - hence there would be little economic or technical incentive to implement two-parameter control given the short time period to develop and implement such additional control schemes; 2.) credible scenarios in facilities for which single-parameter control is the only reasonable option given the design of the facility; and 3.) credible scenarios for which single-parameter control may reasonably be replaced by two-parameter control. A schedule will be prepared to implement appropriate replacement of single-parameter control to two-parameter control. Existing NCSEs do not need to be rewritten specifically to address DOE O 420.1B double contingency changes outside the Program Plan.

Nuclear Criticality Safety Evaluations (NCSEs) and Double Contingency Analyses (DCAs) as required by SCD-3 (Ref. 2) and written for a specific process, operation, or facility, document how the Double Contingency Principle is met for that process or operation. The evaluation includes discussion(s) regarding the parameter(s) and associated controls.

6.4.4 CONTROLLED PARAMETERS

The following parameters are in use in SRS facilities as applicable to a given process or operation:

6.4.4.1 Geometry

Geometry control involves the use of dimension and shape restrictions on equipment to provide "geometrically safe," or "geometrically favorable," containers, vessels, drains, sumps, etc., for fissionable materials, or restrictions on fluid flow preventing fissionable solutions from being configured in an unsafe geometry. All dimensions and nuclear properties upon which reliance is placed shall be verified prior to beginning operation and continuing control shall be exercised over such properties and dimensions.

6.4.4.2 Spacing (Interaction) Control

Spacing or interaction control involves the use of distance, arrangement, and shielding (neutronic isolation) restrictions between, and among units, vessels, containers, equipment, and accumulations of fissionable materials to minimize the potential for neutron interaction of these materials.

6.4.4.3 Neutron Absorber (Poison) Control

Neutron absorber (poison) control involves the use of solid or soluble neutron absorbers in vessels, sumps, etc., to reduce the neutron interaction of fissionable material should it accumulate in such areas.

6.4.4.4 Concentration (Density) Control

Fissionable material concentration, or density control, involves the use of restrictions on items such as the following:

Permitted concentrations of fissionable materials dissolved, or dispersed, in another medium

Density of fissionable material powder, metal chips, and machine turnings

Allowable chemical compounds or the physical state for fissionable materials at particular process stages, workstations, and storage areas

Allowed fissionable mass per unit area (e.g., a floor, or the bottom, of a glovebox) to prevent a nuclear criticality

6.4.4.5 Moderation and Reflection Control

Moderation and reflection control involves the use of restrictions on items such as the following:

- The allowed range of hydrogenous material density relative to fissile material density in moderator/fissionable material mixtures (i.e., H/X ratio) or the quantity of moderating materials allowed
- Limitation on the quantity of any moderating material mixed with or allowed in a given location
- The quantity, composition, and configuration of hydrogenous or other neutron-reflecting materials, in proximity to fissionable material, to prevent a nuclear criticality

6.4.4.6 Mass and Volume Control

Fissionable material mass and volume control involves the use of restrictions on items such as the following:

- Quantity of fissionable material permitted in an individual unit, area, room, or rooms (i.e., a mass control zone)
- Total number of fissionable material units
- Fissionable material volume, container volume, or vessel volume (may be specific to fissionable material composition) to prevent a nuclear criticality.

6.4.4.7 Enrichment Control

Fissionable material enrichment control to prevent a nuclear criticality involves the use of restrictions on the maximum fraction of fissile isotopes (usually expressed as weight percent) for a fissionable element, such as uranium, or plutonium, that has both fissionable and fissile isotopes.

6.4.4.8 Temperature Control

Temperature control involves the consideration of, or the restrictions on, the temperature of a system containing fissionable material. For example, controls may be required to prevent solutions from freezing.

6.5 CRITICALITY PROTECTION PROGRAM

Nuclear criticality safety is administered at SRS by assigning responsibilities for key nuclear criticality safety requirements and activities to appropriate WSRC organizational units.

6.5.1 CRITICALITY SAFETY ORGANIZATION

This section discusses the WSRC organizational units having responsibilities in the implementation of the site nuclear criticality safety program specified in WSRC-SCD-3 (Ref. 2).

6.5.1.1 Washington Savannah River Company President Authority and Responsibility

The WSRC President establishes the company-level policy for implementing the criticality safety requirements of DOE and, in doing so, informs all WSRC employees involved in operations with fissionable materials of the criticality safety requirements. He also accepts overall responsibility for the criticality safety of operations but delegates the authority and assigns the responsibility for day-to-day criticality safety of operations to lower-level management.

6.5.1.2 Washington Savannah River Company Division General Manager and/or Division Chief Engineer Authority and Responsibility

These managers and area chief engineers have authority and responsibility to implement criticality safety responsibilities for projects, facilities, processes and operations involving fissionable materials under their control. They must also ensure that applicable criticality safety standards and DOE Orders are applied in the design, modification, and operation of facilities, under their control. They must ensure that the WSRC policy for nuclear criticality safety, as stated in WSRC-1-01, MP 4.5 and as implemented in WSRC-SCD-3, is applied at the operating and engineering levels of their organizations (Refs. 1, 2).

The Project Design and ConstructionServices (PD&CS) Manager accepts and implements criticality safety responsibilities as delegated by the WSRC President. Engineering designers are responsible for incorporating criticality safety design measures into project designs.

Lower Level Engineering Managers accepts and implement criticality safety responsibilities as delegated by the Area Chief engineers. These managers assist the Area Chief Engineers in the performance of duties indicated above.

The Internal Oversight, Facility Evaluation Board organization has personnel familiar with the physics of criticality and associated safety practices to participate in Facility Evaluation Boards (FEBs), Operational Readiness Reviews (ORRs) and the site Nuclear Criticality Safety Review Committee.

The LWO Site Chief Engineer/T&QS Manager has the responsibility to establish and maintain a site nuclear criticality safety program (Ref. 1). He also administers the sitewide Nuclear Incident Monitor (NIM) program through the site Nuclear Criticality Safety Review Committee (NCSRC) and ensures the WSMS affiliate, working under control of the Site Chief Engineer, provides risk assessments criticality safety engineering services across the site (Ref. 2).

Liquid Waste Disposal Project/Waste Solidification Management and Chief Engineer are responsible to review facility and process changes to determine if criticality safety evaluations are required and to maintain an interface with the WSMS affiliate to obtain criticality safety engineering support when necessary.

6.5.1.3 Facility Managers

Facility managers, whose facilities warrant criticality safety consideration and controls, have primary responsibility for the day-to-day criticality safety of their facility (Ref. 2).

6.5.1.4 Facility Operators

Facility operators are responsible for criticality safety of their own actions and the operating systems under their control. They must follow criticality safety procedures as written, and adhere to all nuclear criticality safety steps in operating procedures related to their assignments (Ref. 2).

6.5.1.5 First-Line Supervisors

First-line supervisors are responsible for the criticality safety of operations under their control. They verify compliance with criticality safety specifications for new, or modified, equipment prior to its use. They require conformance with good safety practices including unambiguous identification of fissile materials and good housekeeping (Ref. 2).

6.5.1.6 Criticality Safety Personnel of the Washington Safety Management Solutions Affiliate

Criticality Safety personnel have responsibilities consistent with SCD-3, including review of criticality-related procedures; preparation or review of documents containing criticality safety limits; validation of computer codes; maintain familiarity with, and interface with, the processes and facilities to which they are assigned; and review criticality training (Ref. 2).

6.5.1.7 Interfaces and Interrelationships with Other Organizations

The interfaces and interrelationships of the organizations specified above are defined in WSRC 1 01, MP 4.5 and WSRC-SCD-3 (Ref. 1, 2).

6.5.1.8 Staff Qualifications

Facility staff qualifications are specified in the facility-specific SARs/DSAs, including consideration of educational levels, related relevant experience, job requirements, and other pertinent special skills that may be necessary.

Criticality safety engineers are qualified per DOE-STD-1135.

6.5.1.9 Staff Levels

Minimum facility staffing requirements are specified in the facility-specific SARsDSAs, including consideration of the number of shifts for normal operation, types of job skills required for certain operations, and manning levels for emergency situations.
Criticality safety engineer staffing levels are determined based on project needs in a cooperative between WSMS and project/facility management and is reviewed periodically by the site Nuclear Criticality Safety Review Committee.

6.5.1.10 Criticality Safety Committees

The nuclear criticality safety program at SRS is monitored by Site and Division/Area Criticality Safety Committees (CSCs). The CSCs are established to monitor criticality safety as follows:

- The NCSRC implements site policy, provides for site coordination of nuclear criticality safety technical issues, procedure requirements, and practices; promotion of nuclear criticality safety in the operation of facilities; and guidance in the area of compliance with appropriate criticality safety related Department of Energy (DOE) Orders and Standards (Ref. 8). The NCSRC conducts reviews of new facilities, facility restart, and major process changes as it deems necessary or assigns an area CSC to perform such reviews.

- The Division/Area CSCs report to the NCSRC. Division/Area CSCs provide support to the facility self-assessment program in the area of criticality safety, as agreed upon with facility management. CSC activities may also include in-process reviews and technical advisory support. Technical support may include reviews by CSC members of operations or projects, proposed facility changes, new or revised limits, progress on criticality safety upgrades, review of occurrences, technical advice or data, etc.

  (Ref. 2).

- The NIM Committee reports to the NCSRC and reviews NIM design changes, troubleshooting, maintenance, and establishes site standards for NIM wiring and mounting (Ref. 2).

6.5.2 INCORPORATING CRITICALITY SAFETY IN PROCEDURES

Operations in a facility (handling or storing fissionable materials) are performed in accordance with approved procedures. Such procedures identify and highlight the appropriate criticality safety procedure steps. All expected activities are addressed by procedures. Activities involving conditions not addressed by a procedure are stopped (in a safe state) until procedures are written and approved to address the unexpected conditions. Criticality safety related procedure requirements are contained in WSRC-SCD-3 (Ref. 2). Criticality safety engineers review all procedures containing steps related to criticality safety and changes thereto.

6.5.2.1 Review of Operations

Operations, (including storage areas) in which criticality safety is a consideration, are governed by written procedures. The facility-specific SAR/DSA provides a summary description of the procedures applicable to the specific facility.

Procedures clearly specify all parameters and limits related to criticality safety that are being controlled. All administrative criticality safety related control steps contained in operating procedures are based on NCSEs and reviewed by criticality safety engineers prior to use. Procedures are designed such that no single inadvertent departure from a procedure should cause a criticality accident.

Deviations from operating procedures and unforeseen alterations in process conditions that affect criticality safety are documented, reported to management, and investigated promptly. Actions are taken to prevent recurrence. See section 5.6.

6.5.2.2 Criticality Safety Posting and Labeling

Positive identification of fissionable materials, particularly fissile materials, is essential to criticality safety. Adequate labeling of fissionable materials and clear posting of work and storage areas where fissionable materials are present are provided to alert workers of the presence of such materials avoid their accumulation in unsafe quantities.

Posting refers to the placement of signs indicating the presence of fissionable materials, summarizing key criticality safety requirements and limits, designating work and storage areas, or providing instructions, or warnings, to personnel. Posting requirements are contained in WSRC-SCD-3 (Ref. 2). At SRS, criticality safety postings are used as operator aids. Work is performed according to approved procedures.

Labeling refers to the placement of clear and positive identifying marks on specific units, or batches of fissionable materials (e.g., cans, packages, containers, boxes, reactor fuel assemblies, and targets) to prevent them from being mistaken for other materials and to clearly show the type and amount of fissionable materials present (Ref. 2).

6.5.2.3 Firefighting and Criticality Safety

Water, the firefighting agent used most often, is an efficient moderator and reflector of neutrons. In the absence of moderating materials such as water, relatively large masses of dry fissile materials, such as powders or metals, may be handled safely. If the presence of water is a normal condition, a credible abnormal condition, or a condition expected during fire fighting, then some operations with dry fissile materials may have to be constrained, modified, or eliminated. SCD-3 contains requirements for firefighting and the interaction between criticality safety and fire safety personnel.

Fire preplans are prepared by facility fire safety engineers. For facilities in which criticality safety is of concern and the use of moderating materials for fire fighting purposes is an option, fire preplans are reviewed by the WSMS criticality safety engineers. Typical categories or types of areas that are considered in developing fire preplans for facilities containing fissile materials are defined in WSRC-SCD-3 (Ref. 2).

6.5.2.4 Procedure Review, Approval, and Control

The procedure review, approval, and control considerations are defined in WSRC-SCD-3

(Ref. 2) and are as follows:

- All procedures that involve operational changes related to systems currently having criticality safety controls, or that may require criticality safety controls because of new or planned operational changes, are reviewed and approved by a criticality safety engineer prior to system operation
- All process flowsheet procedure changes that involve systems currently having criticality safety controls, or that may require criticality safety controls because of such changes, are reviewed and approved by a criticality safety engineer prior to system operation
- All procedural changes that may impact criticality safety are reviewed and approved by a criticality safety engineer prior to use
- Engineering drawings identify equipment and engineered systems important to criticality safety, particularly if such equipment, or systems, are used as a double-contingency defense. Changes to drawings involving equipment important to criticality safety are reviewed by a criticality safety engineer prior to use

6.5.3 CRITICALITY SAFETY TRAINING

WSRC-1-01, MP 1.18 states that it is WSRC's policy to provide training that supports employee performance of work assignments in a cost-effective, consistent, compliant, customer-focused manner and that contributes to the safety and formality of operations (Ref. 9). Regarding criticality safety training, the training policy supports the company-level criticality safety policy in that all reasonable efforts are taken to reduce, or eliminate, the potential for, and consequences of, a criticality accident (Ref. 1). WSRC-SCD-3 describes criticality safety-related WSRC requirements for the selection, criticality safety training, examination, qualification, retraining, reexamination, and requalification of individuals who perform one or more of the following:

- Work with, handle, or store greater than exempt quantities of fissionable materials, or work with equipment (including construction and maintenance) in which greater than exempt quantities of fissionable materials are processed
- Manage facilities, or provide engineering support, to facilities in which greater than exempt quantities of fissionable materials are stored, handled, or processed
- Perform special nuclear material accountability functions involving greater than exempt quantities of fissionable materials
- Perform nuclear materials packaging activities
- Perform independent reviews of criticality safety documentation
- Perform FEB or ORR reviews of facility criticality safety programs

WSRC facilities have each developed criticality safety training programs consistent with SCD-3 (Ref. 2) for their personnel.

6.5.4 DETERMINATION OF OPERATIONAL NUCLEAR CRITICALITY LIMITS

6.5.4.1 Nuclear Criticality Safety Evaluation Methodology and Bases

NCSEs, as described in SCD-3, are an independent, documented analysis that establishes the technical basis for nuclear criticality safety and provides the basis for, and recommends, subcritical operating limits, criticality safety controls, and engineered criticality safety features. These NCSEs identify the minimum subcritical margin when establishing such limits. Operational margins are also imposed to ensure that the criticality safety limits are not easily violated. NCSEs may identify specific procedural actions, process parameter values, and hardware requirements necessary to implement limits. NCSEs may also document criticality evaluations that do not produce specific limits.

A new NCSE is required whenever a new fissionable material handling, processing, transfer, shipping, or storage operation is planned with greater than exempt quantities of fissionable materials. A new or revised NCSE is required when an existing operation involving thehandling, processing, transfer, shipping, or storage of fissionable materials is changed beyond the scope of existing NCSEs and established limits. (Ref. 2)

6.5.4.2 Nuclear Criticality Safety Supplements

Nuclear Criticality Safety Supplements (NCSSs) are criticality safety supplements to Technical Standards for various facilities. WSRC Manual SCD-3 provides the requirements for NCSSs (Ref. 2).

The facility-specific SARs/DSAs provide summaries of NCSSs used to establish the technical basis for nuclear criticality safety of the facility and provide the basis for, and recommendations of, subcritical operating limits, criticality safety controls, and engineered criticality safety features. The only remaining facility with NCSSs is FB-Line, which has been largely de-inventoried and no longer operating.

6.5.4.3 Nuclear Safety Data Sheets

Nuclear Safety Data Sheets (NSDSs) are unique to Spent Fuel Storage Facilities, and serve as basis documents for approval of fuel-specific criticality safety limits (e.g., hardware, number of assemblies per bundle, storage location in pool). An NSDS is generated for each fuel type handled or stored in the Spent Fuel Storage basins. SCD-3 and the Nuclear Criticality Safety and Fuel Receipt Manual: Spent Fuel Basin Facilities provide the requirements for NSDSs (Refs. 2, 10).

6.5.4.4 Nuclear Criticality Safety Analysis Summary Report

A Nuclear Criticality Safety Analysis Summary Report (NCSASR) summarizes applicable NCSEs, criticality accident scenario analyses (e.g., fault trees, and event trees), and/or detailed double-contingency analyses applicable to TSRs or their revisions. The NCSASRs may form the basis for SARs/TSRs. NCSASR requirements are discussed in WSRC-SCD-3 (Ref. 2).

6.5.4.5 Nuclear Criticality Safety Assessment

A Nuclear Criticality Safety Assessment (NCSA) is required to document that a proposed process change is within the scope of an existing NCSE or NCSASR. These technical reports are prepared per the WSRC E7 manual, procedure 3.60, Technical Reports.

6.5.4.6 Safety Analysis Report Nuclear Criticality Safety Information

The basis for criticality safety is included in the facility-specific DSAs/SARs. Operational nuclear criticality limits and TSRs are developed based on NCSEs for the facility and include margins of safety to ensure that criticality safety is maintained. Additional requirements for nuclear criticality safety analysis are delineated in WSRC-SCD-3 (Ref. 2). The DSA criticality safety related input is based on DOE-STD-3009, chapter 6 requirements.

6.5.5 CRITICALITY SAFETY INSPECTIONS/AUDITS

Chapter 17 of this Manual provides additional information concerning safety reviews and performance assessments, including those in the area of criticality safety.

6.5.5.1 Facility Self -Assessments

Each facility that requires criticality safety controls and/or Elements of Incredibility periodically performs criticality safety self-assessments. The criticality safety self-assessments are conducted at least annually and typically use DOE-STD-1158 lines of inquiry or similar facility-specific lines of inquiry where it makes sense to do so (e.g., SRNL). In addition, periodic reviews are performed to ensure that Elements of Incredibility remain in place. The criticality safety self-assessments also review progress on issues and findings from previous self-assessments, DOE appraisals, reviews, and facility walkthroughs.

6.5.5.2 Facility Evaluation Board Reviews

The FEBs perform independent oversight of criticality safety activities in facilities. FEB reviews are distributed to the WSRC President and to the management of the facility under review.

6.5.5.3 Performance Assessments

Per the WSRC 12Q Assessment Manual, Procedure PA-1, Performance Analysis, the Functional Area Manager (i.e., T&QS Nuclear Safety Group Manager) for criticality safety is responsible for preparing a quarterly criticality safety Performance Assessment. On behalf of the T&QS Nuclear Safety Group manager, the Nuclear Safety Group staff prepares the quarterly performance assessments of criticality safety using comprehensive ORPs and STAR database reviews to identify criticality safety issues, recurring problems, and watch list items.

6.5.5.4 Management Evaluation

An integrated Management Evaluation of the criticality safety program is performed annually as directed by the Criticality Safety Functional Area Manager per the WSRC 12Q Assessment Manual, Procedure SA-1.

6.5.5.5 Record Keeping

Each project, area, or facility, as applicable, implements a formal documented system for the control and retention of criticality safety documents and records. As indicated in WSRC-SCD-3, the document and record management system established by the WSRC Sitewide Records Inventory and Disposition Schedule, in conjunction with the WSRC quality assurance program satisfies this requirement (Ref. 2).

6.5.6 CRITICALITY SAFETY OCCURRENCE REPORTING AND FOLLOW-UP

6.5.6.1 Criticality Safety Occurrence Reporting and Follow-up

Criticality safety deficiencies are categorized and reported to DOE in accordance with site SIRIM/ORPS reporting criteria (Ref. 11). The ORPS reporting criteria cover more significant deficiencies and limit violations. Criticality safety deficiencies of lesser significance are recorded in the STAR database. Corrective actions to deal with the deficiencies are identified in ORPS and STAR reports. An unplanned critical excursion is classified as an "event" and handled according to WSRC-SCD-3 (Ref. 2).

A quarterly compilation of ORPS and STAR criticality safety related deficiencies are prepared by the T&QS Nuclear Safety Group and reviewed by the NCSRC.

6.5.6.2 Handling Abnormal Conditions

Project, area, or facility abnormal operating procedures govern actions to be taken, in the event of an unanticipated situation, to place the operation into a stable and safe a condition as possible, until a criticality safety engineer/specialist can conduct an evaluation. Such actions may involve stopping the movement of nearby fissionable material, isolating the particular part of the process, and excluding persons from the immediate area. For example:

- If a criticality control step in an operating procedure is violated, activities controlled by the procedure are discontinued immediately, unless it is unsafe to do so, and supervision is notified.

- If a limit for a mass control zone (i.e., an area, room, or rooms in which the fissionable material inventory is administratively limited) is violated, operations are stopped immediately, unless it is unsafe to do so, and supervision is notified.

- If an equipment failure affects criticality control or monitoring, applicable process operations are placed in safe shutdown, and fissionable material movements through the facility are suspended, if necessary, depending on the nature of the equipment and the facility operation. Facility management is notified immediately.

- If it is determined that fissionable material is being stored, or handled, in excess of exempt quantities without appropriate criticality safety controls, then such activities are suspended immediately and supervision is notified.

Emergency procedures clearly specify reporting responsibilities and duties of the Facility Emergency Coordinator and the Area Emergency Coordinator in the event of a criticality accident or a NIM alarm of unknown origin.

6.5.6.3 Recovery

Recovery from a Criticality Safety Limit violation and upset condition is conducted in a manner to ensure that the remaining safety margin is acceptable, or is not further reduced, if already unacceptable. If the situation permits, safe shutdown and recovery from a criticality safety limit violation or upset condition is conducted under an approved procedure consistent with existing requirements to conduct all operations in accordance with written procedures. These actions require concurrence of a criticality safety engineer.

6.5.6.4 Corrective Action

Following recovery from a criticality limit violation or upset conditions and depending on the severity of the occurrence, corrective actions are developed and implemented to reduce the probability of recurrence (e.g., prepare better procedures, install more reliable equipment, improve training, or install additional controls) or to effectively prevent the event from recurring.

6.6 CRITICALITY SAFETY ALARM & DETECTION INSTRUMENTATION

At SRS, criticality alarm systems, are known as Nuclear Incident Monitors (NIMs) (Refs. 2, 12). The overall NIM program is the responsibility of the NCSRC Chairman. The purpose of NIM systems is 1.) to minimize, by means of quick detection and alarm, the acute dose received by personnel from a criticality accident in areas where the cumulative absorbed dose in free air may exceed 12 rad; 2.) to quickly identify individuals that require medical attention; and, 3.) to notify people to avoid the evacuated area. WSRC-SCD-3 contains NIM related requirements consistent, and in compliance, with applicable standards. (Ref. 2 and 12). Various criticality detection devices are also in place where NIMs are not required.

6.6.1 DESCRIPTION OF CRITICALITY ALARM SYSTEMS

In general, NIM systems (gamma detection instruments) are provided wherever it is deemed that they will result in a reduction in total risk. Specific requirements for NIM coverage are contained in SCD-3. Consideration is given to hazards that may result from false alarms. NIM instruments continually monitor each credible criticality accident site where an evacuation zone is required (Ref. 2). NIM systems are installed and maintained operational for facilities as specified in SCD-3. In the areas requiring NIMs, two NIM arrangements may be used, either independent pairs of NIMs or a two out of three voting logic.

6.6.2 NIM COVERAGE

The conditions requiring NIM coverage are specified in WSRC-SCD-3 (Ref. 2) as well as the conditions for which NIM coverage is not required.

6.6.3 CRITICALITY DETECTION DEVICES

Criticality detection devices are in use where the credible potential for a criticality accident exists but no evacuation zone is required. Typically, such cases involve heavily shielded facilities such as reprocessing canyons. Various methods (e.g., stack radiation monitors) may be used to detect a criticality accident. The intent is to detect a criticality accident and take appropriate action in a reasonable time frame to protect equipment, terminate the accident, and take protective actions as required.

6.6.4 NUCLEAR ACCIDENT DOSIMETRY

Fixed nuclear dosimetry devices are installed in facilities having NIM systems. Personnel badges also contain devices to determine individual exposure in the event of a criticality accident. In areas defined as Not Normally Occupied, electronic personnel dosimeters are used to protect personnel as specified in SCD-3.

6.7 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

1. "Nuclear Safety," MP 4.5, WSRC Policy Manual. WSRC 1-01, Washington Savannah River Company, Savannah River Site, Aiken, SC.

2. Washington Savannah River Company Nuclear Criticality Safety Manual. WSRC-SCD-3, Washington Savannah River Company, Savannah River Site, Aiken, SC.

3. Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports. DOE-STD-3009-94, Change Notice No. 1, U.S. Department of Energy, Washington, DC, January 2000.

4. Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Rule 10 Code of Federal Regulations (CFR) Part 830, Nuclear Safety Management. DOE-STD-1027-92, Change 1, U.S. Department of Energy, Washington, DC, September 1997.

5. Standards/Requirements Identification Document. WSRC-RP-1268-018 Washington Savannah River Company, Aiken, SC..

6. Compliance Assurance Manual. WSRC Procedure Manual 8B, Washington Savannah River Company, Aiken, SC.

7. Facility Safety. DOE Order 420.1, Change 2, U.S. Department of Energy, Washington, DC, October 1996.

8. "Nuclear Criticality Safety Review Committee (NCSRC)," WSRC Policy Manual. Charter 6.10, Rev. 4, WSRC 1-01, Washington Savannah River Company, Aiken, SC..

9. "Employee Training," MP 1.18, WSRC Policy Manual. WSRC 1-01, Rev. 5, Washington Savannah River Company, Aiken, SC, March 2000.

10. Nuclear Criticality Safety and Fuel Receipt Manual – Spent Fuel Storage Facilities. WSRC-TR-95-0302, Washington Savannah River Company, Savannah River Site, Aiken, SC.

11. Site Item Reportability and Issue Management (SIRIM). WSRC Procedure Manual 9B, Washington Savannah River Company, Aiken, SC.

12. American National Standard Criticality Accident Alarm System. ANSI/ANS-8.3-1997,American Nuclear Society, La Grange Park, IL.

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DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

Formerly the
GENERIC SAFETY ANALYSIS REPORT

CHAPTER 7

RADIOLOGICAL PROTECTION PROGRAM

January 2007

Washington Savannah River Company
Aiken, SC 29808

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DISCLAIMER

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ACRONYMS AND ABBREVIATIONS

ACL	Administrative Control Level
ALARA	As Low As Reasonably Achievable
ARA	Airborne Radioactivity Area
ARM	Area Radiation Monitor
CA	Contamination Area
CAMs	Continuous Air Monitors
CFR	Code of Federal Regulations
cm	centimeter
CND	Criticality Neutron Dosimeter
DAC	Derived Air Concentration
DCG	Derived Concentration Guides
DOE	Department of Energy
DSA	Documented Safety Analysis
ESH&QA	Environment, Safety, Health, and Quality Assurance
EM	Environmental Monitoring
EMS	Environmental Monitoring Section
EPA	Environmental Protection Agency
EPD	Electronic Personnel Dosimeter
ESH&QA	Environment, Safety, and Health & Quality Assurance
FARMS	Facility Annual Review of ESH&QA Monitoring Systems
GERT	General Employee Radiological Training
HCA	High Contamination Area

ACRONYMS AND ABBREVIATIONS (continued)

HPT	Health Physics Technology
HRA	High Radiation Area
mrem	milliroentgen equivalent man
NESHAP	National Emission Standard for Hazardous Air Pollutants - Radiological
NIST	National Institute of Standards and Technology
QA	Quality Assurance
RA	Radiation Areas
rad	radiation absorbed dose
RBA	Radiological Buffer Area
RC	Radiological Control
RCI	Radiological Control Inspector
REMS	Radiation Exposure Monitoring System
rem	Roentgen equivalent man
RIDS	Records Inventory and Disposition Schedule
RMA	Radioactive Material Area
RPS	Radiological Protection Department
RW	Radiological Worker
RWP	Radiological Work Permit
RWT	Radiological Worker Training
S/RID	Standards/ Requirements Identification Document
SAR	Safety Analysis Report
SCL	Special Control Level

ACRONYMS AND ABBREVIATIONS (continued)

SRS	Savannah River Site
SRTC	Savannah River Technology Center
TLD	Thermoluminescent Dosimeter
TLND	Thermoluminescent Neutron Dosimeter
VHRA	Very High Radiation Area
WSRC	Westinghouse Savannah River Company

7.0 RADIOLOGICAL PROTECTION PROGRAM

7.1 INTRODUCTION

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then, the user will default to the Site Program Manuals.

This chapter provides information on the Radiological Protection Program for the worker, public, and environment as it applies to the Savannah River Site (SRS) facilities. The scope of this chapter includes summaries of the following:

- Radiological protection organization
- Policies and programs for reducing radiation exposures to values that are As Low As Reasonably Achievable (ALARA)
- Radiological Protection Training
- Radiation exposure control including administrative limits, radiological practices, dosimetry, and respiratory protection
- Radiological monitoring program to protect workers, the public, and the environment
- Radiological protection instrumentation
- Program for maintaining records of radiation sources, releases, and occupational exposures
- Occupational Radiation Exposure

Additional or specific facility requirements are contained in the facility-specific Safety Analysis Reports (SARs) or Documented Safety Analysis. The application of a graded approach may identify areas of this report, which are not relevant to or different from a specific facility. The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

7.2 REQUIREMENTS

Standards/Requirements Identification Documents (S/RID) state the codes, standards, and regulations governing the Radiological Protection Program elements of the SRS (Ref. 1). Programmatic compliance assessment has been performed against the S/RIDs and documented as specified in the Westinghouse Savannah River Company (WSRC) Procedure Manual 8B (Ref. 2).

7.3 RADIOLOGICAL PROTECTION PROGRAM AND ORGANIZATION

Responsibility for radiological protection is assigned to the Environment, Safety, Health, and Quality Assurance (ESH&QA) Division. ESH&QA is headed by a Manager who reports to the Executive- Vice-President of WSRC for Management and Operations (M&O). Within ESH&QA, radiological protection functions are carried out by the Radiological Protection Services (RPS). The RPS manager reports to the Executive Vice-Manager of the Environmental, Safety, Health, and Quality Assurance Section.

RPS is the SRS consulting authority for radiological protection of site personnel and the public. The responsibility for the external dosimetry, internal dosimetry, instrument calibration, regulatory compliance, training, and health physics services aspects of the Radiological Protection Program are within RPS. The operating line organizations are matrixed to RPS and are responsible for implementing the Radiological Protection Program (RPP) for the protection of the environment, the public, and the workers on and around SRS (Ref. 3).

Specific objectives of the RPD include the following:

- Protects the health of employees, the general public, and the environment.
- Provides direction and oversight for the site Radiological Protection Program.
- Ensures compliance with relevant federal and state regulations, Department of Energy (DOE) Orders, and WSRC directives governing the site Radiological Protection Program.
- Enables SRS to safely and effectively meet its mission.

