NUREG-1767

Environmental Impact Statement on the Construction and Operation of a Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina

Draft Report for Comment

U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Washington, DC 20555-0001

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Division of Waste Management
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prepared by

Argonne National Laboratory

for

U.S. Nuclear Regulatory Commission

February 2003

ABSTRACT

The U.S. Department of Energy (DOE) has contracted with Duke Cogema Stone & Webster (DCS) to design, construct, and operate a proposed Mixed Oxide (MOX) Fuel Fabrication Facility that would convert depleted uranium and weapons-grade plutonium into MOX fuel. The proposed MOX facility would be located on the DOE's Savannah River Site in South Carolina. Use of the proposed facility to produce MOX fuel would be part of the DOE's surplus plutonium disposition program. The purpose of the DOE program is to ensure that plutonium produced for nuclear weapons and declared excess to national security is converted to proliferation-resistant forms.

This draft environmental impact statement (EIS) was prepared in compliance with the National Environmental Policy Act (NEPA), the U.S. Nuclear Regulatory Commission's regulations for implementing NEPA, and the guidance provided by the Council on Environmental Quality regulations implementing the procedural provision of NEPA. This draft EIS evaluates the potential environmental impacts of the proposed action. The document discusses the purpose and need for the proposed action, describes the proposed action and its reasonable alternatives, describes the environment potentially affected by the proposal, presents and compares the potential environmental impacts resulting from the proposed action and its alternatives, and identifies mitigation measures that could eliminate or lessen the potential environmental impacts.

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EXECUTIVE SUMMARY

The consortium of Duke Project Services Group, Inc., COGEMA Inc., and Stone & Webster, Inc. has formed a Limited Liability Company called Duke Cogema Stone & Webster (DCS). DCS has been hired by the U.S. Department of Energy (DOE) to design, construct, and operate a facility (the proposed MOX facility) that would convert depleted uranium and surplus weapons-grade plutonium into mixed oxide (MOX) fuel. The DOE is responsible for the surplus plutonium disposition program for the United States. Within this program, the U.S. Nuclear Regulatory Commission (NRC) has the independent responsibility of determining whether the proposed MOX facility can be built and operated in a safe and environmentally acceptable manner. The proposed action requiring this NRC draft environmental impact statement (DEIS) thus involves a decision by the NRC whether to authorize DCS to construct and later operate the proposed MOX facility at DOE's Savannah River Site (SRS) in South Carolina. DCS has submitted to the NRC, among other documents, a revised construction authorization request (CAR) and a revised environmental report (ER), seeking authority to begin constructing the proposed MOX facility.

This DEIS was prepared by the staff of the NRC and its contractor, Argonne National Laboratory, and complies with the National Environmental Policy Act (NEPA), NRC regulations for implementing NEPA (10 CFR Part 51), and the applicable Council on Environmental Quality (CEQ) regulations.

The proposed MOX facility would convert 34 metric tons (MT) (37.5 tons) of surplus weapons-grade plutonium into MOX fuel. This facility would be built on 16.6 ha (41 acres) of land in the F-Area of SRS. If the NRC approves the CAR, DCS plans to request a 10 CFR Part 70 license to possess and use special nuclear material at the proposed MOX facility. Such a license would allow DCS to operate the proposed MOX facility for 20 years. The facility would be designed for maximum annual throughput of 3.5 MT (3.9 tons) of plutonium dioxide.

Feedstock (surplus plutonium dioxide and depleted uranium dioxide) would be required to be transported to SRS to make the MOX fuel. The surplus plutonium is currently stored at seven DOE facilities in various locations in the United States. Additionally, depleted uranium hexafluoride would need to be transported from a DOE site (assumed to be the gaseous diffusion uranium enrichment facility in Portsmouth, Ohio) to a commercial fuel fabrication facility (assumed to be the General Electric Company facility in Wilmington, North Carolina), where it would be converted to depleted uranium dioxide, which would then be transported to SRS. Once manufactured, the MOX fuel would be transported to mission reactors, where it would be irradiated. For purposes of complying with NEPA's requirements, it is assumed that one or more reactors will later be authorized by the NRC to use MOX fuel, and the DEIS includes a generic evaluation of using MOX fuel in a reactor. In order for a specific commercial reactor to use MOX fuel, an amendment to its 10 CFR Part 50 NRC license would be required. The NRC would analyze the site-specific environmental impacts related to such an amendment if and when such a request was made to the NRC. Following irradiation and storage at reactor sites, the spent MOX fuel would be transported to a geologic repository (assuming one is later

licensed by the NRC to operate) for final disposal, and the DEIS includes a discussion of spent MOX fuel transportation impacts.

In addition to presenting the potential environmental impacts of the proposed MOX facility and the related fuel cycle impacts, this DEIS discusses two proposed DOE facilities — the Pit Disassembly and Conversion Facility (PDCF), and the Waste Solidification Building (WSB) — which would also be located at the SRS, that would be required to support operation of the proposed MOX facility. The PDCF would be required to convert approximately 25.6 MT (28.2 tons) of surplus plutonium from a metal form to plutonium dioxide powder. The remaining quantity of surplus plutonium, called “alternate feed stock,” would be in a form that would be suitable to go directly to the proposed MOX facility. The proposed MOX facility would remove impurities from the plutonium dioxide and mix it with depleted uranium dioxide to make MOX fuel.

The WSB would process liquid waste streams from the PDCF and proposed MOX facility. Other waste from the proposed MOX facility, not sent to the WSB, would be transferred to and managed by the SRS. In addition, infrastructure upgrades would be needed to support the proposed MOX facility. These upgrades would include constructing waste transfer pipelines, realigning electric utility lines, and adding access roads.

A brief summary of DEIS Chapters 1-6 follows. Chapter 1 of the DEIS discusses the purpose and need for this action and its relationship to the DOE’s surplus plutonium disposition program. The fundamental purpose of this DOE program is to ensure that surplus weapons-grade plutonium is converted to proliferation-resistant forms. The DOE’s program is intended to lay the foundation for parallel disposition of excess Russian plutonium, thereby protecting against proliferation of materials capable of making weapons of mass destruction.

Chapter 2 of this DEIS describes the proposed action and alternatives to the proposed action, including the no-action alternative. The no-action alternative consists of the continued storage of surplus plutonium in various locations throughout the DOE complex, in the event the NRC does not approve the proposed MOX facility. This alternative is evaluated in detail in Chapter 4. Other alternatives to the proposed action discussed in Chapter 2 include alternate locations for the proposed MOX facility in the F-Area, alternate technology and design options, immobilizing surplus plutonium instead of producing MOX fuel, deliberately making off-specification MOX fuel, and the Parallex Project (which involves irradiating the MOX fuel in Canadian CANDU reactors).

Chapter 3 describes the environment that would be affected by the proposed action and includes discussions on soils, hydrology, air quality, local ecology, waste management, risks to human health, and socioeconomic issues.

Chapter 4 evaluates and compares the environmental effects of the proposed action and the no-action alternative. Significant or more important potential impacts are discussed in Chapter 4, which includes the following topics: (1) human health, (2) air quality, (3) hydrology, (4) waste management, (5) accident impacts, (6) decommissioning, and (7) environmental justice. Indirect impacts of transportation of radioactive materials, conversion of depleted

uranium, and reactor use are discussed in Chapter 4. The following potential impacts for the no-action alternative and proposed action are considered to be less significant and are discussed in Appendixes G and H: (1) geology, seismology, and soils; (2) noise; (3) ecology; (4) land use; (5) cultural and paleontological resources; (6) infrastructure; and (7) socioeconomics. A summary of the significant or more important potential impacts discussed in Chapter 4 is presented below.

The annual collective dose to members of the public (i.e., those living and working within 80 km [50 mi] of the SRS) produced by routine operation of the proposed MOX facility would be expected to result in a latent cancer fatality (LCF) rate of approximately 0.0004/yr or less. Routine operation of the proposed MOX facility, the PDCF, and the WSB is expected to produce insignificant air quality impacts, and would not cause exceedance of any ambient air quality standards for criteria pollutants at the SRS. However, maximum levels of $PM_{2.5}$ in the vicinity of the SRS already exceed the annual standard of 15 $\mu g/m^3$. Facility construction would contribute temporarily less than 0.1% of this $PM_{2.5}$ standard level, and facility operation would contribute less than 0.01% of this level.

Construction and routine operation of the proposed facilities would not be expected to cause any disproportionately high and adverse impacts to low-income or minority populations in the SRS vicinity. Of the accidents evaluated, a hypothetical explosion accident at the proposed MOX facility had the highest estimated short-term impacts, approximately 20 latent cancer fatalities (LCFs) among members of the off-site public. A hypothetical tritium release at the PDCF had the highest estimated 1-year exposure impact, approximately 400 LCFs among members of the off-site public. However, it is highly unlikely that such an accident would occur, and the risk to any population, including low-income and minority communities, is considered to be low. However, the communities most likely to be affected by a significant accident would be minority or low income, given the demographics and prevailing wind direction. The extent to which low-income or minority population groups would be affected would depend on the amount of material released and the direction and speed of the wind.

Transportation of uranium and plutonium feedstock materials, transuranic waste, fresh MOX fuel, and spent MOX fuel would result in approximately 3,400,000 km (2,114,400 mi) traveled by 1,548 truck shipments over the operations period of the proposed MOX facility. No LCFs would be expected from the radioactive nature of the cargo. (Estimated LCFs for members of the public and the transportation crews were 0.2 and 0.1, respectively.) One latent fatality from vehicle emissions was estimated, and no fatalities (0.081 fatality) from the physical trauma of potential vehicle accidents was estimated.

Chapter 4 of the DEIS also evaluates the use of MOX fuel in a generic reactor using a 40% MOX fuel core. For both normal operations and design-basis accidents, the impacts of using MOX fuel in a reactor would not be significantly different from the impacts of a reactor using 100% low enriched uranium fuel. For highly unlikely beyond-design-basis accidents, the impacts for a reactor using a 40% MOX fuel core could be up to 14% greater than for a reactor using 100% low enriched uranium fuel. Since no reactor licensee has yet sought the authority to use MOX fuel, the transportation of fresh MOX fuel is also evaluated on a generic basis, using a surrogate reactor located in the Midwest.

Chapter 4 also presents the costs and benefits of the proposed action. The primary benefit of operating the proposed MOX facility would be the resulting reduction in the supply of weapons-grade plutonium available for unauthorized use. Converting surplus plutonium in this manner is viewed as being a safer use/disposition strategy than the DOE's continued storage of surplus plutonium, as would occur under the no-action alternative, because it would reduce the number of locations where the various forms of plutonium are stored. Further, converting weapons-grade plutonium into MOX fuel in the United States — as opposed to immobilizing a portion of it as the DOE had previously planned to do — lays the foundation for parallel disposition of weapons-grade plutonium in Russia, which distrusted immobilization because of its failure to degrade the plutonium's isotopic composition. Converting surplus plutonium into MOX fuel is thus viewed as a better way of ensuring that weapons-usable material will not be obtained by rogue states and terrorist groups. Implementing the proposed action is expected to promote the above nonproliferation objectives.

In addition to the above primary benefits, there would be secondary economic benefits of the proposed action. Impacts of construction on the regional economic area (REA) and region of influence (ROI) would be beneficial with respect to jobs and income. During operations, the proposed MOX facility, PDCF, and WSB would be expected to generate 480 direct and 780 indirect jobs, producing a total income of $61 million a year in the REA. The economic cost benefit analysis for the proposed action shows an overall net benefit to the ROI and REA of $1,840 million. National economic costs for the proposed MOX facility, PDCF, and WSB are estimated to be $3,850 million. The national economic benefits would include adding employment and income in various sectors of the economy through the purchase of goods and services required during construction and operation.

Chapter 5 of the DEIS identifies mitigation measures that could eliminate or lessen the potential environmental impacts of the proposed action. These measures are summarized in Table ES-1. The NRC evaluated proposed mitigation measures identified by DCS and identified additional measures that could reduce or eliminate adverse environmental impacts of the proposed action. On the basis of its independent review, the NRC is making a preliminary conclusion that the potential significant impacts of the proposed action can be mitigated. However, any possession and use license issued to DCS should be conditioned on the commitments made by DCS and the various proposed NRC mitigation requirements discussed in Chapter 5.

Chapter 6 presents the many federal, state, and local environmental requirements that would be applicable to the proposed MOX facility.

After weighing the costs and benefits of the proposed action, and comparing alternatives, the NRC staff, in accordance with 10 CFR 51.71(e), includes in this DEIS its preliminary NEPA recommendation regarding the proposed action. As discussed further in Chapter 2, the NRC staff recommends that, unless safety issues mandate otherwise, the action called for is the issuance of the proposed license to DCS, with conditions to protect environmental values. As stated in Chapter 2, the NRC staff preliminarily concludes that (1) the applicable environmental requirements presented in DEIS Chapter 6 and (2) the proposed mitigation measures discussed in DEIS Chapter 5 would eliminate or substantially lessen any potential adverse environmental impacts associated with the proposed action.

Table ES.1. Summary of DCS mitigation commitments and additional measures identified by NRC staff for reducing or avoiding impacts from the proposed action[a]

Technical area	Mitigation
Soils and Hydrology	• Creation of foundations and building of structures for the proposed MOX facility, PDCF, and WSB (hereafter "the facilities") will be limited to the upper soil layers, thus minimizing impacts to groundwater. • Good engineering practices will be used during operation and construction to minimize chemical impacts to soils. • Soils on-site will be graded or moved to create a uniform elevation that would reduce soil erosion. • Sediment detention basins will be placed around the facilities during construction to control runoff. • Accidental spills during construction shall be promptly cleaned up as required by DCS's Spill Prevention Control and Countermeasures Plan. • A Sediment Control Plan will be developed prior to disturbance of areas exceeding 2 ha (5 acres). • Sanitary wastes generated during construction will be collected with a combination of portable toilets and semipermanent facilities connected to the Central Sanitary Waste Treatment Facility. • Good engineering practices, such as the use of straw bales or siltation fences adjacent to areas disturbed during construction, will be used to control sediment and limit runoff to Upper Three Runs Creek. • The proposed MOX facility storm-water prevention plan shall be consistent with the existing SRS storm-water and erosion management practices. • Regular monitoring of the double-walled liquid high-alpha waste pipeline will be conducted to detect leaks and develop contingency plans.
Air Quality and Noise	• Dust suppression measures such as watering will be used during construction to reduce fugitive dust emissions by at least 50%. • Particulate emissions from the silo hopper and concrete mixer used during the cementation process to construct the WSB shall be reduced by 90%.
Ecology	• Prior to construction, sites will be surveyed for plants and nests of migratory birds. To ensure compliance with the Migratory Bird Treaty Act and to provide additional protection for other bird species of concern (e.g., raptors), the following steps should be taken: (1) obtain a list from the Department of the Interior of migratory birds protected by the Act; (2) determine if protected migratory birds or their nests exist in the areas to be cleared for the proposed action; and (3) if protected birds or their nests or eggs are present, consult with the Department of the Interior for the appropriate precautions to be taken. This consultation should be undertaken as far in advance of construction as practicable.

Table ES.1. Continued

Technical area	Mitigation
Ecology (cont.)	• Consultation and coordination with state and federal natural resource and wildlife agencies shall be conducted prior to any site disturbances to ensure that all potential sensitive species (including candidate and listed species) are protected to the maximum extent possible. • Environmental supervisors shall be present during vegetation clearing to ensure that impacts are held to a minimum. • Construction crews shall receive environmental briefings as appropriate to alert them to specific areas of concern (e.g., possible harassment and other adverse impact to wildlife species during the construction period) and to explain the reasons for such concern. • The loss of the existing storm-water basin near the southern boundary of the proposed site would be compensated for by construction of a new basin that would provide more viable aquatic habitat. • Measures shall be taken to protect trees not selected for removal. Any trees or other landscape features accidentally scarred or damaged should be replaced. • Reclamation plans shall be developed for laydown areas and other construction areas that will not be occupied by structures, parking lots, or roads. Reclamation will include removal of all temporary construction features, stabilization of soils, and reseeding with appropriate plant species. • Access roads will be sited on previously disturbed areas where possible to minimize sensitive vegetation removal. • The right-of-way for the 610-m (2,000-ft) pipeline to convey liquid high-alpha-activity waste and stripped uranium waste for the proposed MOX facility and PDCF to the WSB will be less than 7.6 m (25 ft) wide and thus minimizes vegetation removal.
Land Use	• No mitigation measures are needed to reduce impacts of the proposed action on land use.
Cultural and Paleontological Resources	Monitoring of ground-disturbing construction activities will be conducted for the two directly affected eligible archaeological sites to complete obligations set forth in the data recovery plan for sites. • Awareness training will be conducted for workers so they do not disturb eligible archaeological sites. • Restrictions will be established regarding where heavy machinery is allowed. • Periodic monitoring of nearby eligible archaeological sites will be conducted to check for possible erosion. • Additional mitigation measures, such as avoidance agreements, will be determined in consultation with the SCSHPO.

Table ES.1. Continued

Technical area	Mitigation
Infrastructure	• Road upgrades for ingress and egress of the proposed MOX site will be conducted in existing traffic rights-of-way.
Waste Management	• No mitigation measures are needed to reduce impacts of the proposed action on the SRS waste management system.
Human Health Risk	• The radiation exposure of radiographers will be monitored or badged during construction. • The radiography contractor will follow the contractor's existing NRC or agreement-state license in evaluating and monitoring radiographer exposure. • Radiation doses to workers during construction will be kept to a minimum by using administrative limits and ALARA programs, including worker rotations. • Construction workers will be protected from inadvertent chemical exposures by soil testing and analysis prior to excavation to ascertain that levels of inorganic and/or organic chemicals in soils would not present a health hazard during construction activities. • Exposures of facility workers during operations will be kept to a minimum through (1) use of engineering controls to keep airborne chemical concentrations below applicable occupational exposure limits, and (2) use of enclosed operations to the extent possible. • During licensing of the proposed MOX facility, DCS should demonstrate that the offgas treatment system will limit hydrazine to very low levels that would not cause adverse health impacts to members of the public or SRS employees. • To minimize adverse effects to facility and SRS workers in the event of an accidental release of a process chemical, DCS shall add appropriate revisions to the SRS Emergency Response Plan for chemicals identified as presenting moderate or high risks to workers (as identified in Section 4.3.5.3). • DCS will appropriately train SRS workers stationed close to the proposed MOX facility and related facilities on actions to take both to prevent chemical accidents and in response to accident situations.
Socioeconomics	• No mitigation measures are necessary to reduce impacts to socioeconomic factors.

Table ES.1. Continued

Technical area	Mitigation
Environmental Justice	• DCS should work closely with SRS to implement procedures to protect low-income and minority groups in the event of an accidental chemical or radiological release from the proposed MOX facility that impacts areas beyond the SRS boundary. • DCS should conduct focused public information campaigns to provide important information to low-income and minority groups/communities. Included in these campaigns would be descriptions of existing monitoring programs, and information on the nature, extent, and likelihood of any future airborne release from the facility. The campaigns would also include a description of the relevant risks associated with the proposed MOX facility and MOX fuel transportation programs. These campaigns should include information on sheltering and other protection strategies that may be needed, including detailed descriptions of any evacuation procedures that may be required. • DCS should provide public information to local agencies and groups representing low-income or minority groups on existing soil or groundwater contamination monitoring programs and the nature, extent, and likelihood of future surface release. Key information would include the extent of any likely damage to drinking water supplies and subsistence resources, and the relevant preventative measures that may be taken. • Meet with local communities providing emergency response services and other emergency facilities to discuss additional measures to ensure that the low-income and minority population in their jurisdictions are located and fully prepared in the event that sheltering or evacuation procedures are required. In addition to public information campaigns targeting low-income and minority groups, this would include the development of spatial databases providing information on the location of low-income and minority populations, local resources available to emergency response agencies, and any evacuation routes that might be required.
Aesthetics	• No mitigation measures are necessary to reduce aesthetic impacts of the proposed action.

[a]The mitigation measures are commitments made by DCS that were identified in the ER (DCS 2002) and additional recommendations/requirements identified by the NRC staff in its review of the proposed action.

ACRONYMS AND ABBREVIATIONS

The following is a list of the acronyms, initialisms, abbreviations, and units of measure used in this document. Some acronyms and abbreviations used only in tables, figures, equations, or as reference callouts are defined in the respective tables, figures, equations, and reference lists.

Acronyms, Initialisms, and Abbreviations

7Q10	7-day low flow, 10-year recurrence flow
AADT	average annual daily traffic
ADU	ammonium diuranate
AEA	Atomic Energy Act
Ag	silver
$AgNO_3$	silver nitrate
ALARA	as low as reasonably achievable
ALI	annual limit on intake
ALOHA	Areal Locations of Hazardous Atmospheres (computer code)
am	americium
ANL-W	Argonne National Laboratory-West
ANSI	American National Standards Institute
APSF	Actinide Packaging and Storage Facility
AQCR	Air Quality Control Region
BAP	Aqueous Polishing Area
BMP	MOX Processing Area
BPIP	Building Profile Input Program
BRP	Reagents Processing Building
CAA	Clean Air Act
CANDU	Canadian Deuterium Uranium (reactor)
CAR	Construction Authorization Request
CAS	Chemical Abstract Services
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CH-TRU	contact-handled transuranic (waste)
CIESIN	Center for International Earth Science Information Network
CIF	Consolidated Incineration Facility
CO	carbon monoxide
CO_2	carbon dioxide
CPT	cone-penetration test
CSWTF	Central Sanitary Wastewater Treatment Facility

CWA	Clean Water Act
D&D	deactivation and decommissioning
DCP	dry conversion process
DCS	Duke Cogema Stone & Webster
DDE	deep dose equivalent
DEIS	Draft Environmental Impact Statement
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DWPF	Defense Waste Processing Facility
EA	environmental assessment
EBR-II	Experimental Breeder Reactor-II
EDE	effective dose equivalent
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
ERPG	Emergency Response Planning Guideline
ETF	Effluent Treatment Facility
FEIS	Final Environmental Impact Statement
FGR	Federal Guidance Report
FOF	F-Area Outside Facility
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
FY	fiscal year
Ga	gallium
Ga.	Georgia
GE	General Electric
GENII	Generation II (computer code)
GRP	gross regional product
$H_2C_2O_4$	oxalic acid
HEPA	high-efficiency particulate air (filter)
HEU	highly enriched uranium
HF	hydrogen fluoride
HI	hazard index
HLW	high-level (radioactive) waste
HQ	hazard quotient
HRCQ	highway route controlled quantity
HSWA	Hazardous and Solid Waste Amendments
HVAC	heating, ventilation, and air conditioning
HYDOX	hydride-oxidation

ICRP	International Commission on Radiological Protection
IMPLAN	Intelligent Multi-Resource Planning (computer code)
INEEL	Idaho National Engineering and Environmental Laboratory
ISA	integrated safety analysis
ISCST3	Industrial Source Complex Short-Term (version 3) model
ISFSI	interim spent fuel storage installation
ITP	in-tank precipitation
KAMS	K-Area Material Storage (SRS)
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
L_{dn}	day-night average sound level
L_{eq}	steady sound level that would contain the same total sound energy as the time-varying sound over a given time
LEU	low-enriched uranium
LLC	Limited Liability Company
LLNL	Lawrence Livermore National Laboratory
LLW	low-level (radioactive) waste
LSA	low specific activity
MAR	material at risk
MC&A	material control and accounting
MEI	maximally exposed individual
MMI	Modified Mercalli Intensity (earthquake intensity scale)
MOX	mixed oxide (plutonium dioxide and uranium dioxide)
MPQAP	MOX Project Quality Assurance Plan
MSL	mean sea level
MWMF	Mixed Waste Management Facility
NAAQS	National Ambient Air Quality Standard
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NMSS	Office of Nuclear Material Safety and Safeguards (NRC)
NNSA	National Nuclear Security Administration
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	*National Register of Historic Places*
NSC	National Safety Council
NSPS	New Source Performance Standards

O_3	ozone
OAQPS	Office of Air Quality Planning and Standards (EPA)
OFASB	Old F-Area Seepage Basin
OHER	Office of Health and Environmental Research (DOE)
OML	oxalic mother liquor
ORR	Oak Ridge Reservation
OSHA	Occupational Health and Safety Administration
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PDCF	Pit Disassembly and Conversion Facility
PEIS	Programmatic Environmental Impact Statement
PM	particulate matter
PM_{10}	particulate matter with a diameter less than or equal to 10 micrometers
$PM_{2.5}$	particulate matter with a diameter less than or equal to 2.5 micrometers
PMF	probable maximum flood
PSD	Prevention of Significant Deterioration
Pu	plutonium
PuO_2	plutonium oxide
RCRA	Resource Conservation and Recovery Act
REA	regional economic area
RFETS	Rocky Flats Environmental Technology Site
ROD	Record of Decision
ROI	region of influence
S&D PEIS	Storage and Disposition Programmatic Environmental Impact Statement
SAAQS	State Ambient Air Quality Standard
S.C.	South Carolina
SCAPA	Subcommittee on Consequence Assessment and Protective Action (DOE)
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCSHPO	South Carolina State Historic Preservation Officer
SER	safety evaluation report
SGT	SafeGuards Transporter
SHPO	State Historic Preservation Office
SIP	state implementation plan
SNF	spent nuclear fuel
SO_2	sulfur dioxide
SO_x	sulfur oxides
SPCC	spill prevention control and countermeasures
SPD	Surplus Plutonium Disposition
SPD EIS	Surplus Plutonium Disposition Environmental Impact Statement
SPL	sound pressure level
SR	State Route

SRARP	Savannah River Archaeological Research Program
SREL	Savannah River Ecology Laboratory
SRS	Savannah River Site
SWB	standard waste box
TAP	toxic air pollutant
TCDD	tetrachlorodibenzo-para-dioxin
TEDE	total effective dose equivalent
TEEL	temporary emergency exposure limit
TI	transport index
TIGR	thermally induced gallium removal
TRU	transuranic (radioactive waste)
TRAGIS	Transportation Routing Analysis Geographic Information System
TRUPACT	transuranic package transporter
TSCA	Toxic Substances Control Act
TSD	Transportation Safeguards Division (DOE Albuquerque Operations Office)
TSP	total suspended particulate
U	uranium
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U.S.C.	*United States Code*
USEC	United States Enrichment Corporation
VOC	volatile organic compound
VRM	visual resource management
WAC	waste acceptance criteria
WIPP	Waste Isolation Pilot Plant
WM PEIS	*Final Waste Management Programmatic Environmental Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*
WMA	Wildlife Management Area
WSB	Waste Solidification Building

Units of Measure

Bq	becquerel(s)	dps	disintegration(s) per second
Btu	British thermal unit(s)	EC	degree(s) Celsius
Ci	curie(s)	EF	degree(s) Fahrenheit
:Ci	microcurie(s)	ft	foot (feet)
cm	centimeter(s)	ft^2	square foot (feet)
d	day(s)	ft^3	cubic foot (feet)
dB	decibel(s)	g	gram(s) or gravitational acceleration
dBA	A-weighted decibel(s)		

:g	microgram(s)	mi	mile(s)
gal	gallon(s)	mi^2	square mile(s)
gpm	gallon(s) per minute	min	minutes
h	hour(s)	mm	millimeter(s)
ha	hectare(s)	mo	month(s)
Hz	hertz	mph	mile(s) per hour
in.	inch(es)	mrem	millirem
K	kelvin degrees (temperature)	mSv	millisievert(s)
kg	kilogram(s)	MT	metric ton(s)
km	kilometer(s)	MWh	megawatt-hour(s)
km^2	square kilometer(s)	nCi	nanocurie(s)
kV	kilovolt(s)	Pa	Pascals
L	liter(s)	ppb	part(s) per billion
lb	pound(s)	ppm	part(s) per million
m	meter(s)	s	second(s)
m^2	square meter(s)	Sv	sievert(s)
m^3	cubic meter(s)	yd^3	cubic yard(s)
:m	micrometer(s)	yr	year(s)
mg	milligram(s)		

1. PURPOSE OF AND NEED FOR ACTION

1.1 Introduction

In 1992, at the end of the Cold War, the President commissioned the National Academy of Sciences to study management and disposition options for surplus weapons-usable plutonium. Several agreements were subsequently reached with Russia on the mutual reduction of plutonium stockpiles. The U.S. Department of Energy (DOE) is responsible for the surplus plutonium disposition program for the United States. Within this program, the U.S. Nuclear Regulatory Commission (NRC) has the independent responsibility of reviewing a proposal to design, construct, and operate a facility in the United States that would convert depleted uranium dioxide and weapons-grade plutonium dioxide into mixed oxide (MOX) fuel. A 1998 amendment to the Energy Reorganization Act of 1974 gave the NRC licensing and related regulatory authority over the proposed facility. In accordance with the National Environmental Policy Act (NEPA) 42 U.S. Code (U.S.C.) 4321 *et seq.*, the proposal to build and operate such a facility is being reviewed by the NRC in this draft environmental impact statement (DEIS), to evaluate the potential environmental impacts that would result if the proposed action is taken.

The surplus plutonium disposition program is discussed in Section 1.1.1. The proposed action is described in Section 1.2, and the purpose and need for the proposed action is discussed in Section 1.3. Section 1.4 describes the process used by the NRC to determine the scope of this DEIS, which identified the issues that are to be studied in detail and those that do not require detailed study.

1.1.1 Surplus Plutonium Disposition Program

Following the end of the Cold War, the United States and Russia took steps to mutually reduce their respective stockpiles of weapons-grade plutonium by declaring some of this plutonium excess to national security needs. The surplus plutonium disposition program involves making sure that this surplus plutonium can not be used again to make nuclear weapons. The DOE evaluated a number of strategies to disposition the U.S. stockpile of surplus plutonium and has published two related environmental impact statements (EISs), a record of decision (ROD), and an amended ROD (DOE 1996, 1999, 2000, 2002). As part of this program, the DOE in 1999 selected a contractor, Duke Cogema Stone & Webster (DCS), to design, construct, and operate a facility that would convert uranium and weapons-grade plutonium into MOX fuel, as discussed further in Section 1.1.2.

To implement DOE's surplus plutonium disposition program, the DOE ROD in January 2000 set forth a "hybrid" approach, which involved immobilizing a portion of the surplus plutonium and converting the remaining portion into nuclear reactor fuel. Three new facilities were proposed for the DOE's Savannah River Site (SRS) in South Carolina to implement the hybrid approach. A Pit Disassembly and Conversion Facility (PDCF) would convert metallic weapons material, called pits, to plutonium dioxide powder. The proposed PDCF would be built and operated

under the DOE's jurisdiction and authority. A plutonium immobilization plant was proposed to convert some of the plutonium dioxide powder from the PDCF and plutonium from other sources into ceramic cylinders to be encapsulated in vitrified high-level waste. The Mixed Oxide Fuel Fabrication Facility (hereafter referred to as "the proposed MOX facility") would convert the balance of the plutonium dioxide powder from the PDCF into MOX fuel for subsequent irradiation in U.S. commercial reactors authorized by the NRC to use such fuel.

Under its January 2000 ROD, the DOE planned to convert 33 metric tons (MT)[1] (36.4 tons) of surplus plutonium into MOX fuel and to immobilize 17 MT (19 tons) in the plutonium immobilization plant. Among the plutonium disposition program's purposes is to reduce over time the number of locations in the United States where the various forms of plutonium are stored, to better ensure that weapons-usable material does not fall into the hands of rogue states or terrorist groups. Irradiated MOX fuel would be highly radioactive, making it inaccessible for reuse as nuclear weapons material. In September 2000, Russia and the United States agreed to disposition 34 MT (37.5 tons) of surplus weapons-grade plutonium from their respective stockpiles (White House 2000). Under this agreement, disposition may be accomplished either by the hybrid approach or by MOX fuel fabrication and subsequent irradiation.

However in April 2002, the DOE issued an amended ROD (DOE 2002), in which it decided not to pursue its hybrid approach. The DOE determined that in order to make progress with available funds that only one approach could be supported. Russia does not consider immobilization alone to be an acceptable approach because immobilization, unlike the irradiation of MOX fuel, fails to degrade the isotopic composition of the plutonium. Russia further contends that the United States could easily retrieve plutonium from the immobilized waste at a later date and reuse that plutonium in nuclear weapons (DOE 2002). Because an immobilization-only approach would jeopardize Russia's continued involvement in the joint effort to reduce supplies of weapons grade plutonium, the DOE decided that if only one disposition approach is to be pursued, the MOX fuel approach is the preferred one. The DOE concluded that implementation of the MOX-only approach is the key to successfully completing the September 2000 agreement between Russia and the United States (DOE 2002). Accordingly, the DOE decided to pursue a MOX-only approach, under which all 34 MT (37.5 tons) of surplus weapons-grade plutonium would be converted into MOX fuel, and the DOE canceled the plutonium immobilization plant. The DOE had earlier identified Duke Power Company's four reactors at the Catawba and McGuire stations (two at each station) as potential candidates to irradiate MOX fuel. The potential candidate reactors can accommodate up to 25.5 MT (28.2 tons) of surplus plutonium in MOX fuel. The DOE has not yet identified the additional candidate reactors necessary to accommodate the additional MOX fuel (8.5 MT [9.4 tons]) to be irradiated under the amended ROD.