The RPS has been assigned certain responsibilities in order to achieve these objectives. These responsibilities are included in Section 7.3.1.

The management at SRS is fully committed to maintaining external and internal exposures to radiation from site processes to ALARA levels. To establish a rigorous and frequent review of the program and performance against challenging goals, a network of review and approval committees is used to ensure adequate oversight by senior management (Ref. 4).

7.3.1 RADIOLOGICAL PROTECTION PROGRAM

The Radiological Protection Program meets the radiological protection S/RIDs requirements, including training, measurements of radiation in the field, radiological design considerations, access and tool control, personnel radiation monitoring (internal and external dosimetry), emergency preparedness, program evaluation, and Quality Assurance (QA).

7.3.1.1 Program Organization

The RPS is the responsible consulting authority within SRS for radiation protection of site personnel and the public. It oversees radiation hazard monitoring, and provides awareness, analysis, direction, and advice to other departments on health hazards incident to the handling, use of, and exposure to radioactive materials. The RPS also provides support to maintain each employee's personal work environment at a safe level of exposure from radiation.

Activities in the RPS are divided among three primary functions:

(1) Provides direction, oversight, and coordination for radiological control field support in SRS facilities and organizations

(2) Responsible for internal and external dosimetry, calibration of portable instruments, and oversight and support of radiological design activities for new and existing facilities.

(3) Development of RPS training programs (Ref. 3)

Responsibilities and functions of radiological protection personnel are described in WSRC Procedure Manual 5Q (Ref. 5). SRS maintains a level of radiological protection staff to ensure that the responsibilities and functions of the RPS are fulfilled. The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

7.3.1.2 Experience/Qualification Requirements

Personnel associated with the Radiological Protection Program must have a combination of education, experience, and training in order to perform their duties. The RPP managers and supervisors oversee the training and qualification of Radiological Control Inspectors (RCI). Experience and qualifications for radiological protection personnel are summarized in the following sections.

RADIOLOGICAL PROTECTION MANAGEMENT AND SENIOR STAFF

The management and professional staffs of the radiological protection organizations have qualifications that include a bachelor's degree (or the equivalent) in science or engineering, technical qualifications pertinent to their assigned duties, and technical education and refresher courses; attendance at professional meetings is encouraged. Senior staff is encouraged to pursue certification by the American Board of Health Physics.

FIRST LINE MANAGERS

First Line Managers are selected from qualified RCIs and participate in continuing radiological training programs. First Line Managers are re qualified periodically through comprehensive written and oral examination boards.

RADIOLOGICAL CONTROL TECHNICIANS

RCI qualification consists of standardized core course training material, on-the-job training in accordance with the Qualification Standard, and passing both a final comprehensive written examination and final oral examination board. RCIs are physically fit to perform assigned functions and have a minimum of a high school education or the equivalent.

Additional information on experience, qualifications, and responsibilities for radiological protection personnel is given in Chapter 6 of WSRC Procedure Manual 5Q (Ref. 5). Radiological protection training for radiological protection personnel is discussed in Section 7.5.

7.4 AS LOW AS REASONABLY ACHIEVABLE POLICY AND PROGRAM

7.4.1 AS LOW AS REASONABLY ACHIEVABLE POLICY CONSIDERATIONS

The Radiological control practices established in this chapter by WSRC apply to WSRC employees, other site contractor and subcontractor personnel, visitors, and members of the general public. These policies ensure radiation exposure of the work force and public are controlled such that they are well below regulatory limits, that there is no radiation exposure without commensurate benefit, and that it is maintained as low as reasonably achievable (ALARA) at all times. The SRS ALARA policy and program are provided in WSRC-SCD-6 and WSRC Manual 1-01 (Ref. 4, 7). The ALARA concept is integrated into all SRS activities involving radioactive materials.

7.4.2 ASSOCIATED RADIOLOGICAL GOALS

The establishment of goals, their periodic review, and comparison with actual data, are methods for tracking the progress toward the ultimate purpose of the ALARA program, reducing exposures to ALARA (Ref. 4). Goals are established by those responsible for performing the work at the division/department/facility level. Periodic review of these goals against performance ensures that ALARA is considered in all facets of work at the site. The Radiological Work Permit (RWP) program and associated ALARA reviews provide a base of historical information. After the type and amount of work that will actually be performed are developed and an estimated exposure value established, the amount of dose savings through implementation of ALARA principles will be determined. References 4, 5, & 8 describe ALARA methods incorporated into the preplanning of tasks and development of procedures.

7.4.3 PERSONNEL PROTECTIVE PRACTICES AND TECHNIQUES

Significant reductions in radiation exposure can occur at the task level, provided good job planning techniques are used each time a job is performed. These techniques not only include conducting pre-job reviews, but also evaluating the documented successes and shortcomings of completed jobs before performing a similar task.

Proper training is important in achieving good performance in radiological protection. Training is designed to supplement an individual's education and experience and provide the skill development and proficiency necessary to perform a particular job assignment. This performance includes the requirement to maintain exposures to radiation resulting from the site's operations to ALARA. Training is provided to all site personnel commensurate with the work to be performed (Ref. 4).

7.5 RADIOLOGICAL PROTECTION TRAINING

The appropriate level of radiological training is provided to each worker in the facility as well as to radiological protection personnel. Training records are maintained for each worker. Figure 7.12-1 illustrates typical control areas and required training. The standardized core courses and training materials are used to achieve site-wide consistency. In establishing training programs, the standardized DOE core courses are presented along with the addition of site-specific information. WSRC Procedure Manual 5Q contains the requirements for training and frequency of training (Ref. 5).

7.5.1 GENERAL EMPLOYEE RADIOLOGICAL TRAINING (GERT)

GERT is required for all personnel who may routinely enter a controlled area unescorted and prior to receiving occupational radiation exposure during access to controlled areas.

Visitors who enter a controlled area must receive a briefing as prescribed by WSRC Procedure Manual 5Q (Ref. 5). The orientation for continuously escorted individuals or groups is commensurate with the areas to be visited.

7.5.2 RADIOLOGICAL WORKER TRAINING (RWT)

RWT consists of Radiological Worker (RW) I and RW II. RW II training includes all of the requirements of RW I training and expands on the topic of hands-on work with radioactive materials. RW II training prepares the worker to deal with higher levels of radiation and radioactive contamination. Specialized RWT must be completed for nonroutine operations or work in areas with changing radiological conditions. This training is in addition to RW II training and is required for personnel planning, preparing, and performing jobs that have the potential for high radiological consequences (Ref. 5).

7.5.3 RADIOLOGICAL CONTROL INSPECTOR (RCI) TRAINING

RCI qualification contains two elements, Phase I and Phase II. Phase I consists of classroom and on-the-job training for required technical knowledge and skills. Phase II consists of additional classroom and on-the-job training to develop the more advanced knowledge and skills applicable to all areas. WSRC Procedure Manual Q1-1 defines and describes the selection, initial training, qualification, continuing training, and re-qualification requirements of the RCI program (Ref. 3). Subcontracted RCIs must have the same knowledge and qualifications required of RCIs performing the same duties.

7.5.4 SUPERVISOR AND MANAGER TRAINING

The Radiological Control (RC) First Line Manager (FLM) selection, initial training, qualification, continuing training, and re-qualification requirements are defined in WSRC Procedure Manual Q1-1 (Ref. 3). The initial training program is implemented to ensure that FLMs are trained in accordance with the performance requirements of the job. The FLM training program consists of classroom and on-the-job training for required technical knowledge and skills, and supervisory skills training in accordance with human resource development programs. The technical continuing training program consists of two technical elements: periodic continuing training and retraining culminating in re-qualification (Ref. 3).

7.6 RADIATION EXPOSURE CONTROL

The site-level document for controlling radiation exposure is WSRC Procedure Manual 5Q (Ref. 5). Lower-tier implementing procedures are included in the 5Q derivative manuals such as WSRC Procedure Manual 5Q1.1 and WSRC Procedure Manual 5Q1.2 (Ref. 8, 9). External radiation exposure control includes limiting yearly and lifetime whole-body exposures; organ exposures; skin and extremity exposures; exposures to the unborn; and exposures during emergencies.

External radiation exposure control is accomplished by establishing administrative dose control levels well below DOE regulatory dose limits, monitoring personnel for external radiation exposure, by tracking exposures received, and identifying and controlling radiation sources. Exposure tracking systems inform personnel and their supervisors of exposures received and are used to plan radiological work. Administrative Control Levels (ACLs) and exposure tracking systems are management tools to help ensure that individual and collective exposures are minimized. Managers in all departments, as well as all workers, are responsible for controlling and minimizing external radiation exposures.

Internal radiation exposure control is accomplished by establishing ACLs, identifying and controlling sources or potential sources of airborne radioactivity, maximizing the use of engineered controls, applying respiratory protection where appropriate, and monitoring workers for internal radioactivity.

7.6.1 ADMINISTRATIVE LIMITS

A multi-tiered system of ACLs has been developed. Increasing levels of authority are required to approve the higher ACLs. WSRC Procedure Manual 5Q establishes practices for the conduct of radiological control activities at SRS (Ref. 5). When taken together, the following describes the SRS ACL system.

7.6.1.1 Administrative Control Levels

A DOE ACL of 2,000 mrem/year per person is established for all DOE activities. Approval by the appropriate DOE Secretarial Official or designee shall be required prior to allowing a person to exceed 2,000 mrem/year (Ref. 5). WSRC establishes an SRS ACL for an individual based on evaluation of historical and projected radiation exposures, workload, and mission and does not exceed the ACL established by DOE. This control level is reevaluated annually but must be maintained more restrictively than the DOE ACL. No person is allowed to exceed the SRS ACL without the prior approval of the WSRC President.

7.6.1.2 Radiological Worker Dose Limits

Dose limits set by DOE provide the upper bounds for exposure of operating personnel. A summary of annual dose limits for occupational workers is provided in Table 2-1 of Ref. 5.

A Special Control Level (SCL) for annual occupational exposure is established for each person with a lifetime occupational dose exceeding N rem, where N is the age of the person in years. Use of the Planned Special Exposure, as allowed by 10CFR 835, is applied only in extraordinary situations as specified in WSRC Procedure Manual 5Q (Ref. 5).

Operating Management shall notify the Head of the responsible DOE field organization after verifying that the conditions under which an unplanned dose was received in excess of limits specified in Table 2-1 of Reference 5, have been eliminated. DOE must approve resumption of operations of an SRS facility following an unplanned dose in excess of the limits in Table 2-1 of Ref. 5.

7.6.1.3 Embryo/Fetus Dose Limits

After a female radiation worker voluntarily notifies her employer in writing that she is pregnant, for the purpose of fetal/embryo dose protection, she is considered a declared pregnant worker. The employee's SRS organization must provide the option of a mutually agreeable assignment of work tasks, without loss of pay or promotional opportunity, such that further occupational radiation exposure is unlikely. For a declared pregnant worker who continues working as a radiation worker: the dose limit for the embryo/fetus from conception to birth (entire gestation period) is 500 mrem, and efforts are made to avoid exceeding 50 mrem per month to the pregnant worker. If the dose to the embryo/fetus is determined to have already exceeded 500 mrem when a worker notifies her employer of her pregnancy, the worker cannot be assigned to tasks where additional occupational radiation exposure is likely during the remainder of the gestation period (Ref. 5).

7.6.1.4 Special Control Levels

Certain situations require lower individualized exposure control levels. SCLs are established with the advice of RPS, Medical, Human Resources, and/or legal, as appropriate. WSRC and other SRS organizations must be attentive to special circumstances of employees, such as those undergoing radiation therapy, and establish SCLs as appropriate (Ref. 9).

7.6.1.5 Planned Special Exposures

Certain employees have specialized skills important to facility and public safety, and for this and other reasons, it is recognized that unusual conditions can arise in which higher-than-normal doses can be justified. Under approved, well-justified, well-planned, well-controlled, highly infrequent and unusual conditions, operating management are permitted to allow exposure of specified individuals to doses exceeding the annual limit (Ref. 5).

The total dose from planned special exposures for an employee during any given year cannot exceed 5 rem to the whole body (internal and external), or five times the limit for any other doses specified in Table 2-1 of reference 5, in addition to the annual occupational dose limit. An employee could receive no more than 25 rem of planned special exposures from DOE and non-DOE operations during his/her career. Every planned special exposure must be approved in advance by DOE and requires the informed consent of the employee involved.

The procedure for conducting a planned special exposure is contained in WSRC Procedure Manual 5Q (Ref. 5).

7.6.1.6 Emergency Exposures

In extremely rare cases, emergency exposure to radiation may be necessary to rescue personnel or to protect major property. Criteria to perform emergency actions are prescribed in WSRC Procedure Manual 5Q (Ref. 5).

Emergency situation radiation exposures in excess of 5 rem, must be performed only by trained individuals. (Ref. 5, 8).

7.6.2 RADIOLOGICAL PRACTICES

7.6.2.1 Radiological Work Permits

The Radiological Work Permit (RWP) is the primary administrative mechanism used to establish radiological controls for intended work activities. The RWP informs workers of area radiological conditions and entry requirements, and provides a mechanism to relate worker exposure to specific work activities (Ref. 5). The RWP program is documented in WSRC Procedure Manual 5Q1.1 (Ref. 8).

Two types of RWPs are currently implemented at SRS. The first type is the general RWP (commonly known as the standing RWP). The second type is the job-specific RWP. RWPs are posted or made available at the access point to the applicable radiological work area. Workers use an electronic sign-in station to indicate that they have read, understand, and will comply with the RWP requirements prior to initial entry to the area and after any revision to the RWP (Ref. 5). The system also tracks dose, validates qualifications and sets alarm setpoints for electronic personal dosimeters.

7.6.2.2 Planning of Radiological Work

WSRC Procedure Manual 5Q establishes practices for the conduct of radiological control activities at SRS (Ref. 5). Technical work documents and RWPs are used to specify conduct of radiological work activities. Technical work documents encompass documents such as procedures, work packages, and job or test authorizations used to control hands-on work with radioactive materials. The RWP is the primary administrative mechanism used for planning and controlling radiological work and for informing the worker of the radiological conditions and entry requirements (Ref. 5, 8).

Technical requirements for the conduct of work incorporate radiological protection control criteria to ensure safety and maintain radiation exposures ALARA. To accomplish this, the design and planning processes include radiological considerations in the early planning stages. WSRC Procedure Manual 5Q contains a checklist to be used for reducing occupational radiation exposure (Ref. 5).

7.6.2.3 Personnel Protective Equipment and Clothing

Clothing for protection against radioactive contamination includes such items as coveralls, hoods, shoe covers, rubber and cotton gloves, laboratory coats, and other specialized articles used for particular tasks. RPS is responsible for ensuring that all clothing meets minimum standards.

Training, qualification requirements, and procedures for donning and removal of personnel protective equipment and clothing are discussed in WSRC Procedure Manual 5Q1.1 and WSRC Procedure Manual 5Q1.2 (Ref. 8, 9). General guidelines for protective clothing selection and use are provided in WSRC Procedure Manual 5Q (Ref. 5). Guidance on maintenance of respiratory protection equipment and training in its use are contained in Manual 4Q (Ref. 18).

7.6.2.4 Infrequent or First-Time Activities

For activities with significant dose implications that are infrequently conducted (less than annually) or that represent first-time operations, planning follows the guidance in Reference 5.

7.6.2.5 Stoppage of Radiological Work

All work personnel have the authority and responsibility to immediately and safely stop work including radiological work activities if proceeding with work compromises the safety of employees, the public, or the environment. Once radiological work has been stopped, it cannot be resumed until proper radiological control has been reestablished. Resumption of radiological work requires the approval of the line manager responsible for the work and the RPS Manager (Ref. 5). To encourage safety, a lower tier method to stop work also exists. This “Time Out” process has worked well. Since it is less onerous, workers seem more inclined to use it.

7.6.2.6 Radiological Area Boundaries, Posting and Controls

Access to and from radiologically posted areas is controlled commensurate with the level of the hazard to minimize radiation exposure, the spread of radiological contamination, and personnel contamination. Containers of radioactive material and radioactive items are labeled to provide information needed for purposes of radiation protection and the prevention of inadvertent transfer to locations outside of controlled areas. Radiological postings are used to alert personnel to the presence of radiation and radioactive materials and to aid them in minimizing exposures and preventing the spread of contamination (Ref. 5).

Figure 7.12-1 illustrates typical control areas and required training.

IDENTIFICATION OF BOUNDARIES

- Controlled Area

A Controlled Area is any area to which access is managed in order to protect individuals from exposure to radiation and/or radioactive materials. Individuals who enter only the Controlled Area without entering radiological buffer areas are not expected to receive a total effective dose equivalent of more than 100 mrem in a year (Ref. 8).

- Radiological Buffer Area (RBA)

RBAs are established within Controlled Areas. RBAs provide a second boundary to minimize the spread of contamination and to limit doses to general employees who have not been trained as radiological workers (Ref. 5). WSRC Procedure Manual 5Q1.1 provides facility-specific radiation and contamination guides, instructions, and protective clothing and equipment requirements for an RBA at SRS facilities (Ref. 8). The perimeter of an RBA is posted on all accessible sides to prevent inadvertent intrusion by personnel.

- Radiological Area

Any area within a Controlled Area which must be posted as a Radiation Area, High Radiation Area, Very High Radiation Area, Contamination Area, High Contamination Area, or Airborne Activity Area.

- Radiation Area (RA)

A RA is any area within an RBA in which an individual can receive a deep dose equivalent greater than 5 mrem, but less than or equal to 100 mrem in 1 hour at 30 centimeter (cm) from the source of radiation, or any surface through which the radiation penetrates. A perimeter boundary must be established to alert personnel to the presence of external radiation (Ref. 5).

- High Radiation Area (HRA)

A HRA is any area within an RBA in which an individual can receive a deep dose greater than 100 mrem in 1 hour at 30 cm, but less than or equal to 500 rad in 1 hour at 100 cm from the source of radiation, or the surface through which the radiation penetrates. Access control for these areas must include applicable features listed in WSRC Procedure Manual 5Q (Ref. 5, 8).

- Very High Radiation Area (VHRA)

A VHRA is any area within an RBA in which an individual can receive a deep dose of 500 rad or greater in 1 hour at 100 cm from the radiation source, or the surface from which the radiation penetrates. Access control for these areas must include applicable features listed in WSRC Procedure Manual 5Q (Ref. 5, 8).

- Airborne Radioactivity Area (ARA)

An ARA is any area in which the airborne concentration of radioactive material exceeds the Derived Air Concentration (DAC), or where an individual without a respirator could receive more than 12 DAC-hrs in a week. The DAC values for radionuclides are provided in 10 CFR 835. When establishing the perimeter boundary for these areas, it is important to remember that air currents can carry airborne radioactivity across open boundaries. The boundary must be positioned so that personnel located outside the posted area will not be exposed to an airborne concentration that is above established limits for airborne radionuclides (Ref. 8).

- Contamination Area (CA) and High Contamination Area (HCA)

CAs and HCAs are areas in which removable radioactivity exceeds levels prescribed in WSRC Procedure Manual 5Q (Ref. 5). Each active exit to a CA or HCA has a step-off pad and appropriate containers for depositing used protective clothing and contaminated waste (Ref. 8).

- Radioactive Material Area (RMA)

RMAs are accessible areas where items or containers of radioactive material in quantities exceeding the values provided in Appendix 4A of Manual 5Q are used, handled, or stored. They are posted: "CAUTION, RADIOACTIVE MATERIAL AREA." RMAs are located within Controlled Areas (Ref. 5).

7.6.2.7 <u>Contamination Control</u>

Contamination control minimizes the potential for worker internal exposure and the spread of contamination. Contamination levels caused by ongoing work shall be monitored and maintained ALARA. Use of engineering and administrative controls should be evaluated before allowing personnel to work with or without respiratory protection. When engineering and administrative controls have been applied and the potential for airborne radioactivity still exists, respiratory protection should be used to limit internal exposures. The selection of respiratory protection equipment includes considerations of worker safety, comfort and efficiency.

In addition, eating, drinking, chewing, and smoking are prohibited inside CAs, HCAs or ARAs to minimize the chance of ingesting contaminated materials. Under certain circumstances, such as high risk of heat stress, drinking may be permitted inside CAs after appropriate monitoring (Ref. 5).

7.6.2.8 <u>Shielding</u>

Temporary and permanent shielding are used to reduce worker exposure. When evaluating the use of shielding, the estimated exposure for installation and eventual removal is considered along with potential dose savings. The overall cost in dollars and initial radiation exposure may outweigh the savings in exposure (Ref. 4).

7.6.3 DOSIMETRY

To ensure that the radiation and contamination control programs are adequately protecting both occupational workers and visitors, a dosimetry program has been established at SRS. The RPS has responsibility for providing a primary means of measuring external radiation exposure and maintaining a permanent radiation history file for employees at SRS.

7.6.3.1 <u>External Dosimetry</u>

The SRS External Dosimetry Technical Basis Manual provides the technical basis for the External Dosimetry Program, including measures to ensure the validity and quality of external dosimetry results (Ref. 10). Through this comprehensive program, the performance of radiological control measures is evaluated, thus helping to ensure that administrative dose control limits are not exceeded.

At SRS several types of radiation dosimeters are used to determine dose equivalent from external radiation exposures. Most dosimetry used at SRS is TLDs. (Ref. 10).

PERSONNEL THERMOLUMINESCENT DOSIMETER BADGE

A whole-body Thermoluminescent Dosimeter (TLD) must be worn by workers who are likely to receive 100-mrem effective dose equivalent in a year. This dosimeter is the primary device used to measure beta-gamma radiation exposure (Ref. 9).

PERSONNEL NEUTRON BADGE

A Thermoluminescent Neutron Dosimeter (TLND) is required if a worker is likely to exceed 100 mrem from neutrons during the calendar year.

SPECIAL DOSIMETRY FOR EXTREMITIES

Extremity TLDs, or finger rings, or wristbands are required to be used by workers who, under typical conditions, are likely to receive a shallow dose equivalent to the skin or to any extremity of 5 rem (0.05 sievert) or more in a year. Positioning of extremity dosimeters is specified by the RPP to ensure that the TLD is facing the exposure source. When required, use of extremity dosimeters should be specified in the RWPs (Ref. 9).

ELECTRONIC PERSONNEL DOSIMETER

The Electronic Personnel Dosimeter (EPD) or equivalent shall be worn by personnel when entering RAs where exposure could exceed 50 mrem from external radiation in one work day, when entering/working in HRAs or VHRAs, or when required by an RWP. Additional details on the use of EPDs, such as control and issuance, handling and storage, or lost or damaged EPDs, are provided in WSRC Procedure Manual 5Q1.2 (Ref. 9).

7.6.3.2 <u>Internal Dosimetry</u>

Internal dosimetry at SRS is accomplished by in-vivo and in-vitro bioassays and subsequent dose assessment. In some cases, personal air sampling may be substituted for bioassay. Personnel whose routine duties may involve exposure to surface or airborne contamination or to radionuclides readily absorbed through the skin are considered for an appropriate bioassay program as described below. The basis for the methods and frequency of these bioassay programs is documented in the SRS Internal Dosimetry Technical Basis Manual (Ref. 12).

CRITERIA FOR REQUIRING BIOASSAYS

The need to participate in a bioassay program is based on the radiological work performed by the individual during the year preceding his/her birthday. Bioassay programs are based on exposure potential as determined by a review of RWP sign-in and may include a whole body count and may be required to submit urine samples and receive a chest count (Ref. 8). Personnel are required to participate in follow-up bioassay monitoring if their bioassay results indicate a potential intake.

Bioassay programs are described in the following sections.

Routine Sampling

Routine bioassay programs consisting of both in-vivo and in-vitro sampling are used to monitor Rad 2 Workers who are not likely to receive intakes of radioactive material in a year that would deliver a committed effective dose equivalent in excess of 100 mrem. The purpose of the routine bioassay program is to verify the effectiveness of procedural and engineered controls and to serve as the final quality assurance check of the contamination control program.

Special Sampling

When jobs with the potential for unknown radiological conditions occur or unusual radionuclides present are undertaken, a non-routine, job-specific bioassay program should be considered. In such cases, an in-vitro sample and/or in-vivo count may be required before beginning work and again when work is completed (Ref. 8).

Special bioassay programs must be performed if an intake of radioactive materials is suspected (Ref. 8). In the event that radioactive material is detected by in-vivo or in-vitro bioassay, a follow-up bioassay-monitoring program is conducted.

Visitors may be required to participate in in-vivo and in-vitro bioassay programs in conjunction with a visit to an RBA. The host organization is responsible for arranging for the appropriate samples and other entry requirements for their visitors (Ref. 8).

7.6.3.3 Combining Internal and External Dosimetry Results

The total effective dose equivalent to an individual during a year is determined by adding the effective dose equivalent from external exposure and the committed effective dose equivalent from intakes during the year. This information is provided to DOE in the Annual Radiation Dose Summary (Radiation Exposure Monitoring System [REMS] report) (Ref. 31).

7.6.3.4 Accident Dosimetry

A Criticality Neutron Dosimeter (CND) would be used to assess the dose to involved personnel if a criticality accident occurred. CNDs are required to be worn by personnel assigned to facilities that handle and store fissionable materials in quantities that would require the installation of Nuclear Incident Monitors. In the event of a criticality incident, the CNDs and any other dosimetry are collected at the rally point by RPS and processed to determine the individual level of exposure (Ref. 5, 9, 10 and 11).

All SRS personnel have a TLD chip and an activation foil contained in a dual compartment opaque pouch attached to the security photobadge. The TLD chip is processed only in the event that an individual is suspected of having received an exposure in excess of 10 rad. The foil is used to verify whether an individual may have received an excessive exposure to neutrons (Ref. 10 and 11).

7.6.3.5 Reports

WSRC Procedure Manual 5Q2.1 describes the process for preparing and distributing reports concerning radiation exposures. It also describes a method which personnel radiation exposure information may be released by the RPS (Ref. 13). In addition, WSRC Procedure Manual 5Q requires the establishment of a radiological records management program. This program ensures that auditable records and reports are controlled through the stages of creation, distribution, use, arrangement, storage, retrieval, media conversion (if applicable) and disposition (Ref. 5).

In accordance with WSRC Procedure Manual 5Q, the Annual Radiation Dose Report must be submitted to DOE for the preceding calendar year for DOE and DOE contractor radiation workers and for non-employee occupational workers, at SRS (Ref. 5).

To support preparation of the DOE REMS report, Health Physics Services (HPS) Internal Dosimetry is responsible for generating the computer file containing all of the internal exposure data (Ref. 14). The REMS report is an annual radiation exposure report for DOE and DOE contractor radiation workers and for non-employee occupational workers at SRS in accordance with Code of Federal Regulations (CFR) 10 CFR 835 (Ref. 15).

7.6.4 RESPIRATORY PROTECTION

Refer to Chapter 8 of this SAR for a discussion of the Respiratory Protection Program.

7.7 RADIOLOGICAL MONITORING

Typical radiological control monitoring includes Area Radiation Monitors (ARMs), Continuous Air Monitors (CAMs), air sampling, personnel contamination monitoring, and ventilation monitoring. WSRC Procedure Manual 5Q1.7 provides additional information on specific types of monitors and systems (Ref. 15). Also, technical basis and additional information for the sampling and monitoring program can be found in the SRS Workplace Air Monitoring Technical Basis Manual (Ref. 32)

7.7.1 RADIOLOGICAL CONTROL MONITORING AND SURVEYS

Workplace monitoring provides a control mechanism to detect and quantify external radiation and radioactive contamination levels, enables measures to be taken to prevent unanticipated and unplanned exposures, and contributes to maintaining actual exposures ALARA. Monitoring results are made available to line management and used in support of pre- and post-job evaluations, ALARA preplanning, contamination control, and management of radiological control operations. The Radiation Monitoring Equipment Technical Basis Manual provides additional information on specific types of monitors and systems (Ref. 17).

Surveys are performed before, during, and at the completion of work that has the potential for causing changes in levels of radiation and radioactivity as well as routinely on predetermined schedules.

7.7.1.1 Radiation Surveys

Radiation surveys are recorded on a Radiation Survey Logsheet, which is used for determining personnel stay time, area postings, and other radiological work planning, as well as historical documentation (Ref. 9). Radiation surveys include dose rate measurements of the general area, dose rates at a distance of 30 cm from a source or surface of interest to evaluate potential whole-body exposures, and dose rates on contact with potential sources of radiation where there is a potential for hands-on work. Instruments used to perform radiation surveys must be response-checked daily or prior to operation if used less frequently (Ref. 5).

7.7.1.2 Contamination Surveys

Contamination surveys are conducted on a routine basis in affected areas. Potentially radioactive materials in CAs, HCAs, or ARAs are surveyed prior to release. Contamination surveys on materials, equipment, and portable facilities for release of material from a Contamination Area, High Contamination Area or Airborne Radioactivity Area are conducted as specified in WSRC Procedure Manual 5Q1.1 (Ref. 8).

7.7.1.3 Area Radiation Monitors (ARMs)

ARMs are installed in frequently occupied locations with the potential for unexpected increases in dose rates and in remote locations where there is a need for local indication of dose rates prior to personnel entering these areas. The need for and placement of ARMs are documented and assessed when changes to facilities, systems, or equipment occur (Ref. 9). ARMs are periodically calibrated and tested to verify audible alarm system operability and audibility under ambient working conditions and operability of visual alarms, as appropriate (Ref. 5).

7.7.1.4 Airborne Radioactivity Monitoring

Building air monitoring equipment is used in situations where airborne radioactivity levels can fluctuate, and early detection of airborne radioactivity could prevent or minimize inhalation of radioactivity by workers. Air monitoring equipment includes portable and fixed air sampling equipment and Continuous Air Monitors (CAMs). CAMs have alarm capabilities and sufficient sensitivity to alert personnel that immediate action is necessary in order to minimize or terminate inhalation exposures (Ref. 5, 17).

7.7.1.5 Review of Monitoring Systems

Each facility that processes/handles radioactive material must have a review of radiation monitoring systems (Ref 5). The Facility Annual Review of Monitoring Systems (FARMS) is a joint venture between Facility Management and RPS personnel. The FARMS considers the criteria for the protection of radiation and non-radiation workers, and facilitates updates in radiological control monitoring programs based on facility and equipment changes. The FARMS is further described in WSRC Procedure Manual 5Q1.2 (Ref. 9).

7.7.2 RADIOLOGICAL ENVIRONMENTAL MONITORING

Radiological environmental monitoring consists of two major activities: effluent monitoring and environmental surveillance. DOE Order 5400.5 requires that an Environmental Monitoring Plan (EMP) be prepared for each DOE site (Ref. 20). The SRS EM Plan (Ref. 23)contains detailed descriptions of the existing activities, procedures, practices, and programs that implement the EM criteria and requirements set forth in the SRS EM Program (Ref. 18, 19).