[1] A metric ton (MT) equals 1,000 kilograms (kg) and is equivalent to 1.1 tons, or approximately 2,200 pounds (lb).

1.1.2 MOX Fuel Fabrication Facility

As referenced above, the DOE selected DCS to design, construct, and operate the proposed MOX facility. Because Congress gave the NRC licensing and related regulatory authority over the proposed MOX facility, its construction and operation will require NRC approvals, issued pursuant to the *Code of Federal Regulations*, Title 10, Part 70 (10 CFR Part 70), "Domestic Licensing of Special Nuclear Material." As part of its licensing review, the NRC has prepared this DEIS in accordance with the NRC's 10 CFR Part 51 regulations implementing NEPA, and the generally applicable Council on Environmental Quality (CEQ) regulations in 40 CFR Part 1500. This DEIS addresses the direct, indirect, and cumulative impacts related to building, operating, and decommissioning the proposed MOX facility. Although the DOE has prepared previous EISs that cover impacts of the proposed MOX facility on a programmatic level, those EISs are not considered sufficient to meet NRC's needs under NEPA, because DCS has since submitted additional site-specific information, and the proposed MOX facility design has been revised since the DOE's EISs were issued.

To obtain approval to construct the facility, DCS submitted a MOX Project Quality Assurance Plan (MPQAP) on June 22, 2000, an Environmental Report (ER) on December 19, 2000 (DCS 2000), a revised MPQAP on January 29, 2001, and a Construction Authorization Request (CAR) on February 28, 2001 (DCS 2001). The NRC then published its Notice of Intent to prepare an EIS for the proposed MOX facility (NRC 2001a). Because of design changes in the proposed MOX facility resulting from DOE's amended ROD, DCS submitted an amended ER on July 12, 2002 (DCS 2002a), and an amended CAR on October 31, 2002 (DCS 2002b). If the amended CAR is approved, DCS plans to submit its application for a 10 CFR Part 70 operating license in October 2003.

Categories of Impacts

Impacts of the proposed and connected actions include:

- Direct effects — caused by the proposed action and occur at the same time and place,
- Indirect effects — occur later in time or are farther removed in distance but that are reasonably foreseeable, and
- Cumulative impacts — potential impacts when the proposed action is added to other past, present, and reasonably foreseeable future actions

The NRC's decision-making process for the proposed MOX facility includes an environmental review and a safety review. In addition to this DEIS, which documents NRC's environmental review, NRC will prepare two safety evaluation reports (SERs). The first SER will evaluate the CAR, and will address whether construction of the proposed MOX facility may be authorized pursuant to 10 CFR Part 70 and the Atomic Energy Act. If construction is authorized, a second SER would address whether the proposed MOX facility, as built, may be authorized to operate under a 10 CFR Part 70 license.

Under NEPA, the scope of this DEIS is broader than that of the SERs. The DEIS addresses the environmental impacts of constructing, operating, and decommissioning the proposed MOX facility. The Final EIS (FEIS) and the construction authorization SER are anticipated to be published in August and September 2003, respectively, and will form the basis for NRC to

decide whether to authorize construction of the proposed MOX facility. The FEIS and the second SER would form the basis for NRC to decide whether to issue a license to operate the proposed MOX facility.

1.2 Description of the Proposed Action and Connected Actions

As described further in Section 1.2.1, the proposed action involves a decision by NRC whether or not to authorize DCS to construct and later operate the proposed MOX facility at the SRS to convert 34 MT (37.5 tons) of surplus weapons plutonium to MOX fuel. Section 1.2.2 describes actions that are connected to the proposed action. Connected actions fall within the scope of the actions evaluated in an EIS (40 CFR 1508.25). More detailed technical information about the proposed action and connected actions is presented in Section 2.2.

1.2.1 Proposed Action

The proposed MOX facility would be built on 16.6 ha (41 acres) of land in the F-Area of the SRS (see Figures 1.1 and 1.2). DCS is expected to request a license for 20 years. The facility would be designed for maximum annual throughput of 3.5 MT (3.9 tons) of plutonium dioxide. Impacts in the ER are based on the maximum annual design capacity. This DEIS is based on a total of 34 MT (37.5 tons) of surplus plutonium. The rate at which DCS actually processes the plutonium would likely be less than the facility's design capacity. Therefore, actual annual impacts should be less than those presented in the ER. The period of operation would likely be less than the 20-year license period. The actual period of operation would vary depending on the annual throughput over time. The 20-year licensing period would allow deactivation and decommissioning to occur prior to license termination. For purposes of this DEIS, a period of operation of 10 years is assumed to bound impacts. If the actual period of operation is longer than 10 years as a result of an actual throughput less than the maximum design capacity, the annual impacts would be less, even though they would occur over a longer period of time.

Proposed Action

- The proposed federal action is for the U.S. Nuclear Regulatory Commission to authorize Duke Cogema Stone & Webster (DCS) to build and operate a facility to fabricate mixed oxide (MOX) fuel.
- NEPA requires preparation of an EIS for major federal actions that could significantly affect the human environment.
- To operate the MOX facility, DCS would need an NRC license to possess and use special nuclear material (surplus plutonium from the U.S. nuclear weapons program).
- Under contract with the DOE, DCS would build and operate a facility to manufacture nuclear fuel using surplus plutonium.
- The NRC-licensed facility for fabricating nuclear fuel would be located on the DOE's Savannah River Site.

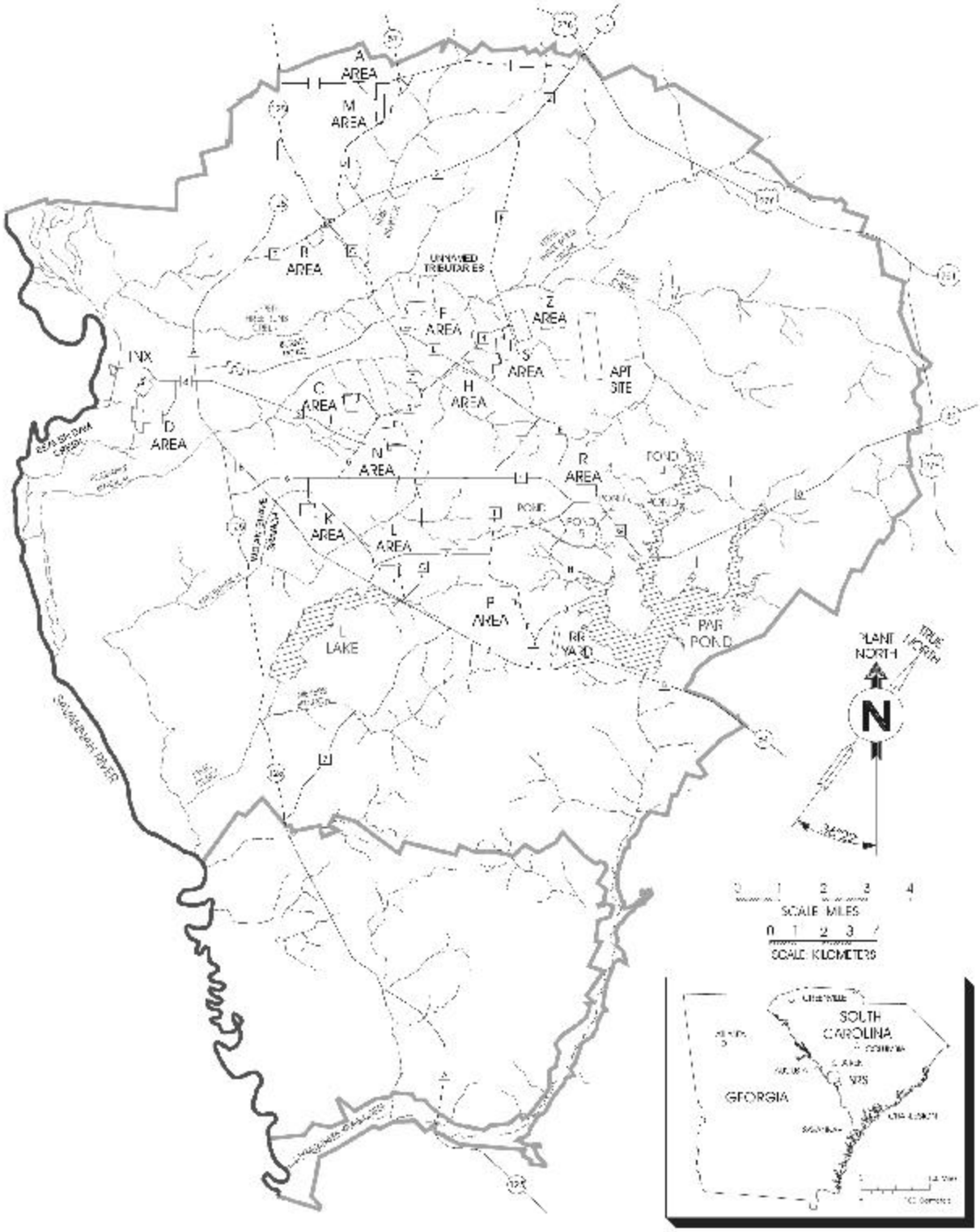

Figure 1.1. Location of Savannah River Site and F-Area (*Source*: DCS 2001).

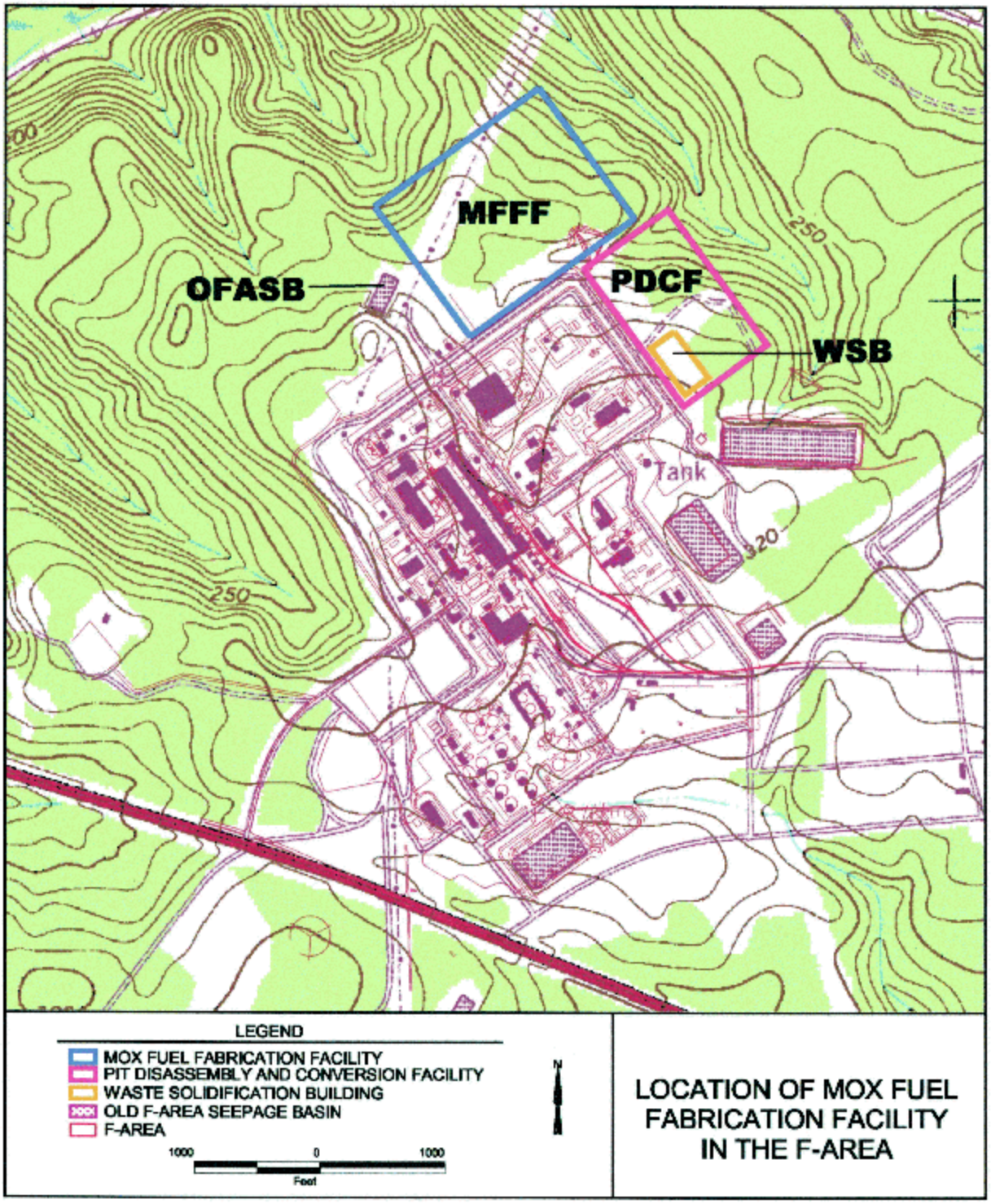

Figure 1.2. Locations of the proposed MOX facility, the PDCF, and the WSB in the F-Area on the SRS complex (*Source*: DCS 2002a).

Direct effects of the proposed action include effects resulting from construction, operation, and decommissioning of the proposed MOX facility to convert 34 MT (37.5 tons) of surplus plutonium into MOX fuel. Plutonium dioxide powder would be processed at the proposed MOX facility to remove impurities, such as americium and gallium, and would be mixed with the depleted uranium dioxide to form the MOX fuel. The final blend for MOX fuel would have a required plutonium content of 2.3% to 4.8% (percent by weight). The facility would be capable of producing MOX fuel with a plutonium content of up to 6% (DCS 2001).

1.2.2 Connected Actions

In order for the proposed MOX facility to fulfill its function, other "connected actions" would also occur. For example, the PDCF would be the source of some of the plutonium dioxide needed to make MOX fuel. Therefore, the PDCF must be constructed and authorized by the DOE to operate, so that the proposed MOX facility would have the required material with which to make MOX fuel.

Connected Actions

Actions closely related to the proposed action that:

- Automatically trigger other actions which may require environmental impact statements,
- Cannot or will not proceed unless other actions are taken previously or simultaneously, or
- Are interdependent parts of a larger action and depend on the larger action for their justification.

Feedstock (surplus plutonium dioxide and depleted uranium dioxide) would be required to be transported to SRS to make the MOX fuel. Because the surplus plutonium is currently stored at seven DOE facilities (see Figure 1.3 and Table 1.1), it would need to be transported to the SRS (DOE 2000). The depleted uranium hexafluoride would first be transported from a DOE site (assumed to be the gaseous diffusion uranium enrichment facility in Portsmouth, Ohio) to an existing commercial fuel fabrication facility (assumed to be the General Electric Company facility in Wilmington, North Carolina), where it would be converted to depleted uranium dioxide, which would then be transported to SRS.

Two new DOE facilities (the PDCF and the Waste Solidification Building [WSB]) are needed to support the proposed MOX facility. The PDCF would be required to convert approximately 25.6 MT (28.2 tons) of surplus plutonium metal to plutonium dioxide. The remaining quantity of surplus plutonium, called "alternate feed stock," would be in a form that would be suitable to go directly to the proposed MOX facility. The WSB would process liquid waste streams from the PDCF and proposed MOX facility. Since the PDCF and WSB would not be under NRC's Atomic Energy Act jurisdiction, the safety issues pertaining to the PDCF and WSB will not be addressed by the NRC in the SERs.

As discussed in Section 4.3.4, other waste from the proposed MOX facility, not sent to the WSB, would be transferred to and managed by the SRS. In addition, infrastructure upgrades would be needed to support the proposed MOX facility. These upgrades include waste transfer pipelines, electric utility line realignment, and addition of access roads.

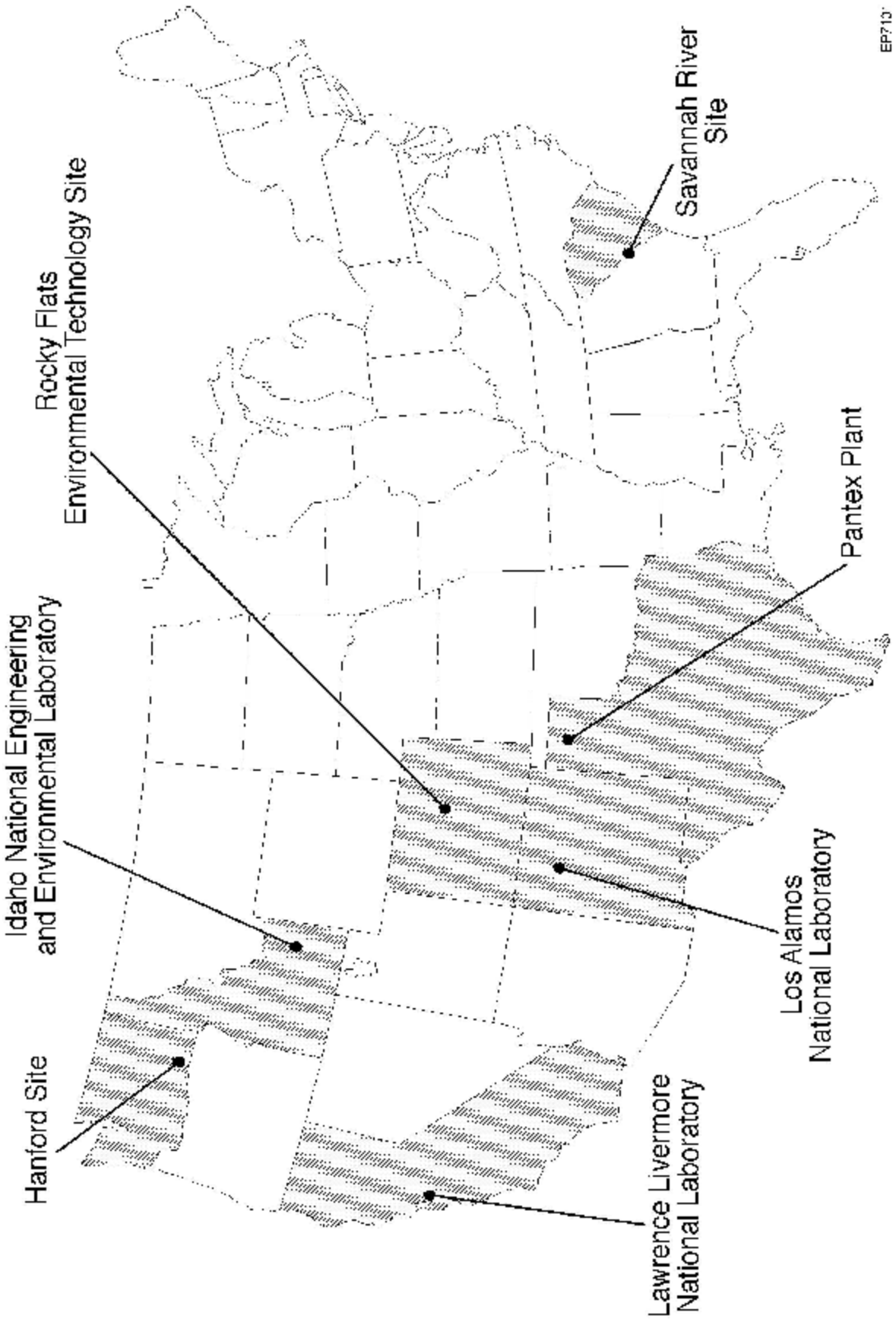

Figure 1.3. Locations of DOE facilities containing surplus plutonium (*Source*: Adapted from DOE 1999).

The DEIS also evaluates transporting the fresh or unirradiated MOX fuel made by the proposed MOX facility (assuming it is built and is authorized to operate) to mission reactors for irradiation. Since no reactor licensee has yet sought the authority to use MOX fuel, the transportation of fresh MOX fuel is evaluated on a generic basis, using a surrogate reactor located in the Midwest. For the same reasons, the potential impacts of using MOX fuel in a reactor are evaluated on a generic basis. These impacts are discussed in Section 4.4.3 of this DEIS. In order for a commercial reactor to use MOX fuel, an amendment to a 10 CFR Part 50 license, issued by the NRC, would be required. NRC would analyze the site-specific environmental impacts of such an amendment if and when such a request is made to the NRC. The DEIS discusses spent MOX fuel transport to a geologic repository.

Proposed Action Elements

- Construction, operation, and decommissioning of proposed MOX facility, PDCF, and the WSB;
- Infrastructure upgrades;
- Shipment of surplus plutonium from the DOE sites to the SRS;
- Transport of depleted uranium hexafluoride from the DOE facility at Portsmouth, Ohio, to the commercial fuel fabrication facility in Wilmington, North Carolina;
- Transport of depleted uranium oxide from the Wilmington facility to the SRS; and
- Transport of MOX fuel and fuel irradiation in surrogate reactors.
- Spent MOX fuel transport to a geologic repository.

Table 1.1. Surplus plutonium inventories at DOE sites

DOE site[a]	Quantity (metric tons)[b]
Pantex	21.3
RFETS	11.9
Hanford	1.7
LANL	1.5
SRS	1.3
INEEL	0.4
LLNL[c]	0.1

[a]RFETS = Rocky Flats Environmental Technology Site, LANL = Los Alamos National Laboratory, SRS = Savannah River Site, INEEL = Idaho National Engineering and Environmental Laboratory, LLNL = Lawrence Livermore National Laboratory.

[b]1 metric ton (MT) = 1,000 kilograms (kg), or approximately 2,200 lb.

[c]Represents total from all other DOE sites and LLNL; LLNL total may increase because some of the surplus plutonium stored at RFETS was shipped to LLNL, where special handling and disassembly processes occur. The total plutonium recovered from processing this inventory at LLNL could be 1.7 MT.

Source: DOE (1996).

1.3 Purpose of and Need for the Proposed Action

The NRC's specific need for action arises from its statutory responsibility under Section 202(5) of the Energy Reorganization Action of 1974 (as amended in 1998), and NEPA, to determine whether a MOX facility can be built and operated in a safe and environmentally acceptable manner. The proposed action is part of the larger DOE surplus plutonium disposition program as described in Section 1.1.1. The DOE has developed a strategy for plutonium disposition that has addressed the purpose and need for the proposed MOX facility on a programmatic level. The underlying purpose and need for the proposed MOX facility is defined by the DOE's surplus plutonium disposition program, which lays the foundation for parallel disposition of excess Russian plutonium, thereby protecting against proliferation of materials capable of making weapons of mass destruction. Thus, the general purpose of and need for the proposed MOX facility is to help reduce the threat of nuclear weapons proliferation by ensuring that surplus plutonium is converted to proliferation-resistant forms (DOE 1999). The purpose and need discussion establishes a range of reasonable alternatives to the proposed action that can satisfy this underlying purpose and need.

Following the subsequent September 2000 surplus plutonium disposition agreement between Russia and the United States (White House 2000), the DOE determined that a MOX-only approach best ensures the joint reduction of existing plutonium stockpiles held by the two nations, and concluded in its amended ROD that reliance on this approach is the key to successfully completing the agreement (DOE 2002). The result of this action would be to reduce over time the number of locations where the various forms of plutonium are stored and to ensure that this weapons-usable material does not fall into the hands of rogue states or terrorist groups.

1.4 Scope of the DEIS

1.4.1 Scoping Process

On March 7, 2001, the NRC issued a Notice of Intent (NOI) in the *Federal Register* (66 FR 13794) to prepare an EIS for construction and operation of the proposed MOX facility at the SRS near Aiken, South Carolina. In the NOI, NRC announced plans for two scoping meetings: one in North Augusta, South Carolina, on April 17, 2001, and another in Savannah, Georgia, on April 18, 2001. In a second *Federal Register* notice on April 11, 2001 (66 FR 18223), the NRC announced that a third scoping meeting would be held in Charlotte, North Carolina, on May 8, 2001.

The three scoping meetings were held as planned. At each meeting, the NRC staff distributed background materials on the MOX fuel program and NRC's plans for conducting licensing and environmental reviews for the facility. An open house held before each meeting provided attendees an opportunity to view informational materials and talk informally with NRC staff. During the meeting, the NRC staff presented an overview of the NRC's role in the facility

licensing process and described the NRC's approach to meeting its obligations under NEPA. The presentations were followed by a question and answer period in which the NRC staff responded to questions from attendees. The majority of time at the meetings was devoted to allowing individuals to express their views on the scope of the EIS.

A total of about 300 individuals attended the three scoping meetings, and about 80 of them asked questions or provided oral comments at the meetings. In addition, approximately 60 individuals or organizations submitted written comments to the NRC by regular mail, fax transmittal, e-mail, or in person at the meetings. Some of the individuals who provided written comments also spoke at the meetings. Some individuals attended and offered comments at more than one meeting. Although issues raised during the scoping period were considered in the preparation of this DEIS, some of those issues were either analyzed in less detail or were not analyzed at all, depending on their relevance to the proposed action and the anticipated impacts. The full scoping summary report (NRC 2001b) is included as Appendix I.

The scoping process helped to determine the scope of the EIS and identify significant issues to be analyzed in depth. For instance, two technology options for the proposed action were identified during the scoping process. The first option is to substitute sand filters for the proposed high-efficiency particulate air (HEPA) filters to control air emissions from the facility. The second option is to substitute a dry process for the proposed wet process to remove impurities from plutonium dioxide powder. Cumulative impacts of the proposed action, in addition to other contaminant sources, were also identified as a relevant issue.

The no-action alternative, if NRC does not authorize construction or operation of the proposed MOX facility, was also refined through the scoping process. In addition to the no-action alternative of continued storage of all of the surplus weapons-grade plutonium at the present DOE sites in an unaltered form, the public suggested considering immobilizing all of the surplus weapons-grade plutonium at the SRS as a no-action alternative.

The scoping process identified several relevant areas of concern to the public.[2] Concerns were expressed about the existing groundwater contamination at the SRS and the potential for the proposed facility and waste disposal to further deteriorate groundwater quality. Existing deep boreholes at the SRS were identified as a possible conduit for contaminant migration. Concerns were also expressed about the existing contamination of the Savannah River and the potential for the proposed facility to affect surface water quality. The impact of facility-induced surface water quality changes on the downstream fishing and marine economy and on the downstream tidal wetlands was also a concern raised at the scoping meetings. Similarly, concerns were expressed regarding air quality impacts from both chemical and radiological materials.

The potential for human health impacts to the public and workers was also a concern. This included workers at the proposed facility, at the SRS, at the proposed reactors, and at disposal facilities. It was also suggested that the impacts to groups other than the "Standard Man" be

[2] The Scoping Summary Report (Appendix I) contains a complete summary of all comments received.

assessed, such as unborn fetuses, children, and elderly populations. Impacts from possible accidents at the proposed facility, during transport of radioactive materials, and at the proposed reactors also were a significant concern. It was suggested that the worst-case accidents should be evaluated, including natural disasters and terrorist acts.

Some issues identified during the scoping process were considered to be beyond the scope of the EIS. In general, these issues are not directly related to the assessment of potential impacts from the proposed action now under consideration. The lack of in-depth discussion in the EIS, however, does not imply that an issue or concern lacks value.

A number of commenters requested that the SPD EIS prepared by the DOE be supplemented and many of the decisions already made by the DOE be revisited. Because the scope of this DEIS is limited to the licensing action now under review by the NRC, which is specific to the proposed MOX facility, issues pertaining to decisions already made by the DOE are addressed by referencing the appropriate DOE analysis.

Comments that seek to alter international treaties or affect national, state, or local laws, statutes, or regulations (e.g., comments that asked to alter Price-Anderson Act[3] limits) were not addressed because they do not pertain to reasonably foreseeable impacts arising from the construction and operation of the proposed MOX facility.

Comments on the scope of assessing reactor use impacts in the EIS for the proposed MOX facility were varied. Considering that the environmental impact of reactor use of MOX fuel was a significant issue with many commenters, it is appropriate to consider those impacts in the EIS. However, the currently available information does not lend itself to performing new analyses. The DOE's SPD EIS (DOE 1999) analyzed impacts of MOX fuel use at the McGuire, Catawba, and North Anna reactors. Therefore, this DEIS will refer to the SPD EIS, but will not reanalyze generic reactor use impacts of MOX fuel. The specific environmental impacts resulting from the use of MOX fuel at the McGuire and Catawba reactors will be addressed by the NRC if the operator of those reactors applies for license amendments to use such fuel.

A number of commenters requested that the EIS analyze the impacts of having to upgrade the emergency response equipment and retrain emergency responders in the communities around the SRS, at the reactors, and along transportation routes. Other commenters requested that the EIS identify capabilities of local, regional, and national medical facilities to manage the casualties resulting from potential accidental releases and assess the readiness of communities to evacuate certain areas along the transportation routes in case of an accident. These issues are discussed in the EIS to the extent that they are required as mitigation measures presented in Chapter 5.

Many commenters raised a number of different issues concerning terrorism. The Scoping Summary Report stated that the EIS would not address the impacts of terrorism because these impacts are not considered to be reasonably foreseeable as a result of the proposed action.

[3] The Price-Anderson Act limits the liability of the nuclear industry in the event of a nuclear accident in the United States.

However, following the events of September 11, 2001, the Commission decided to consider the question of whether NEPA requires the evaluation of such impacts. By order dated December 18, 2002 (CLI-02-24), the Commission ruled that NRC has no obligation under NEPA to consider intentional malevolent acts in conjunction with the licensing of the proposed MOX facility.

In response to the cancellation of the plutonium immobilization facility (DOE 2002), the NRC delayed the issuance of this DEIS. The NRC held three public meetings in North Augusta, South Carolina; Savannah, Georgia; and Charlotte, North Carolina, and solicited additional written comments on how the immobilization of surplus plutonium as a no-action alternative should be discussed (NRC 2002). The NRC also solicited views on other alternatives that should be considered in the DEIS. In response, most commenters said they still wanted immobilization considered as an alternative in the DEIS, while some urged the NRC to instead focus on the proposed action. As discussed further in Section 2.3, the NRC has determined that immobilization of plutonium does not require an in-depth evaluation in this DEIS, because it is not a reasonable alternative to the proposed action. In response to the NRC's solicitation on other alternatives that should be considered, the alternative of deliberately producing off-specification MOX fuel was identified. This alternative is discussed in Section 2.3.

With respect to the proposed PDCF, the DOE's change from a "hybrid" to a MOX-only approach has resulted in a change in the scope of this DEIS from that described in the NRC's March 7, 2001, NOI. The NRC stated there that the PDCF would not be part of the NRC's NEPA review of the proposed MOX facility (NRC 2001a). Initially, the PDCF had independent utility apart from the MOX facility, since the DOE planned to build and operate the PDCF along with the plutonium immobilization plant regardless of whether MOX fuel was also produced (DOE 2000). Now, because of the DOE's subsequent decision in its amended ROD to cancel the plutonium immobilization plant and implement a MOX-only approach (DOE 2002), the PDCF no longer has independent utility apart from the proposed MOX facility. Thus, for NEPA purposes, the PDCF must be evaluated in this DEIS to avoid an improper segmentation of the potential impacts discussion.

1.4.2 Issues Studied in Detail

As discussed in the Scoping Summary Report (Appendix I), the goal of this EIS is to set forth the impact analyses in a manner that is readily understandable by the public. Significant or more important impacts are discussed in Chapter 4 of this DEIS. On the basis of the NRC's analyses and consideration of comments received during the scoping process, the following topics are discussed in detail in Sections 4.2 and 4.3 for the no-action alternative and the proposed action, respectively: (1) human health, (2) air quality, (3) hydrology, (4) waste management, (5) accident impacts, (6) decommissioning, and (7) environmental justice. Transportation of radioactive materials, conversion of depleted uranium, and use of MOX fuel in reactors are discussed in Section 4.4. Cumulative impacts are discussed in Section 4.5. The cost-benefit analysis for the no-action and proposed action alternatives, which builds on the comparison of alternatives in Section 2.4, is provided in Section 4.6. Mitigation actions to address the potential impacts are discussed in Chapter 5.

1.4.3 Issues Eliminated from Detailed Study

Impacts found to be less significant are discussed in DEIS Appendixes G and H. These impacts include those pertaining to geology, seismology, soils, noise, ecology, land use, cultural and paleontological resources, infrastructure, socioeconomics, and aesthetics.

1.4.4 Other National Environmental Policy Act Documents Related to This Action

In preparing this DEIS, the following other NEPA documents were considered:

Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement, DOE/EIS-0229, U.S. Department of Energy, Office of Fissile Materials Disposition, Washington, D.C., December 1996.

Surplus Plutonium Disposition Final Environmental Impact Statement, DOE/EIS-0283, U.S. Department of Energy, Office of Fissile Materials Disposition, Washington, D.C., November 1999.

Record of Decision for the Surplus Plutonium Disposition Final Environmental Impact Statement, U.S. Department of Energy, Washington, D.C., January 11, 2000 (*65 Federal Register* [FR] 1608).

Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Feb. 2002.

1.5 Cooperating Agencies

No cooperating agencies have been involved in preparation of this DEIS.

1.6 Other State and Federal Agencies

Several federal, Native American, state, and local agencies and organizations were contacted to gather relevant information for this DEIS. The scope of the analysis necessitated obtaining information from state agencies in both South Carolina and Georgia. The following is a list of all agencies contacted during early stages of the DEIS preparation:

Federal Agencies

U.S. Department of Energy, Savannah River Operations Office
U.S. Department of Energy, Office of Fissile Material Disposition
U.S. Fish and Wildlife Service

Native American Organizations

Catawba Indian Nation
Pee Dee Indian Association
Ma Chis Lower Alabama Creek Indian Tribe
Muscogee (Creek) Nation
Indian People's Muskogee Tribal Town Confederacy
Yuchi Tribal Organization, Inc.
United Keetowah Band of Cherokee Indians

State Agencies

South Carolina State Historic Preservation Office, Department of Archives and History
South Carolina Department of Natural Resources, Wildlife and Freshwater Fisheries Division
South Carolina Department of Health and Environmental Control, Bureau of Air Quality
South Carolina Department of Transportation
Georgia Department of Natural Resources, Wildlife Resources Division
Georgia Department of Natural Resources, Environmental Protection Division, Air Protection Branch

Towns, Cities, and Counties

Columbia County, Georgia
Town of Grovetown, Georgia
Town of Harlem, Georgia
City of Augusta/Richmond County, Georgia
City of Blythe, Georgia
City of Hephzibah, Georgia
Aiken County, South Carolina
City of Aiken, South Carolina
Town of Jackson, South Carolina
Town of New Ellenton, South Carolina
City of North Augusta, South Carolina
Town of Wagener, South Carolina
Barnwell County, South Carolina
City of Barnwell, South Carolina
Town of Blackville, South Carolina
Town of Williston, South Carolina

School Districts

Columbia County Board of Education, Georgia
Richmond County Board of Education, Georgia
Aiken County Board of Education, South Carolina
Williston School District #19, South Carolina
Williston School District #29, South Carolina
Williston School District #45, South Carolina

1.7 References for Chapter 1

DCS (Duke Cogema Stone & Webster) 2000. *Mixed Oxide Fuel Fabrication Facility Environmental Report.* Docket Number 070-03098. Charlotte, NC. Dec.

DCS 2001. *Mixed Oxide Fuel Fabrication Facility Construction Authorization Request*. Docket Number 070-03098. Charlotte, NC. Feb.

DCS 2002a. *Mixed Oxide Fuel Fabrication Facility Environmental Report, Revision 1 & 2*. Docket Number 070-03098. Charlotte, NC.

DCS 2002b. *Amended Mixed Oxide Fuel Fabrication Facility Construction Authorization Request*. Docket Number 070-03098. Charlotte, NC.

DOE (U.S. Department of Energy) 1996. *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement*, DOE/EIS-0229. Office of Fissile Materials Disposition, Washington, DC. Dec.

DOE 1999. *Surplus Plutonium Disposition Final Environmental Impact Statement*, DOE/EIS-0283. Office of Fissile Materials Disposition, Washington, DC. Nov.

DOE 2000. "Record of Decision for the Surplus Plutonium Disposition Final Environmental Impact Statement." *Federal Register* 65:1608, Jan. 11.

DOE 2002. "Amended Record of Decision for the Surplus Plutonium Disposition Program*."* *Federal Register* 67:19432, April 19.

NRC (U.S. Nuclear Regulatory Commission) 2001a. "Notice of Intent to Prepare an Environmental Impact Statement for the Mixed Oxide Fuel Fabrication Facility." *Federal Register* 66:13794, March 7.

NRC 2001b. *Environmental Impact Statement Scoping Process Scoping Summary Report*, Mixed Oxide Fuel Fabrication Facility Savannah River Site. U.S. Nuclear Regulatory Commission, Aug. [Reproduced in Appendix I of this DEIS.]

NRC 2002. "Notice of Delay in Issuance of the Draft and Final Environmental Impact Statements for the Mixed Oxide Fuel Fabrication Facility." *Federal Register* 67: 20183-20185, April 24.

White House 2000. *Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation.* White House, Washington, DC. Sept.

2. ALTERNATIVES, INCLUDING THE PROPOSED ACTION

This chapter presents details of the alternatives considered in the draft environmental impact statement (DEIS). The no-action alternative, which is discussed in Section 2.1, considers the continued storage of surplus plutonium in various locations throughout the U.S. Department of Energy (DOE) complex in the event the U.S. Nuclear Regulatory Commission (NRC) either denies Duke Cogema Stone & Webster's (DCS's) construction authorization request for the Mixed Oxide Fuel Fabrication Facility (the proposed MOX facility) or, later, denies DCS's subsequent request for a Title 10, Part 70 *Code of Federal Regulations* (10 CFR Part 70) license to possess and use special nuclear material. Section 2.2 presents the technical details of the proposed action and the connected actions.

Section 2.3 considers several alternatives to the proposed action and explains why they are not analyzed further in Chapter 4. These alternatives include alternate locations for the proposed MOX facility in the F-Area, alternative technology and design options, immobilization of surplus plutonium, deliberately making off-specification MOX fuel, and the Parallex Project.

The NRC recognizes that under the provisions of the *Code of Federal Regulations*, Title 10, Part 70 (10 CFR 70), the Commission may approve construction of the proposed MOX facility and subsequently deny the DCS application for a 10 CFR Part 70 license to possess and use special nuclear material. Although this is a possible outcome relative to the proposed action, the NRC is not considering construction alone as a separate alternative because the NRC would not knowingly select an alternative involving construction of a facility that cannot be used for its intended purpose.

Section 2.4 compares the potential impacts related to the proposed action with those of the no-action alternative. Section 2.5 presents the NRC's preliminary recommendation.

2.1 No-Action Alternative — Continued Storage of Surplus Plutonium

The no-action alternative would be a decision by the NRC not to approve the proposed MOX facility. It is reasonable to assume that if the NRC does not approve the proposed MOX facility, the DOE's surplus plutonium would remain in storage at DOE facilities. The surplus plutonium inventory is now stored at seven DOE sites. If this storage were to continue, it is possible that limited new construction would be required at one or more of these sites to upgrade storage conditions. However, the impacts of such construction, if required, would be addressed under a separate site-specific environmental review by DOE. For purposes of this EIS, the impacts of continued storage of surplus plutonium are assumed to be essentially the same as those analyzed by DOE in the Surplus Plutonium Disposition Environmental Impact Statement (SPD EIS) (DOE 1999a). However, the analysis in this DEIS also considers the DOE's recent action to consolidate the storage of 6 MT (6.6 tons) of non-pit surplus plutonium from the Rocky Flats Environmental Technology Site to the Savannah River Site's K-Area Material Storage (KAMS) facility (DOE 2002b). The impacts of the no-action alternative are presented in Section 4.2 and Appendix G.

2.2 Proposed Action — Description of Mixed Oxide Fuel Fabrication Facilities and Connected Actions[1]

2.2.1 Introduction

The proposed MOX facility is designed to convert surplus weapons-grade plutonium and depleted uranium dioxide (UO_2) into MOX fuel that could be used at commercial nuclear power plants authorized to use such fuel. If the construction authorization for the proposed MOX facility is granted, the facility would be built on the north-northwest side of the F-Area at the SRS (see Figure 1.2 in Section 1.2). The Pit Disassembly and Conversion Facility (PDCF) would be built by DOE on the north-northeast side of the F-Area. The PDCF would be used to recover the plutonium metal from the pits[2] of disassembled weapons and would convert the weapons-grade plutonium to plutonium dioxide powder, which would subsequently be transferred to the proposed MOX facility as feedstock.

Within the boundaries of the PDCF, the DOE would also construct the Waste Solidification Building (WSB) (see Figure 1.2). The WSB would be used to process several liquid waste streams from the proposed MOX facility and the PDCF and convert them to solid transuranic (TRU) waste or low-level waste (LLW). This section describes the general layout of the proposed MOX facility, processes to be used to manufacture MOX fuel, and the systems that would be used to handle the waste streams from the facility. As discussed in Section 1.2.2, since the PDCF and WSB are connected actions, these proposed DOE facilities are also discussed in Sections 2.2.2 and 2.2.4, respectively. Other elements of the proposed action as described in Section 1.2 that are not discussed in Chapter 2 are discussed in Chapter 4. Direct and indirect impacts of the proposed action and connected actions are presented in Sections 4.3 and 4.4, and Appendix H.

As discussed in Section 1.4.1, the technology option of substituting a sand filter for the proposed high-efficiency particulate air (HEPA) filters to control air emissions from the proposed MOX facility was identified during the scoping process. This technology option is described in Section 2.2.5 and is analyzed in Section 4.3.8.

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[1] Except as noted, the descriptions provided in this section are based on information from DCS (2000, 2001, and 2002).

[2] Pits are weapon components with a spherical metal core made of plutonium metal and several outer layers.

2.2.2 Pit Disassembly and Conversion Facility

2.2.2.1 Description of the Pit Disassembly and Conversion Facility

The PDCF would be built by the DOE and would not be subject to NRC licensing. The facility would be used to recover plutonium metal from weapon components, and convert it to an unclassified (i.e., no longer exhibiting any characteristics that are protected for reasons of national security) plutonium dioxide. The plutonium dioxide would be transferred to the proposed MOX facility. In addition to excess weapon components, the PDCF would be able to receive excess plutonium metal in other forms and be capable of converting it to plutonium dioxide.

The PDCF would be designed to process up to 3.5 MT (3.8 tons) of plutonium metal into plutonium dioxide annually. Facility operations would require a staff of about 400 personnel. The facility would be built in a hardened space of thick-walled concrete that meets all applicable standards for processing special nuclear material. One or possibly both levels of the two-story building would be below grade. Areas of the facility in which plutonium would be processed or stored would be designed to survive natural phenomena such as earthquakes, floods, and tornadoes, as well as potential accidents associated with fissile and radioactive materials. Ancillary buildings would be required for support activities.

Activities involving radioactive materials or externally contaminated containers of radioactive materials would be conducted in gloveboxes. The gloveboxes would be interconnected by a contained conveyor system to move materials from one process step to the next. Gloveboxes would remain completely sealed and operate independently, except during material transfer operations. Built-in safety features would limit the temperature and pressure inside the gloveboxes and ensure that operations remain within criticality safety limits. When dictated by process needs or safety concerns, an inert atmosphere would be maintained in gloveboxes. The exhaust from the gloveboxes would be continuously monitored for radioactive contamination. The atmosphere in the gloveboxes would be kept at a lower pressure than that of the surrounding areas so that any leaks of gaseous or suspended particulate matter would be contained and filtered appropriately. The building ventilation system would include high-efficiency particulate air (HEPA) filters and would be designed to maintain confinement, thus precluding the spread of airborne radioactive particulates or hazardous chemicals within the facility or to the outside environment. Both intake and exhaust air would be filtered, and exhaust gases would be monitored for radioactivity.

Beryllium may be a constituent of some of the pits that would be disassembled in the PDCF. Because inhalation of beryllium dust and particles has been proven to cause a chronic and sometimes fatal lung disease, beryllium is of special interest from a health effects perspective. However, the process operations in the PDCF are expected to generate only larger, nonrespirable turnings and pieces of the metal, and all work would be performed in gloveboxes. No grinding would be done that could cause small pieces of beryllium to become airborne.

The PDCF would accommodate the following surplus plutonium-processing activities: pit receipt, storage, and preparation; pit disassembly; plutonium conversion; oxide blending and sampling; nondestructive assay; product canning; product storage; product inspection and sampling for international inspection; product shipping; declassification of parts not made from special nuclear materials; highly enriched uranium (HEU) decontamination, packaging, storage, and shipping; tritium capture, packaging, and storage; and waste packaging, sampling, and certification. Additional areas for support activities would be needed, including office space, change rooms, a central control room, a laboratory, mechanical equipment rooms, mechanical shops, an emergency generator to supply power to critical safety systems in the event of a power outage, a warehouse, shipping and receiving areas, waste storage, guard stations, entry portals, and parking.

2.2.2.2 Processes Occurring in the PDCF

At the PDCF, the storage containers in which the plutonium is received would be removed from their overpacks (outer shipping containers), the contents verified, and the information regarding the material entered into the PDCF's material accountability system. Pits and plutonium metal would be placed in a short-term receiving vault, checked for radiological contamination, and transferred to the pit storage vault until processing. Before being processed in the pit disassembly line, the pits would be segregated on the basis of the potential presence of tritium.[3] Pits without tritium would go into the pit bisector glovebox, and those containing tritium would start in the Special Recovery Line glovebox.

In the pit bisector glovebox, external structures would be cut away from the pit, and the pit would be cut in half. Nonbonded pits (pits whose components separate easily) would be separated into plutonium metal, HEU, classified metal shapes, and classified nuclear material parts. The plutonium parts would be assayed as part of the material accountability program. HEU would be sent to the HEU-processing station for material accountability, electrolytic decontamination, and packaging; the classified metal shapes and metal shavings would go to the declassification furnaces; the nuclear material parts to the storage at the pit conversion facility; and the plutonium to the hydride-oxidation (HYDOX) station for the next step of the process. Bonded pits, which cannot be separated prior to processing, would be sent to the HYDOX station intact. For these pits, HEU, classified metal shapes, and classified nuclear material parts would be separated from the plutonium metal during the HYDOX process, then sent to the HEU-processing station, declassification furnaces, and storage at the pit conversion facility, respectively. Recovered HEU would be stored in a vault at the pit conversion facility until shipped to the Y-12 Facility at the Oak Ridge Reservation (ORR) for the declassification, storage, and eventual disposition. The HEU would meet the Y-12 acceptance criteria prior to shipment to ORR.

[3] Tritium can be used as a boosting fuel in high-energy atomic weapons. Although the operators of the pit conversion facility would know which pits contain tritium, the pit types and the number of surplus pits that contain tritium are classified.

Pits with tritium would also be bisected, and the HEU, classified metal shapes, and classified nuclear material parts would be separated from the plutonium; this would occur in the Special Recovery Line glovebox. Under normal circumstances, all the tritium associated with a given pit would be captured and recovered during the tritium removal process in the Special Recovery Line. It is expected that the tritium in a small number of pits will have absorbed into the plutonium. For these pits, an additional step would occur in the Special Recovery Line glovebox: the plutonium would be heated in a vacuum furnace to drive off the tritium as a gas. The tritium would then be captured on a catalyst bed and packaged as LLW for treatment and disposal. HEU and classified metal shapes would be decontaminated and sent to the HEU-processing station and declassification furnaces, respectively; classified nuclear material parts would be placed in storage at the pit conversion facility. After confirmation that the plutonium metal was free of tritium, the plutonium would be assayed as part of the special nuclear material accountability program and transferred to the HYDOX station. Recovered HEU would be stored in a vault at the pit conversion facility until shipped to the ORR for declassification, storage, and eventual disposition. The HEU would meet the Y-12 acceptance criteria prior to shipment to ORR.

In the HYDOX module, plutonium metal would react with hydrogen, nitrogen, and oxygen at the controlled temperatures and pressures in a pressure vessel to produce plutonium dioxide. The plutonium metal would first be reacted with hydrogen gas to form a hydride. Then the vessel would be purged of the hydrogen and the hydride reacted with nitrogen gas to form a nitride. The nitrogen would then be purged and replaced with oxygen for the final reaction forming plutonium dioxide. The plutonium dioxide product would be collected and assayed for the material accountability program to confirm that all the plutonium metal entering the HYDOX process left as an oxide.

In the primary canning module, the cans of plutonium dioxide would be placed into a primary storage can made of stainless steel. This can would then be welded shut and leak tested to ensure that the weld was sound. If the can were to fail the leak test, it would be reopened and rewelded. After passing the leak test, the primary can would be sent to the electrolytic decontamination module. After decontamination, each can would be rinsed, dried, and surveyed to verify decontamination, then sent to the secondary canning module.

In the secondary canning module, primary cans would be placed into secondary stainless steel storage cans meeting the DOE's long-term storage requirements. Also in this module, secondary storage cans would be welded shut and leak tested. After leak testing, each can would be marked with a laser to identify the can and its contents, and passed to the nondestructive assay module. Since the proposed MOX facility and PDCF would be colocated, the plutonium dioxide would most likely be transferred between the two facilities in only the primary can.

In the nondestructive assay module, each can would be assayed to confirm its contents. Following assay, the cans would be moved into the main storage vault and would be available for international inspection. After inspection, the cans would be transferred to another vault that would also be subject to international inspection. The cans would subsequently be transferred to the proposed MOX facility.

2.2.2.3 Radioactive Effluents and Wastes at the PDCF

Potential effluents and wastes from the PDCF are described in LANL (1998) and the SPD EIS (DOE 1999a). The facility would be designed to minimize the quantities of both the effluents and wastes. Preliminary estimates indicate that small quantities of various plutonium isotopes and americium-241 and tritium gas would be emitted to air from the facility. No releases to surface water would be expected. The facility would be expected to generate small quantities of TRU waste, LLW, mixed waste, and nonradioactive hazardous waste. Except for two streams of liquid waste that would be sent to the WSB for processing and treatment (see Section 2.2.4.2), all wastes would be transferred to the SRS waste management system for final processing and disposal.

2.2.3 MOX Fuel Fabrication Facility

2.2.3.1 Description of the MOX Fuel Fabrication Facility

As designed, the project site would occupy an area of about 16.6 ha (41 acres). Approximately 6.9 ha (17 acres) of the site would be developed with buildings, other facilities, and paving. The remaining 9.7 ha (24 acres) would be landscaped with either grass or gravel.

No highways, railroads, or waterways traverse the proposed MOX facility site, and material and personnel would be moved to and from the site on existing SRS roads. The proposed MOX facility would consist of the following buildings:

- MOX Fuel Fabrication Building
- Emergency Diesel Generator Building
- Standby Diesel Generator Building
- Secured Warehouse Building
- Administration Building
- Technical Support Building
- Reagents Processing Building
- Receiving Warehouse Building

All of these buildings except the Administration Building and the Receiving Warehouse Building would be enclosed within a double fence perimeter intrusion detection and assessment system. The area within this system would total about 5.7 ha (14 acres) and would be called the "Protected Area."

The Technical Support Building, located between the Administration Building and the MOX Fuel Fabrication Building, would house the main support facilities for MOX Fuel Fabrication Building personnel and would contain the access facilities for the Protected Area and the MOX Fuel Fabrication Building. The building would not be directly involved in the principal processing functions of the facility. Supporting activities and facilities located in this building would include

health physics, an electronics maintenance laboratory, a mechanical maintenance shop, personnel locker rooms, and a first aid station.

The MOX Fuel Fabrication Building would have three major functional areas: the MOX Processing Area, the Aqueous Polishing Area, and the Shipping and Receiving Area. The MOX Processing Area would include the blending and milling area, pelletizing area, sintering area, grinding area, fuel rod fabrication area, fuel bundle assembly area, a laboratory area, and storage areas for feed material, pellets, and fuel assemblies. Space would also be provided in the MOX Fuel Fabrication Building for support equipment, such as temporary waste storage; heating, ventilation, and air conditioning (HVAC) equipment; HEPA filter plenums; inverters; switchgear; and pumps. The Aqueous Polishing Area would be used to remove impurities from the feed plutonium coming from the PDCF as well as from the plutonium in the alternate feedstock for use in the MOX Processing Area. The aqueous polishing process would extract impurities from the weapons-grade plutonium dioxide. The Shipping and Receiving Area would contain the equipment and facilities used to handle incoming and outgoing materials to and from the MOX Processing Area and Aqueous Polishing Area.

The Emergency Diesel Generator Building would contain the emergency diesel generator to provide the emergency on-site electrical power supply for items relied on for safety. The Standby Diesel Generator Building would contain the diesel generators that would provide the on-site electrical power source in the event of loss of off-site power. The Secured Warehouse Building would include the Material Receipt Area, the Storage Area, the MOX Fresh Fuel Package Storage Area, the Parts Washing Facility, the Vehicle Access Portal, and the Vehicle Gatehouse. The Material Receipt Area would serve as the receiving facility for most of the materials (including depleted uranium dioxide), supplies, and equipment necessary for facility operations. The Administration Building, located outside of the Protected Area of the complex, would provide administrative support to the facility and its operations. Space would be provided in the building for facility management, facility operations, finance and administration, health and safety, quality assurance, and management personnel.

The Reagents Processing Building, located adjacent to the Aqueous Polishing Area of the MOX Fuel Fabrication Building, would provide storage for pure reagent-grade chemicals and facilities for preparation of chemical solutions used in the Aqueous Polishing Area. The Reagents Processing Building would consist of several separate rooms or areas for the various chemicals. Concrete curbs around the chemical storage areas would provide for spill containment. Chemicals would be transferred to the Aqueous Polishing Area from the Reagents Processing Building via piping located in a below-grade concrete trench between the two buildings.

The Receiving Warehouse Building would be a single-story, pre-engineered metal building located outside of the perimeter intrusion detection and assessment system. The building would consist of the Unloading Dock, the Materials Receiving Area, the Inspected Warehouse Holding Area, the Material Transfer Dock, offices, vestibule and Inspection Guard Station.

2.2.3.2 Processes Occurring in the Proposed MOX Facility

The proposed MOX facility is being designed to convert plutonium dioxide and depleted uranium dioxide to MOX fuel. Operations at the facility would begin with the receipt of the plutonium dioxide and depleted uranium dioxide feed materials. The plutonium dioxide would then be purified in the aqueous polishing process before being blended with the depleted uranium dioxide. The blended material would then be formed into pellets, the pellets incorporated into fuel rods, the fuel rods placed in fuel assemblies, and the assemblies loaded into transport casks for shipment to the nuclear power plants authorized to use MOX fuel. The technology used in the fuel fabrication process includes recycling of waste and scrap streams. The major steps in the aqueous polishing and fuel fabrication processes are shown in Figures 2.1 and 2.2, respectively.

2.2.3.2.1 Feed Materials

The plutonium dioxide feed material from the PDCF, transported in approved shipping containers, would be received in the shipping and receiving area of the MOX Fuel Fabrication Building. The feed material would be offloaded, the packaging would then be removed, and control would be transferred to the responsible facility manager. Material control and accounting (MC&A) and radiation protection functions would then be performed, and the feed material would be moved to the MOX Processing Area.

Alternate feedstock (feed material not coming from the PDCF) would be received as plutonium dioxide. Some of this material might contain higher than normal salt contaminants, some would contain chloride contaminants, and some would contain trace amounts of enriched uranium. All alternate feedstock would be milled to a uniform particle size to facilitate dissolution. The alternative feedstock would be analyzed for contaminants.

If chloride contaminant concentrations were found to be above feedstock specifications, they would be removed as a chlorine gas waste stream. The chlorine gas would be passed through a scrubber to convert the chlorine to a sodium chloride solution. If the chloride contaminants were within feedstock specifications, the feed stock would be processed as described in Section 2.2.3.2.2.

For uranium-rich alternate feedstock, an additional scrubbing column would be used to remove uranium to levels that meet the specification for purified plutonium.

Depleted uranium dioxide feed material, packaged in drums and shipped by truck, would be received at the Material Receipt Area of the Secured Warehouse Building. Conventional materials and supplies would be received at the Secured Warehouse Building. The materials would be inventoried, sorted, and removed to storage in the Secured Warehouse Building or delivered via on-site vehicles to the proper processing area.

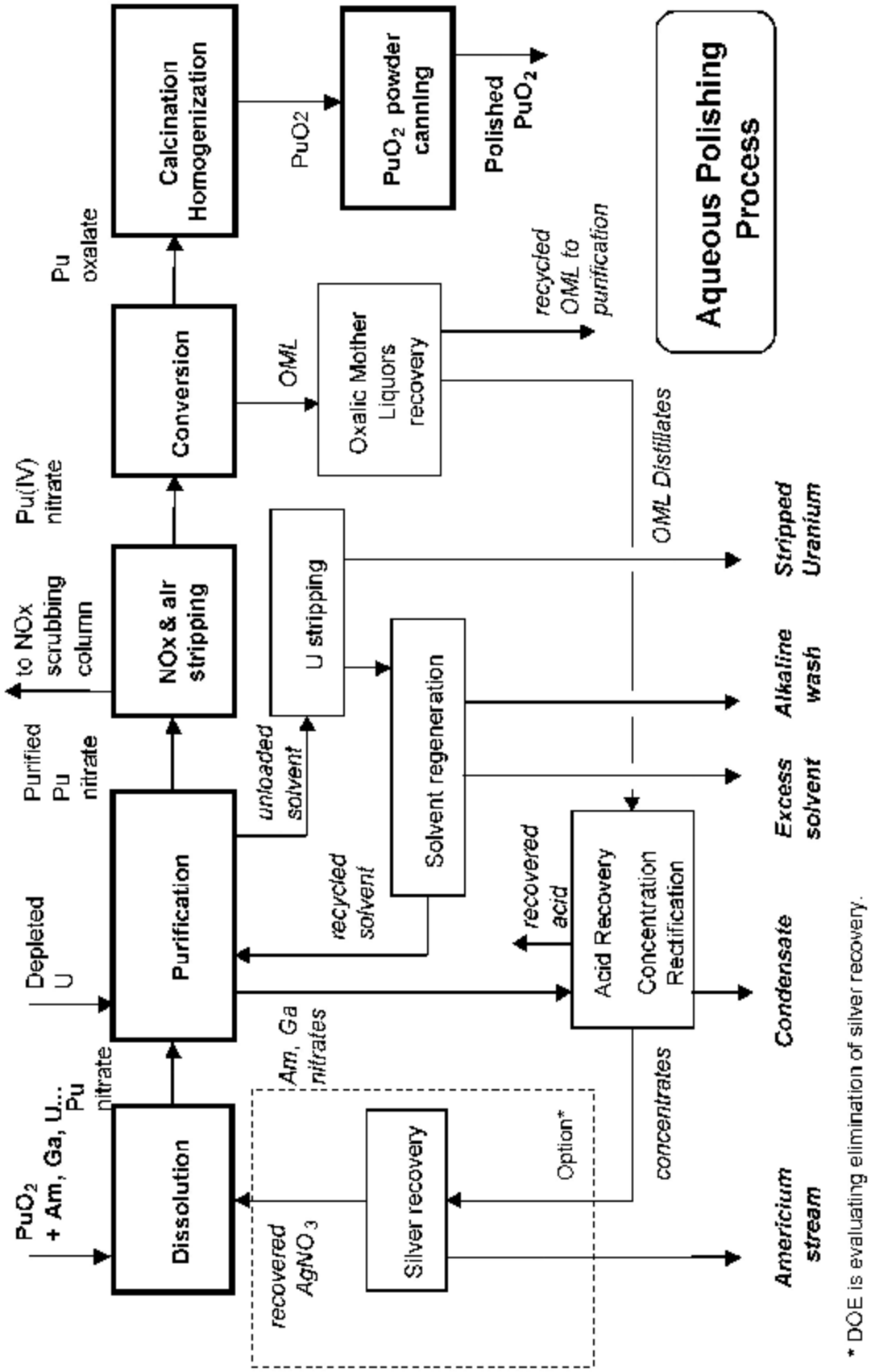

Figure 2.1. Principal steps in the aqueous polishing process (*Source*: DCS 2002).

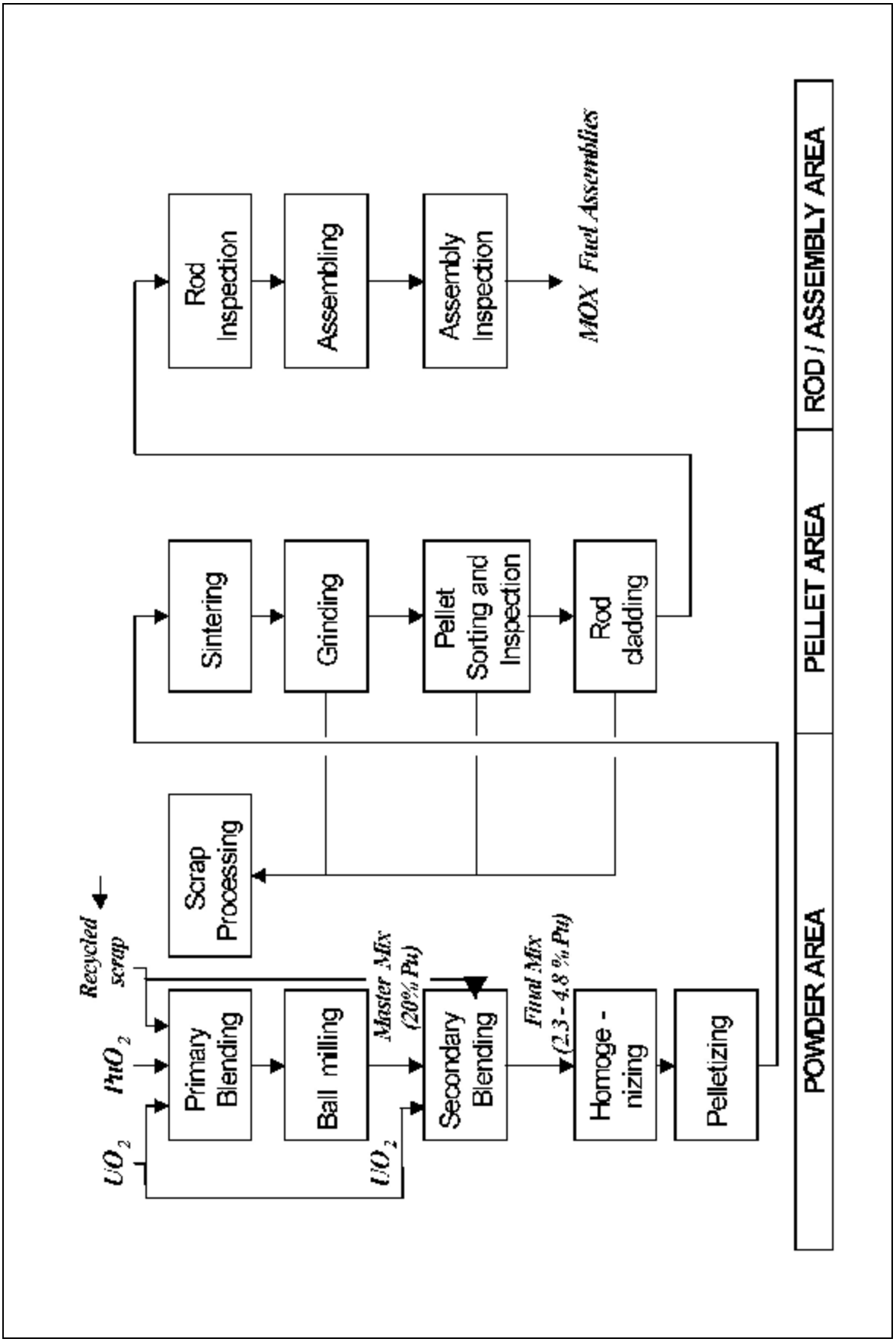

Figure 2.2. Principal steps in the fuel fabrication process (*Source*: DCS 2002).

2.2.3.2.2 Aqueous Polishing Process

The plutonium dioxide received at the facility would contain small amounts of impurities, mainly gallium, americium, highly enriched uranium, and, in the case of alternate feedstock, additional impurities. These impurities would have to be removed before the plutonium could be used in reactor fuel. The chloride contaminants would be removed from alternate feedstock before further aqueous polishing (see Section 2.2.3.2.1). The aqueous polishing process would remove remaining impurities in three major steps: dissolution, purification, and conversion.

The *dissolution step* would involve dissolving the plutonium dioxide powder in a water-based (aqueous) solution of silver (Ag^{2+}) and nitric acid at nearly room temperature. An electrical current would be passed through the solution to help dissolve the powder.

In the *purification step*, the plutonium in the aqueous solution would be separated from uranium, americium, gallium, and other impurities by solvent extraction. In this process, the aqueous solution and an organic solvent solution are mixed. The organic solvent does not readily mix with or dissolve in water, and the two solutions will separate if they are allowed to settle. However, by forcibly mixing the two solutions and adjusting chemical parameters in the aqueous solution, individual metals like plutonium can be selectively extracted from the aqueous solution into the organic solvent. In the process proposed by DCS, the solvent extraction process would involve mixing the aqueous solution with an organic solvent composed of 30% tri-butyl phosphate in dodecane. The mixing would occur in the middle of tall and narrow process vessels called columns. During mixing, the solvent would selectively extract the plutonium and uranium from the aqueous solution. The less dense solvent containing uranium and plutonium would then separate from the aqueous solution at the top of the columns. The impurities would remain in the denser aqueous solution and would be removed at the bottom of the column.

The solvent solution containing the uranium and plutonium would be washed with a nitric acid solution. This wash solution would be returned to the acid recovery unit for recycling of the acid. The plutonium and uranium in the organic solvent would then be mixed with an aqueous solution containing hydroxylamine nitrate. This process would reduce the tetravalent plutonium [Pu(IV)] to trivalent plutonium [Pu(III)], which would allow the plutonium to be removed from the organic solvent in an aqueous solution of nitric acid, hydrazine nitrate, and hydroxylamine nitrate. The organic solvent, which would then contain only high-enriched uranium and residual amounts of plutonium, would be mixed with another aqueous “wash” solution to remove the residual plutonium. The washed solvent would be routed to the uranium stripping process. High-enriched uranium would be stripped from the solvent by mixing the solvent with dilute nitric acid in another separation column. The stripped uranium solution would be diluted with depleted uranium before being transferred to the WSB for further treatment. The solvent, which would no longer contain significant amounts of uranium, plutonium, or impurities, would be routed to the solvent recovery mixer-settlers to be recycled.

The Pu(III) solution would be converted back to a solution of Pu(IV) by driving nitrous fumes (N_2O_4 and NO_2) through the plutonium solution in a packed column. The offgas would be routed through an offgas treatment system before being discharged to the atmosphere.

The conversion step would be a continuous oxalate conversion process. The oxidized Pu (IV) would be reacted with excess oxalic acid ($H_2C_2O_4$) to precipitate plutonium oxalate. Plutonium oxalate would be collected on a filter, then dried in a screw calciner to produce purified plutonium dioxide powder. The purified plutonium dioxide powder would be blended and stored in cans.

Offgas from the screw calciner would be routed through the process offgas treatment unit and HEPA filters prior to discharge to the atmosphere through the exhaust stack. The filtered oxalic mother liquors would be concentrated, reacted with manganese to destroy the oxalic acid, and recycled to the beginning of the extraction cycle, to minimize losses of plutonium to waste.

2.2.3.2.3 MOX Fuel Fabrication Process

The MOX fuel fabrication process would consist of four major steps: (1) powder master blend and final blend production, (2) pellet production, (3) rod production, and (4) fuel rod assembly.

The first operation would be the production of the powder master blend. The purified plutonium dioxide from the aqueous polishing process would be mixed with depleted uranium dioxide and recycled scraps to produce an initial mixture that would be approximately 20% plutonium. This mixture would be ground in a ball mill and mixed with additional depleted uranium dioxide and recycled scraps to produce a final blend with the required plutonium content (typically from 2.3 to 4.8%). This final blend would be further homogenized to meet stringent plutonium distribution requirements. During the final homogenizing, lubricants and pore-formers would be added to control the density of the final mixture.

The final homogenized powder blend would be pressed to form green pellets. The green fuel pellets would be sintered to obtain the required ceramic qualities. Sintering is the process of heating the green pellets in a furnace at temperatures of up to 1,700EC (3,100EF). The sintering step would remove organic products dispersed in the pellets and remove the pore-formers that were added during powder homogenization. The sintered pellets would be ground to a specified diameter and sorted. Recovered powder from grinding and discarded pellets would be recycled through a ball mill and reused in the powder processing.

Fuel rods would be loaded to an adjusted pellet length column, welded, pressurized with helium, and then decontaminated in gloveboxes. The decontaminated rods would be removed from the gloveboxes and placed on racks for inspection and assembly. Fuel rods would be inserted into the fuel assembly frame, and the fuel assembly construction would be completed. The fuel assembly would be subjected to a final inspection before shipment to reactors.

2.2.3.3 Radioactive Effluents and Wastes at the Proposed MOX Facility

2.2.3.3.1 Airborne

DCS has proposed to treat exhausts from the Fuel Fabrication Building and remove airborne radioactive materials with (at a minimum) a two-stage HEPA filter system before exhaust air is discharged to the environment. The exhaust streams would include those from building ventilation; gloveboxes; the process vents of tanks, vessels, and other equipment in the Aqueous Polishing Area; and the sintering furnaces in the Processing Area.

The filtered exhausts would be discharged through a common stack (MOX vent stack) on the roof of the Fuel Fabrication Building. Stack effluents would be continuously monitored. The stack would be 37 m (120 ft) above grade.

2.2.3.3.2 Liquids

After sampling and characterization, liquid waste streams containing radioactive materials would be transferred to the SRS waste management system for final processing and disposal. As described in Section 2.2.4, some of the liquid waste streams from the proposed MOX facility would be transferred to the WSB for further processing and treatment. Thus, no radioactive liquids would be released directly from the facility to the environment. Within the Aqueous Polishing Area, recycling would be used extensively to reduce liquid waste volumes and impurities before transfer to the SRS waste management system.

The liquid waste streams from the Aqueous Polishing Area would include the following:

- Chloride removal waste
- Liquid americium stream
- Excess acid stream
- Excess low-level radioactive solvent waste
- Stripped uranium stream
- Rinsing water
- Contaminated drains

2.2.3.3.3 Solids

Solid radioactive wastes would be placed in appropriate containers (typically 55-gal drums), assayed, and transferred to the SRS waste management system for processing and disposal. Wherever possible, the solid wastes would be compacted by the SRS to reduce volume and disposal costs.

The solid radioactive wastes generated in the Fuel Fabrication Building would include TRU solid wastes and LLW (which would include uranium and/or plutonium contamination). Other

potentially radioactive, mixed, or nonradioactive hazardous wastes that might be generated by the facility would be transferred to the SRS waste management system for disposition.

2.2.4 Waste Solidification Building

2.2.4.1 Description of the Waste Solidification Building

The Waste Solidification Building (WSB), which is not subject to NRC licensing, would be constructed by the DOE on the PDCF site south of the PDCF to process the following liquid waste streams from the PDCF and the proposed MOX facility:

- MOX facility high-alpha-activity waste stream
- MOX facility stripped uranium stream
- PDCF laboratory liquid stream
- PDCF laboratory concentrated liquid stream

The building would occupy approximately 6,970 m^2 (75,000 ft^2) of land and would be a combination of concrete and steel-frame structure. A concrete-cell configuration would be used in areas where the proposed MOX facility high-alpha stream is processed. Process enclosures adjacent to the cells would provide worker protection to accommodate operations and maintenance activities. The shielding and confinement would also serve as fire isolation barriers. The steel-frame construction, composed of a steel siding on structural steel members, would house the low-activity processes, cold chemical feeds, storage, shipping areas, and balance of plant services. Secondary confinement features, such as dikes, sumps, and leak detection, would be provided for those areas with liquid waste spill potential. The major pieces of process equipment would be tanks, evaporators, and cementation equipment.

The building would contain no more than 42,000 L (11,000 gal) of the high-alpha-activity waste stream (including transfer pipeline flush water) and 79,500 L (21,000 gal) (including transfer pipeline flush water) of low-activity waste at one time. Most of the solid waste generated in the WSB would be mixed with concrete and poured into approved containers. Cold chemical processing rooms, waste container storage, and truck loading/unloading areas would be in nonhardened structures. The waste container storage area would be at grade. The waste receipt area would have tanks to separately receive high-alpha waste, stripped uranium waste, and the PDCF laboratory liquid stream waste. The tank volumes would be sufficient to receive and store waste from six weeks of processing by the proposed MOX facility and eight weeks by PDCF.

The PDCF and proposed MOX facility would each transfer a liquid TRU waste and a liquid LLW stream to the WSB. Within the WSB, these TRU and LLW streams would be treated separately. The WSB would process the liquid wastes into a TRU and a LLW solid waste form acceptable for shipment and disposal at their respective disposal locations. The TRU waste form would be sent to the Waste Isolation Pilot Plant (WIPP). The LLW form would be sent to E-Area (SRS) or to another permitted disposal site.

Within the WSB, the waste streams would be collected into receipt tanks, chemically adjusted, evaporated, neutralized, solidified in containers, stored, and shipped. The proposed MOX facility high-alpha stream receipt tanks and process rooms would be located inside a hardened (reinforced concrete) structure. The other streams would be included in a standard metal-constructed building. Emissions from the process areas would pass through a HEPA filtration confinement system before release through an exhaust stack.

2.2.4.2 Processes Occurring in the WSB

The WSB would be designed to process and solidify two waste streams from the proposed MOX facility and two waste streams from the PDCF. The processes that would be conducted for each waste stream are described below.

2.2.4.2.1 Proposed MOX Facility High-Alpha-Activity Waste Stream

The proposed MOX facility high-alpha-activity waste stream, consisting of the liquid americium waste stream and parts of two other liquid waste streams from the proposed MOX facility, namely the excess acid stream and the alkaline waste stream, would be pumped approximately 610 m (2,000 ft) from the proposed MOX facility to the WSB in a double-walled stainless steel pipe. The nominal volume received would be anticipated to be approximately 83,000 L (22,000 gal) per year, which would be received in approximately 25 transfers, at a frequency of about once every two weeks. Each transfer would be accompanied by a flush of the transfer line, estimated to be approximately 2,650 L (700 gal) of distillate wash liquid provided by the proposed MOX facility.

The line flush technique for MOX facility high-alpha waste would pump a line volume of flush (estimated to be 1,325 L [350 gal] in the 610-m [2,000-ft] run to WSB) to the WSB tanks. A second line volume would then be drained back to MOX facility waste tanks.

The WSB receipt tanks would be sized to hold three transfers (six weeks capacity in two 11,400-L [3,000-gal] tanks). The MOX facility high-alpha-activity stream collection tanks are sized for three months capacity. This arrangement would provide continued MOX facility processing capacity in the event of a shutdown of WSB operations because of maintenance or other disruptions. The tanks would be agitated to mix the waste and flush.

In the WSB, the proposed MOX facility high-alpha-activity waste stream would be sent to an evaporator to reduce its water content. The acidic bottoms collected in the evaporator would be neutralized with sodium hydroxide in a neutralization tank. After neutralization, the waste would be pumped to two 110-L (30-gal) cement head tanks. One tank would receive material while the other tank is being pumped to the cement mixer. A metering pump would inject controlled amounts of the waste stream from the 110-L (30-gal) head tank to a cement mixer to be continuously mixed with supplied dry cement powder. The mix would be collected and deposited into approved containers. The waste collected in the containers is anticipated to be TRU waste and would be shipped to WIPP for disposal. The overheads from the evaporation

step would be condensed, collected, sampled, and subjected to further evaporation or chemical treatment as necessary and finally would be sent to the SRS Effluent Treatment Facility (ETF).

2.2.4.2.2 MOX Facility Stripped Uranium Stream

The proposed MOX facility stripped uranium stream would be pumped approximately 610 m (2,000 ft) from the proposed MOX facility to the WSB in a double-walled stainless steel pipe. The nominal waste volume of this stream would be 161,000 L (42,530 gal) per year, received in approximately 42 transfers at a frequency of about one every week. Each transfer would be accompanied by a two-line-volume flush, which is estimated to be 2,650 L (700 gal) total of distillate wash liquid provided by the proposed MOX facility. The first flush volume would go into the WSB stripped uranium stream receipt tanks. The second flush volume would drain back into the proposed MOX facility stripped uranium stream collection tank.

The WSB receipt tanks would be sized to hold six transfers (six weeks of MOX facility capacity). The proposed MOX facility tanks would be sized to hold three months of MOX facility waste. The WSB tanks would be agitated to mix the waste and flush.

In the WSB, the proposed MOX facility stripped uranium stream would be evaporated, the bottoms neutralized with sodium hydroxide, and the resulting waste mixed with cement and deposited into approved containers. The waste in the containers would be classified as LLW and would be shipped to a LLW disposal facility. The overheads from the evaporation step would be condensed, collected, sampled, and subjected to further evaporation or chemical treatment as necessary and finally would be sent to the SRS ETF.

2.2.4.2.3 PDCF Laboratory Liquid Stream

The PDCF laboratory liquid stream would be pumped approximately 240 m (800 ft) to the WSB from the PDCF in a welded-jacketed stainless steel pipe, which would be direct buried. The volume of this waste stream is anticipated to be a nominal 41,600 L (11,000 gal) per year, and would be received in approximately 12 transfers (3,400 L [900 gal] each) at a frequency of about one transfer every month. Each transfer may be accompanied by a two-line-volume flush, which is estimated to be 1,100 L (300 gal) total of water provided by the PDCF.

The line-flush technique for PDCF waste would be to pump one line volume of flush water (estimated to be 570 L [150 gal]) to the WSB tanks. The residual line volume would then be drained back to a PDCF flush water collection tank for use in the next flush.

The WSB receipt tanks would be sized to hold two transfers (eight weeks of PDCF laboratory liquid stream capacity) in two 5,700-L (1,500-gal) tanks. The PDCF tanks are similarly sized, providing a total system storage of 8 to 16 weeks of PDCF processing capacity in the event of a shutdown of WSB operations for maintenance or processing anomalies. The WSB tanks would be agitated to mix the waste and flush water.

In the WSB, the PDCF laboratory liquid stream would be evaporated, the bottoms neutralized with sodium hydroxide, and the resulting waste would be mixed with cement and deposited into approved containers. The waste in the containers would be classified as LLW and would be shipped to a LLW disposal facility. The overheads from the evaporation step would be condensed, collected, sampled, and subjected to further evaporation or chemical treatment as necessary and finally would be sent to the SRS ETF.

2.2.4.2.4 PDCF Laboratory Concentrated Liquid Stream

The PDCF would be anticipated to transport less than 200 1-L (0.26-gal) containers of laboratory concentrated waste to the WSB for processing each year. The average expected receipt rate is approximately 96 containers per year. Processing only a single 1-L (0.26-gal) container of waste at a time, which reflects similar processes currently in use at SRS for materials of this type, would preclude criticality events.

The WSB would accept/store up to 10 containers maximum in a storage rack. This rack and the solidification process would be housed in a glovebox. One container at a time would be processed by pouring its contents into a 5-L (1.3-gal) bottle containing approximately 2 L (0.5 gal) of dry soda ash for neutralization, and set aside to offgas. Up to 3 L (0.8 gal) of a solidification additive would be added to absorb the neutralized material, ensuring no free liquids. The 5-L (1.3-gal) container would be closed, bagged out of the glovebox, packaged into a “paint” can (with a second 5-L [1.3-gal] bagged bottle), the “paint” can inserted into a WIPP “Pipe-N-Go” and over-packed into a 55-gal drum. As an alternative, solidification could also be accomplished by directly placing neutralized material into an approved container with concrete. The waste collected in the containers is anticipated to be TRU waste and would be shipped to WIPP for disposal.

2.2.4.3 Radioactive Effluents and Wastes at the WSB

The WSB would be designed to minimize effluents to air. No emissions to surface water would be expected from the facility. However, there may be small amounts of residual radioactivity in liquid condensate material that results from the evaporation processes at the facility and subsequently would be transferred to the SRS ETF for further treatment and release under approved site permits.

As discussed in Section 2.2.4.2, the WSB would receive four liquid waste streams, two from the proposed MOX facility and two from the PDCF, and convert those waste stream to solid TRU waste or solid LLW. The TRU waste would be shipped to WIPP for disposal. LLW would be disposed of either at the E-Area at SRS or at another permitted disposal site.

2.2.5 Sand Filter Technology Option

This section describes the technology option of using a sand filter for air filtration instead of high-efficiency particulate air (HEPA) filters. Although DCS has selected the use of HEPA filters as its preferred option for removal of particulate contaminants before exhaust air is released to the atmosphere, this DEIS also evaluates the use of a sand filter (Orr 2001). The differences in impacts are discussed in Section 4.3.8.

It is useful to understand the physical differences in the two types of filters. HEPA filters are designed to remove extremely fine particles suspended in the air. HEPA filters are enclosed in rigid casing with full-depth pleated filter medium. The filter medium is normally fiberglass, which is formed into a sheet, folded into a series of accordion pleats. The standard HEPA filter measures 61 cm × 61 cm × 29.2 cm deep (24 in. × 24 in. × 11.5 in. deep). The filter edge normally has an elastomer gasket to prevent bypass leakage, and improper installation or damage to the sealing surface can dramatically reduce the filter's efficiency and performance. HEPA filters function and are used in the HVAC system similar to standard home air filters. DCS proposes to use HEPA filters in multiple stages. The proposed MOX facility would have many HEPA filters (Orr 2001).

Sand filters have a long history of use in DOE facilities at the SRS and at the Hanford Site near Richland, Washington. At SRS, DOE currently uses sand filters in the F-Area, H-Area, and the Savannah River Laboratory. Unlike the case for HEPA filters, a facility would typically use only a single sand filter. A sand filter designed for the proposed MOX facility would be rectangular and would require a surface area of about 313 m^2 (33,650 ft^2). The filter would be about 3 m (10 ft) deep and would consist of gravel layers overlaid with sand layers arranged in order of decreasing particle size (Orr 2001). A coarse sand layer would be placed at the top of the filter to maintain integrity of the lower sand layers during filter operations. Air enters through a supply tunnel at the bottom of the structure and is collected at the top of the sand filter. Large fans or blowers are used to circulate the air through the sand filter media. Suspended particles in the air are trapped by the sand filter. No routine maintenance is required during operation of sand filters (Orr 2001).

It is also useful to understand the performance differences in the two types of filters. Both filter types have approximately the same efficiencies for collection of particulates. Neither filter type is designed to trap gases. The filters would perform differently during some accidents. As discussed below, the selection of filter type can affect the facility design.

Several commenters during the public scoping meetings urged the NRC to evaluate the use of sand filters instead of HEPA filters, claiming sand filters would be better from a safety standpoint, particularly in case of a fire at the facility. Fires often generate large volumes of smoke that threaten the effective functioning of the filtration system by rapidly loading the filters with smoke particles. The resulting pressure drop across the filter could cause a break in the filter, followed by the release of contamination to the environment. This situation would not occur with sand filters in case of a fire because they have much larger surface area that could trap smoke particles (Orr 2001). The integrity of HEPA filters could also be compromised during explosion accidents.

Given the potential vulnerability of HEPA filters during fire accidents, the proposed MOX facility is designed to mitigate the effects of an internal fire. The facility is designed into numerous fire zones, in part to limit the exposure of individual banks of HEPA filters to failure. If a sand filter was used, fewer fire zones could be used because sand filters are more resistant to smoke and sudden pressure changes. However, in the evaluation of the impacts of using sand filters instead of HEPA filters, changes in facility design are not considered.

2.3 Alternatives Considered But Not Analyzed in Detail

This section discusses some of the more significant alternatives identified during the scoping process and alternatives identified by DCS, but that are not subjected to in-depth evaluations in Chapter 4. Such alternatives include alternate locations for the proposed MOX facility in the F-Area, technology and design options, immobilization of surplus plutonium, off-specification MOX fuel, and the Parallex Project.

2.3.1 MOX Facility Location in F-Area

The DOE previously selected SRS as the location of the proposed MOX facility, after evaluating several alternative sites across the country (DOE 2000). In its subsequent Environmental Report, DCS described the process the DOE used in choosing the specific site for the proposed MOX facility within the SRS F-Area (DCS 2000). The currently proposed location of the MOX facility was selected from five proposed sites within F-Area. Final site selection was based on three siting qualification criteria that the site must meet and nine siting evaluation criteria that were more qualitative in nature (DCS 2002). The currently proposed location of the facility, as identified in Figure 1.2, was the only location that met all the qualification criteria and scored the highest when all evaluation criteria were considered. The criteria used by DCS in the selection process were as follows (DCS 2002):

Siting Qualification Criteria

1. Free from subsurface contamination,
2. Adequate terrain and area, and
3. Free from Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act (RCRA/CERCLA) features.

Siting Evaluation Criteria

1. No known or protected plant or animal species,
2. Water table significantly below the facility substructure,
3. Relatively level area in a higher location for increased security and so as not to block drainage,
4. Proximity to existing roads and the Pit Disassembly and Conversion Facility (PDCF) site,
5. Location with respect to subsurface soft zones,

6. Availability of utilities,
7. Location with respect to wetland areas,
8. Proximity to archaeological features, and
9. Interference with existing site operations.

The DEIS does not consider alternatives to SRS in which to locate the proposed MOX facility, nor does it further consider alternative locations within SRS F-Area.

2.3.2 Technology and Design Options

The general design of the proposed MOX facility was provided in DOE's SPD EIS (DOE 1999a). In developing the detailed proposed MOX facility design, DCS used the technology at Cogema's MELOX and La Hague facilities, with modifications to meet U.S. regulations, codes, and standards. A general description of the proposed MOX facility design is provided in Section 2.2.3. In its ER, DCS (2002) considered a number of technology and design alternatives. The technology and design alternatives considered by DCS were discussed if they had a possibility of having some potential impact or significance from an environmental perspective. These technology and design alternatives are summarized below. In evaluating these technology and design alternatives, NRC concluded that, with the exception of sand filters compared to HEPA filters, further detailed analysis was not warranted in Chapter 4. This technology option is also summarized in Section 2.2.5.

2.3.2.1 Dry Compared to Wet Impurity Removal

The polishing process is used to remove gallium and other impurities from the plutonium dioxide feedstock before pellet production. These impurities affect the performance of the MOX fuel in a reactor. Although the proposed aqueous (wet) polishing process meets the criteria for controlling the gallium content to less than 120 parts per billion (ppb) (Framatome 2001), it also generates liquid radioactive and mixed wastes. An alternate technology for purifying the plutonium dioxide is the dry process. The dry process generates significantly less liquid waste and involves thermally induced gallium removal (TIGR). However, in an experimental setting, the TIGR process only reduced the gallium content to 25,000 ppb. The DOE considered the dry process in the SPD EIS (DOE 1999a) and concluded that the dry process would not meet the technical requirements for MOX fuel. The best reported gallium removal (Kolman et al. 2000) results in impurity contents that are over 100 times the required criteria. Thus, the dry process was not further evaluated because it could not meet the technical specifications set for MOX fuel. In addition, TIGR remains an experimental process requiring further testing to scale the process to production while ensuring uniform pellet feedstock (DCS 2002; Kolman et al. 2000).

2.3.2.2 Reagent Storage

DCS considered two options for locating the reagent storage and solution preparation for the aqueous polishing process. The options were to locate the storage and solution preparation process in the same area as the Aqueous Polishing Area or to locate them in a separate building and to pump reagents to the aqueous polishing process. Because of the potential explosion hazards of the chemical reagents, DCS decided to use a separate building to reduce this hazard. Because the design alternative to this approach involves potentially larger environmental impacts, namely an increase in the explosion accident consequences, consideration of colocating the aqueous polishing and reagent storage is not evaluated in Chapter 4.

DCS also considered whether to store the chemical reagents in aboveground or belowground tanks. Belowground tanks have the advantage of limiting immediate human exposure to spills. However, there is increased environmental risk associated with leaking belowground tanks. DCS decided to use aboveground tanks with concrete curbs to contain potential spills and overflows. The NRC considered the design alternative of belowground storage tanks. However, this alternative would likely pose a greater risk of groundwater contamination. For this reason, consideration of belowground tanks is not evaluated in Chapter 4.

2.3.2.3 Acid Recovery Process

DCS added an evaporator to the acid recovery process. This evaporator reduces the activity of the distillates and recycles approximately half of the volume of distillates in lieu of using fresh demineralized water. This also results in a volume reduction of liquid wastes that would be processed and treated by the WSB. Because the design alternative to this approach involves larger environmental impacts, namely a demand for more process chemical shipments and handling, and larger waste volumes, further consideration of the aqueous polishing process without the acid recovery process as an alternative is not evaluated in Chapter 4.

2.3.2.4 Glovebox Cooling

In the MELOX design, gloveboxes are cooled at a higher air flow rate to remove heat generated from the reactor-grade plutonium. Because weapons-grade plutonium has a lower heat release, gloveboxes at the proposed MOX facility can be cooled using natural convective cooling. This results in a reduced airflow and permits a smaller HEPA filter size. The smaller filter size reduces the volume of solid TRU waste generated by filter replacement. Because the alternative to this design consideration (i.e., higher glovebox air flow) is unnecessary to meet any conceivable alternative relative to the proposed MOX facility's purpose and need to disposition weapons-grade plutonium, use of higher glovebox flows and larger HEPA filter banks is not evaluated as an alternative in Chapter 4.

2.3.2.5 Treatment of Aqueous Laboratory Waste

Aqueous laboratory wastes at the MELOX facility are precipitated and solidified, resulting in TRU wastes. DCS decided to remove the plutonium from the laboratory waste and recycle this plutonium into the aqueous polishing process. This step reduces the classification of the laboratory waste from TRU waste to LLW. Because the alternative laboratory waste management design would involve generation of more TRU waste and, therefore, have larger environmental impacts, inclusion of plutonium in laboratory waste streams is not further evaluated as an alternative in Chapter 4.

2.3.2.6 Pellet Grinding Process

In the facility design, DCS replaced the two-stage cyclone separator in the MOX powder processing operation with a decloggable metallic filter. This filter would reduce the TRU waste volume that would result from the periodic replacement of other filters downstream of the pellet grinding process. Therefore, the use of a two-stage cyclone separator instead of a decloggable filter would result in the generation of additional TRU wastes. Since additional TRU waste poses a larger environmental impact, use of a two-stage cyclone separator is not evaluated further as an alternative in Chapter 4.

2.3.2.7 Facility Heat Exchangers

DCS considered two options to remove heat from the facility. The options were to use water-cooled or air-cooled heat exchangers. Water-cooled exchangers can have impacts associated with cooling tower drift or blowdown. To reduce these potential impacts, DCS decided to use air-cooled heat exchangers. Because the water-cooled exchangers would involve generation of cooling tower drift or blowdown and, therefore, larger environmental impacts, using this type of exchanger is not further evaluated as an alternative in Chapter 4.

2.3.2.8 Physical Security Barriers

DCS considered several options to provide a physical security barrier around the proposed MOX facility. One of these was the construction of an earthen berm. Because this method would have resulted in a larger disturbed area for the site, DCS decided to use physical security barriers that resulted in less land disturbance. Because the earthen berms would involve a larger disturbed area and, therefore, larger environmental impacts, use of berms is not further evaluated as an alternative in Chapter 4.

2.3.2.9 Material Transfer from PDCF to the Proposed MOX Facility

As discussed in Section 1.2.1, the PDCF would produce plutonium dioxide feedstock for the proposed MOX facility. The material would need to be transferred to the proposed MOX facility.

DCS considered three transfer options: (1) tunnel, (2) closed transfer trench, and (3) vehicle transfer. Because the first two options would result in greater land disturbance, DCS decided to use vehicles to transfer the plutonium dioxide feedstock. Because the tunnel or closed transfer trenches would involve a larger disturbed area and, therefore, larger environmental impacts and because vehicle-related impacts would be small for the short distance between the facilities, use of tunnels or trenches is not further evaluated as an alternative in Chapter 4.

2.3.3 Immobilization of Surplus Plutonium

As discussed below, the NRC has concluded that immobilizing surplus plutonium is not a reasonable alternative to the proposed action, and, therefore, this alternative does not require detailed analysis in Chapter 4.

Before the DOE's January 2002 decision to cancel the plutonium immobilization plant, plutonium immobilization was available as a no-action disposition alternative to the proposed action. The DOE had already evaluated the environmental impacts of this alternative as alternative 12a in the SPD EIS (DOE 1999a), so that a new NRC analysis of this alternative was not required. However, as discussed in Section 1.4.1, following the DOE's January 2002 decision, the NRC solicited views on whether the immobilization alternative should still be evaluated in this DEIS. The comments solicited did not identify any persuasive reasons to further consider the immobilization alternative.

The NRC has now determined for two reasons that immobilization is no longer a reasonable alternative to the proposed action. First, immobilization of the 34 MT (37.5 tons) of surplus plutonium would not meet a key element of the purpose and need for the proposed action, as described in Section 1.3. In adopting its MOX-only approach, the DOE, after referencing budgetary concerns, explained that Russia does not consider immobilization alone to be an acceptable approach. In the DOE's judgment, reliance by the United States on immobilization would therefore cause Russia to abandon its plutonium disposition efforts. Since immobilization fails to degrade the isotopic composition of the plutonium, Russia fears that immobilization would leave open the possibility of future retrieval and reuse of the plutonium in nuclear weapons (DOE 2002a). As discussed further in Section 1.1.1, the DOE therefore concluded that reliance on a MOX-only approach is the key to successfully completing the September 2000 agreement between Russia and the United States.

The second reason that immobilization is no longer a reasonable alternative to the proposed action is its connection with the conduct of United States foreign policy. Evaluating the immobilization alternative now would involve the NRC in foreign policy matters that the DOE has been conducting on behalf of the United States. In the NRC's view, an alternative that would block the implementation of an agreement with another country involves foreign policy matters that are outside NEPA's scope. Therefore, the NRC concludes that immobilization is not a reasonable alternative requiring detailed analysis in this DEIS.

2.3.4 Off-Specification MOX Fuel

During public information meetings in September 2002, NRC was asked to consider an alternative in which MOX fuel would be manufactured but not irradiated in commercial nuclear power plants. Under this alternative, as understood by the NRC, off-specification fuel rods would be manufactured in the proposed MOX facility and transported to spent fuel pools. These spent fuel pools could be located at either commercial nuclear power plants or interim spent fuel storage installations (ISFSIs). Once at the pool, the rods would be commingled with spent fuel rods, and possibly even incorporated into vacant positions in existing spent fuel assemblies. The final configuration would be a proliferation-resistant form that would be a candidate for the National Academy of Sciences' spent fuel standard for surplus plutonium disposition (NAS 2000).

Since the demands for fuel quality and specifications would be lower, the fuel rods could be manufactured "off-specification." The so-called "off-specification" fuel rods would offer both environmental costs and benefits, as described below. Therefore, the NRC gave some consideration to this alternative based on the information provided by principal proponents of this approach (Macfarlane et al. 2001).

The alternative would involve a modified approach to manufacturing MOX fuel. The final powder blend would still have to be homogenized, pressed into pellets, and the pellets sintered in order to manufacture off-specification fuel rods. However, most impurities, including gallium and americium, could remain in the finished rods. This could significantly reduce liquid radioactive waste volumes associated with polishing the feedstock plutonium. As a result, the demand on the WIPP to accommodate solidified high-alpha-activity waste derived from the aqueous polishing process would be reduced.

Since the off-specification rods would not be used in a reactor, any risks of reactor accidents involving MOX fuel would not occur. In addition, the cause of some accidents in the proposed MOX facility would be prevented. For example, if aqueous polishing could be eliminated, then the risks of inadvertent nuclear criticality, solution spills, electrolyzer fires, and explosions would be considerably lower.

Since the concentration of plutonium dioxide in each off-specification rod would not be constrained by reactor fuel specifications, the mass of plutonium dioxide in each rod could be higher. This would result in lower numbers of manufactured rods and correspondingly lower vehicle-related transportation risks associated with transporting rods to any reactor sites. Less rods would also reduce the time required to operate the proposed MOX facility, which could result in lower operational costs. Criticality issues arising from the higher concentration of plutonium could be avoided by mixing neutron-absorbing gadolinium and hafnium with the plutonium.

However, there would be environmental costs associated with this alternative. Americium-241 would not be removed by the aqueous polishing process. Since americium-241 is a high-specific-activity alpha-emitter and poses a direct radiation hazard, radiation exposures to facility workers, site workers, and the public would be higher during MOX facility operations,

off-specification MOX rod transportation, and handling of the off-specification rods at the reactor site or ISFSI.

The costs of manufacturing off-specification MOX fuel rods would also be affected by the elimination of the "fuel credit." The fuel credit is a project cost offsetting factor that accounts for the price a reactor licensee would pay for completed MOX fuel that meets its specifications. The estimated additional project costs would be $1.0 billion, thereby raising the total project costs from $3.8 billion to $4.8 billion.

The benefit of producing electricity from the use of MOX fuel would also be eliminated by the manufacture of off-specification MOX fuel.

Having qualitatively weighed the costs and benefits of this alternative, the staff find that this alternative likely involves a net increase in environmental costs. Therefore, no compelling reason exists to pursue this alternative in further detail. In addition, it is uncertain that this proposal would meet the National Academy of Science's spent fuel standard for surplus plutonium disposition (NAS 2000). The off-specification rods would not be irretrievably configured in irradiated spent fuel, and the isotopic distribution of the plutonium in off-specification rods would not be altered. As a result, this form is unlikely to meet with approval from the Russian Federation, whose parallel progress on plutonium disposition under formal bilateral agreements is integral to the purpose of and need for the proposed action. As discussed above for the immobilization of plutonium alternative, because this alternative does not meet the purpose of and need for the proposed action, the off-specification alternative is not further analyzed in detail in this DEIS.

2.3.5 Parallex Project Alternative

Another suggested alternative to the proposed action was to transfer the surplus plutonium to Canada under the Parallex Project. The Parallex Project was identified by DOE in its ROD for the Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement (DOE 1997) as a possible option for dispositioning some of the surplus plutonium. The Parallex Project is a joint Canadian, Russian, and U.S. demonstration effort to evaluate the feasibility of burning MOX fuel in heavy-water-moderated reactors. The Parallex Project is still ongoing. It is a limited scale test of approximately 27 kg (59 lb) of MOX fuel that was manufactured at the DOE's Los Alamos National Laboratory (LANL). This MOX fuel was shipped to Canada and is currently being tested in a CANDU reactor. Following irradiation, additional analyses will be required to evaluate the usefulness of this approach. The DOE prepared an environmental assessment (EA) for this action and issued a Finding of No Significant Impact (FONSI) (DOE 1999b).