7.7.2.1 <u>Radiological Effluent Monitoring - General Requirements</u>

Radiological effluent monitoring results are a major component in the determination of compliance with applicable dose standards (Ref. 20, 21). Compliance with dose standards is determined by the Environmental Services Section based on monitoring by the Environmental Dosimetry Group of Savannah River National Laboratory (SRNL) and is documented in the SRS Annual Environmental Report, which is issued to the general public (Ref. 18). SRS Management is committed to and responsible for maintaining radiation exposures to the general public and releases of radioactive materials to the environment at ALARA levels.

Annual average concentrations of radionuclides in effluents are compared to the Derived Concentration Guides (DCGs) of DOE Order 5400.5 (Ref 20) in the SRS Annual Environmental Report. For radioactive liquid effluents, Environmental Monitoring Section (EMS) compares the monthly concentrations and 12-month average concentrations against the DCGs. If, at any liquid effluent point, the sum of the fractional DCG values (based on consecutive 12-month average concentrations) for all radionuclides (except tritium) detectable in the effluent exceeds 1.0, then a Best Available Technology process would be initiated in accordance with WSRC Procedure Manual 3Q (Ref. 22) to control the effluents.

7.7.2.2 <u>Radiological Effluent Monitoring̃ Liquid Effluents</u>

In addition to the requirements of DOE Order 5400.5, each discharge points' monitoring results are compared to ALARA Guides and Standards, and are reported in the Radioactive Release Reports. Each process area liquid effluent discharge point that releases or has the potential to release radioactive materials is sampled routinely and analyzed for radioactivity.

7.7.2.3 <u>Radiological Effluent Monitoring - Airborne Effluents</u>

In addition to the dose standards in DOE Order 5400.5, radiological airborne releases are regulated by 40 CFR 61, Subpart H, National Emission Standard for Hazardous Air Pollutants (NESHAP) - Radiological (Ref. 21). Compliance with the NESHAP dose standards (10 mrem per year) is documented in the SRS Radioactive Air Emission Annual Report.

7.7.2.4 <u>Radiological Environmental Surveillance</u>

DOE Order 5400.5 mandates the establishment of and presents the general requirements for an environmental surveillance program at DOE sites (Ref. 1, 20, 24). Further specific program elements are detailed in DOE/EH 0173T (Ref. 25).

Other regulations impact the implementation and conduct of portions of the radiological surveillance program. These include EPA's Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation, and Liability Act, which describe requirements for environmental surveillance samples to be used for waste site characterization studies (Ref. 27).

7.7.3 ASSOCIATED RECORDS/REPORTS

Records generated as part of the radiological control monitoring program are maintained in accordance with procedures and the department Records Inventory and Disposition Schedule (RIDS) (Ref. 3, 9).

7.7.4 METEOROLOGICAL DATA COLLECTION/EVALUATION

The facility-specific SARs/DSAs contain information on the location of weather monitoring stations, instrumentation and alarms, and equipment surveillance. Chapter 1 of this Manual provides additional information on site characteristics.

7.8 RADIOLOGICAL PROTECTION INSTRUMENTATION

7.8.1 CRITERIA FOR SELECTION OF EQUIPMENT AND INSTRUMENTATION

The criteria for selection, examination, and testing of radiological protection equipment and instrumentation are discussed in WSRC Information Manuals and WSRC Procedure Manual Q3 (Ref. 17, 26, 28). See the facility-specific SARs/DSAs for a summary, which will include selection and placement criteria for technical equipment and instrumentation, types of detectors and monitors, and their quantity, sensitivity, and range.

Fixed instruments, such as ARMs and CAMs, are required by 10 CFR 835 to characterize the workplace (Ref. 15). All records applicable to the purchased RC instruments are retained in project files, purchase requisition files, and/or instrument evaluation files of RPS.

7.8.2 CONTROL OF THE CALIBRATION PROCESS

Calibrations must use National Institute of Standards and Technology (NIST) traceable standards. Calibration procedures are developed by RPS for each radiological instrument type and include frequency of calibration, precalibration requirements, primary calibration requirements, periodic performance test requirements, calibration record requirements, and maintenance requirements. The radiological protection S/RID mandates the requirements for radiological instrumentation calibration (Ref. 1). Details pertaining to the control and calibration of radiation monitoring equipment are provided in the WSRC Procedure Manual Q3 (Ref. 28).

In unusual and limited situations, it may be necessary to use an instrument under conditions that vary significantly from those for which the instrument is designed. Special calibrations are performed for use of instrumentation outside manufacturer's specifications. The instruments are adjusted, calibrated, and labeled to identify the special conditions and used only under the special conditions for which it was calibrated. These special conditions are discussed in WSRC Procedure Manual 5Q (Ref. 5).

A program for preventive and corrective maintenance of radiological instrumentation has been established and documented. Preventive and corrective maintenance is performed using components and procedural recommendations at least as stringent as those specified by the instrument's manufacturer. Radiological instruments undergo calibration prior to use following any preventive or corrective maintenance or any adjustment that voids the previous calibration.

7.9 RADIOLOGICAL PROTECTION RECORD KEEPING

WSRC Procedure Manual 5Q and WSRC Procedure Manual Q1-1 contain the prescribed practices for preparing and retaining radiologically related records (Ref. 3, 5). These records provide employees and management with knowledge of radiological exposures and are needed to demonstrate the effectiveness of the overall program. Where radiological services (e.g., dosimetry and laboratory analyses) are purchased, an agreement is required regarding creation and disposition of records in accordance with WSRC Procedure Manual 1B and WSRC Procedure Manual 1Q (Ref. 29, 30). Records are handled such that personal privacy is protected (Ref. 5).

The site Radiation Protection Program is primarily documented in RPS manuals and procedures. WSRC Procedure Manual Q1-1 establishes the responsibilities and requirements for preparation, review, approval, revision, cancellation, and administration of RPS procedures (Ref. 3). In addition, all RPS procedures are formally reviewed in their entirety at least every 5 years. RPS procedures are reviewed during each use and updated as necessary. WSRC Procedure Manual Q1-1 also prescribes the responsibilities and requirements for controlled revisions to WSRC Procedure Manual 5Q. Records are maintained in accordance with Manual 1B, MRP 3.31 or Manual 1Q, MRP 17-1.

7.10 OCCUPATIONAL RADIATION EXPOSURE

The facility-specific SARs/DSAs provide a summary of projected annual exposures to facility workers from radiological hazards based on historical facility or related operations data. Identification of the methods used in the projected exposures and a comparison of the projected exposures with allowable limits are also included. See Section 7.6.3.5 for information on radiation exposure reports and records.

7.11 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then, the user will default to the Site Program Manuals.

1. Standards/Requirements Identification Document Integrated Safety Management System Description. WSRC-RP-94-1268, Westinghouse Savannah River Company, Aiken, SC.

2. Compliance Assurance Manual. WSRC Procedure Manual 8B, Westinghouse Savannah River Company, Aiken, SC.

3. Safety and Health (S&H) Administrative Procedures Manual. WSRC Procedure Manual Q1-1, Westinghouse Savannah River Company, Aiken, SC.

4. Savannah River Site ALARA Manual. WSRC-SCD-6, Westinghouse Savannah River Company, Aiken, SC.

5. Radiological Control Manual. WSRC Procedure Manual 5Q, Westinghouse Savannah River Company, Aiken, SC.

6. WSRC Procedure Manual 2S, Control of Operations. Procedure 5.1, "Facility Operations Organization and Administration," Westinghouse Savannah River Company, Aiken, SC.

7. Management Policies. WSRC 1-01, Rev. 90 Westinghouse Savannah River Company, Aiken, SC, March 2000.

8. Safety and Health Radiation and Contamination Control Procedures. WSRC Procedure Manual 5Q1.1, Westinghouse Savannah River Company, Aiken, SC.

9. Safety and Health Department Radiation Monitoring Procedures. WSRC Procedure Manual 5Q1.2, Westinghouse Savannah River Company, Aiken, SC.

10. Savannah River Site External Dosimetry Technical Basis Manual. WSRC-IM-92-101, Westinghouse Savannah River Company, Aiken, SC.

11. The Savannah River Site (SRS) Criticality Dosimetry Technical Basis Manual. WSRC-IM-96-145, Westinghouse Savannah River Company, Aiken, SC.

12. Savannah River Site Internal Dosimetry Technical Basis Manual. WSRC-IM-90-139, Westinghouse Savannah River Company, Aiken, SC.

13. Radiological Control and Health Physics External Dosimetry Procedures. WSRC Procedure Manual 5Q2.1, Westinghouse Savannah River Company, Aiken, SC.

14. Health Protection Department Internal Dose Evaluation Procedures. WSRC Procedure Manual 5Q2.6, Westinghouse Savannah River Company, Aiken, SC.

15. Occupational Radiation Protection. Code of Federal Regulations, 10 CFR 835, Office of the Federal Register, Washington, DC.

16. Safety and Health Radiation and Air Monitoring Systems Procedures. WSRC Procedure Manual 5Q1.7, Westinghouse Savannah River Company, Aiken, SC.

17. Radiation Monitoring Equipment Technical Basis Manual. WSRC-IM-2001-00001, Westinghouse Savannah River Company, Aiken, SC.

18. Industrial Hygiene Manual. WSRC Procedure Manual 4Q, Westinghouse Savannah River Company, Aiken, SC.

19. SRS EM Program. WSRC 3Q1-2, Volume 1, Section 1100, Westinghouse Savannah River Company, Aiken, SC.

20. Radiation Protection of the Public and the Environment. DOE Order 5400.5, U.S. Department of Energy, Washington, DC.

21. National Emission Standard for Hazardous Air Pollutants (NESHAP). Code of Federal Regulations, 40 CFR 61.90, Office of the Federal Register, Washington, DC.

22. Environmental Compliance Manual. WSRC Procedure Manual 3Q, Westinghouse Savannah River Company, Aiken, SC.

23. SRS Environmental Monitoring Plan, WSRC-3Q1-2, Volume 1, Section 1000, Westinghouse Savannah River Company.

24. General Environmental Protection Program. DOE Order 5400.1, Change Notice 1, U.S. Department of Energy, Washington, DC.

25. Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance. DOE/EH-0173T, Department of Energy, Washington, DC.

26. Portable Radiation Monitoring Equipment Technical Basis Manual. WSRC-IM-2000-00001, Westinghouse Savannah River Company, Aiken, SC.

27. Comprehensive Environmental Response, Compensation, and Liability Act. EPA CERCLA, 42 U.S. Code. 9601 et seq., Environmental Protection Agency, Washington, DC.

28. HP Instrument Calibration Facility Procedures, Q3, Westinghouse Savannah River Company, Aiken, SC.

29. Quality Assurance Manual. WSRC Procedure Manual 1Q, Westinghouse Savannah River Company, Aiken, SC.

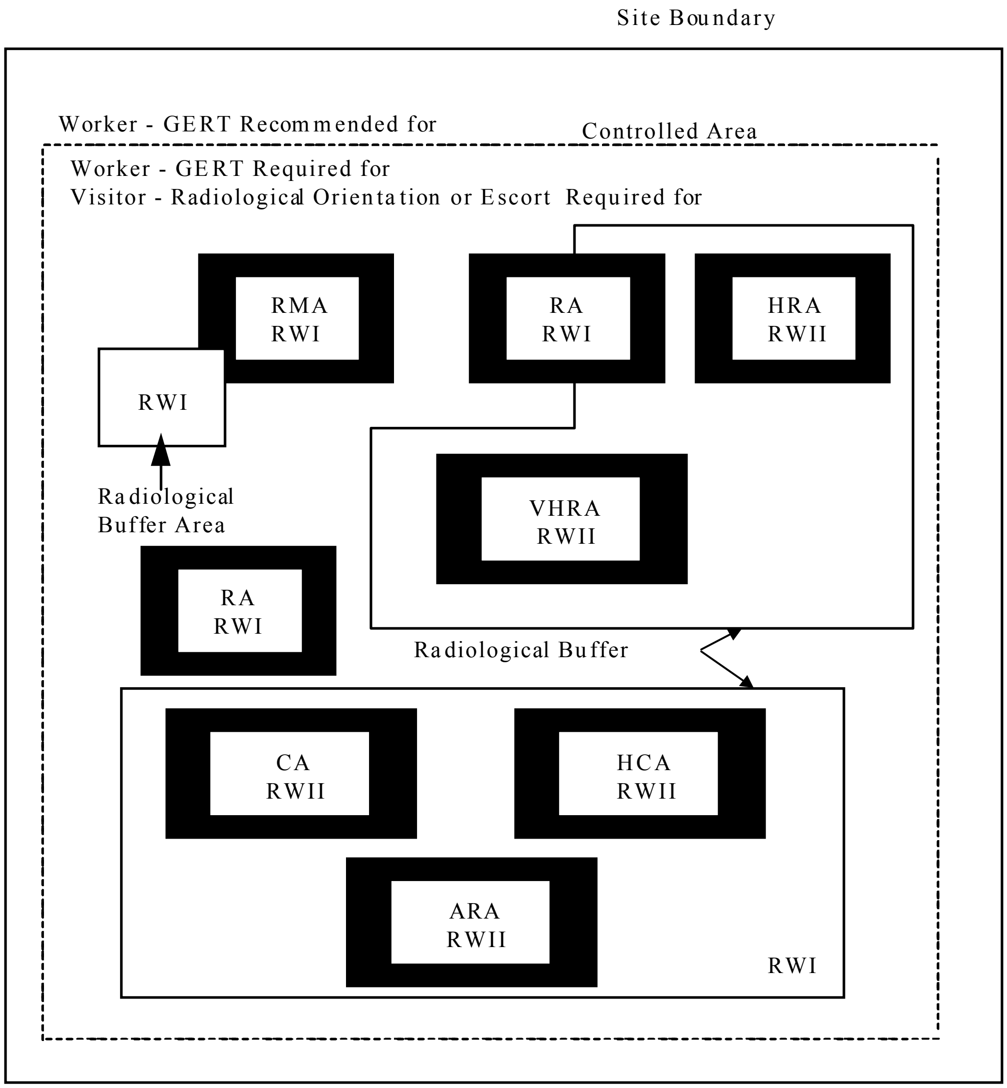
30. WSRC Management Requirements and Procedures. WSRC Procedure Manual 1B, Westinghouse Savannah River Company, Aiken, SC.

31. DOE Order 231.1, Chapter 2, Radiation Protection for Occupational Workers.

32. The Savannah River Site Workplace Air Monitoring Technical Basis Manual (U), WSRC-IM-2001-00025, WSRC, Aiken, SC.

7.12 FIGURES

Figure 7.12-1 Typical Control Areas and Required Training



Legend:

GERT - General Employee Radiological Training

RWI - Radiological Worker I

RWII - Radiological Worker II

RMA - Radioactive Material Area

RA - Radiation Area

HRA - High Radiation Area

VHRA - Very High Radiation Area

CA - Contamination Area

HCA - High Contamination Area

ARA - Airborne Radioactivity Area

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DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

Formerly the
GENERIC SAFETY ANALYSIS REPORT

CHAPTER 8

HAZARDOUS MATERIAL PROTECTION

January 2007

Washington Savannah River Company
Aiken, SC 29803

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

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ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-Containing Material
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
CCMC	Chemical Management Center
CFR	Code of Federal Regulations
CPC	Chemical Protective Clothing
DOE	Department of Energy
DSA	Documented Safety Analysis
ELSA	Emergency Life Support Apparatus
ESH&QA	Environment, Safety, Health, and Quality Assurance
IH	Industrial Hygiene
MRP	Management Requirement and Procedure
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
QA	Quality Assurance
QAP	Quality Assurance Procedure
RC	Radiological Control
REF	Respiratory Equipment Facility
RPD	Radiological Protection Department
S&HP	Safety and Health Programs
S&HD	Safety and Health Department
SAR	Safety Analysis Report
SCBA	Self-Contained Breathing Apparatus
S/RID	Standards/Requirements Identification Document
SRS	Savannah River Site
USQ	Unreviewed Safety Question
WSRC	Washington Savannah River Company

8.0 HAZARDOUS MATERIAL PROTECTION

8.1 INTRODUCTION

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

8.1.1 OBJECTIVE

The purpose of this chapter of the Safety Analysis Report (SAR) for Department of Energy (DOE) nuclear facilities and operations at the Savannah River Site (SRS) is to provide information that satisfies DOE-STD-3009-94 (Ref. 1). Also, this chapter will describe the essential features of the Hazardous Material Protection Program as it relates to facility safety. The requirements of this paragraph pertain to nonradioactive hazardous material protection.).

8.1.2 SCOPE

This chapter describes the hazardous material protection provisions for SRS workers, and the public. The chapter summarizes the hazardous material concerns from the hazard analysis in Chapter 3 of this Manual, and describes the relationship to other SAR/DSA chapters that contain requested information. The products of this chapter are as follows (Ref. 1):

- An overall description of the hazardous material protection policy and program
- A summary of design and administrative controls used by the hazardous material protection program
- Information, as appropriate, on equipment and controls supporting hazardous material protection

When required information is provided in another chapter of this Manual, that chapter is referenced to limit repetition. The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

8.2 REQUIREMENTS

The Washington Savannah River Company (WSRC) Industrial Hygiene (IH) program is designed to comply with various requirements. These requirements form part of the safety basis of each SRS facility that is required to implement the site IH program. The implementing procedure manual for Standards/Requirements Identification Document (S/RID) industrial hygiene requirements is WSRC-4Q (Ref. 2). Any changes to this manual are reviewed for continued compliance with S/RID requirements per Procedure Manual 8B and MRP 3.26 (Ref. 3). Standards/Requirements Identification Documents (S/RIDs) state the codes, standards, and regulations governing the management, organization, and institutional safety provisions, policies and program elements for the SRS (Ref. 4).

8.3 HAZARDOUS MATERIAL PROTECTION AND ORGANIZATION

WSRC is committed to providing a place and condition of employment that is free from or protected against, recognized hazards that cause, or are likely to cause, sickness, impaired health and well-being, or significant discomfort and inefficiency among workers. This occupational health objective is achieved through a professional, comprehensive IH program based on management commitment and employee involvement, worksite analysis, hazard identification, hazard prevention and control, and safety and health training (Ref. 5).

The organizational elements and associated responsibilities outlined in this section provide the framework by which the site IH policy is implemented. This section is not intended to list all the organizational elements involved in implementing the site IH policy, but to list the major elements that ensures its implementation. Additional elements are indicated in later sections of this chapter. For example, the facility industrial hygienist is responsible for completing the baseline hazard assessment (see Section 8.6.1.1) prior to the startup of a new facility.

8.3.1 OVERALL ORGANIZATION

IH programmatic functions are managed by the Industrial Hygiene Services Section (IHSS) within the Environment, Safety and Health Services Department. Safety and Health Programs (S&HP) Safety and Health Department (S&HD), and IH field activities are managed by the S&HD. Organizational responsibilities are discussed in the WSRC 1-01 Manual (Ref. 5). Staffing levels in the facility are addressed in the facility-specific SAR.

8.4 AS LOW AS REASONABLY ACHIEVABLE (ALARA) POLICY AND PROGRAM

The As Low As Reasonably Achievable (ALARA) concepts are integrated into the WSRC IH program, as it relates to known or potential occupational carcinogens. The purpose of the program is to prevent occupationally induced cancer cases illnesses and preserve the health of SRS employees while striving to achieve compliance beyond what is required by DOE Orders and DOE-prescribed Occupational Safety and Health (OSH) standards. This section describes the following aspects of the SRS IH program:

- SRS IH policy
- Program objective
- Program elements
- Program implementation
- Program implementation oversight
- Special program requirements

8.4.1 INDUSTRIAL HYGIENE POLICY

The WSRC policy on IH, which includes hazardous material protection, consists of the following statements (Ref. 2):

- WSRC provides a place and condition of employment that is free from or protected against recognized hazards that cause, or are likely to cause, sickness, impaired health and well-being, or significant discomfort and inefficiency among workers.
- This occupational health objective will be achieved through a professional, comprehensive IH program based on management commitment and employee involvement, worksite analysis, hazard identification, hazard prevention and control, and safety and health training.
- The IH program complies with applicable DOE Orders and DOE-prescribed OSH standards as well as 10 CFR 851. The IH program is directed and implemented by qualified personnel who coordinate IH program elements with other organizations as a component of the OSH program.

8.4.2 INDUSTRIAL HYGIENE PROGRAM

8.4.2.1 Program Objective

The site IH program, which includes hazardous material protection, is implemented through WSRC Procedure Manual 4Q (Ref. 2). The WSRC Procedure Manual 4Q satisfies the program requirements in the DOE Order 440.1A (Ref. 6). The IH program exemplifies management's commitment to the overall site OSH program by establishing essential program elements to address identification, evaluation, and control of chemical, physical, and biological hazards within the workplace.

8.4.2.2 Program Elements

The WSRC Procedure Manual 4Q provides comprehensive direction for the six IH program elements described in this chapter as follows (Ref. 2):

- Hazard assessment
- Hazard prevention and control
- Training
- Self-assessments
- Record keeping
- Special DOE/Occupational Safety and Health Act (OSHA) control programs

These program elements, as well as occupational medical programs and occupational chemical exposures monitoring, are described in the latter sections of this chapter. The IH program complies with the occupational safety and health standards in 29 Code of Federal Regulations (CFR) 1910 and 29 CFR 1926 (Ref. 7).

8.4.2.3 Program Implementation

The IH program is implemented through the WSRC Procedure Manual 4Q (Ref. 2).

8.4.2.4 Special Program Requirements

The ALARA concepts are integrated into the WSRC IH program, as it relates to known or potential occupational carcinogens. The purpose of the program is to prevent occupational illnesses and preserve the health of SRS employees. WSRC implements DOE/OSHA special control programs to maintain occupational exposures ALARA in accordance with specific regulatory programs (DOE Beryllium Rule) or applicable unique OSHA standards (asbestos, lead, benzene, etc.). These programs include, but are not limited to, the activities defined in Ref. 2.

Hazardous material exposure control is addressed in Section 8.6.

The chemical control program provides requirements for control of hazardous chemicals in the workplace and includes the program elements, which are established in WSRC Procedure Manuals 4Q, 7B, 8Q, and 13B (Ref. 2, 8, 9, 10):

The asbestos control program provides requirements for identification, surveillance, and control of work-related exposures to asbestos or Asbestos-Containing Materials (ACMs) in order to meet the intent of 10 CFR 851, DOE Order 440.1A and the following requirements in the CFR: 29 CFR 1910.1001, 29 CFR 1926.1101, and 40 CFR 61, Subpart M. The requirements ensure that SRS work operations involving asbestos or ACM are conducted in such a manner that personnel receive an adequate level of protection and that regulatory requirements are met. Environmental Protection Department develops, implements, and maintains an asbestos program. (Ref. 6, 7, 11):

The IH program establishes operating requirements for laboratory and radiological bench hoods and local exhaust systems used in controlling the emission of nonradiological particulates, gases, vapors, mists, and fumes in the breathing zone of employees. (Ref. 2):

Where feasible, engineering controls are the primary method used to minimize worker exposure and to prevent releases into the work environment (Ref. 2).

8.5 HAZARDOUS MATERIAL TRAINING

The WSRC IH training criteria, found in 4Q Manual, Procedure 1001, Training and Documentation, which include hazardous material protection training, specify IH training requirements for WSRC personnel and subcontractors.

This section describes the training requirements and guidelines established by the IH program for this category.

On-shift training, equipment, and systems status are covered in Chapter 11 of this document. Chapter 12 of this document describes the development, maintenance, and modification of site training programs.

The training of personnel on the configuration of equipment used to store, handle, transport, or process hazardous material, and the training of personnel in the use of up-to-date drawings and other documentation of system design and operation depend on the facility. The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

Training records satisfy the requirements relating to records management procedures described in Section 8.9.

8.5.1 INDUSTRIAL HYGIENE TRAINING

It is WSRC policy to inform its employees and the employees of other groups at SRS of known and potential health hazards encountered in the workplace and the appropriate protective measures to control these hazards. The basic guideline is to inform each employee who has a reasonable potential for exposure of the potential health effects of the hazard, the content of applicable standards and procedures, and the required control measures (i.e., engineering controls, administrative procedures, and/or personnel protective equipment). All training and dissemination of information is, therefore, commensurate with duties, workplace assignment, and responsibilities of employees.

8.5.1.1 General Requirements

Each employee having an exposure potential to a toxic chemical or harmful physical agent receives instruction on operations that may lead to exposure, the potential health effects of the hazard, the content of applicable standards or procedures, and required control measures (i.e., engineering controls, administrative controls, and/or protective equipment). Training and information dissemination are commensurate with the duties, workplace assignment, and responsibilities of the employee. All topics are not required to be addressed with every employee. When the potential for exposure is low, training may not be warranted (Ref. 2).

Each WSRC organization is responsible for ensuring the appropriate training of its employees and its non-WSRC employees, subcontractors, and visitors.

8.5.1.2 Training Frequencies

Training and retraining frequencies are listed in WSRC Procedure Manual 4Q. Area-specific training for new or transferred employees is provided at their initial assignment to any department (Ref. 2, 12).

8.5.1.3 Training Topics

The following site-level training topics, for affected employees, associated with hazardous material protection are presented at SRS in the courses/formats indicated (Ref. 2):

- Respiratory protection: Section 8.6.4 of this document addresses respiratory protection training and the associated training courses.
- Employee medical monitoring and medical exposure records: The consolidated annual training conducted for all site personnel provides a review of DOE policy concerning employee monitoring consistent with the requirements of 10 CFR 851 DOE Order 440.1A and OSHA 29 CFR 1910.20 (Ref. 7, 8).
- Hazard communication: Section 8.10 addresses hazard communication and the associated training courses (Ref. 10).
- Carcinogenic hazards: Area-specific training is provided for each chemical present in the workplace, and to which employees are potentially exposed, that is identified as a potential carcinogenic, reproductive, or developmental hazard (Ref. 2).
- Asbestos control: Asbestos control training is provided for SRS employees who may be required to conduct activities that can cause an exposure to ACMs.
- Lead: Lead training is provided for employees who may be required to conduct activities that can cause an exposure to lead.
- Hearing conservation training is provided periodically for all employees who wear hearing protection in performance of their normal work activities. It is also provided as one time training prior to initial use of hearing protection devices.
- Thermal stress training is provided for employees and their supervision who perform work outdoors, near heat sources, or in indoor non-air conditioned areas.

8.6 HAZARDOUS MATERIAL EXPOSURE CONTROL

8.6.1 HAZARDOUS MATERIAL IDENTIFICATION PROGRAM

This section addresses the hazardous material identification program, referred to as the hazard assessment program, within the WSRC IH program. The information includes descriptions of the methods used for identifying and evaluating health and chemical hazards and for determining the adequacy of and the need for hazard prevention or control measures (Ref. 2).

Prior to the construction of a new facility or modification of an existing facility, hazard prevention and control measures are identified and specified during the design review process. For operating facilities, the adequacy of existing hazard prevention and control measures and/or the need for additional measures is determined during the periodic hazard assessments described in this section (Ref. 2). Additional information concerning hazard prevention and control measures is provided in Section 8.10.

Chemical hazards resulting from postulated accidents such as fires and explosions are identified and quantified in the hazard and accident analyses presented in Chapter 3 of the facility-specific SAR/DSA.

8.6.1.1 Hazard Assessment Program

The IH program establishes the requirements for performing and documenting periodic hazard assessments to anticipate, recognize, evaluate, and control occupational health and chemical hazards as required by DOE Orders and DOE-prescribed OSH standards. The following sections describe the guidance and requirements provided for hazard assessments.

OVERVIEW

The occupational health hazard assessment program consists of worker and workplace surveillance activities that include baseline hazard assessments for new facilities, workplace surveys (surveillances), and periodic workplace assessments. Workplaces are surveyed to identify potential occupational exposures, investigated to establish workplace exposure profiles, and periodically assessed for changes to operations, engineering controls, and/or work practices. An industrial hygienist from the Industrial Hygiene Services Staff conducts or directs hazard assessments and routine surveillance activities (Ref. 2).

The Medical Department simultaneously monitors the health of exposed workers while conducting occupational health examinations that include worker medical histories, biological screenings, and physical examinations. The occupational medical program is described in Section 8.6.3.

BASELINE HAZARD ASSESSMENTS

The initial comprehensive baseline hazard assessment for facilities at SRS is completed by an industrial hygienist. New facilities or equipment are required to have baseline hazard assessments completed prior to operational startup. Once evaluated, no further scheduled reassessments are required prioritized based upon ranking criteria or at such time that until changes or modifications have are to occur red (Ref. 2).

The industrial hygienist completes a baseline hazard assessment by preparing an initial inventory of the occupational hazards within the facility, completing a facility walkthrough survey, and determining the need for additional IH surveys (Ref. 2).

Quantitative Assessment

The industrial hygienist conducts quantitative assessments to document potential health risk under workplace conditions that will require continuing surveillance. Any agent determined to pose a potential health risk will be further evaluated using quantitative exposure monitoring. Exposures are quantified in accordance with WSRC Procedure Manuals 4Q1.1 and 4Q1.2 (Ref. 13, 14).

Medical Surveillance

Based on the results of quantitative exposure monitoring or as required by regulatory requirements, an employee may be placed in the Medical Surveillance Program (Ref. 2).

WORKPLACE SURVEYS

SRS operations involve a wide range of tasks, materials, equipment, and facilities. As a result, the site IH program establishes a generalized process for performing surveillance activities with the primary objective being to determine whether or not occupational exposures pose a potential health risk (Ref. 2).

8.6.2 EXPOSURE CONTROL ADMINISTRATIVE LIMITS

Exposure limits are promulgated by OSHA and the American Conference of Governmental Industrial Hygienists. The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

8.6.3 OCCUPATIONAL MEDICAL PROGRAMS

This section describes the WSRC occupational medical program at SRS, especially as it relates to hazardous material protection (Ref. 4).

8.6.3.1 Site Medical Policy

The WSRC policy on medical programs states that WSRC shall implement an employee medical program in compliance with DOE requirements, and applicable federal and state regulations. Additionally, it is WSRC policy to provide a quality occupational health program that promotes the physical and mental well-being of SRS workers as well as affiliate work force (WSI, BSRI, BNFLSRC, BWSRC and DOE) while maintaining medical information in a confidential, ethical, and legal manner (Ref. 6).

The WSRC medical program satisfies the following requirements (Ref. 6):

- Assist site management in protecting employees from health hazards in their work environment
- Assist site management in ensuring the placement of employees in work that they can perform without undue hazards to themselves, their fellow workers, plant facilities, the plant site and general environments, and the public consistent with the requirements of the Americans with Disabilities Act of 1990
- Provide continuing medical surveillance of employees, job tasks, and work environments
- Ensure the early detection, treatment, and rehabilitation of ill or injured employees
- Apply preventive medical measures toward the maintenance of good physical and mental health of employees
- Encourage employees to maintain their physical and mental health, and educate employees in health and safety by providing them with professional guidance and counseling
- Contribute to the maintenance of good employee health through the application of preventive medical measures, such as immunizations, substance abuse programs, health counseling, wellness program, and proper prescription safety eye wear
- Provide professional guidance and consultation to contractor management on all health related issues
- Provide support to contractor management in the medical, mental, and substance abuse aspects of personnel reliability and fitness for duty
- Protect the privacy of employees and the confidentiality of their medical records

- Manage the substance abuse and rehabilitation programs of site employees in accordance with site and department policies and procedures

- Maintain a Medical Information System to meet growing surveillance and epidemiological needs

8.6.4 RESPIRATORY PROTECTION

It is WSRC policy to protect employees from exposure to atmospheric contaminants (radioactive or nonradioactive) by using facilities and equipment with engineering controls incorporated into their design. When effective engineering controls are not feasible, or while they are being initiated, protection is provided through the use of approved respirators.

DOE Order 440.1A 10 CFR 851 specifies adherence to ANSI standard Z88.2 and 29 CFR 1910.134, which requires that the responsibility and authority for the respirator program be assigned to a single person (Ref. 6, 7). The Respirator Protection Program Administrator is designated by the S&HD Manager and has overall responsibility and authority for the respiratory protection program (Ref. 14). An evaluation of the program is performed annually periodically (Ref. 6).

8.6.4.1 <u>Selection of Respiratory Protection Equipment</u>

The site Respiratory Equipment Facility (REF) provides many types of respirators for the protection of employees. Adequate protection for the user is available only if the proper respirator (and cartridge combination for air-purifying respirators) is used. The IH staff has the responsibility for assessing nonradiological hazards and specifying the respiratory device needed. Radiological Control (RC) has responsibility for assessing radiological hazards and specifying protective clothing and respirators respirator protections. S&HD HIS is responsible for oversight and maintenance of the program.

At SRS, WSRC uses the various types of respirators, all of which are approved by the National Institute for Occupational Safety and Health, or DOE (Ref. 7):

- Negative-pressure, air-purifying respirators (half mask and full-facepiece)

- Powered, air-purifying respirators

- Full-facepiece, airline respirators

- Abrasive blasting hoods

- Plastic hood airline respirators

- Plastic suit airline respirators
- Self-Contained Breathing Apparatus (SCBA)
- Combination airline-type respirator and SCBA
- Escape-only respirators

8.6.4.2 Inspection of Equipment

Respiratory protection equipment must be inspected regularly to ensure that the equipment functions properly when worn. Individuals performing inspections are trained to have a thorough knowledge of respirator operation and inspection procedures.

Routine-use respirators must be inspected prior to before, and after each use. The inspection made before each use is performed by the wearer; subsequently an inspection is made after each device is laundered and during its' reassembly is performed at the REF.

The individual facilities are responsible for inspecting emergency-use respirators in their possession in accordance with site procedures (Ref. 14).

8.6.4.3 Cleaning, Repair, and Maintenance

Replacement of parts or repairs must be done only by properly trained persons in the REF. Replacement parts must be only those designated for the specific respirator being repaired.

The REF assembles, tests, inspects, and maintains respirator facepieces, plastic hoods, airline respirators and plastic suits. HEPA P100 filter cartridges are leak-tested prior to initial use and prior to reuse. New P100 cartridges are leak-tested based upon ANSI / ASQC Z1.4, Sampling Procedures &Tables for Inspection by Attributes. They P100 cartridges are only reused if they are not contaminated and they pass efficiency, flow the leak and resistance testing. SCBAs, excluding facepieces, and escape-only respirators are maintained through Central Services Works Engineering.

Radioactively contaminated respirators must be disposed of in accordance with RC operations guidelines, if unable to they cannot be decontaminated. RC monitors respirators used in radiological controlled areas prior to shipment to the laundry facility.

8.6.4.4 Control, Issuance and Use of Respirators

If respiratory protection is required to perform a task, the user must reference the applicable work permit, or procedure, and present his/her Respirator Qualification Card to a facility respirator issuer. The respirator issuer will issue only the equipment specified on the applicable permit, or procedure after verifying that the user has current medical qualifications, training, and appropriate fit-testing, where applicable. Upon issuing a respirator, the issuer must complete an entry on the Respiratory Protection Equipment Log Sheet.

If a respirator becomes contaminated during the shift, it should be replaced with a clean device. Respirators may be used repeatedly during a single shift by an individual in an approved location, provided they are kept free of contamination and approved by Radiological Controls (RC) RPD. Air purifying respirators and abrasive blasting hoods may be used by the same person for up to one week with RPD Industrial Hygiene and or RC approval. To ensure cleanliness, reused respirators must be identified with the user's name, date, shift/time, and placed in a clean closed container for temporary storage in an approved storage location.

Employees must guard against damage to assigned respirators. Employees must report any respirator malfunction to their supervisor, who in turn ensures that the REF Manager and RPPA are notified (Ref. 15).

8.6.4.5 Training

Wearers of respirators must receive training relating to the application and use of these devices and to the hazards associated with airborne contaminants. Respirator wearers users are required to pass the General Respiratory Protection course prior to attending respirator-specific training. Retraining for all types of respirators is conducted in accordance with site procedures.

Supervisors who either use respirators, or supervise personnel, who use respirators, must complete the General Respiratory Protection course offered by site training and be retrained every 12 months (Ref. 15). Supervisors must complete respirator-specific course(s) for those devices their workers wear. Retraining is conducted in accordance with site procedures.

IH staff receive orientation if necessary in the selection of respiratory protection.trains its technicians in the selection of respiratory protection. RPD RC trains its supervisors in the selection of respiratory protection. Respiratory protection equipment issuers are trained by Site Training in the proper method of storing, handling, and issuing respirators. In each case, periodic retraining is conducted (Ref. 15).

8.6.4.6 Fit and Medical Testing

Since a given respirator will not fit all employees, devices from several manufacturers in several sizes must be available, so employees may be fitted with the device that provides the best fit. Employees must be clean shaven in respirator seal areas before a fit test will be given. Employees must be given medical clearance for respirator use and receive training, before they are given fit tests (Ref. 15). Fit tests are repeated annually. with the exception of fit tests for asbestos, lead and arsenic, which are repeated semi-annually. Special fit test protocols are required for asbestos, benzene, and lead in accordance with 29 CFR 1910 and 29CFR 1926 (Ref. 7). Each employee's fit test results are filed by the S&HD Infrastructure and Services (I&S) Department. A respirator qualification card is completed and given to the employee as a personal record of their quantitative test fitting (Ref. 15).

8.6.4.7 Associated Records

Records generated as part of the Respiratory Protection Program, such as fit testing results, training, log sheets, and tags, are maintained in accordance with procedures and the department Records Inventory and Disposition Schedule (Ref. 4d, 7, 15).

8.7 HAZARDOUS MATERIAL MONITORING

This section describes the hazardous material monitoring and controls programs conducted inside, and outside, the boundaries of the facility (Ref. 4). Records associated with the hazardous material monitoring and control programs satisfy the requirements relating to records management listed in Section 8.9.

8.7.1 HAZARDOUS MATERIAL MONITORING

Air monitoring for determining chemical exposures of facility personnel is addressed in Section 8.7.2. Medical Department responsibilities concerning hazardous material monitoring are listed in Section 8.6.3. The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

8.7.2 AIR MONITORING

This section describes the airborne hazardous material sampling and monitoring programs conducted inside and outside the boundaries of the facility (Ref. 4). Section 8.7.2.1 describes the program for air monitoring in the workplace. Section 8.7.2.2 describes the program for air monitoring outside of the facility.

8.7.2.1 Air Monitoring in the Workplace

The WSRC IH program specifies general requirements for workplace air sampling and data analysis. (Ref. 6, 14) The specified requirements ensure that the information necessary to characterize potential personnel exposure to airborne hazardous materials is generated. Samples must be representative of the conditions to which the employee is normally exposed. The IH field office completes the appropriate IH data form for each sample. The statistical parameters are completed by IH as necessary (Ref. 2).

The facility-specific SAR addresses the following items related to air monitoring in the workplace (Ref. 1):

- Equipment selection, location, and surveillance requirements
- Instrumentation
- Alarms
- Records and reports generated by these programs

8.7.2.2 Air Monitoring Outside of the Facility

This section provides the following information concerning the airborne hazardous material sampling and monitoring programs conducted outside the boundaries of the facility (Ref. 1):

- Equipment selection, location, and surveillance requirements
- Instrumentation
- Alarms
- Records and reports generated by these programs
- Any programs for continuing meteorological data collection and the rationale for the programs

This information is provided by either the IH elements in the 4Q (Ref. 2) or is noted in the facility-specific SA/DSA. Chapter 1 of this Manual describes site meteorology.

8.7.3 HAZARD PREVENTION AND CONTROL

The WSRC IH program establishes guidance for identifying and recommending effective engineering, work practice, and administrative controls to reduce employee exposure to occupational hazards (Ref. 6). This hazard prevention and control process is associated with the hazard assessment process described in Section 8.6.1.1.

The following sections describe the guidance and requirements provided for the control of hazardous materials in the workplace. The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

8.7.3.1 Hierarchy of Hazard Prevention and Control Measures

WSRC achieves regulatory compliance with DOE Orders and DOE-prescribed OSH standards for controlling occupational exposures to specific chemical, physical, and/or biological hazards by using hierarchy of hazard prevention and control measures (Ref. 5):

Built-in protection, inherent in the design of a process, is preferable to a method that depends on continued employee implementation or intervention. Facility management must provide justification to the IH Services Section Department when personal protective equipment is chosen for protecting employees from occupational hazards in lieu of feasible engineering or work practice control measures (Ref. 6).

Personal protective equipment used onsite includes both respirators and Chemical Protective Clothing (CPC). Respirators provide protection from airborne contaminants, both radioactive and nonradioactive, and are used under the conditions specified for respirator protection in Section 8.6.4. CPC provides protection from chemicals that present a skin-contact hazard and is worn whenever the potential exists for contact with corrosive or toxic materials or for contact with materials of unknown toxicity (Ref. 16).

8.7.3.2 <u>Hazard Prevention and Control Measures for New Facilities</u>

The design authority technical engineer for a proposed facility is required to transmit project designs to IH for review prior to facility construction. IH reviews facility project designs to ensure that engineering controls have been integrated into the design of equipment or processes associated with the use or presence of chemical, physical, or biological hazards (Ref. 6).

8.7.3.3 <u>Hazard Prevention and Control Measures for Existing Facilities</u>

The design authority technical engineer is required to transmit project designs to the IH for review prior to construction. IH reviews the project designs to ensure that engineering controls have been addressed and potential health hazards have been accounted for. The project review includes an examination of chemical, physical, biological, or ergonomic hazards with respect to specific equipment or processes undergoing modification (Ref. 5).

8.7.3.4 <u>Engineering Control Design Projects</u>

IH staff provides recommended engineering controls for design projects. Recommendations must be accepted or alternatively dispositioned, with concurrence from the IH staff (Ref. 6).

8.8 HAZARDOUS MATERIAL PROTECTION INSTRUMENTATION

The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

- The types and quantities of detectors and monitoring equipment
- The sensitivity and range of the equipment
- The calibration methods and frequencies for the equipment
- Hazardous material surveys, sampling, area monitoring, and personnel monitoring during normal operations and accidents
- The plans and procedures for control and QA of the calibration and maintenance processes

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8.9 HAZARDOUS MATERIAL PROTECTION RECORDKEEPING

This section addresses the records requirements of the WSRC IH program at SRS (Ref. 4).

8.9.1 RECORDS CONTENT AND ACCESSIBILITY

WSRC maintains the following records to support health surveillance activities (Ref. 6):

- Hazard assessment reports
- Exposure monitoring data
- Survey reports
- Fit testing records reports

This information is included, as required, as part of the hazard assessment and control records addressed in Section 8.6.4.7. IH records comply with the OSH standards in 29 CFR 1910 (Ref. 8).

8.9.2 CONTROLLING INVENTORY, RETENTION, AND DISPOSITION OF RECORDS AND REPORTS

Management Requirement and Procedure (MRP) 3.31, "Records Management," establishes responsibilities and requirements for WSRC compliance with DOE requirements relating to records management. Quality Assurance Procedure (QAP) 17 1, "Quality Assurance Records Management," establishes responsibilities and requirements for generation, identification, validation, receipt, indexing, storage, preservation, retrieval, correction, and disposition of documents designated as QA records. Records associated with the IH program satisfy the requirements of MRP 3.31 and QAP 17 1 (Ref. 2, 10).

8.9.3 DOCUMENT CONTROL OF PLANS AND PROCEDURES

WSRC Procedure Manual 4Q defines the plans and procedures that make up the IH program, including those governing operations involving hazardous materials (Ref. 6). These elements of the IH plans and procedures process are described in the following chapters of this SAR:

- Chapter 12 presents the program for developing, maintaining, and modifying procedures.
- Chapter 14 describes the site QA program.

- Chapter 17 addresses the document control program implemented as part of the site configuration management program. Chapter 17 also describes the independent review, audit, and compliance determination responsibilities of ESH&QA.

8.10 HAZARD COMMUNICATION PROGRAM

This program implements the provisions of the OSHA hazard communication standard for communicating chemical hazards to employees at SRS and applies to chemicals known to be present in the workplace that employees may be exposed to under normal conditions of use, or in a foreseeable emergency. The program includes the following elements described in this section (Ref. 10):

- Written program locations
- Hazard evaluation
- Hazardous chemical list
- Hazard warning labeling
- MSDSs
- Information and training
- Notification of hazards to contractors
- Trade Secrets

WSRC is the controlling employer at facilities addressed by this document. Therefore, no information is presented that addresses a multi-employer worksite as specified in the SAR content guide (Ref. 4).

The hazard communication requirements come from the CFR: 29 CFR 1910.1200 for the general site, 1910.1450 for "Lab Standard" labaoratories, and 29 CFR 1926.59 for construction (Ref. 7). Records associated with the hazard communication program satisfy the requirements relating to record management listed in Section 8.9.

8.10.1 WRITTEN PROGRAM LOCATIONS

The SRS Hazard Communication Program is maintained by the Chemical Management Center (CMC) in the 13B Chemical Management Manual (Ref. 10).

8.10.2 HAZARD EVALUATION

Nonradioactive chemicals either manufactured onsite or imported from offsite are evaluated to determine if they are hazardous. WSRC determines the hazards of chemicals for which manufacturer MSDSs cannot be obtained. Hazard evaluations of chemicals are performed in accordance with the requirements of 29 CFR 1910.1200, Appendix B (Ref. 7). MSDSs and warning labels are developed using current technical information (Ref. 10).

8.10.3 HAZARDOUS CHEMICAL LIST

The Chemical Management Center (CMC) maintains a sitewide list of all chemicals at SRS, which functions as the index to the master MSDS binder located in 704-1N Document Control. Departmental chemical coordinators maintain optional area-specific chemical indexes for MSDS binders under their control (Ref. 10).

8.10.4 HAZARD WARNING LABELING

Each chemical received, delivered, or used by WSRC is labeled, tagged, or marked in English with the following information (Ref. 17):

- Identity of the chemical
- Appropriate hazard warning
- Name and address of the chemical manufacturer, importer, or other responsible party

The identity used on the label (i.e., chemical or trade name) must be traceable to an MSDS. Abbreviations and acronyms used on the label must be cross-referenced in the department's MSDS binder index to facilitate retrieval of the appropriate MSDS (Ref. 6).

A labeling system based on the National Fire Protection Association (NFPA) labeling system has been selected for use at SRS. The objective of the labeling system is to provide a system that characterizes a chemical by its health and physical hazards. In general, containers storing chemicals that are not considered for "immediate use" have a manufacturer's hazard warning label, or an SRS-generated chemical identity/NFPA label. The hazard-warning label is placed in a location on the container that is readily visible to the user. More than one label may be necessary on large tanks and vessels (Ref. 10).

In cases where chemical containers are not provided with the appropriate labeling information or where the label is torn, or defaced, the chemical's custodian performs the following actions (Ref. 10):

- Removes the chemical from, or prohibits its use in, the work area
- Contacts the departmental chemical coordinator for assistance in obtaining a new label from the manufacturer
- If the manufacturer cannot be reached, the appropriate label may be printed using the MSDS system in SHRINE for they may contact the CMC for assistance in generating an SRS hazard-warning label

8.10.5 MATERIAL SAFETY DATA SHEETS

WSRC requires that all employees have access to MSDSs for the products they are required to use. Copies of MSDSs can be obtained from the following sources (Ref. 10):

- The SRS Intranet (SHRINE)
- Departmental chemical coordinator
- Master MSDS binder

The location of optional department MSDS binders and identification of the departmental chemical coordinator are displayed on colored posters throughout WSRC work areas (Ref. 10).

As MSDSs are obtained for chemicals currently used at SRS, they undergo the following process (Ref. 10):

- Reviewed for completeness
- Incorporated into the sitewide chemical listing

8.10.6 INFORMATION AND TRAINING

WSRC provides employees with information and training on hazardous chemicals in their work area at the time of their initial assignment and annually thereafter, whenever a new hazard is introduced into the workplace, and for nonroutine tasks. This training consists of two programs supplemented by area-specific training (Ref. 6, 10).

Employees who have been determined by line management to have a reasonable likelihood for exposure to hazardous chemical/materials during the performance of their work initially receive Basic Hazard Communication Training and annual retraining through attendance at Consolidated Annual Training. In addition, employees may receive facility-or job-specific hazard communication training provided by their individual organizations.

Employees who have been determined by line management to work with hazardous chemicals/materials on a laboratory scale in accordance with an approved Chemical Hygiene Plan will receive Laboratory Standard Training in lieu of Basic Hazard Communication Training.

8.10.7 NOTIFICATION OF HAZARDS TO CONTRACTORS

The Subcontractor Technical Representative is responsible for informing subcontractors of the requirements specified in the SRS hazard communication program. Information on the hazards of chemicals used onsite, is communicated through hazard communication training, MSDSs, and hazard warning labels. Subcontractors are required to label and use chemicals as prescribed in site procedures and MSDSs (Ref. 17). Subcontractor compliance with requirements of the hazard communication program is ensured through contractual stipulations, audits, etc.

8.10.8 TRADE SECRETS

CMC has an active Trade Secret program where information is obtained from manufacturers and placed in secure storage. This information is available to the Medical Department and Industrial Hygiene upon request. In the event of a medical emergency involving a chemical with a "trade secret" designation, where CMC does not already have the required information, the Medical Department, in cooperation with CMC, contacts the manufacturer to obtain the specific chemical identity. Medical provides, at the manufacturer's request, a written statement of need and a confidentiality agreement in accordance with the provisions of 29 CFR 1910.1200(i)(2), (3) and (4) (Ref. 7).

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8.11 OCCUPATIONAL CHEMICAL EXPOSURES

Predicted exposure levels to facility workers from hazardous materials are provided in the facility-specific SARs (Ref. 4).

8.12 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

1. Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports. DOE-STD-3009-94, Change Notice No. 3, U.S. Department of Energy, Washington, DC, March 2006.

2. Industrial Hygiene Manual. WSRC Procedure Manual 4Q, Washington Savannah River Company, Aiken, SC.

3. Compliance Assurance Manual. WSRC Procedure Manual 8B, Washington Savannah River Company, Aiken, SC.

4. Standards/Requirements Identification Document. WSRC-RP-94-1268-004. Washington Savannah River Company, Aiken, SC.

5. Management Policies. WSRC-1-01, Washington Savannah River Company, Aiken, SC.

6. Worker Protection Management for DOE Federal and Contractor Employees. DOE O 440.1A, U.S. Department of Energy, Washington, DC.

7. Code of Federal Regulations; Title 29, "Labor"; Parts 1900-1999, "Occupational Safety and Health Administration." 29 CFR 1900-1999, U.S. Government Printing Office, Washington, DC, as of September 1999.

8. Procurement Management. WSRC Procedure Manual 7B, Washington Savannah River Company, Aiken, SC.

9. Employee Safety Manual. WSRC Procedure Manual 8Q, Washington Savannah River Company, Aiken, SC.

10. Asset Management Manual, WSRC Procedure Manual 3B, Washington Savannah River Company, Aiken, SC.

11. Environmental Compliance Manual. WSRC Procedure Manual 3Q, Washington Savannah River Company, Aiken, SC.

12. Site-Level Training Requirements. WSRC-IM-92-57, Washington Savannah River Company, Aiken, SC.

13. Industrial Hygiene Survey Procedures. WSRC Procedure Manual 4Q1.1, Washington Savannah River Company, Aiken, SC.

14. Industrial Hygiene Instruments. WSRC Procedure Manual 4Q1.2, Washington Savannah River Company, Aiken, SC.

15. Respiratory Protection Manual. WSRC Procedure Manual 4Q1.6, Washington Savannah River Company, Aiken, SC.

16. "Protection of Environment," Parts 1-799, Code of Federal Regulations. Title 40, U.S. Government Printing Office, Washington, DC, as of July 1999.

17. Quality Assurance Manual. WSRC Procedure Manual 1Q, Washington Savannah River Company, Aiken, SC.

9.0 RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

This chapter does not contain information generic to the Savannah River Site. For detailed information on Radioactive and Hazardous Waste Management, refer to Chapter 9 of the facility-specific Safety Analysis Reports/Documented Safety Analysis.

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DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

Formerly the
GENERIC SAFETY ANALYSIS REPORT

CHAPTER 10

INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

January 2007

Washington Savannah River Company
Aiken, SC 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

CONTENTS

CONTENTS (Cont'd)

ACRONYMS AND ABBREVIATIONS

DOE	Department of Energy
DSA	Documented Safety Analysis
IPI	Installed Process Instrumentation
ISI	In-Service Inspection
M&TE	Measuring and Test Equipment
ORR	Operational Readiness Review
S/RID	Standards/Requirements Identification Document
SAR	Safety Analysis Report
SRS	Savannah River Site
SSC	Structure, System, and Component
WSRC	Washington Savannah River Company

10.0 INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

10.1 INTRODUCTION

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

10.1.1 OBJECTIVE

The purpose of this chapter is to provide information that satisfies DOE-STD-3009-94 (Ref. 1). The requirements pertain to initial testing, in-service surveillance, and maintenance policies and programs. The objective of this chapter is to present information demonstrating that testing is performed to ensure that the tested SSCs meet their functional and performance requirements, which may include steady state and/or transient performance, such that the SSC has reasonable assurance of fulfilling its normal and safety functions described in the safety analysis.

This chapter is not intended to be the vehicle for review and approval of the initial testing, in-service surveillance and maintenance programs. It is intended to describe the essential features of the programs as they relate to the authorization basis of each SRS facility.

10.1.2 SCOPE

This chapter provides a description of the site-wide initial testing, in-service surveillance, and maintenance programs established by Washington Savannah River Company (WSRC) that satisfy Standards/Requirements Identification Document (S/RID) requirements. This chapter follows the guidance of DOE-STD-3009-94 (Ref. 1), and Title 10 Code of Federal Regulations Part 830 (Ref. 2).

The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

In those cases where policies, programs, and practices important to safe operation are described in detail in other site documents, the information is summarized in this chapter and the documents are referenced.

10.2 REQUIREMENTS

Standards/Requirements Identification Documents (S/RIDs) state the codes, standards, and regulations governing the initial testing, in-service surveillance, and maintenance policies and program elements of the SRS (Ref. 3). The implementing procedure manuals for S/RID initial testing, in-service surveillance, and maintenance requirements are WSRC-5E, WSRC-1Q, and WSRC-1Y (Ref. 4, 5, 6). Any changes to these manuals are reviewed for continued compliance with S/RID requirements per Procedure Manual 8B (Ref. 7). Programmatic compliance assessment has been performed against the S/RIDs and documented as specified in WSRC Compliance Assurance Manual (Ref. 7). The Standards Management/Compliance Section maintains records of the programmatic compliance assessments.

10.3 INITIAL TESTING PROGRAM

This section summarizes the initial testing programs that ensure operability, of a new facility and facility modifications, prior to service. This topic is covered from the standpoint of a new facility modification to a piece of equipment and its related return-to-service requirements and also from the standpoint of a modification to the facility. This section also contains descriptions of the startup/restart organization and testing activities that exist to support facility safety management where modifications are concerned.

10.3.1 TESTING OF MODIFICATIONS

WSRC E7 – Conduct of Engineering establishes the requirements, implementing procedures, and responsibilities for managing the configuration of SRS facility Structure, System, and Component (SSC), including process computer software (Ref. 8). Among the configuration management requirements are requirements for modifying the configuration of a system and the subsequent testing of that modification prior to release for operation. Section 10.3.1.2 describes these requirements in more detail.

WSRC Startup Test Manual outlines the requirements for starting or restarting a facility at SRS (Ref. 4). Part of this process deals with operational readiness, which involves generation and implementation of a test plan to ensure readiness for operation. WSRC Procedure Manual 5E describes the requirements for an initial startup of a facility or restart testing program to establish uniformity and consistency in methodology for developing and implementing the test program activities (Ref. 4).

10.3.1.1 Testing of Facility Modifications

WSRC Assessment Manual establishes a formalized process for the startup/restart of nuclear facilities, processes, equipment, and systems (called nuclear activity startups) at SRS and provides procedures for the uniform conduct of WSRC Readiness Self-Assessments, WSRC Operational Readiness Reviews (ORRs), and WSRC Readiness Assessments (Ref. 9). Procedures in WSRC Procedure Manual 12Q identify the activities required to accomplish nuclear activity startups based on a graded approach (Ref. 9). Depending on the hazard category of the activity in question and the circumstances surrounding the shutdown (if it is a facility restart situation), various levels of WSRC and DOE assessments are required (up to and including a DOE ORR) to ensure that all requirements identified in startup planning documents, including initial or startup testing, have been satisfied prior to startup/restart.

WSRC Startup Test Manual defines a startup test program designed to simultaneously confirm the operability of SSCs and the viability of procedures and to indirectly support the training of operators (Ref. 4). WSRC Procedure Manual 5E applies to all organizations that perform startup/restart testing activities on SRS facilities as governed by the startup/restart operational readiness requirements contained in WSRC Procedure Manual 12Q and DOE Order 425.1B (Ref. 9, 10). The scope of WSRC Procedure Manual 5E includes startup/restart testing activities of a facility from the completion of construction through the ORR.

NOTE:WSRC Procedure Manual 5E does not apply to post-maintenance testing, to project-related modification testing unless required by DOE or WSRC Procedure Manual 12Q (see Section 10.3.1.2), or to periodic facility related process testing. These types of testing are normally governed by division-level procedures and are not addressed in this Manual (Ref. 4, 9). The facility-specific SARs/DSAs provide more details regarding process testing governed by division-level procedures.

10.3.1.2 Testing of Equipment Modifications

WSRC E7 – Conduct of Engineering l establishes responsibilities and activities for the configuration control process for controlling changes to SSCs and their associated documentation at SRS facilities (Ref. 8). Chapter 17 of this Manual provides more details on configuration control.

Of particular interest in this section are the requirements related to a "configuration change," which is defined as any change to the configuration of an SSC, its technical baseline, or its requirements. Changes to existing facility and system technical documentation are controlled in accordance with procedures 1.55, 1.57, 2.37, or 2.38 of WSRC Procedure Manual E7 – Conduct of Engineering(Ref. 8). This process, which is described in detail in WSRC Procedure Manual 7E, includes requirements for design checking to verify that the intended configuration change is implemented adequately (Ref. 8).

WSRC Conduct of Maintenance Manual contains requirements for post-maintenance testing and modification testing (Ref. 6). WSRC Procedure Manual 1Y states that Facility Operations is responsible for coordinating testing following maintenance or modifications, unless the testing is coordinated by Engineering. Facility Operations is also responsible for monitoring testing in progress. The performance and results of the testing activity are recorded as specified in the work package or post-maintenance test plan, including any rework resulting from unsatisfactory testing.

WSRC Conduct of Operations Manual contains specific requirements for testing equipment and returning equipment to service following maintenance (Ref. 11). The equipment is tested under conditions that represent normal operating parameters (e.g., flow, differential pressure, temperature, input signal values) to demonstrate that it is capable of performing its intended function. These tests are conducted in accordance with written instructions or formal procedures and include performance of all functions that may have been affected by the maintenance or modification. If testing indicates that the original problem was not corrected by maintenance or modification, testing is stopped and the situation is evaluated. The results of testing and requirements for returning equipment to service are recorded in the applicable work controlling document or work package.

Facility Operations provides the final review of the equipment returned to service before it is placed in operation. These activities are performed in accordance with approved procedures.

10.3.2 ADEQUACY OF TESTING ACTIVITIES

Several elements of the initial testing, in-service surveillance, and maintenance programs ensure that SRS facilities are managed safely from the standpoint of testing facility equipment prior to facility startup and prior to use of the equipment following maintenance or modifications. These program elements are described in other sections of this chapter, as indicated in the following paragraphs.

As discussed in Section 10.3.1.1, WSRC Startup Test Manual defines the requirements for testing equipment prior to startup/restart of a facility (Ref. 4). WSRC Procedure Manual 5E provides detailed descriptions of the different programmatic areas considered, the responsibilities of organizations involved, and training and qualification requirements for personnel involved in the startup/restart process. WSRC Procedure Manual 5E also defines the requirements for the establishment of the Test Review Board to perform necessary evaluations that ensure startup testing is adequately completed.

Section 10.3.1.2 discusses modification of a system or a piece of equipment. WSRC E7-Conduct of Engineering clearly describes the detailed requirements in place to control the configuration of SRS SSCs (Ref. 8). The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

Surveillance testing of equipment and testing following routine maintenance is discussed in Sections 10.4 and 10.5, respectively. These sections also discuss training and qualification of personnel, responsibilities of personnel, and the SRS guidance governing these testing programs.

Without the initial testing, in-service surveillance, and maintenance programs in place, proper testing to support facility safety management is not ensured. These programs implement the applicable DOE requirements in the various orders discussed in this chapter. The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

10.4 IN-SERVICE SURVEILLANCE PROGRAM

This section summarizes the in-service surveillance program. The summary covers provisions for testing and calibrations, control and calibration of test equipment, trending of surveillance test results, programmatic review and training of personnel performing surveillance (Ref 3).

The requirements of the S/RID associated with maintenance are implemented at SRS through the WSRC Quality Assurance Manual and WSRC Conduct of Maintenance Manual (Ref. 5, 6).

WSRC Procedure Manual 1Y is the site-level implementing document covering conduct of maintenance (Ref. 6). The facility-specific SAR and/or procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility.

10.4.1 PROVISIONS FOR TESTING AND CALIBRATIONS

WSRC Procedure Manual 1Q provides the requirements and responsibilities for planning, performing, and documenting surveillance tests and other types of tests (Ref. 5). Consistent with the S/RID requirements, WSRC Procedure Manual 1Q states that the type and extent of test controls applied to systems, subsystems, components, and items are based on the functional classification assigned to it (Ref. 3, 5). WSRC Procedure Manual 1Q provides guidance regarding the following (Ref. 5):

- Planning of the test
- Review and approval of the test procedures
- Qualification of testing personnel
- Performance of the test in accordance with the work control requirements stated in WSRC Procedure Manual 1Y (Ref. 6)
- Evaluation and disposition of test results

Sections 10.4.2 and 10.5.5 discuss calibration of Measuring and Test Equipment (M&TE), as well as Installed Process Instrumentation (IPI), used in performing surveillance tests.