The suggested alternative of considering the Parallex Project would mean that the PDCF, WSB, and the proposed MOX facility would be constructed and operated, but that the MOX fuel would be transferred to Canada for irradiation in heavy-water-moderated reactors there. This suggested alternative would be similar to the proposed action, except that the surplus plutonium would be irradiated in Canada. Implementing this alternative would require a change

in national policy regarding the disposition of surplus weapons plutonium that is the responsibility of the DOE. Therefore, this alternative is not considered further in this DEIS.

2.4 Comparison of Alternatives

In weighing the environmental, economic, and other benefits of the proposed action against its environmental, economic, and other costs, the NRC must also consider and compare reasonable alternatives to the proposed action. These evaluations will be factored into the ultimate decision of whether the action called for is the issuance of the proposed license, with any appropriate conditions to protect environmental values. The proposed action and the no-action (continued storage) alternative are compared in the text below and in Table 2.1.

The impacts of the no-action alternative and the proposed action are compared for each technical area considered in this DEIS. The level of impacts associated with the no-action alternative evaluated includes those impacts incurred by continued storage of surplus plutonium at DOE sites if the proposed MOX facility is not approved by the NRC. As stated previously, projected impacts for the no-action alternative were based on the analysis presented in the DOE SPD EIS (DOE 1999a) and were not reevaluated for this DEIS.

The proposed action was evaluated for impacts from the following activities:

- Construction, operation, and deactivation and decommissioning of the proposed MOX facility, PDCF, and WSB at the SRS;
- Transport of depleted uranium hexafluoride from a DOE site at Portsmouth, Ohio, to a commercial fuel fabrication plant at Wilmington, North Carolina, to produce uranium dioxide needed as feedstock for the MOX fuel fabrication process;
- Conversion of depleted uranium hexafluoride to uranium dioxide;
- Transport of the uranium dioxide from Wilmington to the SRS;
- Transport of fresh MOX fuel from the SRS to a surrogate reactor site;
- Reactor use of MOX fuel; and
- Transport of spent MOX fuel to a geologic repository.

The continued storage (i.e., the no-action) alternative would result in no new construction at the DOE locations currently storing surplus plutonium, with the possible exception of minor expansion of storage facilities at the Pantex site in Texas. Construction impacts would be small or negligible at Pantex if storage facility expansion was necessary and would occur on previously disturbed land adjacent to the existing storage facilities (DOE 1999a). For all

Table 2.1. Comparison of alternatives

Impact area	Continued storage (no action)	Proposed action
Human Health Risk		
Construction		
Radiological	Not applicable	Same exposure as SRS employees from existing SRS operations
Chemical	Not applicable	No adverse impacts from inhalation of construction-related emissions
Physical hazards		<1 fatality, 122 injuries annually over 3 to 5 years
Normal Operations		
Radiological (annual impacts)		
• Dose to collective public (person-Sv/yr)	0.029	0.0067
• Annual LCFs	0.002	0.0004
• Dose to public MEI (mSv/yr)	0.065	2.3×10^{-5}
• Risk of LCF	4×10^{-6}	1×10^{-9}
• Collective dose to facility workers (person-Sv/yr)	1.4	2.6
• Annual LCFs	0.08	0.2
• Dose to average facility worker (mSv/yr)	$\leq$3.2	< 5
• Risk of LCF	$\leq$0.0002	< 0.0003
Chemical	Insufficient data	No adverse impacts from chemical exposures
Physical hazards	Insufficient data	<1 fatality, 41 injuries annually over 10 years
Accidents		
Radiological		
• Event	Beyond design basis earthquake	Explosion event (short-term exposure)
• Dose to collective public (person-Sv)	6.6	400
• LCFs	0.4	20
Chemical	No data	Large spills of nitrogen tetroxide, hydrazine hydrate, hydroxylamine nitrate or nitric acid could have adverse impact on SRS workers or general public and would require rapid emergency response actions.

Table 2.1. Continued

Impact area	Continued storage (no action)	Proposed action
Air Quality		
Construction	Continued storage of surplus plutonium at the DOE sites would not require new construction, thus no impacts to air quality would occur	Air emissions impacts would be insignificant
• Annual standard level for $PM_{2.5}$		<0.1% of standard level
• 24-hr standard level for $PM_{2.5}$		4.3% of standard level
• CO_2, SO_2, NO_2 emissions from construction equipment		<0.29% of ambient standard level
Normal Operations	No violation of air quality standards at DOE sites	Air emission impacts would be insignificant
• 24-hr standard level for $PM_{2.5}$		1.8% of standard level[a]
• $PM_{2.5}$ annual standard level		0.01% of standard level
• Toxic air pollutants and PAHs		<0.04% of South Carolina standard levels
• Prevention of significant deterioration of air quality		<6.0% of PSD Class II Area increment for SO_2 emissions <5.0% PM_{10} increments to Class II Areas <6.3% of Class I increment of PM_{10} standard at Cape Romain National Wildlife Refuge 160 km (100 mi) from proposed facilities
Hydrology		
Construction	No impacts on water use from continued surplus plutonium storage at DOE sites	
• Surface water		No surface water use or discharges to surface waters during construction
• Groundwater		139 million L/yr (37 million gal/yr)
Operations		
• Surface water		No significant impacts from discharge of treated sanitary waste effluents
• Groundwater		76 million L/yr (20 million gal/yr). Total F-Area use with proposed facilities would be 11% of F-Area groundwater capacity

Table 2.1. Continued

Impact area	Continued storage (no action)	Proposed action
Waste Management		
Construction	No impacts to waste management systems from continued storage of surplus plutonium at DOE sites	No TRU, LLW, or mixed LLW generation
Waste volumes generated during 5-yr construction period:		
• Hazardous waste [m^3 (yd^3)]		810 (1,055)
• Liquid waste [m^3 (million gal)]		132,390 (34.7)
• Solid waste [m^3 (yd^3)]		53,650 (70,185)
Operations	No significant impacts on waste management systems from continued storage of surplus plutonium at DOE sites	No significant impacts on waste management systems at SRS and WIPP
Waste volumes [m^3 (yd^3)] generated during 10-yr operation period:		
• TRU		5,180 (6,815)
• Liquid LLW		23,500 m^3 (6.2 million gal)
• Solid LLW		3,370 (4,400)
• Hazardous/mixed		1,030 (1,345)
• Nonhazardous liquid		966,000 m^3 (255 million gal)
• Nonhazardous solid		39,900 (52,157)
		TRU waste volume would be 16% of SRS storage capacity; 3% of WIPP disposal capacity. Nonhazardous liquid waste would be 35% of SRS treatment capacity
Environmental Justice		
Construction	No impacts would occur since no new construction would be needed for continued storage of surplus plutonium at DOE sites	No exposure to radiological or chemical emissions, regardless of population group or income status
Operations	Radiological and nonradiological risks from continued storage of surplus plutonium would be small. No disproportionately high and adverse effects would occur	No disproportionately high and adverse effects would occur from routine operations. An environmental justice impact is possible should an accident occur
Aesthetics	No impacts would occur because no new construction is needed for continued storage of surplus plutonium at the DOE sites	Insignificant impacts on visual resources from construction of the proposed facilities

Table 2.1. Continued

Impact area	Continued storage (no action)	Proposed action
Cultural and Paleontological Resources	No impacts on cultural or paleontological resources are expected from continued storage of surplus plutonium at the DOE sites	Two archaeological sites, 38 AK 546/547 and 38 AK 757, would be directly affected by construction of the proposed MOX facility. The South Carolina State Historic Preservation Office accepted a data recovery plan for the sites, and data recovery was completed for both sites in 2002 Five additional eligible sites could experience indirect impacts by the construction work force unless proper mitigation is used Routine operations would not impact archaeological sites near the proposed facilities
Ecology	No new construction is anticipated for continued storage of surplus plutonium at the DOE sites	No significant impacts would occur from habitat loss or noise generation during construction of the proposed facilities
Habitat Loss		No wetlands or endangered/threatened species would be impacted 14.7 ha (36.4 ac) woodlands would be <1% of annual timber harvest at SRS
Noise Impacts		Construction noise levels as high as 80 dBA could impact wildlife within 122 m (400 ft) of the project area
Geology, Seismology, and Soils	Continued storage of surplus plutonium at the DOE sites would not impact soils and geology since no new construct is expected	No significant impacts to soils and geology would occur
Construction		
• Soils		Up to 50 ha (123 acres) would be disturbed in F-Area; some soil erosion and compaction
• Chemical contamination		Chemical contamination of soils from accidental releases would be minimized by following procedures defined in the DCS Spill Prevention Control and Countermeasures Plan
Normal Operations		No impacts to soils from routine operations
Infrastructure	No new construction is expected, thus there would be no impacts to existing DOE infrastructure	No significant impacts to existing infrastructure would occur

Table 2.1. Continued

Impact area	Continued storage (no action)	Proposed action
Construction		
• Roads		An additional 4.8 to 6.4 km (3 to 4 mi) of roadways would be needed in F-Area to support construction
• Electrical Power		17,700 MWh/yr representing about 3.7% of SRS capacity would be needed during the 5-yr construction period
• Water		139 million L/yr (37 million gal/yr) representing about 3.4% of F-Area groundwater capacity
Normal Operations	No significant impacts would occur at DOE facilities during continued storage of surplus plutonium	
• Electrical power		Use of about 186,000 MWh/yr representing 38.5% of F-Area capacity would occur during normal operations
• Water		76 million L/yr (20.1 million gal/yr) or about 11% of F-Area groundwater capacity would be used
Land Use		
Construction	No impacts would occur since no new construction of storage facilities for surplus plutonium is needed at the DOE facilities	No impacts to designated land use at SRS would occur for construction of the proposed facilities
Normal Operations	No impacts to land use would occur at DOE facilities during continued storage of surplus plutonium	No impacts to land use would occur from routine operations
Accidents		Depending on the type and extent of an accident during operations, portions of F-Area could be precluded from employee use until corrective cleanup and appropriate monitoring measures were implemented Impacts to off-site land use in the immediate vicinity of SRS could occur in the unlikely event of a severe accident

Table 2.1. Continued

Impact area	Continued storage (no action)	Proposed action
Noise	No significant impacts would occur at DOE plutonium storage facilities above noise levels currently generated by traffic and worker activities	No significant impacts would occur from noise levels generated during construction or operation
Construction		
• Equipment Noise Levels		Equipment and vehicle noise would reach levels of 85-90 dBA at distances of 15 m (50 ft) from the source Noise levels at SRS boundary could reach 38 dBA which is below EPA guidance of 55 dBA, for protection of the public
Normal Operations		
• Process equipment, diesel generators, air conditioning noise		Noise levels could be as high as <29 dBA, at the SRS boundary, which is well below the 55-dBA EPA guidance level
Socioeconomics	No impacts would occur from continued storage of surplus plutonium at DOE facilities since no new construction is expected	Impacts on the REA and ROI would be insignificant
Construction		
• Employment		1,000 direct jobs, 810 indirect jobs for peak construction year
• Income		$88.2 million in peak construction year
• In-migrating population		350
Normal Operations		No significant impacts on the REA and ROI would occur during operations
• Employment		480 direct jobs, 780 indirect jobs
• Income		$61 million per year
• In-migrating population		180
Cost-Benefit Impacts	Continued storage of surplus plutonium at DOE facilities would not result in additional impacts to the REA and ROI	No significant adverse impacts related to costs would occur from construction and operation of the proposed facilities. Some beneficial impacts would occur
Construction		
REA & ROI impacts		
• Employment		980 average annual employment
• Total Income		$350 million
• Total Regional Product		$720 million

Table 2.1. Continued

Impact area	Continued storage (no action)	Proposed action
Normal Operations	No significant adverse impacts related to costs and benefits from continued storage	
REA & ROI impacts		
• Employment		1,310 jobs
• Total Income		$610 million
• Total Regional Product		$1,130 million
• Net benefit		$1,840 million
National Impacts		
• Costs		$3,850 million
• Benefits		Economic benefits for materials supplied, services, new scientific knowledge, safe use of plutonium stockpile, generation of electricity from MOX fuel
Transportation		
Radiological		
• Routine dose to the public (person-Sv)	No intersite transportation expected	3.1
• LCFs		0.2
• Dose to the transportation crew (person-Sv)	No intersite transportation expected	2.2
• LCFs		0.1
• Accident dose risk to the public (person-Sv)	No intersite transportation expected	0.23
• LCFs		0.01
Nonradiological		
• Vehicle emissions (latent fatalities)	No intersite transportation expected	1
• Accidents (fatalities)	No intersite transportation expected	0.081

[a]Background concentrations of $PM_{2.5}$ in the SRS vicinity currently exceed standard level of 65 µg/m^3.

present DOE storage sites, radiological and nonradiological risks would be small. Continued storage would be expected to have no impacts on air quality, water quality, waste management systems, cultural resources, or soils, and the economic cost would be lower than that for the proposed action. However, continued storage would meet none of the DOE's goals for the plutonium disposition program.

Construction of the proposed MOX facility, PDCF, and WSB (hereafter referred to as the proposed facilities) would disturb up to 50.0 ha (123.4 acres) of land. No impacts would occur to endangered or threatened species, wetlands, or aquatic or terrestrial habitats at the SRS and the F-Area vicinity. Two prehistoric archaeological sites eligible for listing on the *National Register of Historic Places* (NRHP) might be impacted by construction of the proposed MOX facility in the F-Area vicinity. Measures are being planned by DCS in conjunction with the South Carolina Historic Preservation Office and the SRS cultural resources staff to mitigate any potential impacts to archaeological sites before construction.

The primary benefit of operation of the proposed MOX facility would be the resulting reduction in the supply of weapons-grade plutonium available for unauthorized use once the plutonium component of MOX fuel has been irradiated in commercial nuclear reactors. Converting surplus plutonium in this manner is viewed as being a safer use/disposition strategy than the continued storage of surplus plutonium at DOE sites, as would occur under the no-action alternative, since it would reduce the number of locations where the various forms of plutonium are stored (DOE 1997). Further, converting weapons-grade plutonium into MOX fuel in the United States — as opposed to immobilizing a portion of it as DOE had previously planned to do — lays the foundation for parallel disposition of weapons-grade plutonium in Russia, which distrusted immobilization for its failure to degrade the plutonium's isotopic composition (DOE 2002a). Converting surplus plutonium into MOX fuel is thus viewed as a better way of ensuring that weapons-usable material will not be obtained by rogue states and terrorist groups. Implementing the proposed action is expected to promote the above nonproliferation objectives. Additionally, building and operating the proposed MOX facility is expected to result in a gain of scientific knowledge relative to the conversion of weapons-grade plutonium into reactor fuel.

In addition to the above primary benefits, there are secondary economic benefits of the proposed action. Impacts of construction on the regional economic area (REA) and region of influence (ROI) would be beneficial with respect to jobs and income. Construction jobs for the proposed action would total about 1,000 in the peak construction year. Although in-migration of workers during construction would be greater for the proposed action, no adverse impacts are anticipated to public services, schools, housing availability, or the local transportation network. Construction of the proposed facilities would be expected to generate $88 million in total income within the REA during the peak construction year.

During operations, the MOX facility, PDCF, and WSB would be expected to generate 480 direct and 780 indirect jobs, producing a total annual income of $61 million in the REA. Approximately 180 people would be expected to relocate to the SRS area during operation of the proposed facilities. No adverse socioeconomic impacts are expected as the result of proposed facility operations. Adequate public services, schools, and housing exist to satisfy needs of the in-migrating population.

The economic cost benefit analysis for the proposed action showed an overall net benefit to the ROI and REA of $1,840 million. National economic impacts (costs) for the proposed MOX facility, PDCF, and WSB are estimated to be $3,850 million. The economic benefits would include adding employment income in various national economic sectors and adding income to businesses from the purchase of related goods and services.

The following discussion compares the primary and secondary benefits set forth above to the environmental and economic costs of the proposed action.

Construction and routine operation of the proposed MOX facility would not be expected to cause any disproportionately high and adverse impacts to low income or minority populations in the SRS vicinity. Of the accidents evaluated, a hypothetical explosion accident at the proposed MOX facility had the highest estimated short-term impacts, approximately 20 latent cancer fatalities (LCFs) among members of the off-site public. A hypothetical tritium release at the PDCF had the highest 1-year exposure impact, approximately 400 LCFs among members of the off-site public. However, it is highly unlikely that such an accident would occur, and the risk to any population, including low-income and minority communities, is considered to be low. However, the communities most likely to be affected by a significant accident would be minority or low income, given the demographics and prevailing wind direction. The extent to which low-income or minority population groups would be affected would depend on the amount of material released and the direction and speed of the wind.

Continued storage of plutonium by the DOE at its present locations would not be expected to produce additional LCFs. (Annual LCFs of approximately 0.002 in the surrounding population of the storage sites [DOE 1999a] were estimated.) The annual collective dose to members of the public (i.e., those living and working within 80 km [50 mi] of the SRS) produced by routine operation of the proposed MOX facility would be expected to result in an LCF rate of approximately 0.0004/yr or less. Therefore, continued storage results in higher annual impacts.

No adverse impacts from chemical exposure of workers at the proposed MOX facility are anticipated. Less than one fatality, and approximately 120 worker injuries per year are anticipated during construction of the proposed facilities. Facility operations would result in about 40 injuries per year and less than one fatality per year.

Routine MOX facility operations are expected to produce insignificant air quality impacts and would not cause any ambient air quality standards for criteria pollutants at the SRS to be exceeded. However, note that maximum levels of $PM_{2.5}$ in the vicinity of the SRS already exceed the annual standard of 15 $\mu g/m^3$. Facility construction would contribute temporarily less that 0.1% of this $PM_{2.5}$ standard level, and facility operation would contribute less than 0.01% of this level.

Water consumption during operation of the proposed facilities would be about 11% of the F-Area groundwater capacity. Impacts to surface water are not expected during facility operations.

Waste management systems at the SRS would not be adversely affected by wastes generated by the proposed MOX facility, PDCF, and the WSB. Adequate storage capacity and handling procedures are in place at the SRS to process hazardous wastes generated during both construction and facility operations. Nonhazardous liquid and solid wastes would not adversely affect operation of the Central Sanitary Waste Treatment Facility at SRS.

Transportation of uranium and plutonium feedstock materials, transuranic waste, and fresh MOX fuel would result in approximately 3,400,000 km (2,114,400 mi) traveled by 1,548 truck shipments over the operations period of the proposed MOX facility. No latent cancer fatalities (LCFs) would be expected because of the radioactive nature of the cargo. (Estimated LCFs for members of the public and the transportation crews were 0.2 and 0.1, respectively.) One latent fatality from vehicle emissions was estimated, and no fatalities (0.081 fatality) from the physical trauma of potential vehicle accidents was estimated.

The use of sand filters was identified during the EIS scoping process as a potential substitute for final HEPA filters. The sand filter technology is described in Section 2.2.5. A comparison between sand filter and HEPA filter impacts is presented in Section 4.3.8. The NRC concludes that the technology option to install a sand filter poses no clear reduction in overall environmental impacts over the installation and use of HEPA filters.

A sand filter typically is designed to use locally available sand and gravel. The outer wall of the sand filter consists of reinforced concrete placed below or partially below grade. It is designed to withstand a design-basis earthquake and/or flood without cracking or leaking. A sand filter designed for the proposed MOX facility would be rectangular and would require a surface area of about 313 m^2 (33,650 ft^2). The filter would be about 3 m (10 ft) deep and would consist of gravel layers overlaid with sand layers arranged in order of decreasing particle size (Orr 2001). A coarse sand layer would be placed at the top of the filter to maintain integrity of the lower sand layers during filter operations. No routine maintenance is required during operation of sand filters.

Use of the HEPA filters would result in a slightly higher radiological dose to facility workers during the course of normal operations, as discussed in Section 4.3.1.1.2, and the use of a sand filter might result in some accident impacts lower than those estimated in Section 4.3.5.2. As discussed in Section 4.3.2.2, the air filtration method would not have an impact on air quality. Both filter types have approximately the same efficiencies for particulates, and neither filter type is designed to trap gases. In addition, the disposal costs were estimated to be similar for each filter type (Section 4.3.4).

2.5 Preliminary Recommendation Regarding the Proposed Action

After weighing the costs and benefits of the proposed action and comparing alternatives (see DEIS Sections 2.4 and 4.6), the NRC staff, in accordance with 10 CFR 51.71(e), sets forth below its preliminary NEPA recommendation regarding the proposed action. The NRC staff recommends that, unless safety issues mandate otherwise, the action called for is the issuance of the proposed license to DCS, with conditions to protect environmental values. In this regard, the NRC staff preliminarily concludes that (1) the applicable environmental requirements set forth in DEIS Chapter 6 and (2) the proposed mitigation measures discussed in DEIS Chapter 5 would eliminate or substantially lessen any potential adverse environmental impacts associated with the proposed action.

The NRC staff has preliminarily concluded that the overall benefits of the proposed MOX facility outweigh its disadvantages and costs, based upon consideration of the following:

- The national policy decision to reduce supplies of surplus weapons plutonium, as reflected in agreements between the United States and Russia;
- The minimal radiological impacts on, and risk to, human health, that would be caused by constructing, operating, and decommissioning the proposed MOX facility;
- The minimal environmental impact the proposed action would have; and
- The economic benefit to the local community.

As discussed in DEIS Chapter 5, the most significant potential impact of the proposed action would result from a large explosion accident at the proposed MOX facility. While the consequences of this bounding accident would be significant, the likelihood of such an accident occurring would be very low (highly unlikely).

2.6 References for Chapter 2

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3. AFFECTED ENVIRONMENT

3.1 General Site Description

The Mixed Oxide (MOX) Fuel Fabrication Facility (the proposed MOX facility) and its support facilities, the Pit Disassembly and Conversion Facility (PDCF) and the Waste Solidification Building (WSB), are proposed for construction at the U.S. Department of Energy's (DOE's) Savannah River Site (SRS). The SRS is located in the southwestern portion of the state of South Carolina, as shown in Figure 3.1. The SRS is adjacent to the Savannah River, along the state border with Georgia, approximately 20 km (12 mi) southeast of Aiken, South Carolina, and 24 km (15 mi) east of Augusta, Georgia (Arnett and Mamatey 2001). The U.S. Government owns the SRS, which was set aside in 1950 for the production of nuclear materials for national defense. Since the end of the Cold War in 1991, national priorities have shifted and the site's priorities are now focused on waste management, environmental restoration, technology development and transfer, and economic development. The SRS covers approximately 803 km^2 (310 mi^2) in an approximately circular tract of land within Aiken, Barnwell, and Allendale Counties in South Carolina. Public access to the SRS is limited according to DOE security regulations.

The proposed facility sites are located adjacent to the north-northwest edge of F-Area near the center of the SRS (see Figure 1.2). F-Area contains facilities for chemical separations, including F Canyon, which is the main processing facility; and waste storage, which includes 20 of the 49 active liquid high-level (radioactive) waste (HLW) tanks on the SRS.

3.2 Geology, Seismology, and Soils

This section summarizes geology, seismology, and soil conditions of the SRS and discusses site-specific conditions at F-Area. Geologic resources include mineral ores, fossil fuels, and aggregate (sand and gravel) materials that can have significant economic value. The value of soil resources depends upon the soil's ability to grow plants. Prime farmland is protected by the U.S. Department of Agriculture. The site's geology and soil conditions are important in evaluating how water and potential contaminants move through the subsurface, in evaluating erosion impacts, and in predicting subsidence or landslides. Seismology is important in determining potential impacts from earthquakes.

3.2.1 Geology

The SRS is located in the Aiken Plateau portion of the Upper Atlantic Coastal Plain approximately 32 km (20 mi) east of the Fall Line. The Fall Line is a major physiographic and structural feature that separates the Piedmont and Coastal Plain physiographic provinces in southeastern South Carolina (DOE 1996). Soils within the Piedmont are predominantly derived from the weathering of bedrock. In contrast, soils within the Coastal Plain are predominantly

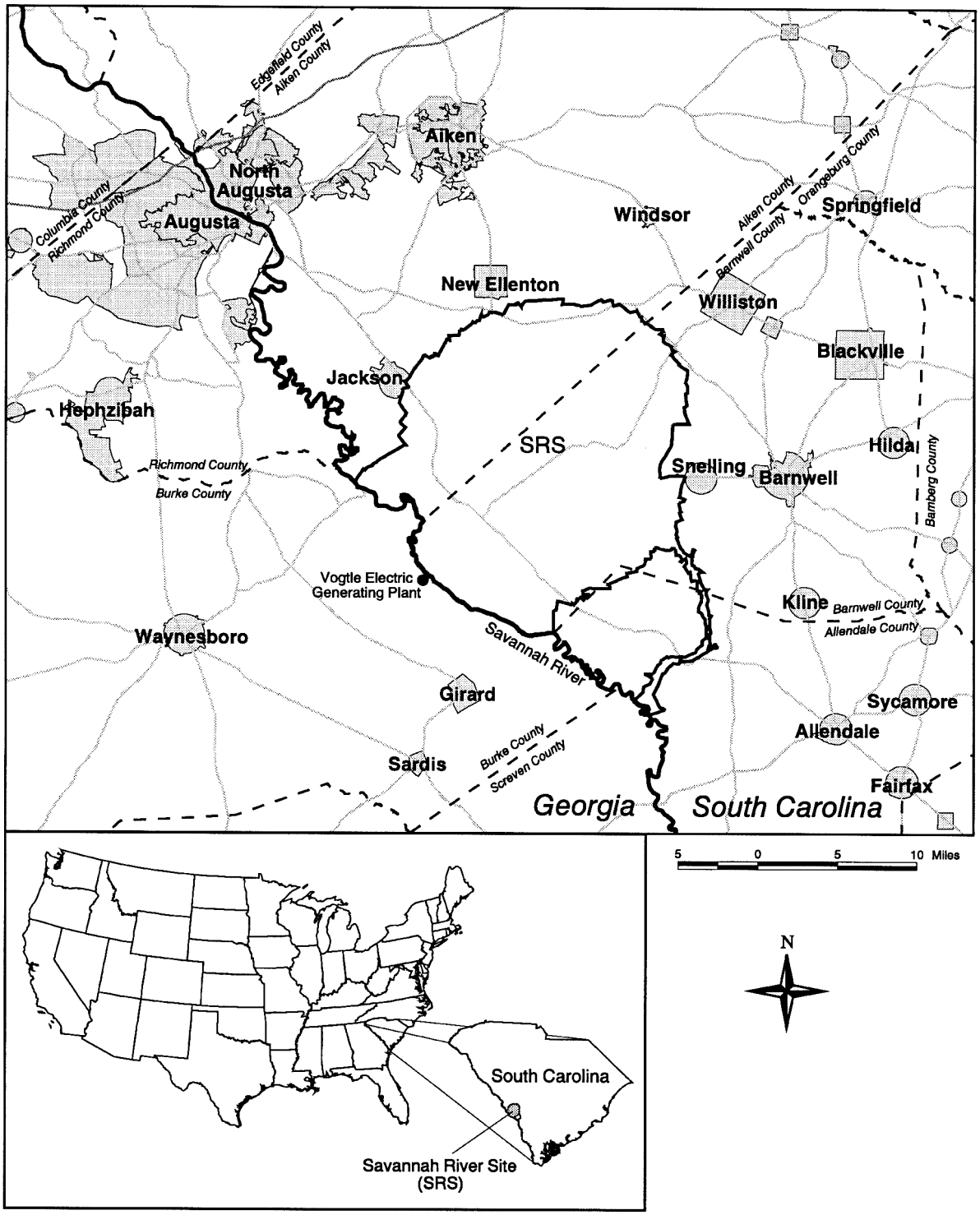


Figure 3.1. Regional location of the SRS.

sediments deposited by water. The Coastal Plain sediments are located above bedrock that consists of Paleozoic-age crystalline rock (such as granite) and Triassic-age sedimentary rock (such as siltstone) of the Dunbarton Basin. These sediments thicken from near zero at the Fall Line to about 1,220 m (4,000 ft) at the South Carolina coast (DCS 2002). In general, the sediments have a regional dip (slant of the top surface) to the southeast. The Aiken Plateau is highly cut by narrow, steep-sided valleys separated by broad, flat areas.

Above the bedrock, the first layer of sediments at the SRS consists of about 210 m (700 ft) of Upper Cretaceous-age quartz sand, pebbly sand, and kaolinitic clay. The next ascending layer (known as the Tinker/Santee Formation) consists of 18 m (60 ft) of Paleocene-age clayey and silty quartz sand, and silt (DCS 2002). Within this layer, there are occasional beds of clean sand, gravel, clay, or carbonate. Deposits of pebbly, clayey sand, conglomerate, and Miocene- and Oligocene-age clay occur at higher elevations. This layer is noteworthy because it contains small, discontinuous, thin calcareous sand zones (i.e., sand containing calcium carbonate) that are potentially subject to dissolution by water. These “soft-zone” areas have the potential to subside, causing settling of the ground surface (WSRC 2000a). These areas were encountered in exploratory borings in F-, S-, H-, and Z-Areas of the SRS at depths between 33 and 45 m (100 and 150 ft) (DOE 1995).

The upper sediment layer in F-Area consists of primarily shallow marine quartz sand containing sporadic clay layers (known as the Barnwell Group) (DOE 1999). This layer is about 21 m (70 ft) thick near the western boundary of the SRS and about 52 m (170 ft) thick near the eastern boundary.

There are 11 deep boreholes at the SRS. The closest deep borehole is located just north of the unnamed tributary of Upper Three Runs Creek. The remaining 10 deep boreholes are not located in the vicinity of F-Area.

In 2000, 13 exploratory borings and 63 cone penetration test (CPT) holes were used to identify subsurface conditions at the proposed MOX facility site (DCS 2002). The CPT holes ranged from about 19.5 m (64 ft) to 42.7 m (140 ft) below the existing grade. Some soft zones related to past dissolution and deposition activity were identified at depth. The CPT holes were used to define the limits of the soft zones. The planned locations of heavily loaded structures, such as the MOX Fuel Fabrication Building and the Emergency Diesel Generator Building, were changed to minimize the potential impact of these underlying soft zones.

Except for some small gravel deposits, no economically viable geologic resources occur in the vicinity of F-Area (DOE 1995).

3.2.2 Seismology

No known faults capable of producing an earthquake (referred to as “capable” faults) occur in the immediate vicinity of the SRS (DOE 1999). Several faults have been

Capable Fault

A fault is described as capable if it has had movement at or near the ground surface at least once within the past 35,000 years, or recurrent movement within the past 500,000 years.

identified from subsurface mapping and seismic surveys beneath the SRS. The largest of these is the Pen Branch Fault. It passes through the SRS in a northeast-southwest direction and is located about 5.6 km (3.5 mi) southeast of F-Area (WSRC 2000a). Because there is no evidence of movement along this fault within the last 38 million years, the Pen Branch Fault is considered not capable.

Two large earthquakes have occurred within 300 km (186 mi) of the SRS. The larger of these was the Charleston earthquake of 1886. The Charleston earthquake is the most damaging earthquake known to have occurred in the southeastern United States and one of the largest historic shocks in eastern North America. This earthquake had an estimated Modified Mercalli Intensity of X (USGS 2001); it damaged or destroyed many buildings in the old city of Charleston, killed 60 people, and produced structural damage up to several hundred kilometers from its epicenter. At the SRS, this earthquake had an estimated Richter Scale magnitude ranging from 6.5 to 7.5. The SRS area experienced an estimated peak ground acceleration[1] of 0.10 g (1/10 the acceleration of gravity — 9.81 m/s/s [32.2 ft/s/s]) during this event.

Modified Mercalli Scale

The Modified Mercalli Intensity Scale is a measure of the shaking strength of an earthquake at different locations in the region where an earthquake is felt. Earthquake intensities are characterized in terms of how the shaking affects people and buildings. The Modified Mercalli Intensity (MMI) Scale was originally developed in Italy nearly a century ago and includes 12 degrees of shaking. It was modified for use in the United States in 1931.

Three earthquakes have occurred at the SRS during recent years. They occurred on June 8, 1985, August 5, 1988, and May 17, 1997. These earthquakes were small, shallow events and were probably the result of strain release near intrusive bodies or the edges of metamorphic belts, typical of South Carolina Piedmont type seismic activity (WSRC 2000a). None of these earthquakes were associated with major faults (e.g., the Pen Branch Fault) in the area. Rather, these earthquakes are inferred to have seismic sources in the lower Paleozoic platform rock at a depth of about 12 km (7.5 mi) (DCS 2001a). These earthquakes had Richter Scale magnitudes of 3.2 or less and had epicenters that were within the SRS boundaries. Earthquakes of this magnitude are not felt, but do register on seismic instruments (Kirkham and Rogers 1981). Seismic alarms at the SRS reactor buildings were not triggered by any of these events (WSRC 2000a).