10.4.2 CONTROL AND CALIBRATION OF MEASURING AND TEST EQUIPMENT

Section 10.5.5 discusses the control and calibration of M&TE, as well as IPI. The guidelines of WSRC Procedure Manual 1Q and S/RID described in that section also applies to M&TE and IPI used for in-service surveillance (Ref. 3, 5).

10.4.3 TRENDING OF SURVEILLANCE TEST RESULTS

This section summarizes the in-service surveillance program. The summary covers provisions for testing and calibrations, control and calibration of test equipment, trending of surveillance test results, programmatic review and training of personnel performing surveillance (Ref. 3).

10.4.4 PROGRAMMATIC REVIEW

DOE Order Guide 433.1-1 states that inspections, audits, reviews, investigations, and self assessments are necessary for an effective maintenance program (Ref. 12). The DOE Order Guide recommends that senior managers periodically review and assess elements of the maintenance program to assist line managers and supervisors in identifying and correcting program deficiencies. The DOE Order Guide also states that management should conduct periodic inspections of equipment and facilities to ensure that excellent facility condition and housekeeping exist. Chapter 17 of this Manual discusses formal self-assessment and facility programmatic review processes in more detail.

WSRC Procedure Manual 1Q provides additional details regarding the following (Ref. 5):

- Performance of inspections
- Qualifications and authority of inspection personnel
- Reporting of inspection results
- Final review and acceptance of independent inspection activities

10.4.5 TRAINING OF SURVEILLANCE TESTING PERSONNEL

Section 10.5.2 discusses training of maintenance personnel. The guidelines of WSRC Procedure Manual 1Y and DOE Order 433.1 described in that section also apply to training used for in-service surveillance personnel (Ref. 6, 12).

10.5 MAINTENANCE PROGRAM

Maintenance at SRS is performed in accordance with the S/RID requirements for maintenance, which is DOE Order 433.1 (Ref. 3, 12). This DOE Order provides general policy and objectives for the establishment of programs for the management and performance of cost-effective maintenance and repair of DOE property. This section addresses the site-level implementation of the requirements contained in this DOE Order.

WSRC Procedure Manual 1Y addresses DOE Order 433.1 and is the single site document for Site (nuclear & non-nuclear) facilities that establishes the conduct of maintenance requirements for each division and facility (Ref. 6, 12). This Manual is the Site's DOE approved Maintenance Implementation Plan (MIP). All Projects/Facilities are responsible and accountable for the implementation of this manual so as to preserve cost-effectiveness at a Site level. The 1Y Manual allows deviations to the manual. If deviations from the requirements of the 1Y Manual are considered necessary, such deviations are documented by approved addenda.

The facility-specific SAR and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility.

10.5.1 MAINTENANCE ORGANIZATION AND ADMINISTRATION

DOE Order 433.1 requires each contractor to develop and implement a program that conforms with the objectives of the DOE Order (Ref. 12). The organization and administration of the maintenance function should ensure that a high level of performance in maintenance is achieved through effective implementation and control of maintenance activities. This goal is achieved primarily by establishing written policies, procedures, and standards for maintenance; periodically observing and assessing performance; and holding personnel accountable for their performance.

WSRC Procedure Manual 1Y establishes the requirements and responsibilities for the maintenance organization and administration of the SRS maintenance program (Ref. 6). It is the primary responsibility of the Maintenance Manager to ensure implementation of contractor management and facility policies that affect the maintenance organization. Maintenance organization procedures support contractor management and facility maintenance policies. WSRC Procedure Manual 1Y defines the responsibilities for implementing these policies, including the responsibilities of maintenance personnel (Ref. 6). Maintenance personnel should clearly understand their authority, responsibility, accountability, and interfaces with other groups. Procedures or other definitive documents specify policies that are used to guide maintenance organization activities. These documents also specify the types of controls necessary to implement maintenance policies.

DOE Order 433.1 requires that each facility develop an integrated approach to maintenance so that working relationships are developed among all organizational units that support the maintenance function. DOE Order 433.1 further requires that the maintenance program be documented in a site maintenance plan and/or a maintenance implementation plan. These DOE Order requirements are met by SRS through the DOE Approved Maintenance Implementation Plan, and the WSRC Senior Maintenance Manager committee structure, which serves as the maintenance focal point for interfacing with DOE on site-wide maintenance issues and coordinates the development of the Maintenance Implementation Plan. (Ref. 6, 12).

The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

10.5.2 TRAINING AND QUALIFICATION OF MAINTENANCE PERSONNEL

Maintenance managers are responsible for helping to select personnel for maintenance responsibilities. These managers are involved in defining entry-level criteria and in screening new personnel. A maintenance training and qualification program is required by DOE Order 433.1 to develop and maintain the knowledge and skills needed by maintenance personnel to effectively perform maintenance activities (Ref. 12). The Maintenance Manager and supervisors are directly involved in training maintenance personnel.

The training organization is required to maintain maintenance training programs that meet the intent of established industrial guidelines and that address specific company and facility needs. These programs are supported and guided by the maintenance organization.

On-the-job training is a formal part of the maintenance training program that is normally conducted in the facility as part of the day-to-day work activities. Chapter 12 of this Manual provides further information regarding on-the-job training and WSRC training program development and requirements.

10.5.3 MAINTENANCE FACILITIES, EQUIPMENT, AND TOOLS

DOE Order 433.1 states that maintenance facilities, equipment, and tools should efficiently support facility maintenance and maintenance training (Ref. 12). The DOE Order requires a program for evaluating the adequacy of maintenance facilities, tools, and equipment to ensure that maintenance activities can be effectively accomplished. Deficiencies in the areas of facility equipment and housekeeping should be identified through periodic inspections ranging from management walkthroughs to detailed facility inspections. Facility condition inspections by management ensure that proper condition, cleanliness, and housekeeping are maintained to support safe and reliable facility operations.

To determine the adequacy of maintenance facilities, equipment, and tools, annual assessments of the maintenance facilities are performed in accordance with the requirements of DOE Order 433.1 (Ref. 12).

10.5.4 IN SERVICE INSPECTION

WSRC Procedure Manual 1Q provides guidance for conducting In-Service Inspections (ISIs) of specified SSCs (Ref. 5). An ISI is an inspection performed on operable equipment to verify that characteristics of an item remain in compliance with specified requirements. The cognizant technical function and cognizant quality function for a particular facility are required to evaluate the processes, activities, and items for which they are responsible and for establishing the level, extent, and acceptance criteria for inspections. The basis for the assignment, level, and intensity of inspections is directly related to functional classifications or design document requirements. Items classified as Safety Class or Safety Significant are inspected by independent inspection personnel. Independent personnel may also be used for other important items classified as Production Support or General Services (Ref. 14).

10.5.5 POST-MAINTENANCE TESTING

Post-maintenance testing is performed to verify that components and systems are capable of performing their intended function when returned to service following maintenance and to ensure that the original deficiency is corrected and that no others are created. A post-maintenance test, if required, should be performed after corrective maintenance activities and after some preventive maintenance activities. The test performed should be commensurate with the maintenance work performed and the importance of the equipment to safe and reliable operations.

At SRS, test requirements and acceptance criteria are determined by the cognizant technical function.(Ref. 6).

DOE Order 433.1 requires that a program be established to control post-maintenance testing, particularly for cases where more than one group is involved in the testing (Ref. 12). At SRS, Facility Operations is responsible for maintaining the status of incomplete post-maintenance testing and for coordinating post-maintenance testing performance. The Operations organization reviews completed post-maintenance test results and approve the work package to document satisfactory completion of the maintenance/modification work (Ref. 6).

If a test is unsatisfactory, the equipment is tagged to indicate that a deficiency still exists and the deficiency is identified in the work package. The original work package may be revised and the testing may be repeated, or, if the post-maintenance testing criteria cannot be met by revising the post-maintenance test plan, a nonconformance report may be generated as required by WSRC Quality Assurance Manual, QAP 15-1, “Control of Nonconforming Items” (Ref. 5).

The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

10.5.6 CONTROL AND CALIBRATION OF MEASURING AND TEST EQUIPMENT

A program for the control and calibration of M&TE is instituted to ensure the accurate performance of facility instrumentation and equipment for testing, calibration, and repairs (Ref. 12). M&TE includes all devices or systems used to inspect, test, calibrate, measure, or troubleshoot in order to control or acquire data for verifying the conformance of an instrument or piece of equipment to specified requirements. A similar program exists for the control and calibration of IPI.

- Operators depend on installed instrumentation for accurate indications, process control actions, and trip functions to operate the facility safely and reliably. The accuracy of the installed instrumentation is established and maintained through an M&TE control and calibration program.

WSRC Procedure Manual 1Q implements the DOE Order requirements related to M&TE and IPI at SRS (Ref. 5). Division-level procedures that are specific to the various SRS facilities also exist. WSRC Quality Assurance Manual, QAP 12-1, “Control of Measuring and Test Equipment,” provides additional specific guidance (Ref. 5).

- Currently at SRS, the manager for the organizations having custody of the M&TE, the M&TE users and calibrators, and the M&TE Coordinators are responsible for ensuring that a program for the control of M&TE is in effect and maintained.

M&TE require scheduled calibrations to ranges and tolerances based on technical requirements or design documents for the process or item being measured. WSRC Procedure Manual 1Q states that the Savannah River Standards Laboratory is the primary standards laboratory for SRS (Ref. 5). The Savannah River Standards Laboratory is responsible for providing technical guidance, training, development, maintenance, and/or specification of primary standards to ensure that the correct measurement standards are applied and that these measurements are compatible site-wide.

10.5.7 MAINTENANCE HISTORY AND TRENDING

An equipment repair history and vendor information program is established and maintained to provide historical information for maintenance planning and to support the maintenance and performance trending analysis of facility systems and components (Ref. 12). The equipment repair history is used to support maintenance activities, upgrade maintenance programs, optimize equipment performance, and improve equipment reliability. Trending is directed toward identifying improvements for the maintenance program, as well as needed equipment modifications.

Maintenance trending involves the implementation of a maintenance problem analysis program. This program ensures that a systematic analysis methodology is used to determine and correct root causes of problems, unplanned events, and occurrences related to maintenance activities.

WSRC Procedure Manual 1Y contains a site-level procedure for development and use of maintenance history and trending (Ref. 6). The facility-specific SAR/DSA and/or applicable procedures should be referenced for more details regarding the implementation of the DOE requirements for a particular facility on this subject.

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10.6 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

1. Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports. DOE-STD-3009-94, Change Notice 3, U.S. Department of Energy, Washington, DC, March 2006.

2. Nuclear Safety Management. Title 10 Code of Federal Regulations (CFR) Part 830, U.S. Department of Energy, Washington, DC, January 2001.

3. Standards/Requirements Identification Document (S/RID), Functional Area 10.0 Maintenance. WSRC-RP-94-1268-010, Rev 01-13, Westinghouse Savannah River Company, Aiken, SC,October 31, 2001.

4. Startup Test. WSRC Procedure Manual 5E, Westinghouse Savannah River Company, Aiken, SC, November 1999.

5. Quality Assurance Manual. WSRC Procedure Manual 1Q, Westinghouse Savannah River Company, Aiken, SC, November2001.

6. Conduct of Maintenance Manual. WSRC Procedure Manual 1Y, Westinghouse Savannah River Company, Aiken, SC, November 2001.

7. Compliance Assurance Manual. WSRC Procedure Manual 8B, Westinghouse Savannah River Company, Aiken, SC, October 2001.

8. Conduct of Engineering and Technical Support Manual. WSRC Procedure Manual E7, Westinghouse Savannah River Company, Aiken, SC, January 2006.

9. Assessment Manual. WSRC Procedure Manual 12Q, Westinghouse Savannah River Company, Aiken, SC, July 2004.

10. Startup and Restart of Nuclear Facilities. DOE Order 425.1B, U.S. Department of Energy, Washington, DC, December 2000.

11. Conduct of Operations Manual. WSRC Procedure Manual 2S, Westinghouse Savannah River Company, Aiken, SC, July 2000.

12. Maintenance Management Program for DOE Nuclear Facilities. DOE Order 433.1, U.S. Department of Energy, Washington, DC, June, 2001.

13. Nuclear Facility Maintenance management Program Guide for Use with DOE O433.1. DOE Order Guide 433.1-1, U.S. Department of Energy, Washington, DC, September 2001.

14. Westinghouse Savannah River Company Site Maintenance Plan. WSRC-RP-93-608, Rev. 1, Westinghouse Savannah River Company, Aiken, SC, August 29, 1995.

15. Conduct of Engineering and Technical Support. WSRC Procedure Manual E7, Westinghouse Savannah River Company, Aiken, SC, December 2001.

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Rev. 1

DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

Formerly the
GENERIC SAFETY ANALYSIS REPORT

CHAPTER 11

OPERATIONAL SAFETY

January 2007

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

Washington Savannah River Company
Aiken, SC 29808

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

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ACRONYMS AND ABBREVIATIONS

AHJ	Authority Having Jurisdiction
ALARA	As Low As Reasonably Achievable
CA	Control Area
DNO	Do Not Operate
DOE	Department of Energy
DSA	Documented Safety Analysis
ESH&QA	Environment, Safety, Health and Quality Assurance
FHA	Fire Hazards Analysis
FPC	Fire Protection Coordinator
FSD	Fire Safety Deficiency
GSAR	Generic Safety Analysis Report
ITS	Important to Safety
MOU	Memorandum of Understanding
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PA	Public Address
RRP	Required Reading Program
S/RID	Standards/Requirements Identification Document
SAR	Safety Analysis Report
SRS	Savannah River Site
T/E	Trainer/Evaluator
TSR	Technical Safety Requirement
UL	Underwriter Laboratories
WSRC	Washington Savannah River Company

11.0 OPERATIONAL SAFETY

11.1 INTRODUCTION

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

11.1.1 OBJECTIVE

The purpose of this chapter) is to provide information that satisfies Department of Energy (DOE)-STD-3009-94 (Ref. 1). The requirements pertain to operational safety.

11.1.2 SCOPE

This chapter discusses general aspects of operational safety and fire protection. It specifically points to the implementation of the operations programs specified by DOE Order 5480.19 (Ref. 2). DOE Order 5480.19 addresses many of the other topics covered in DOE Rule 10 CFR Part 830 (e.g., management, organization, the institutional safety provisions, procedures, training, and human factors) (Ref. 3). Therefore, some elements of conduct of operations are covered in other chapters of this document. Specifically, major issues of operations organizations, administration, and training are covered in Chapter 12 and Chapter 17 of this site characteristics Manual . Major issues of notification, reporting practices, and investigation of abnormal events are covered in Chapter 17. Control of procedures is covered in Chapter 12.

The scope of this chapter includes:

- Identification of operational safety aspects of the Conduct of Operations Program
- Integrated summary of the main features of the Conduct of Operations Program
- Description of the Fire Protection Program

When required information is provided in another chapter of this Manual, that chapter is referenced to limit repetition. In those cases where policies, programs, and practices important to safe operation are described in detail in other site documents, the salient features are summarized for inclusion in this chapter and the documents are referenced (Ref. 1).

11.2 REQUIREMENTS

Standards/Requirements Identification Documents (S/RIDs) state the codes, standards, and regulations governing operational safety at Savannah River Site (SRS) (Ref. 4). The primary implementing procedure manual for operational safety requirements are Washington Savannah River Company Manuals WSRC-2Q and WSRC-2S (Ref. 5, 6). Additional site manuals and procedures are credited with implementation of other DOE Order 5480.19 requirements (see Ref. 4, Functional Area 9). Any changes to these manuals are reviewed for continued compliance with S/RID requirements per Procedure Manual 8B and Manual WSRC 1-01, Management Policies (Ref. 7, 8). Programmatic compliance assessments have been performed against the S/RIDs and documented as specified in the WSRC Procedure Manual 8B (Ref. 7). The Standards Management/Compliance Section maintains records of the programmatic compliance assessments.

11.3 CONDUCT OF OPERATIONS

WSRC, in accordance with S/RIDs, has established and maintains a Conduct of Operations Program to enhance the safe operation of its facilities at SRS (Ref. 4). Conduct of operations requirements apply to the programs and functions of SRS operations that may have an impact on the safety of the public, environment, and all site personnel.

Conduct of operations is defined here as the assurance of acceptable performance of all operations and support activities that may affect safety. These activities may vary widely in complexity and potential safety impact, ranging, for example, from the performance of a simple chemical analysis to the startup of a Hazard Category 2 nuclear facility. Regardless of the degree of complexity, the same quality level of performance is expected. Conduct of operations also requires a commitment to continuously improve operations by using total quality principles (Ref. 8).

The SRS Conduct of Operations Program is primarily implemented through WSRC Procedure Manual 2S (Ref. 6). The Manual provides detailed performance expectations in the areas of procedures, communications, training, operations practices and protocol. In addition, the Manual describes an alternate implementation method for the program requirements, the conditions under which the graded approach may be used, and the method for documenting and obtaining approval for the use of the graded approach (Ref. 6).

Other implementing documents and procedures (e.g., Manuals, 1B, 7Q, 4B) may be found in the S/RIDS (Reference 4, Functional Area 9).

11.3.1 SHIFT ROUTINES AND OPERATING PRACTICES

The Conduct of Operations Program specifies the shift routines and operating practices that apply to facility operations and support personnel. The program includes standards for professional conduct, good watchstanding practices, equipment monitoring, and management responsibilities that are fundamental to operating a facility (Ref. 6).

The following sections describe the guidance and requirements provided for shift routines and operating practices by WSRC Procedure Manual 2S (Ref. 6).

11.3.1.1 Facility Operating Practices

Various facility-operating practices are specified. For example, operation of mechanisms and apparatus, other than controls, that may indirectly affect the process is only accomplished with the knowledge and consent of the qualified operators on-shift and the shift manager. Also, operations personnel respond to instrument indications and alarms until such indications and alarms are proven to be false. The shift manager is promptly notified of changes in facility status, abnormalities, or difficulties encountered in performing assigned tasks (Ref. 6).

11.3.1.2 Operation During Abnormal or Emergency Conditions

Operators believe instrument indications and alarms unless they are proven to be false. When process operations are not as expected, the process is returned to a known safe condition, and the shift manager is notified. If conditions warrant, the process is discontinued until the cause of the condition has been determined and safe conditions are restored. Operators manually shut down the process using approved procedures if system parameters for trips or safety systems exceed their actuation setpoints and automatic actuation does not occur (Ref. 6).

11.3.1.3 Authority to Operate Equipment

The shift manager directs the overall operation of the facility. In general, Control Area (CA) operators (where assigned) and shift managers are aware of all activities affecting facility equipment. However, activities that do not affect safety, regulatory compliance, or operating capability may be performed without informing the CA operator or shift manager, if decided in advance of the activity and properly documented. In addition, during emergencies, operators are expected to take necessary immediate actions required to ensure personnel, facility, environmental, and general public safety without prior approval; however, the appropriate supervisors are informed promptly of these actions (Ref. 6).

11.3.1.4 Operator Rounds and Tours

Operators conduct tours of the areas within their responsibility on a regular basis. Each tour is of sufficient detail to ensure that the status of equipment is known. Equipment is inspected to ensure that it is operating properly or, in the case of standby equipment, that it is fully operable. Operators take appropriate action to correct or report deficiencies noted during tours. Supervision ensures that appropriate corrective action has been initiated for each abnormal condition noted in round sheets and logbooks (Ref. 6).

11.3.1.5 Personnel Protection

Operations personnel must be appropriately qualified to follow good radiological protection practices to maintain personnel radiation exposure As Low As Reasonably Achievable (ALARA). They must also minimize exposure to chemicals, electromagnetic fields, toxic materials, and other personnel hazards. Operations supervisory personnel periodically review exposure trends of operations personnel under their supervision as part of the ALARA program (Ref. 6).

11.3.1.6 Shift Operating Bases

Each facility establishes a base where an operator returns when not performing duties within the facility. The base is located at a convenient place within the operator's area of responsibility and is appropriately equipped with the office equipment necessary to maintain required procedures and references for conducting administrative duties and to maintain adequate communications equipment. Shift turnovers are conducted at the operating base or at a central location in the case of group shift turnover briefings (Ref. 6).

11.3.1.7 Shift Turnover

The purpose of the shift turnover process is to assure that relief personnel are provided with the knowledge required to accomplish their shift assignment responsibilities. Shift turnover is a critical period during which it is essential that the oncoming shift or relief personnel are provided with complete and accurate information regarding the facility’s overall status (Ref. 6).

11.3.1.8 Resetting of Alarms or Protective Devices

Personnel do not adjust or operate alarm, interlock, or equipment-operating setpoints unless such action is specifically authorized by approved operating procedures or work orders. Protective devices (e.g., circuit breakers, fuses) are not reset until the cause of the trip is understood with reasonable assurance. Reset criteria and associated requirements are described in the Conduct of Operations Manual (Ref. 6).

Alarm status is addressed in Sections 11.3.5 and 11.3.9.

11.3.1.9 Potentially Distractive Written Material and Devices

Written materials that do not relate to operation and entertainment devices such as radios, televisions, tape players, and computer games are prohibited from use by operations personnel to minimize distractions from their responsibilities. Operators may read training bulletins, technical manuals, or operating experience information, or they may review other written, audible, or visual materials that relate to operator duties (Ref. 6).

11.3.1.10 Key Control

To facilitate control over keys that are used in day-to-day operations, a key accountability log is in place to record the keys being used and the individuals in possession of the keys. The key storage cabinet contains an inventory list to expedite the locating of keys. Key accountability is maintained by conducting routine inventories (Ref. 6).

11.3.1.11 Overtime

General overtime guidelines are provided for operations and support personnel (Ref. 6). Adequate shift coverage is maintained without relying on overtime. The use of overtime to cover for vacationing employees is avoided, if possible.

11.3.2 CONTROL AREA ACTIVITIES

The Conduct of Operations Program establishes guidelines and requirements for performance of Control Area (CA) activities to ensure that the following conditions are maintained:

- CA activities are conducted in a businesslike manner, in a professional atmosphere that is conducive to safe and efficient operation.
- CA operators are not overburdened with administrative responsibilities.
- Distractions are minimized so operators may properly monitor facility parameters.

The guidelines and requirements apply to facility operations and support personnel and to activities conducted in the CAs of the facility. The following sections summarize the guidance and requirements provided for CA activities by the Conduct of Operations Manual (Ref. 6).

11.3.2.1 Control Area Identification and Access

A CA is an area or room having an assemblage of control devices (e.g., switches, dials, breakers, and valves) and indicating/monitoring equipment (e.g., meters, gauges, recorders, digital and analog readouts) that are used for the control of a process or system, where interruption or mis-operation of that process or system could jeopardize personnel safety, create a hazard to the environment, or result in significant financial loss. Requirements concerning the assignment of CA operators are determined by the facility manager.

The facility manager clearly defines the CAs within the facility. Each CA is physically identified by visible means such as floor markings, signs, barrier ropes, or chains. Entry requirements are posted at the entrance to the CA. Only designated personnel can grant entry.

The presence of personnel in the CA other than the assigned shift complement and other personnel designated by facility policies, procedures, or instructions is limited. The senior operations staff individual controls specific limits for the number of personnel allowed in the CA. During periods of abnormal or emergency operations, the shift manager normally directs nonessential personnel to exit the CA (Ref. 6).

11.3.2.2 Professional Behavior

Activities in the CA are performed in a disciplined, formal, businesslike, and professional manner. Only activities essential to supporting operation and activities authorized by management are conducted. The noise level in the CA is kept to a minimum. Non-job-related discussions are minimized. Potentially distractive activities, such as reading non-job-related literature, are prohibited. Facility business is conducted at a location in the CA and in a manner that neither distracts on-duty control personnel nor compromises the professional atmosphere of the CA (Ref. 6).

11.3.2.3 Monitoring the Main Control Panels

Operators monitor control panel indications and alarms, monitor control panel indications frequently, and take prompt action to determine the cause of and correct abnormalities. Emphasis is placed on closely monitoring and trending control panel data to detect problem situations early (Ref. 6).

11.3.2.4 Control Area Operator Ancillary Duties

Secondary duties assigned to operators are not allowed to interfere with their primary responsibilities indicated in Section 11.3.2.3. Secondary duties include preparation of tagouts, review of operating procedures, required reading, and review of maintenance work activities. This administrative workload of operators responsible for monitoring and operating the control board is minimized (Ref. 6).

11.3.2.5 Operation of Control Area Equipment

Only operations and support personnel specifically authorized by facility procedures operate CA equipment. When trainees operate this equipment, they are supervised and controlled by the qualified operator who normally performs the operation (Ref. 6).

11.3.3 COMMUNICATIONS

The Conduct of Operations Program establishes the methods for effective, reliable, and accurate transmission of information through both verbal and written means. The program specifies restrictions on the use of wireless communication devices. The requirements apply to facility operations and support personnel (Ref. 6).

The WSRC Procedure Manual 2S provides guidance and requirements for communications within the facility, including guidance and requirements for both individuals sending communications and individuals receiving communications. Each of the areas addressed represents an avenue for contacting facility personnel and communicating information to personnel during normal, abnormal, and/or emergency conditions.

11.3.3.1 Written Communications

Written communication consists of both formalized, controlled documents such as procedures and standing orders, and informal written material. The handling, review, and approval of formal written communication are conducted in accordance with administrative procedures (Ref. 6).

11.3.3.2 Verbal Communications

Verbal communication is the most common form of communication and ranges from formal communications, such as performing the notifications required for an unusual event, to routine face-to-face communications. Operating directions are verbal instructions given to an operator that involves the operation of a system or piece of equipment. These instructions are brief and straightforward; otherwise, written communications must be used. Operating directions are to be explicit and understandable and may be given face to face, by telephone, by radio, or through the use of the Public Address (PA) system.

Excluding verbal operating directions given over the PA system, the recipient of verbal operating directions is to acknowledge the directions by repeating (verbatim or paraphrasing) the directions back to the person giving the instructions to ensure understanding. The recipient of the operating directions is responsible for reporting the completion of the activity and, if possible, the results. If the recipient of the directions is concerned that the associated actions cannot or should not be completed as directed, he/she should communicate those concerns to shift management. The person originating the operating directions is to observe any parameters available for confirmation that the activity is proceeding as intended.

The WSRC Procedure Manual 2S provides information and guidance on defining attributes of good verbal communications, and performing verbal communications. The practices described are used during both normal and emergency operations (Ref. 6).

11.3.3.3 Public Address Communications

Normal use of PA systems is restricted to communications essential to operations and vital to personnel safety, as a result of associated noise, volume, and distraction. In the event of emergencies or unusual situations, the PA system is used to instantly pass information to personnel. When a PA system is used to announce an emergency, personnel are informed of the nature of the emergency and are directed to report to specific locations (rally points, shelter, etc., as applicable) (Ref. 6).

11.3.3.4 Radio Communications

The use of wireless communication devices in and around CAs or other areas where sensitive electronic equipment is installed is forbidden except as approved by the facility manager or during specified emergency situations. Personnel using wireless communication devices must be formally trained in their use and restrictions. The Facility Manager should require written instructions stating when and where transmissions shall not occur. This may be in the form of postings or standing orders. The Shift Manager shall provide instructions regarding radio frequency usage (channels) and location for use (postings) (Ref. 6).

11.3.3.5 Emergency Communications

Emergency communication systems are required to ensure that individuals working in an area can be promptly alerted to facility emergencies. The emergency communication systems are tested periodically to ensure that they are functioning properly. To ensure that the proper notifications are made, CA personnel have the authority to override other users of the PA system.

Personnel working in areas where emergency communications cannot be heard make their presence in that area known to the shift manager so that, in the event of an emergency, alternate means of notification may be made (Ref. 6). If the facility has made provisions for area sweeps or other formal means of notifying personnel in areas not reached by emergency communications, the shift manager does not need to be contacted (Ref. 6).

11.3.4 CONTROL OF ON-SHIFT TRAINING

The Conduct of Operations Program specifies requirements for control of on-shift training by facility personnel. On-shift training is the portion of a qualification program where the trainee receives training, within the work environment, with as much hands-on experience as possible. The requirements apply to operations personnel in the facility as part of the shift or normal work routine (Ref. 6).

See Chapter 12 for information regarding compliance of training programs with DOE Orders.

The following sections describe the guidance and requirements provided for control of on-shift training by WSRC Procedure Manual 2S (Ref. 6).

11.3.4.1 On-Shift Training Program Development

Each facility ensures that on-shift-training programs are developed for its supervisors, operators, and trainees seeking certification/qualification. The Training and Qualification Program Manual 4B specifies the administrative requirements for on-shift training (Ref. 7). Training is implemented in accordance with the Conduct of Operations Manual 2S (Ref. 6).

11.3.4.2 Adherence to Programs

On-shift training is conducted in accordance with qualification programs that specifically identify items that the trainee must accomplish on-shift. The knowledge requirements for each item are defined, as well as what actions the trainee must do (i.e., perform, simulate, or discuss). Both the Trainer/Evaluator (T/E) and the trainee must understand what is required for each item (Ref. 6).

11.3.4.3 Trainer/Evaluator Qualification

T/Es who conduct on-shift training are qualified in on-shift instructional techniques and are currently or previously qualified as an operator in the duty area to be taught (Ref. 6, 7).

11.3.4.4 Control of Trainees

Whenever a trainee operates equipment, the T/E observes the trainee. When trainees' record entries on official documents the recorded information is verified to be correct.

Trainees may be used to support operations work activities when approved by the facility manager and with a qualified operator present. Trainee participation in production functions is limited to those duties for which the trainee has been qualified.

The T/E must receive approval from the shift manager or the control room supervisor prior to beginning any job performance measures that involve actual operation of equipment. Prior to actually performing activities that affect production or facility safety, approval by the control room supervision of the planned task is required (Ref. 6).

11.3.4.5 Training Documentation

Completion of the trainee qualification program must be formally documented (Ref. 6). A qualified instructor documents completion of classroom requirements. On-shift training is conducted in accordance with the requirements of Manual 4B (Ref. 22). Job performance examination results are documented by the facility training coordinator. Documentation requirements, including training record retention, are addressed in the WSRC Procedure Manual 4B (Ref. 7).

11.3.4.6 Suspension of Training

Trainee operation of equipment is immediately suspended during unanticipated or abnormal events, accident conditions, or whenever qualified operations personnel or the T/E believe suspension is necessary to ensure safe and reliable facility operation (Ref. 6).

11.3.4.7 Maximum Number of Trainees

Limiting the trainee-to-instructor ratio ensures that the trainees are provided with effective instruction and that the instructor is not distracted by having too many trainees. The facility manager normally limits the number of trainees to no more than three trainees per T/E (Ref. 6).

11.3.5 CONTROL OF EQUIPMENT AND SYSTEMS STATUS

To satisfy design bases and operational limits, the proper component, equipment, and system configurations must be established and maintained. Site-level procedures contain guidelines and requirements for maintaining a configuration control program in SRS facilities and for ensuring that the current configuration of equipment is known to facility operators (Ref. 6, 23).

The requirements apply to facility operations and support personnel responsible for administrative controls, procedures, and requirements that govern equipment and systems status (Ref. 6).

WSRC Procedure Manuals 4Q and 8Q address control of equipment and systems status in terms of personnel protection (Ref. 9, 10). Various elements of the WSRC Procedure Manual 4Q are described in Chapter 8 of this Safety Analysis Report (SAR).

The following sections describe the guidance and requirements provided for control of equipment and systems status by WSRC Procedure Manual 2S (Ref. 6).

11.3.5.1 Status Change Authorization and Reporting

Each facility is evaluated to identify equipment and systems subject to status control requirements. As a minimum, the following equipment is required to satisfy status control requirements:

- Safety-related/ Important to Safety (ITS) equipment and systems (i.e., those equipment and systems, including their structures and components, identified in the facility safety documentation such as the SAR/DSA and Technical Safety Requirements [TSRs] as necessary to ensure safe facility operation)
- Equipment and systems used to monitor or control environmental releases

Changes in equipment and system configuration, such as the ones that result from maintenance, modification, and testing activities, are communicated from shift to shift through the shift turnover process (see Section 11.3.9). Turnover checklists and equipment status boards are used as aids for compiling and transmitting status information efficiently and accurately.

The shift manager is responsible for maintaining proper facility configuration and is the only individual allowed to authorize status changes to equipment and systems subject to status control requirements.

Authorization of status changes to equipment and systems of lesser importance may be delegated by the shift manager to cognizant operators, but the shift manager retains responsibility. The shift manager is periodically advised of status changes to delegated equipment and systems.

The shift manager ensures that status changes to equipment and systems are communicated to facility operators. Normally, facility operators are in the line-of-information flow to and from the shift manager.

Status changes to equipment and systems are reported to the governing station (e.g., CA) or to the individual, or relief, who authorized the change. Obtaining the authorization for the performance of the procedure, and then reporting the completion of the procedure, constitutes status change reporting (Ref. 6).

11.3.5.2 Status Boards

Status boards are used as aids for compiling and transmitting information efficiently and accurately. The status board provides a visual overview of the current status of selected equipment and systems for which a specific CA is responsible. Status boards are not normally developed for equipment and systems that undergo frequent status changes (i.e., several changes per shift). Status boards are kept current and reviewed at shift turnover (see Section 11.3.9) (Ref. 6).

11.3.5.3 Equipment and System Alignments

Individual components for facility equipment and systems are properly aligned or checked for proper alignment before the equipment or system is initially placed into operation, which includes new equipment and systems. Alignment checklists or procedures with the same degree of control are used to establish the correct component positions. Alignments are only required for equipment and systems required to be operational.

An initial alignment establishes a baseline configuration upon which further operations are measured. Once the equipment or system is aligned and operating properly, frequent complete alignments may not be necessary. Typical situations that may require equipment and systems to be aligned include startup from major outages, changes in operational mode, and special alignments for portions of equipment or systems affected by maintenance or danger tag removal. The alignment of equipment and systems is verified periodically.

Status control requirements may be temporarily relaxed with the approval of the facility manager (Ref. 6).

11.3.5.4 Equipment Locking for Administrative Control

Control locks provide a physical restraint on the operation of equipment and provide assurance that equipment will only be operated by qualified personnel performing required evolutions. The facility operations manager develops, evaluates, and updates the list of equipment that requires control locks. The shift manager authorizes removal of control locks and the repositioning of control-locked equipment before manipulation.

Control-locked equipment is periodically inspected. If at any time equipment that is normally locked is found unlocked or locked in the wrong position, the process is placed in a safe condition, and the shift manager is notified (Ref. 6).

Additional information concerning lockouts and tagouts is provided in Section 11.3.6.

11.3.5.5 Equipment Deficiency Identification and Documentation

Deficiencies and malfunctions are logged and, when necessary, investigated. In some cases, a report is made. Equipment deficiencies are identified using a uniquely numbered and controlled tag. Equipment classified as out of service or inoperable is noted on the applicable equipment status boards (Ref. 6).

11.3.5.6 Work Authorization and Documentation

The shift manager (or designee) gives initial written authorization on the document controlling work activities and continuing authorization for shift activities performed on facility areas under his/her cognizance. As a minimum, this authorization applies to work activities that affect equipment important to safety, equipment important to operations, or equipment that changes CA indications or alarms. Documentation of work status includes log entries and turnover checklists that are available in the CA for review by operations personnel (Ref. 6).

11.3.5.7 Equipment Post-Maintenance Testing and Return to Service

Equipment is tested following maintenance to demonstrate that the equipment is capable of performing its intended function, that the maintenance was performed correctly, and that no problems were introduced during the maintenance. Required testing is specified on the maintenance work order or accompanying documentation and includes the equipment functions that may have been affected by the maintenance. Tests are conducted in accordance with written instructions or formal procedures. Unsatisfactory test results require evaluation, corrective action, and retesting.

Requirements for returning equipment to service are entered on the applicable work controlling documents. Prior to returning equipment to service, the shift manager ensures proper facility conditions including completion of required alignments and surveillance tests (Ref. 6).

11.3.5.8 Alarm Status

The status of control area and local panel alarms must be readily available to operations personnel and included in the shift turnover process. Available information includes a list of the following alarms (Ref. 6):

- Alarms that are totally disabled
- Alarms with individual inputs disabled

- Alarms with temporarily changed setpoints
- Alarms that are normally illuminated during operation
- Multiple input alarms that do not re-indicate (i.e., reflash) when more than one input is activated.

The shift manager shall ensure appropriate actions are taken to monitor equipment parameters for abnormal conditions that would be masked by deficient or non-re-indicating (i.e., non reflashing) visual or audible alarms. The shift manager determines and implements the actions (Ref. 6).

11.3.5.9 Temporary Modification Control

Temporary modifications to configuration items of facility equipment, components, and systems are controlled in accordance with the temporary modification requirements in WSRC Procedure Manual E7, which specifies requirements concerning temporary modification initiation, technical evaluation, review and approval, installation, periodic reviews, removal, extensions, control form revisions, work package closure, and documentation (Ref. 11).

11.3.6 LOCKOUTS AND TAGOUTS

This section describes the guidance contained in WSRC Procedure Manual 2S concerning the use of lockouts and tagouts for the purpose of hazardous energy control, performed in accordance with requirements specified in the WSRC Employee Safety Manual 8Q (Ref. 6, 10). Lockouts and tagouts for the purpose of hazardous material control are performed in a similar manner.

The Conduct of Operations Manual specifies the use of lockouts/tagouts for hazardous energy control (Ref. 6). Lockout/tagout is a method of hazardous energy control for the protection of site personnel. This is accomplished through the isolation and restoration of equipment and systems to protect personnel from injury, protect equipment from damage, and prevent the release of hazardous material to the environment during maintenance, inspections, testing, training, and similar activities (Ref. 10).

The lockout/tagout program provides the primary means of controlling the position of energy isolation devices such as valves and circuit breakers, in order to protect personnel, equipment, and the environment from inadvertent release of energy or hazardous material. Locks are used in conjunction with the tagout system to provide additional protection against inadvertent movement of energy isolating devices except where equipment design or arrangement makes the use of a lock impractical (Ref. 10).

DANGER - DO NOT OPERATE (DNO) tags shall be regarded as inviolable by all personnel. No person shall change the position of an energy-isolating device that has a DNO tag affixed from the position specified on the tag, nor shall anyone direct or authorize such a change of position except as provided by procedure. No person shall remove a DNO tag from an energy-isolating device or direct or authorize such removal except as provided by procedure. Any person who violates these rules is subject to disciplinary action, up to and including dismissal and may be subject to civil and criminal penalties as well (Ref. 10).

Control locks provide a physical restraint on the operation of equipment and provide assurance that only qualified personnel performing required evolutions will operate equipment. The facility operations manager develops, evaluates, and updates the list of equipment that require control locks. The shift manager authorizes removal of control locks and the repositioning of control-locked equipment before manipulation (Ref. 10).

11.3.7 INDEPENDENT VERIFICATION PRACTICES

The Conduct of Operations Program provides uniform requirements for the site operations independent verification program and establishes a high degree of reliability in ensuring correct facility operation and correct positioning of components such as valves, switches, and circuit breakers. The requirements apply to facility operations and support personnel involved in the performance of independent verifications.

Independent verification is performed in those cases where a reasonable potential exists for component mis-positioning or where the consequence of error is great. The application of the program is dependent upon the safety and operations considerations of each process, system, or facility. Because the possibility of mis-positioning may be quite remote or because the effect of mis-positioning may not be significant to safe and reliable operation, not all components require independent verification. Those systems or components that require independent verification are designated by the facility (Ref. 6). Independent verifications involving hazardous energy control are performed in accordance with requirements specified in WSRC Procedure Manual 8Q (Ref. 10).

The following sections describe the guidance and requirements provided by the Conduct of Operations Manual (Ref. 6) for independent verification practices.

11.3.7.1 Components Requiring Independent Verification

The facility manager prepares and maintains a facility-specific list of systems and components requiring independent verification.

Safety-related/ITS systems require independent verification and are included on the facility-specific list of systems and components requiring independent verification. Safety-related/ ITS systems, including their structures and components, are identified in the facility safety documentation such as SARs/DSAs and TSRs as necessary to ensure safe facility operation. Facility-specific SARs/DSAs provide further details in this area. The need for independent verification of specific components in safety-related/ITS systems is evaluated on a case-by-case basis.

Independent verifications are performed for certain components in systems not related to safety that, if mis-positioned, could lead to challenges to safety systems or to inadvertent radioactive or chemical releases. In addition, the facility manager considers independent verification for non-safety-related/non-ITS components that, if mis-positioned, could lead to an unplanned shutdown (Ref. 6).

11.3.7.2 Occasions Requiring Independent Verification

Components receive independent verification when the equipment they serve must be available and a possibility exists that the components may have been mis-positioned. Independent verifications are performed to ensure that systems are properly aligned when equipment is returned to service following maintenance or testing. The site safety program often requires that independent verifications be performed when equipment is removed from service by a lockout/tagout. Independent verifications are performed during equipment and system lineups after extended shutdowns or major maintenance. To verify that associated equipment is fully functional, facilities often perform routine periodic verifications of certain critical components during normal operations (Ref. 6).

11.3.7.3 Verification Techniques

Specific techniques are used for independent verification of common components, such as manual valves and air-operated valves. General techniques that address items, such as valve position and valve position indicators, are also specified (Ref. 6).

11.3.7.4 Guidelines for Personnel Performing Independent Verifications

Guidelines for performing independent verifications include, but are not limited to, the following items (Ref. 6):

- There must be no doubt as to the determination of the actual position of a component.
- Independent verifications are conducted in a manner such that each check constitutes an actual identification of the component and determination of both its required and actual positions.

- Unless otherwise specified in a procedure, individuals performing the initial action and those performing the independent verification, must be physically separated in location and time to ensure independence.

- The individual performing the independent verification must not rely upon the observed actions of the individual performing the initial action requiring the verification.

- If the actual position of a component cannot be verified due to unfamiliarity with the device, then the independent verifier is directed to seek assistance from the shift manager and/or appropriate manager to resolve the uncertainty.

11.3.8 LOGKEEPING

The Conduct of Operations Program specifies the requirements for establishing and maintaining operating logs for key operations positions in order to fully record the data necessary to provide an accurate history of facility conditions. An operating log is defined as a narrative sequence of events or functions performed by a specific shift position. Operating logs provide a system for ensuring that pertinent information is passed from one shift to the next, allows the history of a key position to be reviewed in event reconstruction, and supports trending analysis.

Facility managers identify operations and support positions that are defined as key positions and develop a key position list for their facility. These are identified in facility standing orders. Each facility provides guidance to its operating personnel, which defines the scope of information unique to each key position's shift operating log. This may be described in standing orders.

Personnel making entries in operating logs fully document all data necessary to provide an accurate shift history. The types of information that should be recorded in operating logs are delineated in WSRC Procedure Manual 2S (Ref. 6).

11.3.9 SHIFT TURNOVER

The Conduct of Operations Program defines the site shift turnover process (Ref. 6). This process ensures that relief personnel are provided with the knowledge required to accomplish their shift assignment responsibilities. The program describes the controls necessary for conducting an orderly and accurate transfer of information regarding the overall status of the facility at shift turnover.

Shift turnover is a critical period during which it is essential that the oncoming shift or relief personnel are provided with a complete and accurate transfer of information regarding the facility's overall status. Requirements have been established to provide shift personnel with a standard format for documenting shift turnovers. The shift turnover process applies to those facility operations that will be continued by an oncoming or relief shift without interruption of the operation. The requirements apply to facility operations and support personnel (Ref. 6).

Each facility develops and maintains turnover checklists that are specific to the CAs and workstations of the facility. As a minimum, shift supervisory and key positions have a turnover checklist to be used in the turnover process. When completed, shift turnover checklists are reviewed for completeness, accuracy, and legibility; each checklist is authenticated by the person who completes it. Additional requirements regarding shift turnover checklists and responsibilities are delineated in the WSRC Procedure Manual 2S (Ref. 6).

The following sections describe the guidance and requirements provided for operations turnover practices by the WSRC Procedures Manual 2S (Ref. 6).

11.3.9.1 Document Review

Before shift turnover, the off-going shift reviews the turnover checklist. Before assuming responsibility for their shift position, the oncoming shift personnel review the turnover checklist as intensively as necessary to understand important history, present status, and planned events. The oncoming shift also reviews status documents for their position, such as operating and system status logs (Ref. 6).

11.3.9.2 Walkdowns

The purpose of a walkdown is to determine a facility's current status through observation of the system control indicators, such as status boards, and to verify that equipment is tagged/locked as indicated by the appropriate logbooks. Walkdowns are specified for oncoming personnel (accompanied by off-going personnel), supervisors, and shift test conductors (Ref. 6).

11.3.9.3 Discussion and Exchange of Information

Sufficient time is allotted at turnover to allow the off-going shift to discuss and explain any important items that affect facility operations and safety with the oncoming shift or relief personnel. Oncoming and off-going shift personnel conduct a discussion that includes, but is not limited to, the following items:

- Safety and critical equipment status
- Status of individual systems

- Equipment in operation at turnover
- Inoperable and tagged equipment, including instrumentation and alarms
- Surveillance and equipment work in progress at turnover
- Reportable events
- Special procedures and temporary procedure changes generated during shift

The off-going personnel are relieved only when the oncoming personnel verbally accept responsibility for the shift position, which is documented in writing in the appropriate operating log (Ref. 6).

11.3.9.4 Relief Occurring During the Shift

Relief occurring during the shift as a result of situations such as meetings and lunch breaks must have a turnover that ensures that the oncoming person is at least as knowledgeable of the facility conditions as he/she would have been had the complete shift turnover process been conducted. Relief occurring during the shift is documented in the applicable operating log (Ref. 6).

11.3.10 OPERATIONS ASPECTS OF FACILITY CHEMISTRY AND UNIQUE PROCESSES

Operational monitoring of facility chemistry or unique data and parameters should ensure that parameters are properly maintained. Monitoring parameters is important to verifying system operation in accordance with design expectations. In order to enhance proper process control of systems, operations personnel must have an understanding of all facility processes and must effectively coordinate operations activities with the respective technical support departments.

Facility managers are responsible for ensuring that each operation's specific responsibilities with respect to chemistry control are defined through approved operations procedures and that specific facility/process training is appropriately addressed. The facility manager shall also ensure that chemical parameters and requirements within the facility are properly identified and implemented. WSRC Procedure Manual 2S provides additional guidance and requirements for the involvement of operations personnel in facility chemistry and other unique processes (Ref. 6).

11.3.11 REQUIRED READING

The Required Reading Program (RRP) is a site method for ensuring that individuals are kept informed of important information that will enhance their ability to effectively perform their job assignment. The RRP is required for all operations personnel and those organizations that provide direct support to operations organizations. This may also include information contained in video and audio media as well as written materials.

A designated manager ensures that all appropriate material is included in the RRP and properly completed by personnel. That manager is also responsible for determining if any required reading material is of such significance that affected personnel must read it and understand it before assuming shift or work station responsibilities. Only information that needs documentation indicating an individual has read and understood the material should be included in the RRP (Ref. 6).

WSRC Procedure Manual 2S provides additional guidance and requirements regarding the establishment, maintenance, and records associated with the RRP (Ref. 6).

11.3.12 TIMELY ORDERS TO OPERATORS

Shift orders are issued to communicate short-term information and administrative instructions to shift personnel. Information, such as special operations, increased frequency in monitoring certain parameters, classification of administrative instructions, etc., should be conveyed in shift orders.

Standing orders are issued to communicate long-term information and administrative instructions to shift personnel. Special instructions, such as minimum shift manning requirements for all facility conditions, may be included in standing orders (Ref. 6).

Facility and facility operations managers are responsible for the approval and issuance of both standing and shift orders. Standing and shift orders are not to be used in lieu of approved operating procedures or as a means to circumvent necessary procedure changes. If the orders cannot be followed or completed as written, they should be revised only after approval by the issuing authority or designated alternate.

11.3.13 OPERATOR AID POSTINGS

The operator aid posting program describes the requesting, authorization, documentation, placing, and reviewing required to ensure that operator aids are current, complete, and necessary (Ref. 6). The use of informal, unauthorized, or out-of-date instructions, notes, graphs, drawings, and other documents in the facility can detract from proper operation or maintenance. Information used in the operation of facility systems must be properly controlled.

Operator aids are in many forms, such as copies of procedures, system drawings, handwritten notes, curves, and graphs. Any facility employee may develop an operator aid; however, the operator aid must be approved before posting or use. Facility operations managers are responsible for approving both the need for and the content of operator aids.

CA operators frequently make use of information such as tables or graphs of tank volumes, chemical concentrations, etc. All such information is controlled to ensure the information is the latest revision.

11.3.14 EQUIPMENT AND PIPING LABELING

The equipment and piping labeling program provides the general guidelines required to establish and maintain a standardized and consistent labeling program for permanent identification of plant equipment, valves, instruments, and piping

Facility managers designate Labeling Coordinators for facilities.

WSRC Procedure Manual 2S provides further details concerning this program, including labeling requests, temporary label approval and installation, label specifications, label ordering, label installation, and program maintenance (Ref. 6). Labeling of piping, containers, and vessels containing hazardous materials for the purpose of hazard communication is in accordance with the Occupational Safety and Health Administration (OSHA) requirements specified in WSRC Procedure Manual 4Q (Ref. 9). Chapter 8 of this Manual provides additional information concerning these requirements.

11.4 Fire Protection

Fire protection activities are addressed under Operational Safety in this Manual. WSRC, in accordance with S/RIDs, ensures that the following general criteria are satisfied (Ref. 4, 8). The following criteria are not all inclusive of all required criteria:

- New construction conforms with the applicable building code supplemented with additional safety requirements associated with the facility in a graded manner.
- The potential for the occurrence of a fire and related event is minimized.
- Fire does not cause an unacceptable onsite or offsite release of hazardous or radiological material that will threaten health and safety of employees, the public, or the environment.
- Vital DOE programs will not suffer unacceptable interruptions as a result of fire and related hazards.
- Property losses from fire and event perils does not exceed defined limits established by DOE.
- The potential for critical process controls and Safety Class systems being damaged as a result of a fire and related events is minimized.
- Requirements are established that will provide an acceptable degree of life safety to DOE and contractor personnel and the public from fire in DOE facilities.

The specific requirements of this policy are met through the implementation and enforcement of a comprehensive Fire Protection Program based on applicable DOE Orders, nationally recognized codes and standards, and accepted industry practices (Ref. 8). The site Fire Protection Program is implemented through WSRC Procedure Manual 2Q (Ref. 5). Major elements of the program are described in Section 11.4.2.

11.4.1 FIRE HAZARDS

The facility-specific SAR/DSA and/or applicable procedures should be referenced for details regarding the implementation of the DOE requirements for a particular facility on overall assessments such as Fire Hazards. Section 11.4.3 discusses administrative fire prevention controls used to identify and control potential fire hazards.

11.4.2 FIRE PROTECTION PROGRAM AND ORGANIZATION

This section discusses the WSRC Fire Protection Program. Program requirements are specified in WSRC S/RIDs. The program is procedurally implemented at the site level through WSRC Fire Protection Program Manual 2Q (Ref. 5).

11.4.2.1 Fire Protection Policy, Organizations, and Administrative Plans and Procedures

The objectives of the WSRC fire protection policy are implemented by the site Fire Protection Program, which establishes minimum requirements for ensuring compliance with the higher-level-of-protection criteria as outlined in DOE Order 420.1 (Ref. 12). The program meets applicable building codes and National Fire Protection Association (NFPA) codes, or exceeds them (when necessary to meet safety objectives) unless written relief is explicitly granted by DOE. This program is characterized by the inclusion of a continuing, sincere interest on the part of management and employees in minimizing losses from fire and related perils and by the inclusion of preventive features necessary to ensure that objectives related to safety are met (Ref. 8).

Implementation of the site Fire Protection Program involves many specific activities by multiple organizations as summarized in MP 4.16, “Fire Protection,” in the WSRC 1-01 Manual (Ref. 8, 5). These activities and responsibilities are summarized in the following sections.

FIRE PROTECTION ADMINISTRATION PROGRAM AND FIRE PROTECTION ENGINEERING (FPE)

Fire Protection Engineering (FPE) has the primary programmatic responsibility for fire protection at SRS and serves as the primary technical resource for all company-level fire protection matters. FPE assists facility managers in the consistent application of the fire protection program and development and implementation of memoranda of understanding and fire protection program plans. (Ref. 8)

ALL WSRC ORGANIZATIONS

All WSRC organizations, construction contractors, and subcontract organizations are responsible for complying with all plans, procedures, instructions, and requirements of the WSRC Fire Protection Program (Ref. 5). This includes reporting any action, circumstances, or deficiency that could adversely affect or reduce the fire safety at SRS.

MEMORANDUM OF UNDERSTANDING

Memoranda of Understanding (MOUs) may be utilized (not a requirement) by divisions that own facilities that have fire protection systems. MOUs establish organizational responsibilities for fire protection related duties. They should confirm responsibilities as stated in WSRC Procedure Manual 2Q and address any specific changes in those responsibilities as specifically allowed in the WSRC Procedure Manual 2Q responsibilities section (Ref. 5).

WSRC Procedure Manual 2Q provides the administrative plans and procedures involved in the implementation of the site Fire Protection Program (Ref. 5).

11.4.2.2 Fire and Explosion Protection Criteria

DOE has established specific requirements in DOE Order 420.1 for the operation of departmental facilities to protect the public, site personnel, and facilities from the effects of fire. All new SRS facilities, and any modifications of a substantial nature to existing facilities, are designed and built in accordance with DOE Order 420.1 and the mandatory fire protection it contains. The Fire Protection Program has been established by management in accordance with DOE requirements to ensure that the criteria listed in Section 11.4 are satisfied (Ref.13).

The WSRC S/RIDs are the major sources of DOE fire protection requirements. However, other documents specify additional requirements (e.g., DOE Standard, DOE-STD-1066-99 [Ref. 13]). A list of mandatory fire protection criteria are provided in the WSRC Procedure Manual 2Q along with additional criteria and guidelines pertaining to the DOE Fire Protection Program (Ref. 5).

11.4.2.3 Fire Protection Requirements

The Fire Protection Program provides direction and guidance in specifying fire protection requirements for facilities for compliance with DOE Orders and nationally recognized codes and standards such as NFPA codes. Generic requirements are listed in the WSRC 1-01 Manual for the fire protection systems and activities (Ref. 8).

The fire protection related codes and standards in effect when facility design commences (Code of Record) remain in effect for the life of the facility. When modifications of a substantial nature occur, as determined by the Authority Having Jurisdiction (AHJ), the current edition of the code applies to the modification. There are two exceptions as follows:

- Exception 1: If there is a significant hazard that endangers building occupants or the public, as determined by the AHJ, shall meet the requirements of the current edition of the code or standard.

- Exception 2: The Code of Record for NFPA 101, Life Safety Code, is the current edition. This code applies to all new construction and existing buildings. This code stipulates specific provisions for existing buildings that may differ from those for new construction.

Specific standards and site procedures governing maintenance, testing, inspection, and repair are indicated for each of the fire protection systems (Ref. 5).

Regular surveillance tests of fire protection equipment and systems are conducted as required by NFPA codes, and the results are documented. Specific in-service maintenance procedures are written for individual systems, detailing inspection requirements and frequencies. Maintenance, testing, and inspection schedules are established based on the requirements of the individual NFPA codes, standards, and recommended practices applicable to the individual system or component (Ref. 5).

11.4.2.4 Fire Protection Reviews

DOE Order 420.1 specifies that each facility that is termed significant, having major modifications, and/or facilities with significant fire safety risks, shall undergo an FHA (Ref. 13). WSRC Procedure Manual 2Q lists the minimum content requirements for FHAs. An FHA is performed under the direction of a qualified fire protection engineer (Ref. 5).

11.4.2.5 Fire Safety Deficiency Classification

WSRC Procedure Manual 2Q outlines procedural steps for evaluating and assigning corrective action priority to previously determined Fire Safety Deficiencies (FSDs). The condition constituting an FSD is the failure to meet the minimum objectives of the DOE Fire Protection Program as delineated in DOE Orders 420.1 and 440.1A (Ref. 12, 14). This classification methodology uses the existing priority classification system developed in WSRC Procedure Manual 1Y to provide a consistent approach to assigning corrective action priorities across the SRS (Ref. 15).

The classification system assists personnel and organizations that have the responsibility for FSD corrective actions in accurately prioritizing these deficiencies. Accurate FSD priority assignment ensures the appropriate level of management attention until the FSD condition is adequately mitigated.

11.4.3 COMBUSTIBLE LOADING CONTROL

11.4.3.1 Control of Combustibles

SRS facilities employ administrative controls to identify and control potential fire hazards. Certain administrative controls minimize the risks associated with flammable and combustible materials. The Fire Protection Program includes guidelines and requirements specified in the following areas (Ref. 5):

- General control of transient combustibles
- Use and handling
- Storage criteria for transient combustibles, flammable/combustible liquids, and compressed gases
- Inspections

The use of transient combustibles is limited to those materials and quantities necessary to support work activities. Metal planking, where practical, is used in the construction of scaffolding. Pressure-treated, fire-retardant lumber is used where metal scaffolding is inappropriate. Plastic or fabric tarpaulin sheets must be Underwriter Laboratories (UL)-listed fire retardant materials unless otherwise approved by the fire protection coordinator (Ref. 5).

Transient combustible is stored in areas designated and established by the Fire Protection Coordinator (FPC). General storage criteria, as well as storage criteria for specific materials and containers, are discussed in the WSRC Procedure Manual 2Q (Ref. 5).

Site and facility inspections serve an important role in the control of combustibles. The fire prevention inspection program is discussed in Section 11.4.5.

11.4.3.2 Control of Ignition Sources

SRS facilities employ administrative controls to identify and control potential fire hazards. Ignition sources within a facility are controlled and minimized as noted below (Ref. 5):

- Only UL-listed portable electrical heaters are used (Ref. 5).
- Coffee pots, hot plates, cooking equipment, and portable heaters are turned off at the end of the workday and when not in use.

- Hot work activities, including the use of acetylene welding and cutting torches, electrical welding equipment, blow torches, propane torches, melting pots, portable furnaces and heaters, grinding, spark producing operations and open flames of any kind, require compliance with NFPA standards. A hot work permit is required for all hot work activities (Ref. 5).

11.4.4 FIREFIGHTING CAPABILITIES

11.4.4.1 Fire Protection Personnel and Training Requirements

The following organizations and personnel are involved with the implementation of the Fire Protection Program (Ref. 8):

- Safeguards, Security and Emergency Services (SS&ES)
- Facility personnel
- FPCs
- Fire watches
- Fire patrols

The following paragraphs describe the fire protection functions of these organizations, groups, and positions; specify personnel qualifications and training requirements; and specify firefighting and rescue capabilities (Ref. 5).

SAFEGUARDS, SECURITY AND EMERGENCY SERVICES

SS&ES serves the following purposes:

- Protect life, including maintaining acceptable life safety for workers in the event of a fire emergency
- Reduce property damage by confining and extinguishing fires
- Assist in avoiding unacceptable interruptions of vital DOE programs as a result of fire
- Assist in ensuring that fire does not cause a release of radiological and other hazardous material that will threaten the public health and safety or the environment

- Mitigation of hazardous materials incidents

To serve the above purposes, the following emergency services are provided (Ref. 16):

- Fire fighting
- Emergency Medical Service
- Rescue
- Hazardous materials response

S/RIDs, WSRC Procedure Manual 2Q, WSRC Procedure Manual 2Q2, and WSRC-SCD-7 establish the site requirements for SS&ES (Ref. 4, 5, 16, 17). Implementing WSRC Procedure Manual 2Q2 establishes the internal operating procedures for SS&ES to include such activities as administration, deployment of resources, staffing requirements, training, and response procedures for the services provided (Ref. 16).

SS&ES personnel receive initial training prior to independently providing service and continuing training while assigned to perform such services.

LINE ORGANIZATIONS

Line organizations involved in the site Fire Protection Program require qualified WSRC SS&ES or subcontractor fire protection engineers and technical personnel to develop and maintain the program. Each organization develops and maintains its own organizational chart that outlines the responsibilities and required qualifications of its various fire protection professionals (Ref. 5).

FACILITY PERSONNEL

All SRS employees complete Occupant Fire Prevention Training as part of initial General Employee Training and on an annual basis as part of Consolidated Annual Training Program.

FIRE PROTECTION COORDINATORS

Each facility has an FPC who serves as a single point of contact for overall coordination of fire protection related activities within the facility. Qualifications to fill this position is the successful completion of Fire Safety Course Training (Ref. 5).

FIRE WATCHES

Fire watches are typically performed to provide constant fire coverage for activities associated with hot work (Ref. 5).

Personnel performing fire watch duties are trained to ensure compliance with NFPA and OSHA requirements (Ref. 5).

Fire watch personnel have no other duties that would interfere with their ability to monitor the work place or to immediately sound the fire alarm in the event of a fire. Fire watch personnel have the authority to correct or stop any condition that might lead to a fire (Ref. 5).

FIRE PATROLS

Personnel performing fire patrol duties are trained to ensure compliance with NFPA and OSHA requirements (Ref. 5).

Fire patrols, when instituted, provide protection to the facility by performing a scheduled walkthrough inspection of areas identified by the facility manager. Fire patrol personnel patrol their assigned area on a regular basis and are provided with a positive means of documenting the completion of their route (i.e., fire patrol log) (Ref. 5).

Typically, fire patrols monitor a specified area on an hourly basis. When personnel complete fire patrols, the working copy of the fire patrol log is retained to document the patrol (Ref. 5).

11.4.4.2 Firefighting in Radiation and Hazardous Chemical Environments

Facility-level procedures contain fire control plans that define the specific responses of facility personnel in the event of a fire. Fire Department Pre-plans exist that define control strategies both inside and outside of radiologically controlled areas and hazardous chemical environments.