Richter Scale

The magnitude of an earthquake is a measure of the energy released during the event. It is often measured on the Richter Scale, which runs from 0.0 upwards, with the largest earthquakes recorded having a magnitude of 8.6. The Richter Scale is logarithmic; a quake of magnitude 5 is 10 times more destructive than a quake of magnitude 4. Earthquakes greater than magnitude 6.0 can be regarded as significant, with the likelihood of damage and loss of life (Press and Siever 1982).

[1] Peak ground acceleration is the greatest acceleration (change in velocity with respect to time) that can be expected at a particular location caused by an earthquake.

According to the Uniform Building Code, the SRS is in Seismic Zone 2. For this zone, moderate damage could occur as a result of an earthquake (DOE 1999). An earthquake with a maximum horizontal acceleration of 0.20 g is estimated to have an annual probability of occurrence of 1 in 10,000 (1×10^{-4}) at the SRS (DCS 2002).

3.2.3 Soils

As discussed in Section 3.2.1, the surface soils at the SRS consist of Coastal Plain sediments. The surface soils are primarily sands and sandy loams with sporadic clay layers (DOE 1999). Currently, a stockpile of soils removed from the Actinide Packaging and Storage Facility (APSF) site on the SRS is mounded up to 15 m (50 ft) thick on the central portion of the proposed facility site in the F-Area. These soils are similar in texture to the natural soils at the site and would be removed from the site during construction.

The majority of soils in F-Area are classified by the U.S. Department of Agriculture, Natural Resources Conservation Service, as the Fuquay-Blanton-Dothan Association. These soils are nearly level to sloping and are well drained. Soils along stream floodplains are classified as the Troup-Pickney-Lucy Association. Both of these soil associations are subject to erosion. Slope stability, however, has not been a significant regional issue.

The surface soils allow precipitation to drain rapidly. Because of their sandy texture and drainage characteristics, some soil units at the SRS meet the requirements as prime farmland. However, the U.S. Department of Agriculture, Natural Resources Conservation Service, does not identify these areas as prime farmlands because they are not available for agricultural use.

3.3 Hydrology

This section discusses the hydrologic environment of the SRS and the proposed site for the facilities. Hydrology deals with the properties, distribution, and circulation of water, particularly surface water and groundwater. The surface waters emphasized in this section are the Savannah River and on-site streams, including treated effluent and runoff discharges to them. Groundwater resources are waters that occur within aquifers (e.g., water-bearing strata that can store and transmit water in significant quantities). These resources are discussed in relation to their use and potential contamination.

3.3.1 Surface Water

The principal surface water feature at the SRS is the Savannah River (see Figure 3.2). It borders the southwest boundary of the site for 32 km (20 mi) (DOE 1996). Six major streams flow through the SRS and discharge to the Savannah River: Upper Three Runs Creek, Beaver Dam Creek, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs Creek. Upper

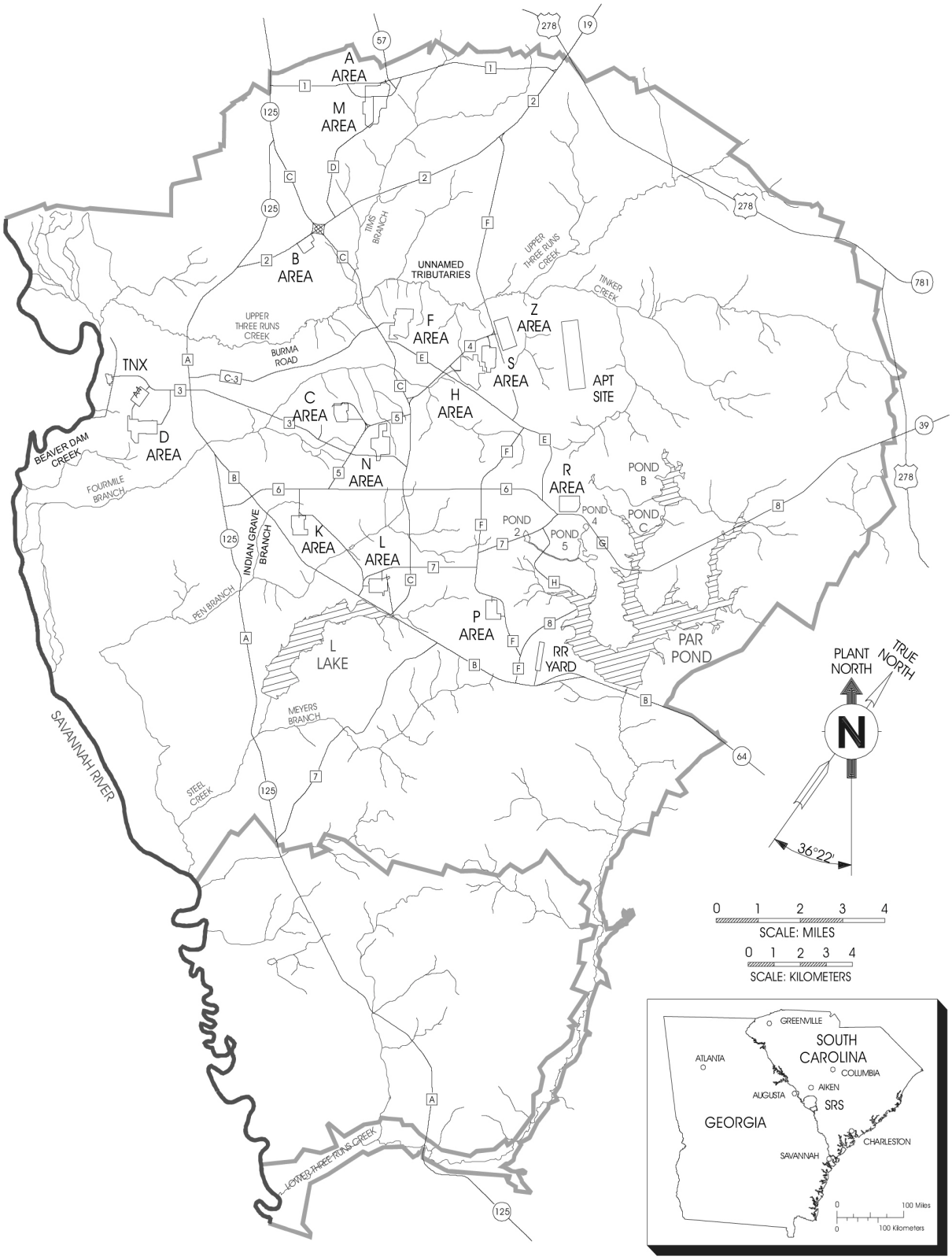


Figure 3.2. Locations of principal surface water features at the SRS (*Source*: DCS 2002).

Three Runs Creek has two named tributaries, Tims Branch and Tinker Creek. Pen Branch has one tributary, Indian Grave Branch. Steel Creek also has one tributary, Meyers Branch. These tributaries are not federally designated as Wild and Scenic Rivers (DCS 2002). In the vicinity of the F-Area, Upper Three Runs Creek has two unnamed tributaries (see Figure 3.3) that flow to the northwest.

Two man-made lakes are located at the SRS: L Lake, which discharges to Steel Creek; and Par Pond, which discharges to Lower Three Runs Creek (DCS 2002). There are also about 50 other small man-made ponds and about 300 natural Carolina bays (closed depressions capable of holding water) at the SRS. The Carolina bays do not receive any direct effluent discharge; however, they do receive storm-water runoff.

The SRS withdraws surface water from the Savannah River mainly for industrial cooling. In 2000, the SRS withdrew about 49.7 billion L (13.1 billion gal) of water from the river. Most of this water is returned to the river through various discharges (DOE 1999).

The average flow in the Savannah River is 269 m^3/s (9,493 ft^3/s). The 7-day low flow, 10-year recurrence (referred to as “7Q10") flow is 123 m^3/s (4,332 ft^3/s) (WSRC 2000a). This flow is the lowest flow recorded over any 7 consecutive days within any 10-year period. Three large upstream reservoirs (Hartwell, Richard B. Russell, and Strom Thurmond/Clarks Hill) regulate flow in the Savannah River. This regulation is done to lessen the impacts of drought and flooding downstream. Several communities in the area use the Savannah River as a source for domestic water. The closest downstream water intake to the SRS is that of the Beauford-Jasper Water Authority at Hardeville, South Carolina, about 130 river miles downstream of the SRS (WSRC 2000a). The Authority withdraws about 0.34 m^3/s (5,390 gpm) of water to service a population of 51,000 people.

Treated effluent is discharged to the Savannah River from upstream communities and from treatment facilities at the SRS. The average annual volume of flow discharged by the sewage treatment facilities at the SRS is about 700 million L (185 million gal). These effluents are released under National Pollutant Discharge Elimination System (NPDES) permits. The SRS has five NPDES permits, two (SC0000175 and SC0044903) for industrial wastewater discharges, two (SCR000000 and SCR1000000) for general storm-water discharges, and one (ND0072125) for land application (DOE 1999). Permit SC0000175 regulates 76 outfalls (points of discharge); permit SC0044903 regulates another 7 outfalls. The 2000 compliance for these outfalls was 99.7%. The 48 storm-water-only outfalls regulated by the site’s storm-water permits are monitored as required. A sediment reduction and erosion plan is required for storm-water runoff from any construction area that exceeds 2 ha (5 acres).

The Savannah River is classified as a freshwater source that is suitable for primary and secondary contact recreations, drinking after appropriate treatment, fishing, balanced native aquatic species development, and industrial and agricultural purposes. Primary contact means direct contact with the water, such as while swimming. Secondary contact means having some direct contact with the water but where swallowing is unlikely to occur, such as while fishing. Data from the river’s monitoring locations generally indicate that South Carolina’s freshwater standards are being met.

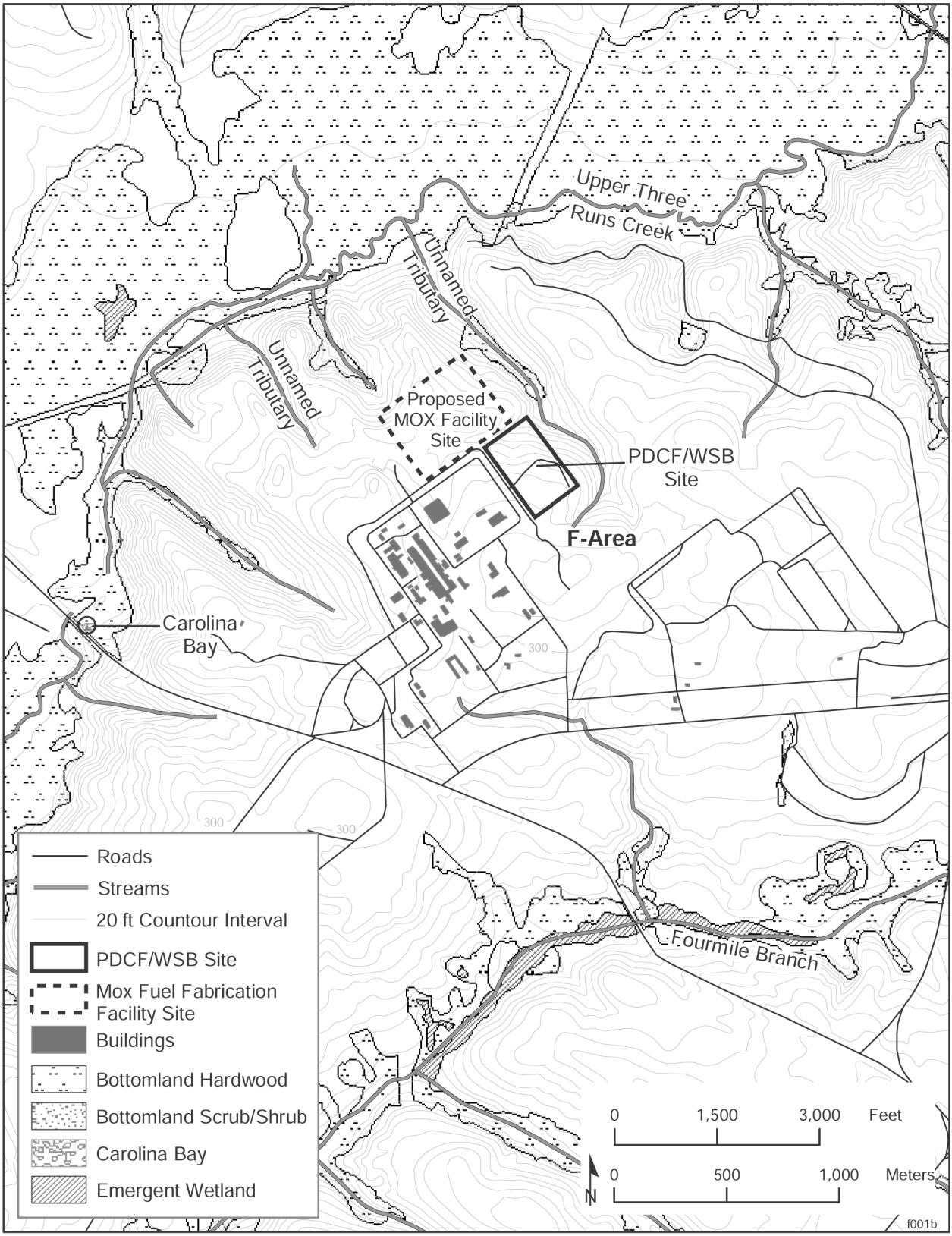


Figure 3.3. Locations of surface water and wetlands in F-Area (*Source*: Modified from DCS 2002).

Runoff from the land area around F-Area drains to Upper Three Runs Creek and Fourmile Branch (DOE 1999). Runoff from the proposed facilities drains into unnamed tributaries of Upper Three Runs Creek and flows to the northwest. Runoff from southern portions of the F-Area flow to the southeast into Fourmile Branch. The location for the proposed MOX facility is approximately 670 m (2,200 ft) southeast of Upper Three Runs Creek (WSRC 2000a). An unnamed tributary to Upper Three Runs Creek is located within about 150 m (500 ft) of the proposed MOX site (see Figure 3.3). The proposed MOX facility is located about 610 m (2,000 ft) north of Fourmile Branch.

Upper Three Runs Creek is a large, cool blackwater stream (i.e., a freshwater stream that has a dark color because of organic debris and tannin-containing compounds) that flows into the Savannah River along the western boundary of the SRS (see Figure 3.2). It drains an area of about 544 km^2 (210 mi^2) and had a mean discharge of 6.9 m^3/s (245 ft^3/s) near its mouth during water year 1995 (WSRC 2000a). A water year is measured from October 1 through September 30. The 7Q10 low-flow is about 2.8 m^3/s (100 ft^3/s). The stream is about 40 km (25 mi) long. It receives water from groundwater aquifer discharges and permitted discharges from several areas at the SRS, including F-Area, S-Area, the S-Area sewage treatment plant, and treated industrial wastewater from the Chemical Waste Treatment Facility steam condensate. The stream, however, has never received heated discharges of cooling water from the former SRS production reactors. Flow from the sanitary wastewater discharge averages less than 0.001 m^3/s (0.035 ft^3/s).

Fourmile Branch is a blackwater stream that has been affected by past operational practices at the SRS (DOE 1999). Its headwaters are near the center of SRS, and it flows southeasterly to the Savannah River. Until June 1985, it received large volumes of hot cooling water from the production reactor in C-Area. While the C-Area reactor was operational, the ambient temperature in Fourmile Branch was 60°C (140°F) (DOE 1999). It has a watershed area of about 54 km^2 (21 mi^2) and receives permitted effluent discharges from F-Area and H-Area. Average flow in the stream is approximately 1.8 m^3/s (64 ft^3/s). The 7Q10 low flow at the same location is about 0.23 m^3/s (8.2 ft^3/s) (WSRC 2000a). In its lower reaches, the stream widens and flows via braided channels through a delta. Downstream of the delta, it reforms into one main channel, with most of the flow discharging into the Savannah River at river mile 152.1; the remainder of the flow enters the Savannah River Swamp.

Under NPDES permit SC0000175, five outfalls discharge effluent to Fourmile Branch. Permitted discharges include 186 basin overflows, cooling water, floor drains, steam condensate, process wastewater, laundry effluent, storm water, sanitary treatment wastewater, ash basin runoff, and lab drains. Within the vicinity of F-Area, there are four permitted outfalls: F2, F3, F4, and F5. Discharge from the F2 outfall averages 0.4 million L/d (0.11 million gal/d). F5 has a flow of 0.1 million L/d (0.03 million gal/d). Outfall F3 is not currently used, but discharges storm water. Outfall F4 is an “administrative outfall” (i.e., an outfall with no pollutant load).

When the Savannah River floods, water from Fourmile Branch flows along the northern boundary of the floodplain and joins with other streams to exit the swamp via Steel Creek instead of flowing directly into the Savannah River. The location for the proposed facilities

would not be within the 100-year floodplain of Upper Three Runs Creek (DCS 2002). Similarly, estimated water levels for the probable maximum flood (PMF) for Upper Three Runs Creek are about 15 m (50 ft) below the lowest elevation in F-Area (67 m [220 ft]).

3.3.2 Groundwater

Sole Source Aquifer

- An aquifer that supplies at least 50% of the drinking water to the area above the aquifer.
- Areas that have no other water supply capable of physically, legally, or economically providing drinking water to local populations.

Several underground aquifers occur at the SRS (see Figure 3.4). However, no federally designated sole-source aquifers occur there. The uppermost aquifer is known as the Upper Three Runs Aquifer. It occurs at an elevation of about 55 to 67 m (180 to 210 ft) above mean sea level (MSL) in F-Area (DCS 2002). This elevation corresponds to a depth of about 1 to 20 m (3.3 to 66 ft) below the existing ground level (DOE 1999). The Upper Three Runs Aquifer lies on top of the leaky Gordon Confining Unit (Green Clay aquitard), which forms a confining layer for the Gordon Aquifer (Congaree Aquifer). The Upper Three Runs Aquifer along with the Gordon Confining Unit and the Gordon Aquifer constitute the Floridan Aquifer System (WSRC 2000a). To the north, the Gordon Confining Unit is not present, and the Gordon and Upper Three Runs Aquifers merge to form the Steed Pond Aquifer. Beneath the Gordon Aquifer is the leaky Crouch Branch Confining Unit (Ellenton aquitard), which, in turn, confines the Crouch Branch Aquifer (Cretaceous Aquifer) (DOE 1999; WSRC 2000a).

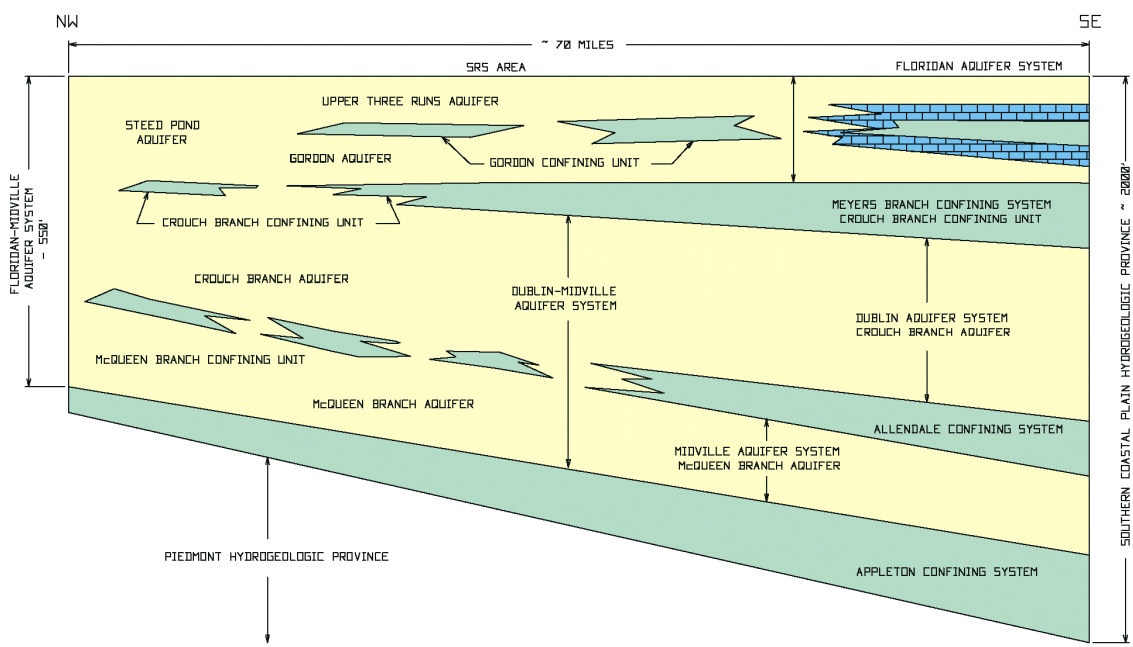


Figure 3.4. Underground aquifers at the SRS (Source: DCS 2001a)

Groundwater in aquifers predominantly flows horizontally to points of discharge, such as streams and swamps. In addition, some flow also occurs vertically to either underlying or overlying groundwater aquifers. Groundwater in the Upper Three Runs Creek Aquifer, in general, flows horizontally and discharges to nearby streams. A small portion of the groundwater flows vertically downward to the Gordon Aquifer. Flow in the Gordon Aquifer is mostly horizontal to eventual stream discharge or discharge to the Savannah River, depending on location. Some of the water also flows downward to the underlying Crouch Branch Aquifer. Water in the Crouch Branch Aquifer primarily discharges to Upper Three Runs Creek and the Savannah River. Groundwater beneath the SRS flows slowly at rates that range from inches per year in the clay aquitards that confine the aquifers to several hundred feet per year in the sandy aquifers (WSRC 2000c).

The Crouch Branch Aquifer is an abundant and important water resource for the SRS region. At the SRS, groundwater is the only source of domestic water. All groundwater at the SRS is classified by the U.S. Environmental Protection Agency (EPA) as a Class II water source (i.e., a current and potential source of drinking water). In 2000, the SRS withdrew 7.95 billion L (2.1 billion gal) of groundwater from the Crouch Branch Aquifer in support of site operations. Some nearby towns, such as Aiken, South Carolina, obtain groundwater from the Crouch Branch Aquifer, but most of the rural population draws water from the Gordon, Upper Three Runs, or Steed Pond Aquifers. About 8 billion L/yr (2.1 billion gal/yr) of groundwater is withdrawn from these upper aquifers within a 16-km (10-mi) radius of the site (DCS 2002).

F-Area is located on a groundwater divide between Four Mile Creek and Upper Three Runs Creek. Near-surface groundwater in the southern portion of the F-Area primarily moves laterally and discharges to Four Mile Creek and its tributaries to the south. In the northern portion of the F-Area, including the proposed location of the facilities, near-surface groundwater also primarily moves laterally, but discharges to Upper Three Runs Creek and its tributaries to the north (WSRC 2000c).

Beneath the site for the proposed MOX facility, the Upper Three Runs aquifer is divided into upper and lower zones by the Tan Clay confining unit of the Dry Branch Formation (DCS 2002). In the area near the proposed MOX facility site, the topography drops sharply to the north toward Upper Three Runs Creek, and the water table occurs in the lower aquifer zone beneath the Tan Clay confining unit. Water table elevation data and computer modeling indicate that shallow groundwater flows away from the OFASB in a north-northwesterly direction and is discharged to a tributary of Upper Three Runs Creek. A small component of this groundwater flows beneath the westernmost corner of the proposed MOX site. Depth to groundwater in the area of the OFASB and the proposed MOX facility site ranges from 23.2 to 28.3 m (76 to 93 ft) below the present ground surface. Site preparation for the proposed MOX facility, PDCF, and WSB would involve shallow grading and excavation to a depth of about 12.2 m (40 ft). These activities would not encounter groundwater.

Groundwater varies in quality across the SRS. In some areas, it meets drinking water quality standards; in other areas, such as near waste sites, it does not. The deep Crouch Branch Aquifer is generally unaffected by site operations, except for a location near A-Area, where trichloroethylene contamination has been found. Tritium has been reported in the Gordon

Aquifer under the Separation Areas (F- and H-Areas). The Upper Three Runs Aquifer is contaminated with solvents, metals, and low levels of radionuclides near several SRS areas and facilities, including the F-Area.

Groundwater is the only source of domestic water at the SRS. The existing capacity at the SRS is approximately 33.5 billion L/yr (8.9 billion gal/yr). Groundwater rights in South Carolina are associated with the absolute ownership rule. Owners of land overlying a groundwater resource are allowed to withdraw as much water as they desire; however, the state requires users who withdraw more than 138 million L/yr (36.5 million gal/yr) to report their withdrawals. Because the groundwater use at the SRS exceeds this value, DOE is required to report its usage to the state (DCS 2002).

Within F-Area, four groundwater wells are used for process water. Pumping capacities for these wells range from 1,500 to 3,800 L/min (400 to 1,000 gpm). They extract groundwater from the Crouch Branch Aquifer. Two of these wells were formerly used for domestic water supply. The current annual groundwater use at F-Area is 374 million L (98.8 million gal). The estimated capacity of the wells in F-Area is about 4.2 billion L/yr (1.1 billion gal/yr) (DCS 2002)

Groundwater quality in F-Area is not significantly different from that of groundwater throughout the rest of the SRS. It is abundant, usually soft, slightly acidic, and low in dissolved solids. F-Area groundwater can exceed drinking water standards for several contaminants. In 1999, 18% of 365 wells sampled at the General Separations and Waste Management Areas (Areas F, E, H, S, and Z) measured metal concentrations that exceeded metal drinking water standards; 10% of 471 wells sampled had organic concentrations that exceeded organic drinking water standards; 53% of 483 wells sampled exceeded drinking water standards for tritium; 40% of 372 wells sampled exceeded drinking water standards for other radionuclides; and 31% of 307 wells sampled exceeded drinking water standards for other constituents. The sources of the detected groundwater contamination included burial grounds, canyon buildings, seepage basins, and saltstone disposal facilities (WSRC 2000c).

Near the F-Area seepage basins and inactive process sewer line, there is widespread radionuclide contamination. Near the F-Area Tank Farm, tritium, mercury, nitrate-nitrite (as nitrogen), cadmium, gross alpha, and lead were detected in concentrations that exceeded drinking water standards in one or more wells. At the Sanitary Sludge Application Site, tritium, specific conductance, lead, and copper values exceeded their drinking water standards in one or more wells. In addition, a subsurface plume of tritium and strontium contamination has recently been found in F-Area. This plume is believed to originate from the Old F-Area Seepage Basin (OFASB).

The OFASB is located about 180 m (600 ft) north of F-Area. Other contaminants of concern at the OFASB include iodine-129, nitrate, uranium-234, and uranium-238. The site has been remediated by filling the basin with clean soil, capping, and stabilizing the contaminated soil within the basin with in-situ grout (WSRC 1997a). Groundwater monitoring is performed on a regular basis with 15 monitor wells. The aquifer is expected to return to an uncontaminated state within a period of 2 to 115 years, depending on the specific contaminant.

The predicted fate and transport of shallow groundwater contaminants near the OFASB were examined as part of the *Groundwater Mixing Zone Application for the Old F-Area Seepage Basin* (WSRC 1997a). The results of sampling in the compliance wells for the OFASB indicated that concentrations of several target constituents were above drinking water standards in several wells. These contaminants included iodine-129, nitrate, radium-226, radium-228, strontium-90, tritium, uranium (total), and lead.

Groundwater in the Upper Three Runs aquifer beneath the proposed MOX facility site is contaminated with various heavy industrial and nuclear contaminants. Contamination is present beneath the entire site, but is greatest beneath the western edge of the site. The results of recent groundwater sampling for the proposed MOX facility site indicate that groundwater contamination is absent above the Tan Clay confining zone. Beneath the Tan Clay zone, groundwater is contaminated from upgradient sources. Concentrations of gross alpha and beta activity, tritium, uranium, and trichloroethylene exceeded maximum contaminant concentration limits for drinking water. The sources for the groundwater contamination are related to the OFASB and nuclear operations over the past 50 years in the F-Area (DCS 2002). The contaminants appear to originate inside the F-Area and extend beneath the site of the proposed MOX facility, with movement in a fan-like direction of groundwater flow under the site. The deepest construction activities for the proposed facilities are expected to occur at least 9.1 m (30 ft) above the zone of contamination.

3.4 Meteorology, Emissions, Air Quality, and Noise

This section discusses the existing meteorology, current airborne pollutant emissions, air quality, and noise environment in the vicinity of the SRS. Section 3.4.1 describes the meteorology, or weather conditions, around the SRS. Meteorology includes the atmospheric conditions that determine where pollutants released into the atmosphere travel and how they are mixed with existing air and become diluted as they travel. Section 3.4.2 describes existing air emissions from the SRS and the surrounding area. Section 3.4.3 describes regional air quality and air quality standards. Air emissions from the proposed MOX facility, the PDCF, and the WSB would combine with existing emissions to affect local and regional air quality. Comparing the resulting combined air quality against the standards provides one measure of the facilities' impact on air quality. Section 3.4.4 describes the existing noise environment and applicable regulations. Noise generated by the facilities would combine with existing levels to produce the overall noise impact.

3.4.1 Meteorology[2]

To provide a thorough picture of weather conditions at a given location often requires the use of data from several locations. Different locations that record meteorological data may record different parameters. Data recorded near the site of the proposed action is generally considered most representative of the site. Meteorological data for F-Area (the site of the proposed facilities), H-Area, and Bush Field in Augusta, Georgia, were used to describe meteorological conditions of the affected environment.

Meteorology

Meteorology deals with weather conditions. Air pollution meteorology emphasizes weather conditions that determine how pollutants released into the air travel and mix with the air. The more important weather conditions involved in this process include wind speed and direction and atmospheric stability, a measure of how much mixing is occurring in the atmosphere.

The climate at the SRS is characterized by short, mild winters and long, humid summers (DCS 2002). Mountains to the north and west prevent or delay the approach of many cold air masses (Ruffner 1985).

The annual average wind speed is 2.8 m/s (6.2 mph) at Bush Field, which is located in Augusta, Georgia, about 24 km (15 mi) northwest of F-Area. Wind speed is highest in the spring, averaging 3.1 m/s (7.0 mph). March has the highest monthly average wind speed of 3.4 m/s (7.7 mph) and August the lightest, 2.3 m/s (5.1 mph). The prevailing monthly wind direction is from the west-northwest from November through February and variable for the rest of the year. On the basis of observations for 1995-1999, the highest 2-minute wind speed was 20 m/s (45 mph) from the north-northwest in June 1998, and the maximum gust (5-second wind speed) was 25 m/s (55 mph) from the north-northwest in April 1997.

A wind rose based on data from the 5-year period 1992 through 1996 from the 62-m (200-ft) meteorological tower in H-Area at the SRS is presented in Figure 3.5. The wind rose indicates no strongly predominant prevailing wind direction, but the wind is from the northeast about 10% of the time and from the west-southwest over 9% of the time. Annual average wind speeds ranged from 3.6 to 4.2 m/s (8.0 to 9.4 mph) during the 5-year period (DCS 2002).

Wind Rose

A *wind rose* summarizes wind speed and direction graphically as a series of bars pointing in different directions. The direction of a bar shows the direction *from* which the wind blows. Each bar is divided into segments. Each segment represents wind speeds in a given range of speeds, for example, 6-8 m/s. The length of a given segment represents the percentage of the summarized hours that winds blew from the indicated direction with a speed in the given range.

October and November are the driest period, with rainfall increasing after then to a peak in

[2] Unless otherwise noted, the information presented in this section is based on meteorological data collected at Bush Field in Augusta, Georgia, about 24 km (15 mi) northwest of F-Area, and summarized by the National Climatic Data Center (NOAA 1999).