Guidelines for control of emergency exposures to radiation are specified in the site radiological control program (Ref. 18).

11.4.4.3 Fire Response Procedures

WSRC Procedure Manual 2Q provides the administrative plans and procedures involved in the implementation of the site Fire Protection Program (Ref. 5). SS&ES prepares facility fire preplans for facilities larger than 5,000 square feet or possessing a special hazard.

11.4.4.4 Firefighting Equipment

Specific information on firefighting equipment is provided in WSRC Procedure Manual 2Q2 (Ref. 16).

11.4.5 FIREFIGHTING READINESS ASSURANCE

11.4.5.1 Fire Prevention Inspection Program

The facility manager or a designee performs a periodic facility inspection to confirm the adequacy of the following items related to fire protection per NFPA codes (Ref. 19):

- Transient combustible liquids and solids
- Flammables, combustibles, liquids, and gases
- Impairments
- Exit doors, corridors, stairwells, and signs
- Housekeeping practices
- Emergency lights
- Fire lanes
- Hot work

The results of these inspections are documented, and outstanding deficiencies are tracked until resolution is complete.

SS&ES conducts a periodic observation of pre-planned SRS facilities. A detailed report is submitted to the facility manager with a copy forwarded to SS&ES develops and maintains internal operating procedures outlined in WSRC Procedure Manual 2Q2 (Ref. 16).

Environment, Safety, Health and Quality Assurance (ESH&QA) is responsible for performing periodic independent appraisals of facilities to satisfy the independent oversight requirements of DOE G 414.1-1, providing quality assurance support for the Fire Protection Program, and performing biennial site Fire Protection Program assessments to satisfy the independent oversight requirements of S/RIDs (Ref. 4, 5, 20).

The WSRC self-assessment program ensures that facilities meet the requirements of DOE Orders. WSRC Procedure Manual 2Q specifies a list of program-related, facility-related, and combined aspects of the Fire Protection Program that are assessed and included in the appraisals and also specifies appraisal responsibilities for both facility managers and ESH&QA (Ref. 5).

11.4.5.2 Fire Safety Drills and Exercises

Fire protection drills are conducted in accordance with the requirements contained in fire control pre-plans.

11.4.5.3 Fire Protection Program Reports and Record Keeping Practices

Fire investigations and reports are performed and prepared in accordance with DOE Order 231.1 (Ref. 21). In addition, field reporting is performed in accordance with the applicable NFPA codes and site documents. The fire investigation report for any fire loss greater than $5,000 is submitted to ESH&QA Division.

The Annual Summary of Fire Damage Report is prepared and submitted to the DOE Operations Office by March 31 of each year in accordance with DOE Order 231.1 (Ref. 21). WSRC Procedure Manual 2Q provides guidance for preparing this report (Ref. 5).

Records and documentation retention schedules conform to the requirements established in the WSRC Site Records Inventory and Disposition Schedule (Ref. 5).

11.5 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

1. Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports. DOE-STD-3009-94, U.S. Department of Energy, Washington, DC, July 1994.

2. Conduct of Operations Requirements for DOE Facilities. DOE Order 5480.19, U.S. Department of Energy, Washington, DC, May 1992.

3. Nuclear Safety Management: DOE_Rule 10 Code of Federal Regulations (CFR) Part 830, U.S. Department of Energy, Washington, DC, January 2001.

4. Standards/Requirements Identification Document Integrated Safety Management System Description. WSRC-RP-94-1268, Rev. 99-19, Washington Savannah River Company, Aiken, SC.

5. Fire Protection Program. WSRC Procedure Manual 2Q, Washington Savannah River Company, Aiken, SC.

6. Conduct of Operations Manual. WSRC Procedure Manual 2S, Washington Savannah River Company, Aiken, SC.

7. Compliance Assurance Manual. WSRC Procedure Manual 8B, Washington Savannah River Company, Aiken, SC,.

8. Management Policies. WSRC-1-01, Washington Savannah River Company, Aiken, SC.

9. Industrial Hygiene Manual. WSRC Procedure Manual 4Q, Washington Savannah River Company, Aiken, SC.

10. Employee Safety Manual. WSRC Procedure Manual 8Q, Washington Savannah River Company, Aiken, SC.

11. Conduct of Engineering and Technical Support. WSRC Procedure Manual E7, Washington Savannah River Company, Aiken, SC.

12. Facility Safety. DOE Order 420.1, Change 2, U.S. Department of Energy, Washington, DC, October 1996.

13. Fire Protection Design Criteria. DOE-STD-1066-99, U.S. Department of Energy, Washington, DC, July 1999.

14. Worker Protection Management for DOE and Federal Contractor Employees. DOE Order 440.1A, U.S. Department of Energy, Washington, DC, March 1998.

15. Conduct of Maintenance Manual. WSRC Procedure Manual 1Y, Washington Savannah River Company, Aiken, SC.

16. Fire Department Operating Standards. WSRC Procedure Manual 2Q2, Washington Savannah River Company, Aiken, SC.

17. SRS Emergency Plan. WSRC Manual WSRC-SCD-7, Washington Savannah River Company, Aiken, SC.

18. Radiological Control Manual. WSRC Procedure Manual 5Q, Washington Savannah River Company, Aiken, SC.

19. Facilities Handling Radioactive Materials. NFPA 801, National Fire Protection Association, Quincy, MA, 1995.

20. Implementation Guide for Use with Independent and Management Assessment Requirements of 10 CFR Part 830.120 and DOE 5700.6C Quality Assurance. DOE G 414.1-1, U.S. Department of Energy, Washington, DC, August 1996.

21. Environmental Safety, and Health Reporting Requirements. DOE Order 231.1, Change 2, U.S. Department of Energy, Washington, DC, November 1996.

22. Training and Qualification Program Manual. WSRC Procedure Manual 4B, Washington Savannah River Company, Aiken, SC.

23. Configuration Management Manual. WSRC Procedure Manual 7E, Washington Savannah River Company, Aiken, SC.

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DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

Formerly the
GENERIC SAFETY ANALYSIS REPORT

CHAPTER 12
PROCEDURES AND TRAINING

January 2007

Washington Savannah River Company
Aiken, SC 29808

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

CONTENTS

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ACRONYMS AND ABBREVIATIONS

AOP	Abnormal Operating Procedure
ARP	Alarm Response Procedure
CQF	Cognizant Quality Function
CTF	Cognizant Technical Function
DOE	Department of Energy
EM	Emergency Management
EOP	Emergency Operating Procedures
FEB	Facility Evaluation Board
FOSC	Facility Operations Safety Committee
PC	Procedure Coordinator
RM	Records Management
RPD	Radiological Protection Department
QA	Quality Assurance
SAR	Safety Analysis Report
S/RID	Standards/Requirements Identification Document
SRS	Savannah River Site
TMC	Training Managers Council
TRAIN	Training Records and Information Network
V&V	Verification and Validation
WSRC	Washington Savannah River Company

12.0 PROCEDURES AND TRAINING

12.1 INTRODUCTION

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

12.1.1 OBJECTIVE

The objective of this chapter is to provide information that will satisfy the requirements of Department of Energy (DOE) STD-3009-94 (Ref. 1). This chapter documents the processes by which the technical content of procedures and training are developed, verified, and validated. This chapter also documents the mechanisms for identifying and correcting technical or human factors causing deficiencies in procedures and training programs.

12.1.2 SCOPE

This chapter describes the processes by which the technical content of the procedures and training programs are developed, verified, and validated at the Savannah River Site (SRS). The training and procedures processes assure that the facility is operated and maintained by personnel who are qualified and competent to carry out their job responsibilities. In addition, procedures and training elements have been developed to keep the processes current through the use of feedback and continuous improvement. This chapter is not intended to be the vehicle for review and approval of the sitewide Procedures and Training Programs. It is intended to describe the essential program features as they relate to facility safety.

12.2 REQUIREMENTS

Standards/Requirements Identification Documents (S/RIDs) state the codes, standards, and regulations governing the procedures and training programs (Ref. 2). Any changes to these manuals are reviewed for continued compliance with S/RID requirements in accordance with Procedure Manual 8B (Ref. 3). Programmatic compliance assessment has been performed against the S/RIDs and documented as specified in the Washington Savannah River Company (WSRC) Procedure Manual 8B (Ref. 3). The Standards Management/Compliance Section maintains records of the programmatic compliance assessments.

12.3 PROCEDURES PROGRAM

WSRC Procedure Manual 2S provides requirements and methods for developing and writing, reviewing, approving, revising, canceling, controlling, and using technical and response procedures (Ref. 4). WSRC Procedure Manual 1B provides requirements and responsibilities for preparation, review, approval, revision, and cancellation of all program-specific administrative procedures.

12.3.1 DEVELOPMENT OF PROCEDURES

WSRC Procedure Manual 2S and WSRC-SCD-2 provide standard practices for generating technical and response procedures (Ref. 4, 5) to assure uniformity. Department managers are responsible for ensuring that all activities affecting quality performed in their area of responsibility shall be prescribed by, and performed in accordance with, documented instructions, procedures, or drawings. The 2S Manual implements procedure requirements contained in DOE Order 5480.19 (Conduct of Operations) as well as requirements contained in the 1Q Manual and the 1B Manual, "WSRC Management Requirements and Procedures" (Ref. 6). The 1B Manual provides requirements and responsibilities for preparation, review, approval, revision, and cancellation of program-specific administrative procedures.

These guidelines apply to technical procedures, including Standard Operating Procedures, maintenance procedures, test procedures, surveillance procedures, and other procedures that provide step-by-step instructions for the performance of an activity or evaluation and response procedures, including Abnormal Operating Procedures (AOPs), Emergency Operating Procedures (EOPs), and Alarm Response Procedures (ARPs) (Ref. 4).

Note that the emergency plan-related procedures, such as Emergency Preparedness Administrative/Implementing Procedures, are distinct from ARPs, EOPs, and AOPs. Emergency plan-related procedures are discussed in Chapter 15.

12.3.1.1 Procedure Preparation

WSRC Procedure Manual 2S and WSRC-SCD-2 establish a recommended approach for developing technical procedures that are accurate, complete, clear and consistent, including guidance for the following (Ref. 5).

- Planning, organizing, and structuring the procedure
- Formatting the procedure
- Writing action steps

A Procedure Coordinator (PC) in cooperation with the originating organization develops facility-level administrative procedures. The PC is responsible for promoting standardization and consistency of procedure development for a particular facility, and for ensuring that facility procedures are processed for review, comment, approval, and issuance.

12.3.1.2 Procedure Verification

WSRC Procedure Manual 2S (Ref. 4) establishes the responsibilities and requirements for the verification of procedures. Procedure verification is the process for evaluating a procedure for technical and written correctness. This procedure applies to all WSRC facilities and organizations that generate, and use, operations, technical, or response procedures, and to all personnel who perform procedure verification. This procedure also applies to the verification of administrative procedures.

Procedure owners review technical and response procedures to ensure that they are correct and complete, and that independent verification points are identified. They review administrative procedures for impact on group or facility functions. The Cognizant Technical Function (CTF) verifies the technical accuracy of the procedures with respect to Technical Safety Requirements, Safety Analysis Report (SARs), Process Requirements, etc. The Cognizant Quality Function (CQF) ensures that all applicable Quality Assurance (QA) requirements are met in procedures, particularly in administrative procedures that implement site quality requirements. Radiological Protection Department (RPD) and Safety and Health Programs review procedures for radiation and contamination control and/or the control and handling of radioactive materials. When all concurrence reviews are completed, the procedure is prepared for validation (Ref. 4).

12.3.1.3 Procedure Validation

WSRC Procedure Manual 2S provides guidance and direction for validating operations, technical, or response procedures. Validation is the process for evaluating a procedure for user and facility compatibility. Validation is not required for administrative procedures. For procedures that require validation, the PC is responsible for identifying a group to perform the validation and for assembling the validation package including the Procedure Validation Checklist.

The two principal methods of validation are the walkdown and the tabletop methods. The walkdown method requires users of the procedure to perform a step-by-step enactment of the actions detailed in the procedure with no changes to facility configuration or operational conditions. This is the preferred method for validating procedures.

Tabletop reviews are usually performed in a conference room with the lead validator talking through the procedure, and Verification and Validation (V&V) team members asking questions to enhance the assessment. This method is used only when a walkdown validation is not possible because, this method does not validate the communication or manpower aspects of the procedure being validated.

12.3.2 MAINTENANCE OF PROCEDURES

WSRC Procedure Manual 2S provides guidance regarding the maintenance and control of procedures to assure proper dissemination and utilization of facility procedures. This guidance is consistent with the requirements provided by WSRC Procedure Manual 1B for document control (Ref. 4, 6).

12.3.2.1 Periodic Review of Procedures

To ensure the technical accuracy and the proper consideration of human factor issues in procedures, the PC establishes periodic review schedules for all procedures. Periodic reviews may be initiated in conjunction with a major revision, an incident investigation, a design change, or the satisfactory performance of the entire procedure rather than waiting for the scheduled review time.

12.3.2.2 Procedure Control and Dissemination

The PC issues and controls procedures in accordance with WSRC Procedure Manual 1B, which establishes the responsibilities and methods for control, distribution, revision, and cancellation of controlled distribution documents (Ref. 6). These methods ensure that the correct procedure revision is available for use to perform work. The PC for each organization establishes, maintains, and controls the controlled distribution list and the controlled index of procedures for that organization. The controlled index of procedures lists all controlled procedures that are issued and ready for use. Records Management (RM) or an appointed organization distributes copies of controlled procedures and applicable controlled indexes. RM also maintains record copies of controlled procedures (Ref. 6).

12.3.2.3 Procedure Training and Coordination

Procedure revisions that affect the performance of the applicable procedure, such as a change in intent, technique, or sequential order of steps, require V&V. As part of this process, the training organization, when required, reviews procedures to determine impact on training for the procedure owner. This ensures the training program is maintained current with the procedures.

12.4 TRAINING PROGRAM

The mission of WSRC training is to improve job and safety performance of the SRS workforce by providing skills and knowledge in a manner that is compliant, consistent, customer-focused, creative, and cost-effective. WSRC Procedure Manual 4B provides controls for training and qualification programs (Ref. 7, 8). Project Training Managers and Program Training Managers are responsible for the training programs within their organizations.

12.4.1 DEVELOPMENT OF TRAINING

This section summarizes the process by which the technical content of training programs is developed, reviewed, and approved (Ref. 8). All development is based upon the learning objectives and design specifications identified in the design phase and the skills and knowledge necessary as identified in the analysis phase. Training developed, using these guidelines, may apply to various aspects of project training including conduct of normal, abnormal, and emergency operations.

12.4.1.1 Site Level Guidance for Training Areas

Specific areas for which training is typically developed and implemented for a project and the site-level guidance governing that area are summarized in the following sections. The types of training mentioned below may include, but are not necessarily limited to, both on-shift and classroom training.

CRITICALITY TRAINING

The WSRC Nuclear Criticality Safety Manual (Ref. 9) governs criticality training. This manual establishes criticality safety related requirements for the selection, training, examination, qualification, retraining, re-examination and re-qualification of personnel whose duties are related to nuclear materials or criticality safety. Further details on the criticality training methods and qualification requirements are discussed in Chapter 6 of this document.

RADIATION AND HAZARDOUS MATERIAL PROTECTION TRAINING

WSRC Procedure Manual 5Q governs radiological Protection Training. The level of training required is determined by the frequency with which personnel are exposed to radiological hazards, the types of potential radiological hazards present, and the type and duration of tasks assigned within radiological areas. Several levels of Radiological Protection Training are available to WSRC personnel (Ref. 10).

MAINTENANCE TRAINING

Training requirements for maintenance personnel are described in the Maintenance Training and Qualification Program Description. Task-specific training and qualification requirements for each maintenance organization are documented and approved on the Task-to-Training Matrix for that organization.

FIRE PROTECTION TRAINING

Fire protection training is governed by Fire Protection Program (Ref. 11). This guidance requires each SRS employee to receive Occupant Fire Prevention Training on an annual basis. Employees who perform fire watches receive additional training as part of their qualification.

QUALITY ASSURANCE TRAINING

QA training is required as part of the employee indoctrination by WSRC Procedure Manual 1Q (Ref. 12). All employees receive general employee training and general QA program indoctrination to become familiar with the QA programs administered at WSRC. Guidance on both initial and continuing training at the general site and division levels is discussed in more detail in WSRC Procedure Manual 1Q (Ref. 12).

EMERGENCY PREPAREDNESS TRAINING

Emergency preparedness or Emergency Management (EM) training is governed by the SRS Emergency Plan (Ref. 13). Further details regarding these training programs and the objectives they meet are discussed in Chapter 15 of this SAR and WSRC-SCD-7 (Ref. 13).

12.4.1.2 Analysis of Training Requirements

Training analysis describes the process for defining the positional requirements, from which training requirements are generated, which process includes the systematic determination of prioritized tasks, as well as the knowledge and skills necessary to ensure successful job performance. It also describes the process of defining needs when positional requirements have already been defined. The analysis is accomplished by gathering information on a particular task or job from procedures, by interviewing subject-matter experts, and by direct observation of job incumbents.

Changes to job and task analysis data are initiated and the appropriate training personnel conduct analyses, if there are indications that training has been unsatisfactory, or when other situations arise that may require analysis (Ref. 8).

12.4.1.3 Design and Development of Training

WSRC Procedure Manual 4B describes the process for design and development of training for a documented requirement or need (Ref. 8). The sequenced learning objectives, testing formats, test items, and task-to-training matrix are reviewed for correspondence with analysis data and designed setting, as well as for conformance with production guidelines. Resultant instructional packages are reviewed by Subject Matter Experts (SME's) for technical accuracy prior to being approved by training management and submitted to records.

Design is the translation of the skills and knowledge required for a given task, as identified during the analysis phase, into learning objectives and specifications. Learning objectives define a measurable performance to be demonstrated by trainees at the end of the instruction. Design specifications indicate conditions (location, equipment, atmosphere, etc.) that are considered in providing the training.

12.4.2 MAINTENANCE OF TRAINING

This section describes the methods used to ensure that training programs reflect actual plant conditions and current procedures, and that necessary coordination is done before introducing new training programs or changes in procedures covered by training programs. WSRC Procedure Manual 4B provides controls for the training programs (Ref. 7, 8).

12.4.2.1 Training Committees

The TMC provides a vehicle for communications among training personnel associated with Washington Savannah River Company organizations. The Committee is a forum for consistent programmatic integration of activities, problem identification and resolution, and policy recommendations among the WSRC Training Program Managers, and Project Training Managers, with direct involvement of selected training professionals from across the site.

Line management through the application of the training review committee process (Ref. 8) validates training materials. The training program manager selects representatives from the training organization and line management to serve on a training review committee. As a minimum, a training review committee will include training personnel, personnel who will be performing the work the training is intended for, and management, when needed. This action ensures that the training program reflects actual plant conditions and current procedures. The committee's purpose is to serve as a quality check for the performance-based training process for specific training programs within a division.

Records kept at training review committee meetings include a list of attendees and decisions made on training-related functions. If changes to training are recommended, these changes are recorded and forwarded to the training program manager to administer the process of approving and incorporating the changes to training (Ref. 8).

12.4.2.2 Training Oversight and Assessment Program

Training oversight and assessment at WSRC is accomplished through a two-part process consisting of (1) facility and organizational self-assessments and (2) Facility Evaluation Board (FEB) activities. These processes are covered in Chapter 17.

12.4.2.3 Maintenance of Training Records

WSRC has established a sitewide training records management system and a standard file format for individual training records. Individual training records indicate each individual's participation in, and successful completion of, required training. WSRC has also established a standard record keeping system for training program records. Training program records document the design, analysis, development, implementation, and evaluation of training programs. Training records shall be dispositioned in accordance with the Sitewide Records Inventory and Disposition Schedule. WSRC has also established separate requirements for personnel who are involved in handling and maintaining examination materials. The training record administrator stores approved exams in a locked repository or lockable record room.

An automated records management system (Training Records and Information Network [TRAIN]) has been established to improve the quality and management of employee training information. TRAIN is a standard, sitewide, automated training support system that utilizes a site computer network. Interfaces between TRAIN and other sitewide systems ensure data integrity and reduce redundancy (Ref. 8).

12.4.3 MODIFICATION OF TRAINING MATERIALS

This section describes the methods used to identify and correct technical or human factor deficiencies in facility training programs, including operating experience, personnel examinations, and Lessons Learned from other facilities. Additional details regarding the responsibilities of individuals involved in modifying training programs are contained in WSRC Procedure Manual 4B (Ref. 8).

12.4.3.1 Incorporating Changes to Training

WSRC specifies a process that ensures Lessons Learned, occurrences, significant items, and other pertinent information are screened, evaluated, and incorporated, when applicable, to training programs, courses, or modules at SRS.

WSRC provides guidelines for the timely identification, screening, dissemination, and evaluation of Lessons Learned experiences. The Lessons Learned program involves a systematic review of the operating experiences of similar facilities, processes, systems or equipment for the purpose of applying Lessons Learned in areas of process safety and personnel safety from those experiences. Applicable material is disseminated to division Lessons Learned coordinators, who are responsible for administering division Lessons Learned processes.

An area Lessons Learned Coordinator is assigned to administer the Lessons Learned process within functional operating organizations, usually Lessons Learned at the departmental level. Area Lessons Learned Coordinators screen applicable Lessons Learned information from both in-house and external sources and disseminate it for information only, or for evaluation.

The Facility Operations Safety Committee (FOSC) ensures implementation of Lessons Learned corrective actions transmitted to them by the site Lessons Learned committee or coordinator (Ref. 6). Any SRS employee may identify a lesson learned, significant item, or other information with potential applicability to training or submit an individual request that impacts training.

The Project Training Manager reviews the request for applicability within the project (Ref. 8). After identifying an internal source with an impact on training within the division, the Project Training Manager assigns responsibility for implementing an action plan and schedule for resolving the situation to the training program manager responsible for the affected training area. The Project Training Manager generates a training needs analysis to forward to the Site Training Compliance and Support Manager if training in other projects is affected.

The Site Training Compliance and Support Manager determines if the training requested affects the training programs of more than one project. If the training is determined to be interproject, the training program manager defines an action plan and schedule for changing existing training or developing new training (Ref. 8).

12.4.3.2 Evaluation of Training Effectiveness

An annual evaluation plan is prepared for each training program (Ref. 8). The plan identifies what evaluation activities will be conducted and the schedule for conducting them. The division training manager is responsible for developing and implementing this plan, and for submitting to the site training manager an Annual Evaluation Report that summarizes the results of all evaluation activities conducted during the year.

12.5 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

1. Standards/Requirements Identification Document. Functional Area 04.0, "Training & Qualification (U)," Rev. 99-25b, WSRC-RP-94-1268-004, Westinghouse Savannah River Company, Aiken, SC.

2. Compliance Assurance Manual. WSRC Procedure Manual 8B, Westinghouse Savannah River Company, Aiken, SC.

3. Conduct of Operations Manual (U). WSRC Procedure Manual 2S, Westinghouse Savannah River Company, Aiken, SC.

4. Procedure Writing. WSRC-SCD-2, Westinghouse Savannah River Company, Aiken, SC.

5. WSRC Management Requirements and Procedures. WSRC Procedure Manual 1B, Westinghouse Savannah River Company, Aiken, SC.

6. Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities. DOE Order 5480.20A, U S. Department of Energy, Washington, DC, November 1994.

7. Training and Qualification Program Manual. WSRC Procedure Manual 4B, Westinghouse Savannah River Company, Aiken, SC.

8. Westinghouse Savannah River Company Nuclear Criticality Safety Manual. WSRC-SCD-3, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

9. Radiological Control Manual. WSRC Procedure Manual 5Q, Westinghouse Savannah River Company, Aiken, SC.

10. Fire Protection Program. WSRC Procedure Manual 2Q, Westinghouse Savannah River Company, Aiken, SC.

11. Quality Assurance Manual. WSRC Procedure Manual 1Q, Westinghouse Savannah River Company, Aiken, SC.

12. SRS Emergency Plan. WSRC-SCD-7, Westinghouse Savannah River Company, Aiken, SC.

13. Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports. Change 1, DOE-STD-3009-94, U.S. Department of Energy, Washington, DC, January 2000.

13.0 HUMAN FACTORS

This chapter does not contain information generic to the Savannah River Site. For more detailed information on Human Factors, refer to Chapter 13 of the facility-specific Safety Analysis Reports/Documented Safety Analysis.

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DSA SUPPORT DOCUMENT – Site Characteristics and Program Descriptions

Formerly the
GENERIC SAFETY ANALYSIS REPORT

CHAPTER 14

QUALITY ASSURANCE (U)

January 2007

Washington Savannah River Company

Aiken, SC 29808

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

This document was prepared by Washington Safety Management Solutions LLC (WSMS) under contract with Washington Savannah River Company (WSRC), subject to the warranty and other obligations of that contract and in furtherance of WSRC's contract with the United States Department of Energy (DOE).

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This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

14.0 QUALITY ASSURANCE

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

The WSRC Quality Assurance (QA) Program has been tailored appropriately to apply to all facilities operated and activities conducted, under Contract DE-AC09-96SR18500 and associated modifications. The QA Program serves an important role as part of the WSRC Integrated Safety Management System (ISMS). QA is an integral part of all of the processes by which work is prioritized, facilities designed, hazards analyzed, standards and controls identified and applied, equipment procured, work performed, and performance evaluated and improved.

The Washington Savannah River Company (WSRC) Quality Assurance Program is described in the WSRC Quality Assurance Management Plan (QAMP), WSRC-RP-92-225. The QAMP is approved by WSRC, DOE, and NNSA. It is written to meet the requirements of 10 CFR 830.120, Subpart A, "Quality Assurance Requirements" and DOE Order 414.1C, "Quality Assurance". It documents how WSRC implements the requirements of the rule and the order.

The QA Program is applicable to all WSRC facilities and operations using a graded approach. Facility-specific Safety Analysis Reports (SARs)/Documented Safety Analyses (DSAs) present descriptions of the QA programs of individual facilities and reference the documents detailing the program. Standards/Requirements Identification Documents (S/RIDs) state the codes, standards, and regulations governing the Quality Assurance policies and program elements of the Savannah River Site (SRS). Programmatic compliance assessment has been performed against the S/RIDs and documented as specified in the WSRC 8B Compliance Assurance Manual. The record of the programmatic compliance assessments are maintained in the S/RID database that is available through the SHRINE intranet.

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GENERIC SAFETY ANALYSIS REPORT

CHAPTER 15

EMERGENCY PREPAREDNESS PROGRAM

January 2007

Washington Savannah River Company
Aiken, SC 29808

SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

CONTENTS

ACRONYMS AND ABBREVIATIONS

DOE	Department of Energy
EP	Emergency Preparedness
EPHA	Emergency Planning Hazards Assessment
ERO	Emergency Response Organization
SAR	Safety Analysis Report
S/RID	Standards/Requirements Identification Documents
SRS	Savannah River Site
WSRC	Washington Savannah River Company

15.0 EMERGENCY PREPAREDNESS PROGRAM

15.1 INTRODUCTION

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

The objective of this chapter is to describe the philosophy, objectives, and organization of the Emergency Preparedness (EP) program for a wide spectrum of emergencies, ranging from local area emergencies to those that could affect the general public. This chapter is not intended to be the vehicle for review and approval of the SRS EP program, but is intended to describe the salient features of the program as it relates to the site and its various facilities.

The SRS EP program has been identified as being a Safety Significant administrative control program in regards to worker safety. This program emphasizes proper response to emergency conditions and establishes a notification program that alerts personnel to unusual or potentially dangerous conditions.

15.2 REQUIREMENTS

The Standards/Requirements Identification Documents (S/RIDs) state the codes, standards, and regulations governing the emergency preparedness policies and program elements of the SRS (Ref. 1). Programmatic compliance assessment has been performed against the S/RIDs and documented as specified in the Washington Savannah River Company (WSRC) Procedure Manual 8B (Ref. 2). The Standards Management/Compliance Section maintains records of the programmatic compliance assessments.

The SRS Emergency Plan has been developed to comply with all the requirements as identified in the S/RIDs database (Ref. 1, 3). The SRS Emergency Plan has a series of annexes (Ref. 3). These annexes describe in detail those emergency plan elements that are unique to each of the facilities at SRS.

The SRS emergency management program administration is described in Section 14 of the SRS Emergency Plan. Appendix VIII of the SRS Emergency Plan provides support documents (Ref. 3).

15.3 SCOPE OF EMERGENCY PREPAREDNESS

SRS emergency planning is concerned with individual and organizational responses to a range of potential accidents, including hypothetical accidents with very low occurrence frequencies.

More information can be found in the facility specific Safety Analysis Reports (SARs), facility specific Emergency Planning Hazards Assessments (EPHAs) and the SRS Emergency Plan Annexes (Ref. 3). In the facility-specific EPHAs, those events that could result in classifiable operational emergencies and the severity of those events have been identified.

15.4 EMERGENCY PREPAREDNESS PLANNING

The SRS Emergency Plan and facility annexes address the activation of emergency organizations, assessment actions, notification processes, emergency facilities and equipment, protective actions, training and exercises, and recovery actions (Ref. 3).

15.4.1 EMERGENCY RESPONSE ORGANIZATION

Section 2 of the SRS Emergency Plan describe the SRS site level Emergency Response Organization (ERO) (Ref. 3). The facility annexes describe the ERO for the individual facilities. The Emergency Plan and associated facility annexes delineate authorities and responsibilities of key individuals and groups, and identify the communication chain for notifying, alerting, and mobilizing the necessary personnel (Ref. 3).

The ERO is activated for all emergencies that fall within the parameters of the emergency classification system described in the SRS Emergency Plan, Section 4. The ERO may also be partially activated for events that do not fall within the classification system but warrant an increased level of management attention (Ref. 3).

15.4.2 ASSESSMENT ACTIONS

Section 4 and facility annexes of the SRS Emergency Plan summarize the processes by which the onset of an operational emergency is recognized (Ref. 3). The methodology used to obtain meteorological information and estimate release rates and source terms is identified in Section 6 and the facility annexes (Ref. 3).

The computer models used at SRS for consequence assessment of radiological and non-radiological hazardous material releases are described in Section 6 of the SRS Emergency Plan (Ref. 3). The specific models used and the plume methodologies employed (e.g., Gaussian plume) are detailed in the SRS Emergency Plan and supporting procedures (Ref. 3).

15.4.3 NOTIFICATION

Section 5 and facility annexes of the SRS Emergency Plan summarize the provisions for prompt initial notification of emergency response personnel and response organizations, including appropriate Department of Energy (DOE) elements and other federal, state, tribal, and local organizations (Ref. 3). Section 5 also defines the follow-up notification processes. Section 10 describes how emergency public information is integrated into the emergency management program (Ref. 3).

15.4.4 EMERGENCY FACILITIES AND EQUIPMENT

Section 11 and facility annexes of the SRS Emergency Plan identify the pertinent aspects of the emergency facilities (i.e., location, and function) and equipment (i.e., communication capabilities, hazardous material detection instrument ranges and types, and dosimetry) required to support the facility emergency responses (Ref. 3).