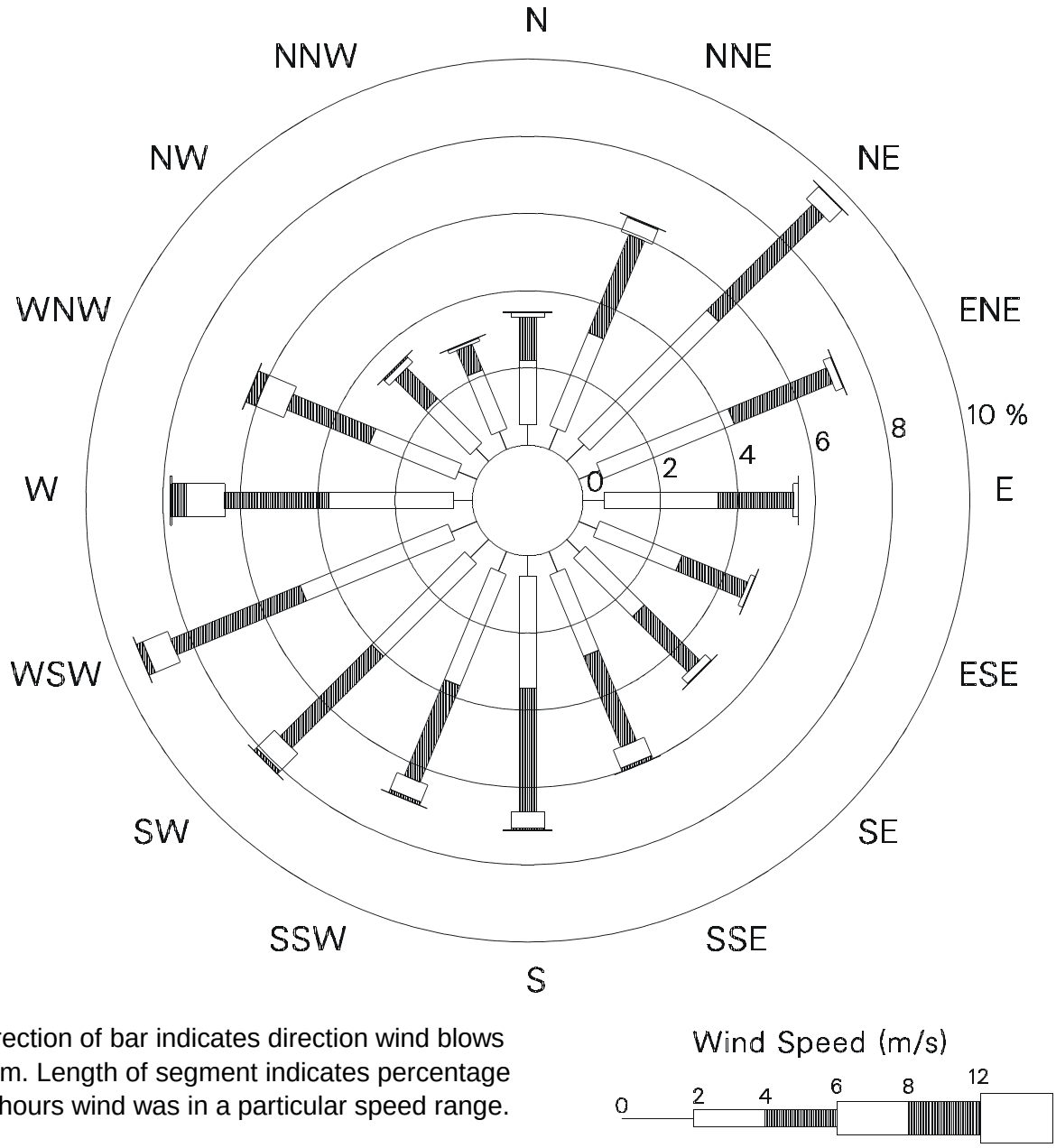


Figure 3.5. Annual wind rose for the SRS (*Source*: Arnett and Mamatey 2000a, Table 31).

March. A dry period extends from April through early June, followed by a wet period from late June through early September caused primarily by thunderstorms and showers (Ruffner 1985). Average annual precipitation at Bush Field is 114 cm (44.7 in.). Data from 1967 to 1996 at the SRS show an average annual precipitation of 126 cm (49.5 in.) (DCS 2002). Average monthly precipitation ranges from 6.30 cm (2.48 in.) in November to 11.8 cm (4.65 in.) in March. The greatest amount of precipitation recorded in a single month was 37.6 cm (14.8 in.) in October 1990, and the least amount was in October 1953, when only trace amounts of rainfall were recorded. The greatest amount of precipitation recorded in a 24-hour period was 21.8 cm (8.57 in.) in October 1990. Snowfall occurs only one to three times in the winter and usually remains on the ground for only a short period (Ruffner 1985). Annual snowfall averages 3.3 cm (1.3 in.). The greatest monthly snowfall occurred in February 1973, with 35.6 cm (14.0 in.), and the greatest 24-hour snowfall was 34.8 cm (13.7 in.) in the same month. Freezing rain may occur one to three times per winter (Ruffner 1985).

The average annual temperature at Bush Field is 17.5°C (63.5°F). At the SRS, the average annual temperature is 17.3°C (63.2°F) (DCS 2002). January is the coldest month, with an average temperature of 7.39°C (45.3°F), and July the warmest, averaging 26.7°C (80.1°F). Daily extreme temperatures have ranged from 42.2°C (108°F) in August 1983 to -18°C (-1°F) in January 1985. An average of 309 freeze-free days (days with a minimum temperature greater than 0°C [32°F]) occur per year. There are no freeze days from May through September. Temperatures above 32°C (90°F) occur about 73 days per year, with 56 of them occurring in June, July, and August.

Average annual relative humidity at Bush Field ranges from 83% in the early morning to 51% in the afternoon. In July and August, the early morning relative humidity averages 90%, with afternoons averaging 55-56%. At the SRS, comparable values for August are 97% and 50% (DCS 2002). Dew point temperatures at Bush Field range from 1.33°C (34.4°F) in January to 21.0°C (69.7°F) in July. Heavy fog with visibility less than 0.40 km (0.25 mi) occurs on an average of about 32 days per year. Heavy fog occurs throughout the year but is most likely in November and December.

Thunderstorms, tornadoes, and hurricanes provide occasional severe weather to South Carolina (Ruffner 1985). Thunderstorms occur on an average of 53 days per year at Bush Field. July averages 12.6 thunderstorm days, December 0.7. More than 70% of the thunderstorms occur in the four-month period from May through August. They are most common in the summer months, but the more violent storms generally occur along active cold fronts in spring (Ruffner 1985). Hail with thunderstorms is infrequent and occurs about once every 2 years on the average (DCS 2002).

Tornadoes are rare in South Carolina. Most that do occur are during the period March through June. April is the peak month for tornadoes, with a smaller peak in August and September (Ruffner 1985). For the 49-year period of 1950-1998, an average of 11 tornadoes per year occurred in South Carolina (Storm Prediction Center 2001). Between 1880 and 1995, a total of 17 significant tornadoes were reported in Aiken and Barnwell Counties, South Carolina, and Burke County, Georgia. Nine tornadoes have caused damage on the SRS, one with estimated

wind speeds as high as 67 m/s (150 mph). None have caused damage to buildings on the SRS (DCS 2002).

Tropical storms or hurricanes affect South Carolina about once every 2 years. Most do little damage and affect only the costal areas, decreasing in intensity as they move inland. Those that do move far inland can cause considerable flooding (Ruffner 1985). Thirty-six hurricanes caused damage in South Carolina between 1700 and 1989, and the interval between them has ranged from 2 months to 27 years. About 80% have occurred in August and September. The only hurricane-force winds measured at the SRS were associated with Hurricane Gracie on September 29, 1959, when wind speeds of 34 m/s (75 mph) were measured at F-Area (DCS 2002).

Air Quality Terms

Particulate matter (PM) is dust, smoke, other solid particles, and liquid droplets in the air. The size of the particulate is important and is measured in micrometers (µm). A micrometer is 1 millionth of a meter (0.000039 in.).

Total suspended particulate (TSP) is PM with a diameter less than 30 µm. PM_{10} is PM with a diameter less than 10 µm and $PM_{2.5}$ is PM with a diameter less than 2.5 µm. The U.S. Environmental Protection Agency (EPA) has set standards for PM_{10} and $PM_{2.5}$ designed to protect human health and welfare.

Criteria pollutants are pollutants for which the EPA has prepared documents detailing their health and welfare impacts and set standards specifying the air concentrations that avoid these impacts. The criteria pollutants are sulfur oxides, nitrogen dioxide, carbon monoxide, PM_{10}, $PM_{2.5}$, lead, and ozone.

Volatile organic compounds (VOCs) are organic vapors in the air that can react with other substances, principally nitrogen oxides, to form ozone. The reactions are energized by sunlight.

Background is a concentration value, usually based on measured pollutant data, that accounts for the impacts of emission sources not included explicitly in the air quality model.

3.4.2 Emissions

The SRS is classified as a “major source” (of airborne pollutant emissions) under the Clean Air Act (CAA), with potential emissions of more than 227,000 kg/yr (250 tons/yr). The SRS has construction and operating permits from the South Carolina Department of Health and Environmental Control (SCDHEC), Bureau of Air Quality, for about 199 point sources. Thirty-eight of these sources are permitted for air toxics. During 2000, 137 sources operated at least part of the year, and 62 were on cold standby or under construction.

Significant sources of criteria air pollutants[3] or their precursors and toxic air emissions at the SRS include coal-fired powerhouse boilers (two in A-Area and three in H-Area) and No. 2 oil-fired package steam generators (two in K-Area and two portable units). Other facilities emitting nonradiological emissions include 128 pieces of equipment powered by diesel engines, the Defense Waste Processing Facility, groundwater air strippers, the Consolidated Incineration Facility, and controlled burning. During 2000, the SRS continued to be in compliance with permitted emission rates and special conditions (Arnett and Mamatey 2001b).

[3] “Criteria” air pollutants are common air pollutants for which federal standards have been established.

SRS point source emissions for 1999 are compared with point source and total emissions within the four surrounding counties — Aiken, Allendale, and Barnwell Counties in South Carolina and Burke County in Georgia — in Table 3.1. The SRS contributed less than 6% of the four-county point source emissions of nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and particulate matter less than 10 μm and less than 2.5 μm in diameter, (PM_{10} and $PM_{2.5}$, respectively) in 1999. The SRS contributed about 17% of the four-county area point source emission of carbon monoxide (CO). However, CO is generated primarily by mobile sources, and the SRS emitted only about 0.20% of the total point and nonpoint CO for the four-county area. Arnett and Mamatey (2001a) provide an inventory of about 200 toxic air pollutant emissions from the SRS for 1999. Table 3.2 lists the emissions that exceeded 1 ton per year.

3.4.3 Air Quality

The SRS is located in the Augusta-Aiken Interstate Air Quality Control Region (AQCR) #53, which comprises 6 counties in South Carolina and 13 in Georgia (see Figure 3.6) (EPA 1972). Both South Carolina and Georgia have adopted State Ambient Air Quality Standards (SAAQSs) identical to the federal National Ambient Air Quality Standards (NAAQSs) for the criteria pollutants (see adjacent text box). In addition, South Carolina has retained the annual standard for TSP and adopted an additional standard for gaseous fluorides (SCDHEC 2000; GDNR 2000).

National Ambient Air Quality Standards (NAAQSs)

The EPA sets NAAQSs for criteria pollutants (sulfur oxides, PM_{10}, $PM_{2.5}$, carbon monoxide, nitrogen dioxide, lead, and ozone). The primary NAAQS specify maximum ambient (outdoor air) concentrations of the criteria pollutants that would protect public health with an adequate margin of safety. Secondary NAAQSs specify maximum concentrations that would protect public welfare. If both a primary and a secondary standard exist, the lower (more restrictive) standard is normally used for assessment purposes. Some of the NAAQSs for an averaging time of 24 hours or less allow the standard values to be exceeded a limited number of times per year.

South Carolina is currently designated as being in attainment (i.e., in compliance with standards) for all criteria pollutants (40 CFR 81.341). Georgia is designated as in attainment except for the 13-county area around Atlanta, which is designated as nonattainment for the 1-hour ozone standard (40 CFR 81.311). A list of the ambient standards and the highest ambient concentrations at the air quality monitoring stations in the vicinity of the SRS is shown in Table 3.3. The regulations for Prevention of Significant Deterioration (PSD) of air quality (40 CFR 52.21) place limits on the total increase in ambient pollution levels above established baseline levels for SO_2, NO_2, and PM_{10}. Under those regulations, the allowable increases are smallest in Class I areas (national parks and wilderness areas). The rest of the country is subject to PSD II increments. States can choose a less stringent set of Class III increments, but no states have chosen to do so. The Cape Romain National Wildlife Refuge, the PSD Class I area closest to the SRS, is about 160 km (100 mi) to the east. The facilities at the SRS have not been required to obtain PSD permits (DCS 2002).

Table 3.1. Estimated emissions from four counties around the SRS and SRS point sources in 1999[a]

	Four-county area emissions (tons/yr)[d]		SRS emissions		
				As percentage (%) of four-county area	
Pollutant[b,c]	Point	Total	Total (tons/yr)	Point	Total
CO	712	62,300	124	17	0.20
NO_x	6,800	17,700	337	5.0	1.9
SO_2	14,600	15,400	346	2.4	2.3
PM_{10}	1,250	1,747	54.5	4.4	3.1
$PM_{2.5}$	696	1,120	37.9	5.4	3.4
VOC	1,770	8,330	7.45	0.42	0.089

[a]Four SRS border counties: Aiken, Barnwell, and Allendale, South Carolina; and Burke, Georgia. "Point" values are for all point sources. "Totals" are for all sources, including point, area, and mobile.

[b]The reference does not include lead. Lead emissions have been lowered by reductions in the lead content of gasoline.

[c]Ozone is not emitted directly and is not listed in this table. It is formed in the air by chemical reactions involving VOCs and NO_x.

[d]To convert tons to kilograms, multiply by 907.2.

Source: EPA (2001).

3.4.4 Noise

The *Noise Control Act of 1972* and subsequent amendments (*Quiet Communities Act of 1978,* 42 USC 2901-4918) delegate the authority to regulate noise to the states. However, South Carolina and Georgia do not have noise regulations. The Aiken County Zoning and Development Standards Ordinance limits noise levels by frequency band (see Table 3.4). The EPA guideline recommends an L_{dn}[4] of 55 dBA[5] to protect the public from the effects of noise in typically quiet outdoor and residential areas (EPA 1974). To protect the general population

[4] L_{dn} is a 24-hour average sound level that gives additional weight to noise that occurs during the night (10:00 p.m. to 7:00 a.m.).

[5] dBA is A-weighted decibels, a unit of weighted sound-pressure level measured by specific methods and using the A-weighting specified by the American National Standards Institute (ANSI). It duplicates the ear's sensitivity to sound.

Table 3.2. Toxic air pollutant emissions at the SRS in 1999

Pollutant[a]	CAS number[b]	Emissions (tons/yr)[c]
Benzene	71-43-2	4.16
Chloroform	67-66-3	6.30
Formaldehyde	50-0-0	1.28
Formic acid	64-18-6	3.45
Hexane	110-54-3	1.14
Hydrochloric acid	7647-1-0	1.73
Hydrogen sulfide	7783-6-4	5.71
Methoxychlor	67-56-1	1.46
Nitric acid	7697-37-2	1.04
Sodium hydroxide	1310-73-2	1.32
Tetrachloroethylene	127-18-4	2.17
Toluene	108-88-3	1.87
Trichloroethylene	79-1-6	5.53
Xylenes	1330-20-7	4.96

[a]Only pollutants with emissions of more than 1 ton are listed.

[b]Chemical Abstract Services (CAS) number — a number assigned to a specific chemical by CAS. The number avoids the ambiguity associated with multiple names for the same chemical and also avoids problems associated with name differences between languages.

[c]To convert tons to kilograms, multiply by 907.2.

Source: Arnett and Mamatey (2001a, Table 45).

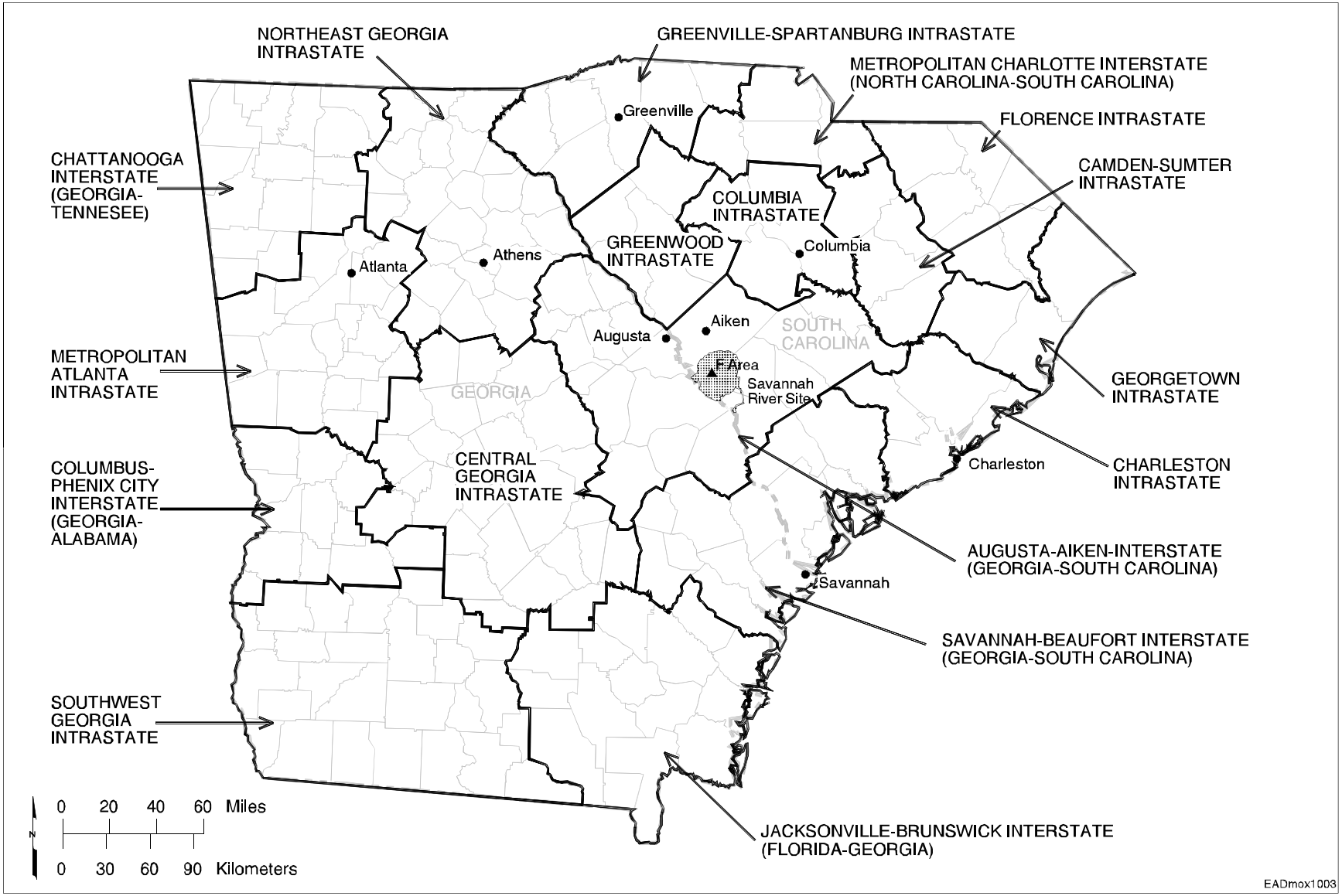


Figure 3.6. Air quality control regions, South Carolina and Georgia.

Table 3.3. Ambient air quality standards and highest pollutant levels in the vicinity of the SRS

Pollutant	Averaging time	Ambient standard ($\mu g/m^3$)[a, b]	Highest level in vicinity of SRS[c]		
			Concentration ($\mu g/m^3$)	Location (city, county, state)	Year
SO_2	3 hours	1,300[d]	290	Irmo, Lexington, S.C.	1997
	24 hours	365[e]	76	Irmo, Lexington, S.C.	1999
	Annual	80[e]	10[f]	Irmo, Lexington, S.C.	1998
NO_2	Annual	100[g]	9.4	–, Aiken, S.C.	1997-2000
CO	1 hour	40,000[e]	–[h]	–	–
	8 hours	10,000[e]	–[h]	–	–
O_3	1 hour	235[g]	253	Augusta, Richmond, Ga.	2000
	8 hours[i]	157[g]	227	Augusta, Richmond, Ga.	1998
PM_{10}	24 hours	150[g]	218	Cayce, Lexington, S.C.	1998
	Annual	50[g]	55	Cayce, Lexington, S.C.	1999
$PM_{2.5}$	24 hours[i]	65[g]	71	Ashton, Colleton, S.C.	2001
	Annual[i]	15[g]	21.5	Cayce, Lexington, S.C.	1998
Pb	Calendar Quarter	1.5[g]	0.04	–, Lexington, S.C. Augusta, Richmond, Ga.	1999 1996
TSP[j]	Annual	75[e]	42[k]	Cayce, Lexington, S.C.	2000

See footnotes on next page.

TABLE 3.3. Continued

[a]Unless otherwise noted, South Carolina and Georgia SAAQS are the same as NAAQS. South Carolina has additional standards for gaseous fluorides that are not shown because they are not emitted by the proposed facility.

[b]Methods of determining whether standards are attained depend on pollutant and averaging time. The 3-hour and 24-hour SO_2 standards and the 1-hour and 8-hour CO standards are not to be exceeded more than once per calendar year. The annual TSP, SO_2, and NO_2 standards are not to be exceeded in any calendar year. The lead standard is not to be exceeded in any calendar quarter. The 1-hour ozone (O_3) standard is attained when the expected number of days per calendar year with maximum hourly concentrations above the standard is less than or equal to one and applies only in areas designated nonattainment when the 8-hour O_3 standard was adopted in July 1977. The 8-hour O_3 standard is attained when the 3-year average of the annual fourth-highest daily maximum 8-hour concentrations is less than or equal to the standard. The 24-hour PM_{10} standard is attained when the expected number of days per calendar year with a 24-hour average concentration above the standard is less than or equal to one. In areas that meet certain criteria, attainment of the 24-hour PM_{10} standard is based on having the 3-year average of the 99th percentile 24-hour averages less than or equal to the standard. The annual PM_{10} standard is met when the 3-year average of the annual means is less than or equal to the standard. The 24-hour $PM_{2.5}$ standard is met when the 3-year average of the 98th percentile 24-hour averages is less than or equal to the standard. The annual $PM_{2.5}$ standard is met when the 3-year average of the annual means is less than or equal to the standard.

[c]Based on available data for 1997 through 2001 unless otherwise noted. The vicinity of the SRS was taken to be Aiken, Bamberg, Barnwell, Colleton, Edgefield, Hampton, Lexington, and Orangeburg Counties in South Carolina and Burke, Columbia, Jenkins, Richmond, and Screven Counties in Georgia. The concentrations are the highest measured values and are not always directly comparable to the ambient standards. Except for 13 counties around Atlanta, Georgia, that are nonattainment for 1-hour O_3, both South Carolina and Georgia have been designated as in attainment for all implemented standards. Footnote b summarizes criteria for determining standard attainment.

[d]Secondary (welfare-based) standard.

[e]Primary (health-based) standard.

[f]Years 2000 and 2001 data for Aiken County not available.

[g]Primary and secondary standard.

[h]No CO data in vicinity of SRS for 1997-2001.

[i]NAAQS only; implementation of the standard has been delayed, and states have not developed attainment plans.

[j]South Carolina standard.

[k]Based on South Carolina data for 1998-2001.

Sources: 40 CFR 50; SCDHEC (2002a-d); EPA (2002).

Table 3.4. Aiken County maximum allowable noise levels[a]

Frequency band (Hz)	Nighttime[b] sound pressure level at property boundary (dB)	
	Nonresidential	Residential
20-75	69	65
75-150	60	50
150-300	56	43
300-600	51	38
600-1,200	42	33
1,200-2,400	40	30
2,400-4,800	38	28
4,800-10,000	35	20

[a]This table gives nighttime sound pressure levels (SPLs). Allowable daytime levels are generally louder than nighttime levels.

[b]Nighttime: 9:00 p.m. to 7:00 a.m.

Source: DOE (1996).

against hearing loss, the EPA guideline recommends an $L_{eq}(24)$[6] (L_{eq} averaged over 24 hours) of 70 dBA or less over a 40-year period. The Federal Aviation Administration and the Federal Interagency Committee on Urban Noise have issued land use compatibility guidelines indicating that yearly day-night average sound levels (L_{dn}) of less than 65 dBA are compatible with residential land uses and that, if a community determines it is necessary, levels up to 75 dBA may be compatible with residential uses and transient lodgings (but not mobile homes) if such structures incorporate suitable noise reduction features (14 CFR 150, Appendix A).

Major noise sources in active areas at the SRS include industrial facilities and equipment such as cooling systems, transformers, engines, vents, paging systems; construction and materials-handling equipment; and vehicles. Outside of active operational areas, vehicles and trains generate noise. Most industrial facilities at the SRS are located far enough from the site boundary that the associated noise levels at the boundary would be barely distinguishable from background levels.

Noise impacts to the general public arise primarily from transportation of people and materials to and from the site by vehicles, helicopters, and trains (DCS 2002). A noise survey was

[6] For sounds that vary with time, L_{eq} is the steady sound level that would contain the same total sound energy as the time-varying sound over a given time.

conducted in the SRS area in 1989 and 1990 (NUS 1990). Seven off-site locations were selected along major routes used by SRS employees entering and leaving the site. Summer L_{dn} levels ranged from 62-72 dBA; winter L_{dn} levels ranged from 51-70 dBA. Summer 24-hr L_{eq} levels ranged from 60 to 67 dBA; winter values ranged from 54 to 65 dBA.

3.5 Ecology

This section describes the plant and animal resources at the SRS, with emphasis on those components that could be affected by the construction and operation of the proposed MOX facility and associated Pit Disassembly Conversion Facility/Waste Storage Building (PDCF/WSB) complex. Particular attention is given to species and special habitats protected by the federal government under the Endangered Species Act, as well as species of special concern listed by the states of South Carolina (Aiken and Barnwell counties) and Georgia (Burke County). In addition to federal and state regulations, DOE protects plants, animals, and Carolina bays in DOE Research Set-Aside Areas. Unless otherwise cited, the information presented in this section has been abstracted from DCS (2002).

Ecological Resources

Ecological resources include plant and animal species and the habitats on which they depend (e.g., forests, fields, wetlands, streams, and ponds).

3.5.1 Terrestrial

This section describes the native plant communities and wildlife species at the SRS and in the F-Area where the facilities would be constructed. Wildlife habitats, wildlife management areas, and ecological research sites are also described.

3.5.1.1 Vegetation

At the time land for the SRS was purchased by the government in 1950, about 40% of the site was old field, crop land, or developed by the former town of Ellenton. The remainder of the area was forested (WSRC 1994). As the DOE developed the SRS, the vegetation changed over time. Many of the old fields reverted back to forested areas. In addition, this increase in wooded area also resulted from timber and watershed protection management directed by the U.S. Forest Service (WSRC 1994; DOE 1999).

In 1972, the entire SRS was designated as the nation's first National Environmental Research Park (NERP). Thirty specified areas within the SRS are designated as DOE Research Set-Aside Areas that are reserved for ecological research. These areas total 5,672 ha (14,005 acres), or about 7% of the SRS (Davis and Janecek 1997), and are selected and managed by the Savannah River Ecology Laboratory (SREL) (WSRC 1994). They serve as control areas, providing a context for comparisons with other areas on the SRS that may be affected by human activities. The set-asides are located in each of the major vegetation

communities characteristic of the SRS (DOE 2000b). The closest set-aside area to the proposed facilities is Set-Aside Area No. 13 (Organic Soils), located about 500 m (1,640 ft) northwest of the proposed facilities. Most of this 310.8-ha (767.3-acre) area is located on the north side of Upper Three Runs Creek. Set-Aside Area No. 15 (Whipple/Office of Health and Environmental Research [OHER] Study Site) is located about 1.8 km [1.1 mi] northeast of the proposed facilities, and three other set-asides (No. 1 [Field 3-412/Ellenton Bay], No. 6 [Beech-Hardwood Forest], and No. 14 [Mature Hardwood Forest]) are located more than 3.4 km (2.1 mi) southwest of the facility area. Upper Three Runs Creek borders or runs through these set-aside areas (Davis and Janecek 1997).

In June 1999, the DOE designated a 4,055-ha (10,012-acre) area of the SRS as a biological and wildlife refuge. This area, known as the Crackerneck Wildlife Management Area (WMA) and Ecological Preserve (Crackerneck WMA), is located in the western portion of the SRS. It is bordered by a narrow buffer zone along South Carolina State Route 125 and by Upper Three Runs Creek. The South Carolina Department of Natural Resources (SCDNR) manages this area (DOE 2000b).

Currently, nearly 90% of the land (72,900 ha [180,000 acres]) at the SRS is forested with upland pine, hardwood, mixed (pine and hardwood), and bottomland hardwood forests. The major upland and wetland forest types at the SRS (including major species and coverage) are listed in Table 3.5. Pine forests cover about 65% of the upland areas of the SRS (DOE 1999). These pine forests are managed by the U.S. Forest Service and have displaced much of the upland hardwood communities (DOE 1991a). Natural resource management is actively practiced on more than 80% of the SRS, including about 73,710 ha (182,000 acres) of commercial forests and 4,860 ha (12,000 acres) of nonforest lands (DOE 2000b; WSRC 1994).

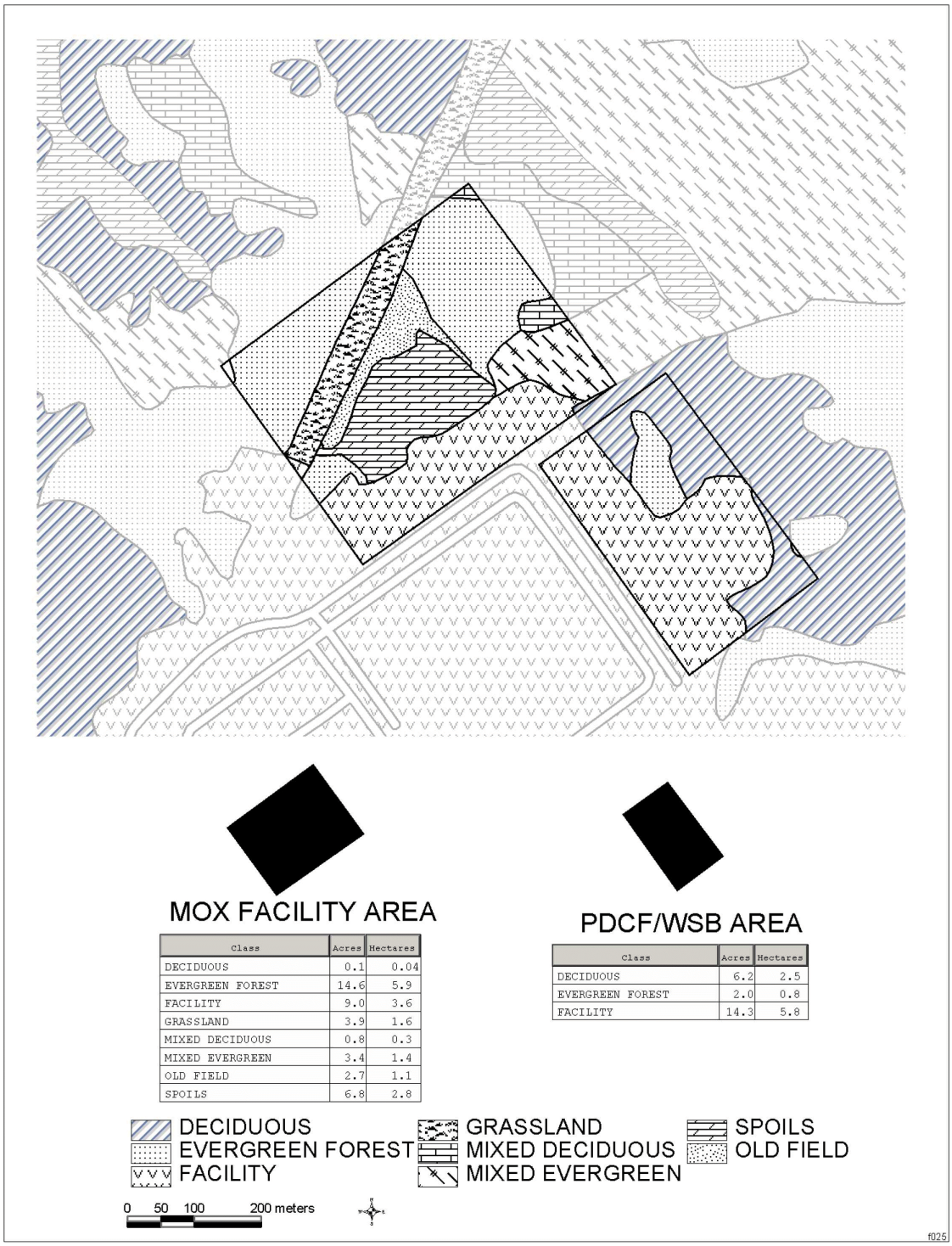
Approximately 5% of land at the SRS is developed with industrial and transportation infrastructure and grassland, old fields, or shrub vegetation (WSRC 1994). This land is generally classified as “facility.” The industrial and transportation development includes administrative and production facilities, electrical substations, roads, and railroads and occupies about 1,587 ha (3,919 acres). Vegetated areas associated with the developed areas are actively maintained (lawns and landscaped areas). These associated vegetated areas occur primarily on power line rights-of-way, roadsides, some borrow pits, some burial sites, and in forest openings and occupy about 1,345 ha (3,322 acres) (DOE 2000b). Unless managed, most scrub-shrub areas will develop into forest within 5 to 10 years (WSRC 1994). The vegetated areas also include permanent upland meadows, scrub-shrub areas, and SRS wildlife food plots. Controlled burns of 6,075 to 7,290 ha (15,000 to 18,000 acres) of pine-dominated uplands are conducted annually to reduce flammable materials and to enhance the development of fire-tolerant plant communities and improve wildlife habitat. Additionally, improved planting techniques and seedling survival have resulted in conversion of significant areas of loblolly and slash pine forests to young longleaf pine forests over the past 10 years (DOE 2000b).