15.4.5 PROTECTIVE ACTIONS

Section 7 and facility annexes of the SRS Emergency Plan establish the protective actions that are required to minimize the exposure of workers and the public for each facility, the site, and the general pubic. The capability to provide medical support is described in Section 8. Decontamination facilities/capabilities are described in Section 11. The methodology for population evacuations is described in Section 7 and Appendix VII (Ref. 3).

15.4.6 TRAINING AND EXERCISES

Section 12 and facility annexes of the SRS Emergency Plan establish and describe the emergency management training program for all facility emergency response personnel. The drill and exercise program is described in Section 13 to include an exercise plan (Ref. 3). The emergency training program is conducted in accordance with the requirements of the SRS site level training program (Ref. 4).

15.4.7 RECOVERY AND REENTRY

Section 9 and facility annexes of the SRS Emergency Plan describe the provisions for the recovery from an operational emergency and planned reentry provisions for an affected facility (Ref. 3). The SRS Emergency Plan and facility annexes describe the process for establishing a recovery organization and how the site and the affected facility will transition from an emergency response organization to a recovery organization (Ref. 3).

15.5 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

1. Standards/Requirements Identification Document. WSRC-RP-94-1268-005, Washington Savannah River Company, Aiken, SC, March 2006.

2. Compliance Assurance Manual. WSRC Procedure Manual 8B, Washington Savannah River Company, Aiken, SC, June 2005.

3. Savannah River Site Emergency Plan. WSRC-SCD-7, Washington Savannah River Company, Aiken, SC, June 2006.

4. Training and Qualification Program Manual. WSRC Procedure Manual 4B, Washington Savannah River Company, Aiken, SC, May 2006.

16.0 PROVISIONS FOR DECONTAMINATION AND DECOMMISSION

This chapter does not contain information generic to the Savannah River Site. For more detailed information on Provisions for Decontamination and Decommission, refer to Chapter 16 of the facility-specific Safety Analysis Reports/Documented Safety Analysis.

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CHAPTER 17

MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

January 2007

Washington Savannah River Company
Aiken, SC 29808

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

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CONTENTS (Cont'd)

ACRONYMS AND ABBREVIATIONS

B&W	Babcock and Wilcox
CM	Configuration Management
DOE	Department of Energy
DSA	Documented Safety Analysis
ES	Energy Solutions
ES&H	Environment, Safety, Health and Quality Assurance
FEB	Facility Evaluation Board
FOSC	Facilities Operations Safety Committee
GSAR	Generic Safety Analysis Report
ISMS	Integrated Safety Management System
MP	Management Policy
MRP	Management Requirement and Procedure
NCSRC	Nuclear Criticality Safety Review Committee
OED	Operations Evaluation Department
PD&CS	Project Design and Construction Services
QA	Quality Assurance
SAR	Safety Analysis Report
SIRIM	Site Item Reportability and Issue Management
S/RID	Standards/Requirements Identification Document
SRS	Savannah River Site
SRNL	Savannah River National Laboratory
USQ	Unreviewed Safety Question
WSRC	Washington Savannah River Company

17.0 MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

17.1 INTRODUCTION

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies, if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

17.1.1 OBJECTIVE

The purpose of this chapter of this document for the Department of Energy (DOE) nuclear facilities and operations at the Savannah River Site (SRS) is to provide information that satisfies DOE-STD-3009-94 (Ref. 1). The requirements of this paragraph pertain to safety management policies and programs not described elsewhere in the document. This chapter presents information on management, technical and other site organizations that support safe facility operation not described elsewhere in this document. This chapter describes the requirements used to develop the safety management programs, including descriptions of the responsibilities of and relationships between the non-operations organizations' safety function and their interfaces with the operations organization. The objective of this chapter is to present information that demonstrates that the following two conditions exist (Ref. 1):

1. The operations organization is a part of a network of supporting management, technical, and support functions.

2. The network is sufficient to ensure that hazards and safety issues are identified, communicated, evaluated, resolved, and documented.

17.1.2 SCOPE

This chapter presents sufficient information on the safety management policies and programs to demonstrate that facility operation are embedded in a safety-conscious environment. The products of this chapter are descriptions of the following items (Ref. 1):

- The overall structure of the organizations and entities involved in safety-related functions not described elsewhere in this document, including key responsibilities and interfaces

- The safety programs that promote safety consciousness and morale, including safety review and performance assessment, configuration and document control, occurrence reporting, and safety culture

When required information is provided in another chapter of this document, that chapter is referenced to limit repetition. In those cases where policies, programs, and practices important to safe operation are described in detail in other site documents, the salient features are summarized for inclusion in this chapter and the documents are referenced (Ref. 1).

This document describes site- and division-level organizations within Washington Savannah River Company (WSRC). The facility specific Safety Analysis Report (SAR)/Documented Safety Analysis (DSA) and/or applicable procedures should be referenced for details regarding organization and facility interfaces.

17.2 REQUIREMENTS

Standards/Requirements Identification Documents (S/RIDs) state the codes, standards, and regulations governing the management, organization, and institutional safety provision policies and program elements of the SRS (Ref. 2). The implementing procedure manuals for these S/RID provisions are WSRC-1-01, WSRC-1B (Ref. 3), and derivative site manuals. Any changes to these manuals are reviewed for continued compliance with S/RID requirements per MRP 3.26 (Ref. 3) and Procedure Manual 8B (Ref. 4). Programmatic compliance assessment has been performed against the S/RIDs and documented as specified in the Compliance Assurance Manual (Ref. 4). The WSRC Standards Management/Compliance Section maintains records of the programmatic compliance assessments.

17.3 ORGANIZATIONAL STRUCTURE, RESPONSIBILITIES, AND INTERFACES

17.3.1 ORGANIZATIONAL STRUCTURE

WSRC is a safety-conscious and responsive organization that ensures and enhances safe operations at the SRS. Major entities within the WSRC organization structure as of December 2006 include:

- Internal Oversight
- Public Affairs Division
- Chief Financial Officer and Site Business Manager
- General Council
- Project Design and Construction Business Unit
- Savannah River National Laboratory
- Liquid Waste Organization
    - Integrated Salt Disposition Project
    - Technical and Quality Services
    - Information Technology
    - Procurement and Materials Management
- M&O Organization
    - Defense Programs
    - Nuclear Nonproliferation Program
    - Closure

- Site Decommissioning and Decontamination
- Soil and Groundwater Closure Projects
- Waste Management Area Project

o Analytical Laboratories

o Nuclear Materials Management

o Material Disposition

- H Area
- Spent Fuels

o Environment, Safety and Health

o Safeguards, Security and Emergency Services

o Human Resources

The facility specific Safety Analysis Report (SAR)/Documented Safety Analysis (DSA) and/or applicable procedures should be referenced for details regarding implementation of the DOE requirements for a particular facility on staffing for programs such as radiation and hazardous materials.

17.3.2 ORGANIZATIONAL RESPONSIBILITIES

This section describes WSRC organizational responsibilities in terms of the following safety related functions that form part of the safety basis of each SRS facility:

- Management staff
- Technical and engineering support, maintenance, and modifications
- Safety issue discovery, communication, management, and resolution
- Independent safety review, audit, and compliance determination
- Safety analysis services
- Support services

Section 17.4 indicates the implementation of the organizational responsibilities identified in this section and provides interfaces important to the policies and programs described in that section.

17.3.2.1 Management Staff

WSRC Management Staff responsibilities include, but are not limited to, the following activities (Ref. 3):

Maintaining close liaison with the DOE

- Ensuring that Washington corporate management is informed about operations at SRS and that the experience and advice of corporate management, as well as that of other Washington resources are applied to SRS issues and programs
- Ensuring that operations are conducted in conformance with the WSRC DOE contract and applicable corporate and DOE policies and regulations, and that operations are in compliance with applicable procedures, rules, regulations, and standards
- Ensuring that contact with an environmental regulator is not made without involving appropriate ES&H representatives.

17.3.2.2 Technical and Engineering Support

Technical and Quality Services provides engineering and quality support on a site-wide basis. This includes development of resources and assurance of consistency, discipline, cost-effectiveness, uniformity, and quality in design, development, nuclear safety, regulatory, geotechnical, information technology, process controls, transportation and maintenance activities. The Site Chief Engineer has Site-wide responsibility for career development, training, rotational assignment, succession planning, and professional advancement programs for engineering personnel. Oversight of subcontracted engineering functions is also provided by TQS.

Washington Safety Management Solutions (WSMS) provides engineering and consulting services in the area of safety analysis, safety documentation, regulatory, licensing and criticality analysis functions for Operating Divisions. Activities include preparation of authorization basis documents (Safety Analysis Report (SAR)/Documented Safety Analysis (DSA), Basis for Interim Operation (BIO), Technical Safety Requirements (TSR), Hazard Analysis (HA), Health and Safety Plan (HASP), Auditable Safety Analysis (ASA), etc.), development of regulatory positions, creation of nuclear criticality safety evaluations and maintenance of methodologies for such analyses.

Nuclear facilities at SRS also have engineering support within their own organizations. This typically includes systems engineering and design authorities and regulatory compliance.

Project Design Design and Construction Services (PD&CS) provides engineering and construction services at SRS and is also responsible for technical direction of the principal subcontractor, Bechtel Savannah River, Inc., and any other design and construction services required by WSRC under the Savannah River Management and Operations contract. The mission of this division is to design and construct various new facilities and renovation projects in a safe, secure, cost effective, environmentally sound, and high quality manner. PD&CS responsibilities include, but are not limited to, the following activities:

- Preparing and maintaining engineering standards and specifications and site project specifications
- Managing all assigned construction projects
- Ensuring procedures for engineering and project design are reviewed and approved by all applicable disciplines
- Establishing and maintaining a sitewide configuration management program
- Providing engineering and technical support activities for the site upon request
- Assuring sitewide uniformity in the discipline of technical processes
- Providing risk management methods and results for use in design and operational activities
- Performing fire protection analyses
- Participating in the development of functional performance requirements and other inputs to the project definition and functional design criteria phases of new projects
- Providing advanced scientific computational methods for analysis, modeling, and process development
- Performing analyses for and supporting the development, revision, or review of authorization basis documents.
- Establishing safety documentation requirements via WSRC Procedure Manual 11Q (Ref. 5).

17.3.2.3 Employee Responsibility

Each WSRC employees is responsible for reporting workplace issues and concerns as promptly and effectively as possible, and working to assist in the resolution process whenever possible. This employee right and responsibility is defined in WSRC Management Policy (MP) 1.11, which is stated in Section 17.4.4.4 and implemented through the employee concerns program (Ref. 3). Each WSRC organization is responsible for the evaluating, responding to, and resolving corrective action requests issued to the organization. Chapter 14 of this document describes the corrective action process.

17.3.2.4 ES&H Division Support

The ES&H Division provides a single, consistent, and continuing point of contact between the line organizations, DOE, and regulatory agencies on all ES&H matters. The mission of ES&H is to ensure safe, secure, high quality, and environmentally sound operations. ES&H responsibilities include, but are not limited to radiation protection, industrial hygiene, and facility industrial safety activities combined with the Radiological Protection Department. Safety related responsibilities in the area of radiation protection are discussed in Chapter 7 of this document, and safety related responsibilities in the areas of industrial safety and hygiene are discussed in Chapter 8 of this document.

17.3.2.5 Independent Safety Review, Audit, and Compliance Determination

Performing independent oversight is accomplished through the Facility Evaluation Board (FEB) program implemented and managed in part by the Internal Oversight/Operations Evaluations Department (OED) organization. OED manages and implements the FEB program to ensure compliance with S/RIDs requirements, management requirements, and procedures (Ref. 3, 4, 6).

17.3.2.6 Savannah River National Laboratory (SRNL) Responsibilities

SRNL develops new technologies associated with the SRS mission, refines existing technologies to meet evolving needs, and provides analytical and experimental technical aspects of safety, environmental, and production support to other WSRC organizations. SRNL is managed by a WSRC vice president. SRNL responsibilities include, but are not limited to, the following activities:

- Providing the technical basis for reactor, reactor material, separations, tritium, and waste management processes including technical assessment of commercial nuclear, other industrial and governmental codes, standards, special conditions, and guidelines for application at SRS; where codes, standards, specifications, or guidelines needed for SRS do not exist or are inadequate, defining alternatives and making recommendations to WSRC management

- Providing technical assistance to other WSRC organizations when requested

17.3.2.7 Support Services

Sitewide safety related support services are provided by the following WSRC organizations:

- Administrative and Infrastructure
- Technical Services Division

Departments of the Technical Services Division providing services are as follows:

- Safeguards and Securities Department consists of the following:
- Safeguard and Security Programs Section
- Security Services Section
- Personnel Security Section
- Material Control and Accountability Section
- Emergency Services Department consists of the following:
- Emergency Operations Section
- Site Fire Protection Section
- Site Emergency Management Programs Section
- Facility Emergency Management Support Section
- Fire Protection Program Department

The site fire protection program and specific fire protection responsibilities, authorities, and interfaces are described in Chapter 11 of this document. Fire protection is also addressed in WSRC Procedure Manual 2Q (Ref. 7). The site emergency response organization is described in Chapter 15 of this document, and is addressed in WSRC-SCD-7 (Ref. 8).

The Safeguards and Security Department of the Technical Services Division provides support for safeguards and security systems projects. The Fire Protection Program Department of the Technical Services Division provides support for fire protection projects.

Certain groups in the Technical Services Division have fire protection responsibilities. The Fire Protection Program Department is responsible for emergency response activities, site fire protection training, fire protection inspections, oversight of fire protection equipment testing, and submitting the annual fire loss summary to DOE. The site fire protection program (including additional fire protection responsibilities, authorities, and interfaces) is described in Chapter 11 of this document.

17.3.3 STAFFING AND QUALIFICATIONS

The staffing levels and knowledge, skills, and abilities of personnel in organizations covered in this chapter contribute to the safety basis of each SRS facility. This section discusses sitewide training, qualification, and fitness for duty requirements and the programs and provisions for monitoring staff safety performance.

The facility specific Safety Analysis Report (SAR)/Documented Safety Analysis (DSA) and/or applicable procedures should be referenced for details regarding implementation of the DOE requirements for a particular facility on staffing for programs such as radiation and hazardous materials.

The WSRC training program is established by WSRC Management Policies Manual (1-01), MP 1.18, "Employee Training" that is implemented through the WSRC Procedure Manual 4B and described in Chapter 12 of this document (Ref. 3, 9). Onshift training is addressed in Chapter 11 of this document.

Procedure 2.6 of the WSRC Procedure Manual 5B, "defines the fitness for duty program and establishes the responsibilities and requirements for the implementation of the WSRC fitness for duty program. This program is implemented through the WSRC Procedure Manual 5B (Ref. 10).

The phrase "fitness for duty" is defined as an individual's ability to perform the assigned job free from impairments due to drug and alcohol abuse, emotional distress, and personal health problems. Practice 2.6 consists of the following statements (Ref. 10):

- WSRC is committed to providing a safe and secure workplace.
- WSRC will seek to provide a work environment free of the negative influences of a range of behavioral factors that jeopardize safe work practices required to achieve its primary commitment of providing safe operations and quality services.

- All employees must be fit for duty at their assigned tasks.
- The use, sale, or possession of illegal drugs and/or alcohol while onsite is prohibited.
- Employees who are found to be sellers, distributors, or repeated users of illegal drugs onsite or offsite will be denied access to the facilities.

WSRC safety reviews and performance assessments are addressed in Section 17.4.1. The facility programs and provisions for monitoring staff safety performance are specified in WSRC Management Policies Manual (1-01), MP 4.20, "Conduct of Operations" implemented through the WSRC Procedure Manual 2S and addressed in the following paragraphs (Ref.11). The conduct of operations program establishes high operating standards and ensures communication of those standards to operations personnel. The program also addresses accountability, utilization of resources, and general policies.

Operational performance is monitored, documented, and trended for future reference and to make improvements in operational performance. Supervisors and managers spend approximately one quarter of their time in the field observing operations activities. In addition, various successes and performance problems are monitored, documented, and trended on a regular basis (Ref. 12).

Each SRS facility has a monitoring and assessment program to ensure that the material condition, industrial safety practices, cleanliness and housekeeping, and radiological and hazard protection practices meet management's standards. The facility monitoring program ensures that noteworthy practices are recognized, performance deficiencies are identified, and associated corrective actions are implemented to provide continuous improvement in facilities and operations. The comprehensive self assessment program ensures that key attributes of conduct of operations, maintenance, and training are understood and are being effectively implemented in the facility.

The facility specific Safety Analysis Report (SAR)/Documented Safety Analysis (DSA) and/or applicable procedures should be referenced for details regarding implementation of the DOE requirements for a particular facility on the Conduct of Operations Program.

17.4 SAFETY MANAGEMENT POLICIES AND PROGRAMS

17.4.1 SAFETY REVIEW AND PERFORMANCE ASSESSMENT

This section describes the oversight functions in program specific areas such as industrial safety, fire protection, and hazardous material control. The facility specific Safety Analysis Report (SAR)/Documented Safety Analysis (DSA) and/or applicable procedures should be referenced for details regarding implementation of the DOE requirements for a particular facility on programs listed in Section 17.3.2.7.

17.4.1.1 Safety Review Committees

WSRC Procedure Manual 1B, Management Requirement and Procedure (MRP) 4.19, "Requirements for Facility Operations Safety Committees (FOSCs)", applies to all nuclear, radiological, safety support, or process facilities (excluding administrative) functions, and establishes requirements and charter of the following committee (Ref. 3):

- FOSC (generic title to denote facility level committees)

MRP 4.19 applies to the chairman, secretary, members, alternates, and interfacing personnel for the FOSCs and addresses function, membership, qualifications and training, and meeting requirements for each committee to provide consistent sitewide application of advice and expertise.

MRP 4.19 requires each Area or Facility Manger responsible for nuclear operations (HC1, 2 or 3) to establish a FOSC (Ref. 3). The FOSC consists primarily of line members from the affected facility, including Operations, Maintenance, Safety and Health Operations (nuclear facilities), Engineering, Quality Assurance (QA), and Training. The FOSC functions to advise the area or facility manager on all matters affecting operation of the facility and associated activities that affect safety (Ref. 3).

The WSRC Nuclear Criticality Safety Review Committee (NCSRC) is a committee composed of senior managers and professionals from divisions having responsibility for operation of major facilities or areas involved in the handling of fissionable material or those having major oversight or technical responsibility for those facilities or areas. The NCSRC is responsible for the independent review and assessment of nuclear criticality safety policies, procedures, and performance; for the promotion of nuclear safety in the operation of facilities; and for compliance with appropriate criticality safety related DOE Orders. The NCSRC charter, which describes the committee in detail, is presented in WSRC Management Policies Manual (1-01), Charter 6.10. The responsibilities of the committee are presented in the NCSRC charter.

Prevention of inadvertent criticality, including further information concerning the NCSRC, is addressed in Chapter 6 of this document.

17.4.1.2 Environment, Safety and Health Responsibilities

The ES&H Division has responsibility for providing independent oversight for facility and site environmental, safety and health, activities. Effective oversight is accomplished by providing a sufficient and appropriately trained oversight staff capable of preparing and maintaining sitewide policies, standards, procedures, practices, guidelines, and instructions related to ES&H matters (Ref. 4).

17.4.1.3 Unreviewed Safety Question Determinations

USQ determinations are used to determine whether or not a proposed activity involves a USQ as defined in the S/RID, FA-18 (Ref. 2).

The USQ determination process is established in Procedure 1.05 in WSRC Procedure Manual 11Q (Ref. 5). This procedure is approved by DOE in accordance with 10 CFR 830, Subpart B.

17.4.1.4 Self-Assessments and Independent Assessments

The WSRC self-assessment and independent assessment programs are specified in WSRC Procedure Manual 12Q (Ref. 6).

WASHINGTON SAVANNAH RIVER COMPANY INDEPENDENT ASSESSMENT: FACILITY EVALUATION BOARD

The WSRC FEB of the OED has been chartered to (1) provide an accurate, consistent, and gradeable measure of performance effectiveness; (2) evaluate adequacy of the line self-assessment process; and (3) satisfy contractual obligations for company-level independent oversight (Ref. 6).

The independent assessment process periodically performs performance based assessments of WSRC operational and other selected assessment units. The frequency of assessment may vary depending on the status, complexity, hazard level, and previous performance of the process or activity in question. This program implements all DOE requirements for continuing contractor oversight programs as set forth in the S/RIDs. WSRC Procedure Manual 12Q defines the Nuclear Facility Safety structure, principles, responsibilities, associated requirements, and procedures for conducting WSRC independent assessments through the FEB program (Ref. 6).

17.4.1.5 Lessons Learned Program

MRP 4.14, "Lessons Learned Program," documents the following two commitments (Ref. 3):

- WSRC will accomplish the systematic review of operating experiences at SRS facilities and of similar DOE complex and commercial nuclear industry facilities.
- The Lessons Learned from such reviews will be applied to promote the safe, effective operation of SRS facilities and to enhance the safety and health of SRS employees and the public.

MRP 4.14 establishes the specific responsibilities and actions required for implementing the site Lessons Learned program (Ref. 3). Chapter 12 of this document discusses the application of Lessons Learned to the procedures and training programs.

17.4.2 CONFIGURATION AND DOCUMENT CONTROL

Configuration and document control at SRS are achieved through implementation of the WSRC Configuration Management (CM) program outlined in Section 17.4.2.1. Document control activities are conducted in accordance with the MRPs listed in Section 17.4.2.2. All activities are performed in accordance with the site QA program described in Section 17.4.2.3.

17.4.2.1 Configuration Management

The site CM program is specified in MP 5.7, "Configuration Management" (Ref. 3). This policy states that CM will be used in development, design, construction, startup, maintenance, operation, and dispositioning of facilities to help achieve full accountability and traceability in the areas of safety, environment, and health protection. The CM program is implemented through WSRC Procedure Manual E7 (Ref. 13).

This section provides an overview of the CM program. Operational aspects of configuration control as they relate to the facility are presented in Chapter 11 of this document.

WSRC Procedure Manual E7 establishes specific requirements and defines implementing procedures for managing the configuration of structures, systems, and components, including process software, at SRS nuclear, radiological and other facilities that will implement configuration management. This program ensures that adequate CM is maintained from project inception to facility decommissioning. All facilities and projects are required to comply with the CM program requirements contained in the WSRC Procedure Manual E7. The specifics as to when each individual facility or project is to comply with these requirements are defined in each CM implementation plan prepared in accordance with the WSRC Procedure Manual E7. A first step in preparing these plans is CM baselining performed in accordance with the WSRC Procedure Manual E7 (Ref. 13).

The Technical and Quality Services Department, is responsible for the content and periodic update of the WSRC Procedure Manual E7.

17.4.2.2 Management Requirements and Procedures for Document Control

WSRC document control activities, including revisions to the WSRC Procedure Manual E7 are conducted in accordance with the following MRPs (Ref. 3,13):

- MRP 3.26, "Management of Company Level Policies and Procedures," establishes responsibilities and requirements for preparation, review, approval, revision, and cancellation of company level policies and procedures.
- MRP 3.27, "Management of Program Specific Procedures," establishes responsibilities and requirements for preparation, review, approval, revision, and cancellation of all program specific procedures.
- MRP 3.31, "Records Management," establishes responsibilities and requirements for WSRC compliance with applicable DOE regulations relating to records management.
- MRP 3.32, "Document Control," establishes responsibilities and requirements for WSRC compliance with applicable DOE requirements relative to document control.

17.4.2.3 Quality Assurance

CM and document control activities are performed in accordance with the site QA program. The QA program is specified in WSRC Management Policies Manual (1-01), MP 4.2, "Quality Assurance," and in WSRC Procedure Manual 1Q, (Ref. 3, 14).

The site QA program is implemented through the QA Management Plan and is described in detail in Chapter 14 of this document. Chapter 14 includes additional information concerning CM.

17.4.3 OCCURRENCE REPORTING

Occurence reporting is implemented through a series of WSRC Procedure Manuals (9B and 9B1 9B6) (Ref. 15). These manuals, together with lower tiered implementing procedures, form a system of procedures referred to as the Site Item Reportability and Issue Management (SIRIM) process. The SIRIM process was developed to provide the basic elements for complying with the requirements of S/RIDs.

WSRC Procedure Manual 9B specifies the overall process for selection and analysis of information for occurrence reports required by S/RIDs (Ref.15). The conduct of operations program establishes the process for notifications; the reporting of events, conditions, concerns, and occurrences; and the management of issues at WSRC facilities. The program also specifies the responsibilities and activities required in the process of investigating and documenting events, conditions, or concerns. The final report on an event, condition, or concern contains the information required to satisfy S/RIDs and normally includes a copy of the root cause analysis, a copy of the event and causal factors chart, and other pertinent information (Ref. 14, 15).

17.4.4 SAFETY CULTURE

A safety culture is a work atmosphere that promotes the interest and involvement of all personnel in site safety, that facilitates a questioning attitude toward safety related activities and equipment, and that ensures that personnel understand the potential risks to the facility and workers as well as the rewards and sanctions associated with their own personal safety performance (Ref. 1). This atmosphere is exemplified by employee participation in the site occupational safety and health program as implemented through documents such as the WSRC Procedure Manual 8Q (Ref. 16).

WSRC MPs, along with their implementing programs, foster a safety culture at SRS. WSRC MPs are specified in WSRC 1-01 and are implemented through WSRC Procedure Manual 1B, and program specific site manuals (Ref. 3, 4). This section presents only a partial listing of the MPs specified in WSRC 1-01. This partial listing is intended to provide a well rounded picture of the safety culture that exists at SRS and is not meant to imply that the other MPs fail to contribute to the site safety culture. Additional MPs are stated in other sections of this Chapter.

When not explicitly stated as part of an MP presented in this section, personnel involvement is indicated through related requirements, responsibilities, and procedures and in program specific SAR/DSA chapters.

17.4.4.1 MP 1.1 Quality and Performance Leadership

WSRC recognizes that total quality occurs when every employee strives to meet customer expectations by doing the right things right the first time every time. To achieve this, WSRC shall manage its operations to remove barriers to total quality and to create a climate that encourages the commitment of all employees to excellence and performance leadership.

WSRC also recognizes that performance leadership is required for the SRS to fulfill its strategic national mission and to provide responsible stewardship for the Site’s physical, fiscal, and human resources. To meet this recognized requirement WSRC shall:

- Institute programs and initiatives to achieve excellence and performance leadership in each of the five areas that are imperative to our success. These 'Imperatives' are:

- Safety – achieving injury-free and incident-free personnel and nuclear safety performance without harm to the environment

- Disciplined Operations – achieving company-wide adherence to best business practices in all operations

- Cost Effectiveness – performing all operations at the lowest cost possible to effectively meet customer requirements

- Continuous Improvement - a never-ending pursuit and achievement of performance improvements in all aspects of all operations

- Teamwork – everybody contributing their skills and capabilities as needed to achieve our common goal of success for SRS

- Ensure that all company plans and procedures promote the above Imperatives and the implementation of Total Quality management principles

- Establish and maintain a top-level Management Council. This council shall be defined by the WSRC President, but generally consists of the WSRC Senior Staff

17.4.4.2 MP 1.2 Management Policies, Requirements, and Procedure System

WSRC has established and maintains a controlled system of written management directions in the form of policies, requirements, and procedures. These management directions shall govern the activities of WSRC employees performing work under the prime contract with DOE, as well as those of its subcontractors.

- Written management directions provide WSRC and subcontractor employees with clear documented guidelines consisting of policies, work procedures, performance requirements, process or equipment operational limits, and rules of conduct.

17.4.4.3 MP 1.10 Employee Communications

WSRC shall keep employees informed of matters that affect them and their jobs and shall ensure that the information is accurate, timely, and applicable in accordance with WSRC and DOE requirements.

17.4.4.4 MP 1.11 Open Communication

WSRC recognizes that free and open expression of employee workplace issues and concerns is a fundamental characteristic essential to the safe, efficient and effective operation of the SRS. In order to safeguard employee and public health and safety, ensure compliance with applicable laws and regulations, and support the WSRC mission to operate SRS in a safe, efficient and cost effective manner, WSRC promotes and encourages open and honest communication of issues and concerns that have the potential to adversely affect the site or its employees. It is the policy of WSRC that employees be allowed to identify and seek resolution of their workplace issues and concerns in a reprisal free environment, with the expectation that they will be fully addressed.

17.4.4.5 MP 1.22 Integrated Safety Management Program

WSRC operates within a framework aligned with the principles and functions of a DOE Integrated Safety Management System (ISMS). The objective of the WSRC ISMS Program is to systematically integrate safety into management and work practices at all levels of the company (including subcontracted work) so that missions are accomplished while protecting the public, the worker, and the environment.

The ISMS Program and this policy apply to all segments of WSRC and its partners and subcontractors. The ISMS satisfies all requirements of the Department of Energy Policy 450.4, Safety Management System Policy.

17.5 REFERENCES

This document has been prepared with the most current information available during development. Due to the dynamics of the updating of site program manuals and policies if a conflict or inconsistency is encountered with this document then the user will default to the Site Program Manuals.

1. Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports. DOE-STD-3009-94, Change Notice 3, March 2006, U.S. Department of Energy, Washington, DC.

2. Standards/Requirements Information Document. WSRC-RP-94-1268, Washington Savannah River Company, Aiken, SC.

3. Management Requirements and Procedures, WSRC-1B, Washington Savannah River Company, Aiken, SC.

4. Compliance Assurance Manual, WSRC Procedure Manual 8B, Washington Savannah River Company, Aiken, SC.

5. Facility Safety Document Manual, WSRC Procedure Manual 11Q, Westinghouse Savannah River Company, Aiken, SC.

6. Assessment Manual, WSRC Manual 12Q, Westinghouse Savannah River Company, Aiken, SC.

7. Fire Protection Program, WSRC Procedure Manual 2Q, Washington Savannah River Company, Aiken, SC.

8. WSRC SRS Emergency Plan. WSRC-SCD-7, Washington Savannah River Company, Aiken, SC.

9 Training and Qualification Program Manual. WSRC Procedure Manual 4B, Washington Savannah River Company, Aiken, SC.

10. HR Policies, Practices, and Procedures. WSRC Procedure Manual 5B, Washington Savannah River Company, Aiken, SC.

11. Conduct of Operations Manual. WSRC Procedure Manual 2S, Washington Savannah River Company, Aiken, SC.

12. Project Management System. DOE Order 4700.1, Change 1, U.S. Department of Energy, Washington, DC.

13. Conduct of Engineering Manual. WSRC Manual E7, Washington Savannah River Company, Aiken, SC.

14. Quality Assurance Manual. WSRC Procedure Manual 1Q, Washington Savannah River Company, Aiken, SC.

15. Site Item Reportability and Issue Management (SIRIM). WSRC Procedure Manual 9B, Washington Savannah River Company, Aiken, SC.

16. Employee Safety Manual. WSRC Procedure Manual 8Q, Washington Savannah River Company, Aiken, SC.