Table 3.5. Major forest types at the SRS

Forest type	Canopy species	Midstory species	Coverage [hectares (acres)]
Upland Forests			
Dry longleaf pine-scrub oak	Longleaf pine (sparse)	Oaks, black cherry, common persimmon (continuous)	3,058 (7,551)
Longleaf pine	Longleaf pine, loblolly pine, water oak	Black cherry, common persimmon, sand hickory, sassafras, water oak	15,533 (38,353)
Mixed yellow pine	Loblolly, slash and/or longleaf pines	American holly, black cherry, common persimmon, sand hickory, sassafras, water oak, sweetgum, red maple, redbay, sweetbay magnolia	27,020 (66,716)
Southern mixed hardwood	Oaks (white, scarlet, laurel, post, southern red, turkey, bluejack, blackjack), hickories (mockernut, pignut), yellow poplar, blackgum, red maple, sweetgum, white ash, pines (loblolly, longleaf)	Sparkleberry, vaccinium, American holly, black cherry, mockernut hickory, white ash, sassafras, dogwood, Georgia hackberry	12,805 (31,618)
Wetland Forests			
Bottomland	Oaks (water, laurel, overcup, willow), southern magnolia, sweetgum, elms (American, winged), red maple, yellow poplar, river birch, tag alder, waxmyrtle, loblolly pine	American holly, redbay, sweetbay magnolia, ironwood, southern hackberry, red buckeye, honeysuckle	12,531 (30,941)
Southern swamp	Bald cypress, water tupelo, sweetgum	Ashes (water, red), sourgum, red maple, American elm	4,285 (10,581)
Total:			75,232 (185,760)

Sources: DOE (1991a, 2000b); Workman and McLeod (1990); WSRC (1994).

Habitats in the 16.7-ha (41.3-acre) area proposed for the MOX facility include pine (or evergreen) forest (5.9 ha [14.6 acres]), mixed pine (combination of both pine and deciduous [hardwood] species, with pine trees predominant) (1.4 ha [3.4 acres]), mixed deciduous (0.3 ha [0.8 acre]), grassland (1.6 ha [3.9 acres]), “facility” (developed) (3.6 ha [9.0 acres]), old field (fields formerly used for agriculture but now undergoing natural succession) (1.1 ha [2.7 acres]), spoils (2.8 ha [6.8 acres]), and deciduous (hardwood trees, essentially the southern mixed hardwood forest type of Table 3.5) (0.04 ha [0.1 acre]) (see Figure 3.7). The grassland habitat occurs within the transmission line right-of-way that crosses the proposed MOX site. The spoils habitat originated from the excavation for the Actinide Packaging and Storage Facility (APSF) in the F-Area. Although soil was excavated, the APSF was not



Class	Acres	Hectares
DECIDUOUS	0.1	0.04
EVERGREEN FOREST	14.6	5.9
FACILITY	9.0	3.6
GRASSLAND	3.9	1.6
MIXED DECIDUOUS	0.8	0.3
MIXED EVERGREEN	3.4	1.4
OLD FIELD	2.7	1.1
SPOILS	6.8	2.8

Class	Acres	Hectares
DECIDUOUS	6.2	2.5
EVERGREEN FOREST	2.0	0.8
FACILITY	14.3	5.8

Figure 3.7 Current land cover in the area of the project site.

constructed. This area is covered primarily with various grass and forb species. The standard seed mixture used to establish a plant cover on such areas includes grass and forb species such as unhulled and hulled common Bermuda grass, browntop millet, and unscarified Appalachian lespedeza (Bowling 2001).

Habitats in the 9.1-ha (22.5-acre) area proposed for the PDCF and WSB include pine forest (0.8 ha [2.0 acres]), deciduous (2.5 ha [6.2 acres]), and facility (5.8 ha [14.3 acres]) (see Figure 3.7).

Forested and facilities areas primarily surround the immediate project area (see Figure 3.7). The forested areas are dominated by loblolly pine with some mixed hardwoods (e.g., sweetgum, turkey oak, and water oak). The sparse understory and shrub layers consist of sparkleberry, dogwood, jasmine, and wax myrtle. Also present are areas dominated by a closed canopy of longleaf pine with sweetgum and willow oak as minor components. Vegetation along the unnamed tributaries to Upper Three Runs Creek include loblolly pine, sweetgum, red oak, and sycamore in the canopy, with black cherry, dogwood, and young individuals of the canopy tree species in the understory (Wike and Nelson 2000). The grassland habitat associated with the transmission line also occurs in this area. The Old F-Area Seepage Basin area located west of the proposed MOX facility site also contains a vegetated cover similar to that over the spoils area within the proposed MOX facility site.

3.5.1.2 Wildlife

Among the numerous wildlife species reported from the SRS are 44 species of amphibians, 59 species of reptiles, 258 species of birds, and 54 species of mammals. The SRS has among the highest biodiversity of herpetofauna (reptiles and amphibians) in the United States because of the area's warm, moist climate and its wide variety of habitats (DOE 2000b). Snakes that could occur in the project area include eastern hognose snake, eastern garter snake, eastern coachwhip, scarlet king snake, rat snake, corn snake, and pine snake. Lizards could include the green anole, southern fence lizard, several species of skinks, and the eastern glass lizard. Amphibians could include the southern toad and oak toad. The southern leopard frog, bullfrog, and other frogs and toads could occur in the small drainage basins near the site, while amphibians such as tree frogs and salamanders could occur within the unnamed tributary to Upper Three Runs Creek (Conant 1958; Mayer and Wike 1997).

Bird species at the SRS that are very common to abundant include black vulture, eastern kingbird, acadian flycatcher, common crow, northern mockingbird, blue-gray gnatcatcher, ruby-crowned kinglet, red-eyed vireo, northern parula, black-throated warbler, ovenbird, northern cardinal, savannah sparrow, white-throated sparrow, and song sparrow (WSRC 1994). As many as 17,000 ducks and coots are winter migrants at the SRS. Most of these congregate on Par Pond, L Lake, and other large ponds and Carolina bays (DOE 1991a). Wood ducks are the only waterfowl species that commonly breed on the SRS (WSRC 1994). Several mammal species can be found in old field/clearcuts, pine plantations, and scrub oak/longleaf pine habitats (these are the generalized habitat types that occur within the vicinity of the facilities). These species include southern short-tailed shrew, Virginia opossum, golden mouse, oldfield

mouse, raccoon, eastern cottontail, and white-tailed deer. Other mammals that can occur within two of these habitat types include least shrew, striped skunk, raccoon, eastern harvest mouse, gray and fox squirrels, southeastern shrew, spotted skunk, feral hog, and gray fox. Several bat species also occur in one or more of these habitats (WSRC 1994).

Populations of white-tailed deer, feral hogs, and beaver are controlled through selective harvest strategies (DOE 2000b), which has included public hunts for white-tailed deer and feral hogs (Noah 1995; DOE 1996). The deer herd is estimated at about 3,000, with harvests averaging about 1,580 animals per hunting season. The feral hog population now exceeds 2,500 (DOE 2000b). The feral hogs originated from free-ranging domestic swine abandoned after resident farmers were relocated in 1952. They now occur over about 70% of the SRS (WSRC 1994). The hogs are trapped wherever they are found. Beavers are trapped where they compromise the safety or operations of roads, railroads, culverts, or research plots, or where they are causing significant resource damage. Increasing numbers of coyotes and armadillos may require the SRS to initiate control measures for these species in the future (DOE 2000b). Other commercial and recreational wildlife resources at the SRS are not exploited over most of the SRS because of restricted access and safety concerns. These species include bobcat, gray and red fox, mink, muskrat, Virginia opossum, river otter, eastern cottontail, raccoon, fox and gray squirrels, waterfowl, northern bobwhite, mourning dove, wild turkey, common snipe, and American woodcock (WSRC 1994). Hunting has been allowed for most of these species (except for bobcat, foxes, river otter, and fox squirrel) at the Crackerneck WMA (SCDNR 2000/2001). However, since late September 2001, hunting has been closed to the general public in this area. A controlled hunt was later allowed to help regulate the SRS deer herd.

The developed areas of the SRS include buildings, parking lots, infrastructure, and landscaped areas. Nevertheless, a number of wildlife species have been reported from these areas. A total of 43 species have been reported from the F-Area, including four species of amphibians, 12 species of reptiles, 18 species of birds, and 9 species of mammals. Several bird species are abundant: rock dove, common crow, northern mockingbird, American robin, and European starling. Common mammals include Virginia opossum, eastern cottontail, house mouse, feral cat, striped skunk, and raccoon. The densities of most wildlife species are higher in undeveloped areas then in developed areas. Exceptions include the house sparrow, house finch, rock dove, house mouse, Norway rat, and feral cat. Nevertheless, the use of developed areas of the SRS by wildlife is more common than previously reported, and these areas can be expected to contribute to the site's environmental diversity (Mayer and Wike 1997).

3.5.2 Aquatic

Six major streams and several associated tributaries flow through the SRS, and the Savannah River bounds the southwestern border of the SRS. More than 50 man-made ponds also occur at the SRS (DOE 1999). The two largest are L Lake (405 ha [1,000 acres]), which discharges into Steel Creek, and Par Pond (1,069 ha [2,640 acres]), which discharges into Lower Three Runs Creek (Section 3.3.1). These lakes do not have any direct interactions with the F-Area. Altogether, about 2,000 ha (4,940 acres) of open water occurs at the SRS (WSRC 1994).

At least 81 fish species have been identified at the SRS (DOE 2000b). Sport and commercial fishing on the SRS is allowed only within the Crackerneck WMA. Extensive fishing also occurs in the Savannah River. Commercial fish species include the American shad, hickory shad, and striped bass. Recreational species include largemouth bass, chain pickerel, crappie, bream, sunfish, and catfish (DOE 1996; WSRC 1994, 1997b). The man-made ponds support populations of bass and sunfish (DOE 1999).

Some SRS surface waters are classified as Category I resources. These waters are defined by the U.S. Department of the Interior as unique and irreplaceable on a national or eco-regional basis. These areas would include Carolina bays and cypress-tupelo swamps. Any surface waters supporting species of concern and areas containing high-quality wetlands or headwater streams (e.g., portions of Upper Three Runs Creek) would also be considered for Category I status (DOE 2000b).

The F-Area is drained by Upper Three Runs Creek and Fourmile Branch (see Figure 3.3). Upper Three Runs Creek is the most pristine stream at the SRS and would be considered a Category I resource. It contains more than 550 species of aquatic insects and supports about 60 fish species. The more abundant fish species include bowfin, American eel, redfin pickerel, dusky shiner, yellowfin shiner, coastal shiner, flat bullhead, tadpole madtom, mosquitofish, redbreast sunfish, warmouth, spotted sunfish, and blackbanded darter. More than 10 other fish species are common in Upper Three Runs Creek (Bennett and McFarlane 1983). Upper Three Runs Creek is an important spawning area for blueback herring and provides seasonal nursery habitat for American shad, striped bass, and other Savannah River species (DOE 1999). This stream also appears to be an important spawning site for the spotted sucker (WSRC 1994).

About 48 fish species have been collected from Fourmile Branch. Those in the stream's lower reaches include species common to the Savannah River. The only abundant fish species collected from Fourmile Branch are mosquitofish, redbreast sunfish, and spotted sunfish. Common species include longnose gar, bowfin, golden shiner, bluehead chub, creek chub, creek chubsucker, pirate perch, and brook silverside (Bennett and McFarlane 1983).

Water bodies in the vicinity of the proposed facilities include unnamed tributaries to Upper Three Runs Creek (see Figure 3.3) and small drainages and detention basins associated with permitted discharge outfalls. Macroinvertebrate (e.g., aquatic insects, snails, clams, and worms) and fish surveys indicate that Upper Three Runs Creek is unaffected by SRS NPDES-permitted discharges (Specht and Paller 2001).

3.5.3 Wetlands

More than 20% of the SRS consists of wetlands, including open waters. Most wetlands on the SRS are associated with floodplains, streams, and impoundments. Wetland types on the SRS include bottomland hardwoods, southern swamp (cypress-tupelo), freshwater marshes, and

Carolina bays. Areal coverage of forested wetlands is given in Table 3.5. The freshwater marshes total 1,380 ha (3,407 acres), and the Carolina bays total about 785 ha (1,939 acres) (DOE 2000b). The conditions of many wetlands at the SRS are similar to conditions that existed before the government assumed control of the site, except for those wetlands along stream corridors and adjacent portions of the Savannah River swamp that were degraded by thermal releases from reactor operations. These areas have been recovering since cessation of cooling water releases (WSRC 1994).

Wetlands

Wetlands are areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions.

Over 300 Carolina bays (closed depressions capable of holding water) occur on the SRS (DOE 2000b). Carolina bays are characterized by their elliptical or ovoid shape, with a northwest/southeast orientation of their long axis (WSRC 1994). The Carolina bays on the SRS have remained largely undisturbed since 1950 and thus are valuable examples of these regional wetlands (Schalles et al. 1989). The median size of the Carolina bays is about 0.8 ha (2.0 acres), and only 15 exceed 4 ha (10 acres). The Carolina bays have characteristics similar to other wetlands (e.g., shallow marshes, herbaceous bogs, shrub bogs, or swamp forests). They also have a xeric to hydric (dry to moist) gradient from their peripheral sand rim to the center depression (Schalles et al. 1989). More than 135 species of plants have been identified from these wetlands. Most are dominated by grasses and sedges (Schalles et al. 1989; WSRC 1994). Amphibians are the most prevalent vertebrates that utilize the Carolina bays, but many reptiles, birds, and mammals also have been observed at these wetlands (Schalles et al. 1989). Less than 20 of the Carolina bays contain permanent fish populations. Fish species include redfin pickerel, mud sunfish, lake chubsucker, and mosquito fish (DOE 1999). An accelerated program has been initiated at the SRS to restore impacted Carolina bays (DOE 2000b). No Carolina bays occur near the facility sites.

No wetlands occur on the proposed facility sites. Wetland habitat does occur along the unnamed tributary to Upper Three Runs Creek located near the eastern border of the proposed facility site (see Figure 3.3). The dominant species of vegetation in this wetland are yellow poplar, laurel oak, red maple, red bay, and cherrybark oak. Maiden cane also occurs near the wetland boundary (Wike and Nelson 2000).

3.5.4 Protected Species

Table A.1 (Appendix A) lists the threatened, endangered, and other special status species that may be found in the vicinity of the SRS. Appendix A also discusses the federally and state-endangered red-cockaded woodpecker (*Picoides borealis*), which receives special attention at the SRS.

Protected Species

Endangered species. Any species in danger of extinction throughout all or a significant portion of its range.

Threatened species. Any species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

No federal- or state-listed wildlife species have been reported from the project area, but several species may exist in the general vicinity. The American alligator (*Alligator mississippiensis*) is federally threatened (by virtue of its similarity to the endangered American crocodile). While it is fairly common at the SRS, it has only been recently observed near the F-Area, and its occurrence there is considered uncommon. The federally threatened (state-endangered) bald eagle (*Haliaeetus leucocephalus*) actively nests in the Pen Branch area and in an area south of Par Pond. These areas are 14 km (8.7 mi) and 12 km (7.5 mi) southwest and southeast of the project area, respectively. The closest nesting area of the federally and state-endangered red-cockaded woodpecker to the proposed facility site is about 5 km (3.1 mi) away. The proposed area for the facilities does not occur within red-cockaded woodpecker management areas (see Appendix A). However, all areas containing pines, including those at the proposed sites, provide suitable forage areas for this species. The federally and state-endangered wood stork (*Mycteria americana*) has been observed near the Fourmile Branch delta, about 21 km (13 mi) from the proposed site. The federally endangered (state-endangered) shortnose sturgeon (*Acipenser brevirostrum*) occurs in the Savannah River as far upstream as the SRS.

Walk-through surveys did not reveal any federal- or state-listed wildlife species within the facility area (USFS 2000). However, suitable habitat exists for two bat species: *Myotis lucifugus* and *Myotis austroriparius*. Both species could roost in nearby F-Area facilities and forage throughout the area. The common ground dove (*Columbia passerina*), Bachman's sparrow (*Aimophila aestivalis*), and loggerhead shrike (*Lanius ludovicianus*) are adapted to open meadow and shrubby meadow habitats such as those that occur throughout F-Area. The eastern woodrat (*Neotoma floridana*) could inhabit the transitional areas between the hardwood forest and F-Area facilities, and the moist stream bottom area is suitable for the star-nosed mole (*Condylura cristata*). The upland pine and pine-oak ridge habitats are highly suitable for the southern hognose snake (*Heterodon simus*) and pine snake (*Pituophis melanoleucus*) (USFS 2000). The American sandburrowing mayfly (*Dolania americana*) is a relatively common aquatic insect in Upper Three Runs Creek (WSRC 1994). This species was formerly a candidate species for federal listing.

More than 1,300 species of plants occur at the SRS (WSRC 1994); however, only 53 species are considered to be sensitive, as determined by state, federal, and global ratings. The smooth coneflower (*Echinacea laevigata*) is the only federally listed (endangered) plant species at the SRS; it is also state endangered. Smooth coneflowers inhabit roadsides and open, sunny areas. The collection of plants from natural populations was a significant factor in the endangerment of the species (Arnold et al. 1998). Three populations of the smooth coneflower occur at the SRS. Activities near these known populations are highly restricted (DOE 2000b).

Nearly 300 populations of other sensitive plant species occur at the SRS (DOE 2000b). Included are three populations of the state-listed (species of concern) Oconee azalea (*Rhododendron flammeum*) that have been found along the steep slopes adjacent to the Upper Three Runs Creek floodplain in an area northwest of F-Area (DOE 1999).

Walk-through surveys of the proposed MOX facility site in October 1998 and March 2000 did not reveal any populations of the smooth coneflower (USFS 2000). Because this species is adapted to meadow and open forest habitats, the project area appears to be too disturbed or

shady for the coneflower's establishment and successful survival. The survey did indicate that suitable habitat for several rare plant species exists in areas adjacent to the survey site. The hardwood slope provides habitat suitable for Indian-olive (*Nestronia umbellata*), oconee azalea, striped garlic (*Allium cuthbertii*), and Chapman's sedge (*Carex chapmanii*). The moist bottom and lower slope sections are suitable for green-fringed orchid (*Habenaria lacera*), Carolina trillium (*Trillium pusillum*), large-whorled pogonia (*Isotria verticillata*), and two-wing silverbell (*Halesia diptera*). The upland pine and pine-oak ridge areas are suitable for lance-leaf false-indigo (*Baptisia lanceolata*), blue false-indigo (*Baptisia australis*), and milk-vetch (*Astragalus villosus*) (USFS 2000).

3.6 Land Use

This section briefly describes land use patterns on and around the SRS. Land use is a classification of parcels of land relative to their suitability for or the actual presence of human activities (e.g., industry, agriculture, recreation, etc.) and natural uses. Natural resource attributes and other environmental characteristics could make a site more suitable for some land uses than for others. Changes in land use may have both beneficial and adverse effects on other resources (e.g., ecological, cultural, geological, and hydrological).

3.6.1 Savannah River Site Land Use

Existing land use at the SRS can be characterized into three main categories: (1) undeveloped/ forest, (2) wetlands/water, and (3) developed. Approximately 73% of the SRS is undeveloped; 22% consists of wetlands, streams, and lakes; and 5% is developed (e.g., facilities, roads, and utility corridors). The forested areas are managed for timber production. The U.S. Forest Service, under an interagency agreement with DOE, harvests approximately 7.3 km^2 (2.8 mi^2) of timber from the SRS each year. Prime farmland soils exist at the SRS, but areas of prime farmland are not identified within the SRS because the land is not available for agricultural activities (DCS 2002). A portion of the SRS is open for fishing, as discussed below for the Crackerneck WMA. Since late September 2001, hunting has been closed to the general public in this area. A limited hunting period was later allowed to control the SRS deer herd.

As discussed in the previous section, the SRS has been designated a National Environmental Research Park by DOE. The scientific community can use the site to study the impacts of human activity on cypress swamp and hardwood forest ecosystems. Approximately 57 km^2 (22 mi^2) of land is set aside at the SRS for nondestructive environmental research (DOE 1999).

The F-Area is generally classified by the SRS land use plan as developed; some areas within F-Area are classified as industrial or heavy industrial.

Future land use at the SRS is determined by the DOE through site development, land use, and future planning processes (DCS 2002). SRS planners have developed a land use zone planning model for the site that is consistent with their past support of a multiple-use planning concept where compatible. Three principal planning zones have been established: Site

Industrial, Site Industrial Support, and General Support. The *SRS Long Range Comprehensive Plan* includes the construction and operation of the proposed facilities as part of the plan for its Nuclear Materials Stewardship mission (DOE 2000b). New missions for the SRS in the 21st Century, as stated in the *Savannah River Site Strategic Plan*, include the construction and operation of new facilities for tritium extraction and the storage and disposal of surplus plutonium. In addition to these new facilities, the SRS plans to play an increased role in the advancement of nuclear materials protection, control, and accounting (DOE 2000a).

3.6.2 Off-Site Land Use

Predominant regional land uses in the vicinity of the SRS include urban and residential, industrial, agricultural, and recreational areas. Forest and agricultural land predominantly border the SRS, with only limited urban and residential development. The nearest residences are located to the west, north, and northeast, some within 60 m (200 ft) of the SRS boundary. Farming is diversified throughout the region and includes such crops as peaches, watermelon, cotton, soybeans, corn, and small grains. Incorporated and industrial areas are also present near the site, including textile mills, polystyrene foam and paper plants, chemical processing plants, and a commercial nuclear power plant. Open water and nonforested wetlands occur along the Savannah River Valley. Recreational areas within 80 km (50 mi) of the SRS include Sumter National Forest, Santee National Wildlife Refuge, and Clark's Hill/Strom Thurmond Reservoir. State, county, and local parks include Redcliffe Plantation, Rivers Bridge, Barnwell and Aiken County State Parks in South Carolina, and Mistletoe State Park in Georgia. The Crackerneck Wildlife Management Area, which includes a portion of the SRS along the Savannah River, is open to the public for fishing (DOE 1999).

3.7 Cultural and Paleontological Resources

Cultural and Paleontological Resources

Cultural resources include archaeological sites, historic structures and features, and traditional cultural properties.

Paleontological resources are the fossil remains of past life forms.

Cultural resources include archaeological sites and historic structures and features that are protected under the National Historic Preservation Act of 1966, as amended. Cultural resources also include traditional cultural properties that are important to a community's practices and beliefs and that are necessary to maintain the community's cultural identity. Cultural resources that meet the eligibility criteria for listing on the *National Register of Historic Places* (NRHP) are considered "significant" resources and must be taken into consideration during the planning of federal projects. Federal agencies are also required to consider the effects of their actions on sites, areas, or other resources (e.g., plants) that are of religious significance to Native Americans as established under the American Indian Religious Freedom Act. Native American graves and burial grounds are protected by the Native American Graves Protection and Repatriation Act.

Paleontological resources are the fossil remains of past life forms. Paleontological resources with significant research potential are protected under the Antiquities Act.

3.7.1 Archaeological Resources

The Savannah River Archaeological Research Program (SRARP) of the South Carolina Institute of Archaeology and Anthropology, University of South Carolina, has been conducting archaeological investigations at the SRS since 1973 (SRARP 1989). The SRARP prepared an archaeological resource management plan for the SRS in 1989. The purpose of the plan is to provide the DOE with a means of addressing future archaeological resource management needs at the SRS and to establish a series of research directions to facilitate better management of these resources. The SRS currently manages its archaeological resources under the terms of a 1990 Programmatic Agreement among the DOE Savannah River Operations Office, the South Carolina State Historic Preservation Officer (SCSHPO), and the Advisory Council on Historic Preservation.

Over a period of more than 25 years, members of the SRARP have been very active in recording more than 850 archaeological sites at the SRS.[7] Although most of these sites have not been formally evaluated for eligibility for listing on the NRHP, 67 sites have been identified as potentially eligible (DOE 1999). In general terms, prehistoric sites within the SRS consist of village sites, base camps, limited-activity sites, quarries, and workshops. Nearly 800 prehistoric sites have been recorded at the SRS (DCS 2002). As detailed below, several prehistoric sites have been recorded within or near the proposed facilities. Two prehistoric sites within the footprints of the proposed facilities and their associated grading area have been determined to be eligible for listing on the NRHP.

Historic sites at the SRS include farmsteads, tenant dwellings, mills, plantations, slave quarters, rice farm dikes, dams, cattle pens, ferry locations, churches, schools, towns, cemeteries, commercial buildings, and roads. About 400 historic sites have been recorded to date at the SRS (DOE 1999). No historic sites have been recorded within the vicinity of the proposed facilities.

Archaeological surveys have been conducted in the F-Area in the vicinity of the proposed facilities. Fifteen prehistoric sites have been identified. Nine of these sites were recorded during 1993 and 1994 (Cabak et al. 1996). Four sites were recorded during SRS surveys conducted between 1973 and 1977 (Hanson et al. 1978). One site was recorded in 1983 (as cited in Cabak et al. 1996), and the remaining site was recorded in a 1999 survey covering unsurveyed lands remaining for the proposed location of the surplus plutonium disposition facilities (King and Stephenson 2000).

Four sites are located within the area of direct project disturbance. Two of the four prehistoric sites (38AK546/547 and 38AK757) are eligible for listing on the NRHP. Site 38AK546/547 is

[7] Of the 850 plus sites that have been recorded at the SRS, some are prehistoric, some are historic, and some have both a prehistoric and historic component. For this reason, the sum of prehistoric sites plus historic sites is much greater than the approximate total of 850 sites.

eligible because of its potential to provide significant information about the prehistory of the Aiken Plateau, in particular the use of ridge slope settings during the Early Mississippian period (King and Stephenson 2000). Site 38AK757 is located within the boundary of the proposed PDCF facility and is important for learning more about the use of upland settings by prehistoric inhabitants of the area during the Mississippian Period (King and Stephenson 2000). Two sites within the area of the proposed MOX facility, 38AK330 and 38AK548, were determined not eligible in consultation with the SCSHPO, and no further work is required for these two sites (Green 2000, as cited in DCS 2002).

Eleven prehistoric sites are located near the proposed facilities. Five of those sites (38AK106, 38AK155, 38AK563, 38AK564, and 38AK581) have been recommended eligible for listing on the NRHP. Site 38AK106 has been recommended eligible on the basis of its integrity, high density of artifacts, and research potential for providing information on the Early Archaic, Early Woodland, and Late Woodland time periods. Site 38AK155 is eligible because of its potential to yield important information on subsistence strategies and the use of upland streamside settings between 3000 B.C. and A.D. 1450 (between the Late Archaic and Early Mississippian periods). Site 38AK563 is important because it contains cultural deposits ranging from the Early Archaic Period through the Late Woodland Period and has the potential to provide information on the changes in human use of the floodplain over a considerable time range. Site 38AK564 has been recommended eligible because it contains stratigraphically[8] separated evidence of site use from the Early Archaic and Late Archaic/Early Woodland time periods. Site 38AK581 contains evidence of numerous occupations by prehistoric people during the Woodland Period. The site has been recommended eligible on the basis that these various occupations appear in a well-defined stratigraphic sequence and potentially contain important information about changes that occurred during that time period (Cabak et al. 1996).

Date Ranges of Prehistoric Time Periods Used by Archaeologists at the SRS

Mississippian	A.D. 1100 – 1450
Late Woodland	A.D. 500 – 1100
Middle Woodland	600 B.C. – A.D. 500
Early Woodland	1,000 B.C. – 600 B.C.
Late Archaic	3,000 B.C. – 1,000 B.C.
Middle Archaic	6,000 B.C. – 3,000 B.C.
Early Archaic	8,000 B.C. – 6,000 B.C.

Source: SRARP (1989).

3.7.2 Historic Structures

No architectural inventories have been conducted to date at the SRS. The SRS has a number of nuclear production facilities, including facilities important to tritium and plutonium production, that may have historic value as related to events during the Cold War. Construction of the F-Area began in 1951 under the Atomic Energy Commission. The F-Area was historically used for plutonium recovery during DOE's plutonium production phase (DCS 2002). The areas of

[8] Archaeologists look at the position of artifacts relative to layers of soil and other artifacts to help determine sequences of events. Objects found closer to the surface of an undisturbed site were deposited more recently than objects found below them (i.e., an archaeologist would expect to find Woodland Period artifacts in one or more layers of soil above Archaic Period artifacts in a stratigraphically preserved site).

construction for the proposed facilities do not contain structures. No existing buildings within the F-Area have been identified for reuse, modification, or demolition related to MOX facility activities.

3.7.3 Traditional Cultural Properties

Traditional cultural properties are places and resources important to traditional American cultures, which include, but are not restricted to, Native American cultures. Village sites, ceremonial locations, burials, cemeteries, and natural areas containing important resources, such as traditional plants, are typical types of properties of concern to Native American cultures. Properties of traditional value to immigrant groups (e.g., from Europe and Africa), such as cemeteries, also can be considered as traditional cultural properties. Native American groups with traditional ties to the area include the Apalachee, Cherokee, Chicksaw, Creek, Shawnee, Westo, and Yuchi (DCS 2002). Many of these groups were relocated to the Oklahoma Territory in the 1800s. However, issues related to the American Indian Religious Freedom Act have surfaced within the central Savannah River valley. Native American representatives have expressed concern over traditional plant resources that could exist at the SRS (DOE 1991b; DCS 2002). None of the identified plant resources is currently known to exist in the F-Area. Consultations with appropriate Native American Tribes, Bands, and Nations are underway regarding the proposed MOX facility (Appendix B).

3.7.4 Paleontological Resources

While some fossil-bearing strata are known to exist at the SRS, none are known within the F-Area. Paleontological resources that have been recorded within the SRS area mostly date to 54 to 39 million years ago during the Eocene Age. Those resources include fossil plants, invertebrate fossils, giant oysters, other mollusks, and bryozoa. Most known paleontological resources in the area are considered common and of low research potential (DOE 1999). The discovery of paleontological resources within the area of the proposed facilities is not anticipated.

3.8 Infrastructure

This section briefly describes the existing infrastructure of the SRS as it pertains to the proposed action. Site infrastructure includes utilities, roads, and railroads needed to support construction and operation of the facilities. A detailed discussion of the SRS infrastructure is provided in the DOE Surplus Plutonium Disposition EIS (DOE 1999).

3.8.1 Electricity

The SRS uses a 115-kV power line system in a ring arrangement to supply electricity to the operations areas. Power is supplied by three transmission lines from the South Carolina Electric and Gas Company. The F-Area receives power from the 200-F power loop supplied by the 251-F electrical substation. The current F-Area power consumption rate is about 63,000 MWh/yr; the F-Area total capacity is about 700,000 MWh/yr (DCS 2002). The total SRS usage of electrical power is 370,000 MWh/yr out of a site capacity of 4,400,000 MWh/yr.

3.8.2 Water

Domestic water supplies at the SRS come from a system composed of several wells and water treatment plants. The system includes three wells and a water treatment plant in the A-Area and two wells and a backup water treatment plant in the B-Area. A 43-km (27-mi) piping loop provides domestic water from the A- and B-Areas to other SRS operations areas, including the F-Area (DCS 2002). Current domestic water usage in F-Area is 378 million L/yr (100 million gal/yr) compared with a capacity of 890 million L/yr (235 million gal/yr).

Within F-Area, four deep groundwater wells are used for process water. Pumping capacities for these wells range from 1,500 to 3,800 L/min (400 to 1,000 gpm), and they extract groundwater from the Crouch Branch Aquifer. Two of these wells were formerly used for domestic water supply. The current annual groundwater use at F-Area is 1.4 billion L (370 million gal) (DCS 2002). The estimated capacity of the wells in F-Area is about 4.2 billion L/yr (1.1 billion gal/yr).

3.8.3 Fuel

Coal and oil are used at the SRS to power steam plants located in A-, D-, H- and K-Areas. The produced steam is distributed across the site in an aboveground pipeline distribution system. Coal is delivered by rail and is stored at coal piles in A-, D-, and H-Areas. Number 2 grade fuel oil is delivered by truck and is used in the K-Area. Natural gas is not used at the SRS.

3.8.4 Roads and Railroads

Vehicular access to the SRS is provided by South Carolina State Routes (SRs) 19, 64, and 125 and U.S. Highways 78 and 278 (DCS 2002). The SRS has 230 km (143 mi) of roads to handle transportation needs within the site (see Figure 3.8).

Three road projects are planned in the region to alleviate traffic congestion in the SRS area. The first project would widen SR 302 from U.S. 78 and provide new segments that would extend the route to SR 19. A second project is planned to extend Interstate Highway 520 (I-520) southwest of the SRS across SRs 126 and 125 and U.S. 1 before crossing the

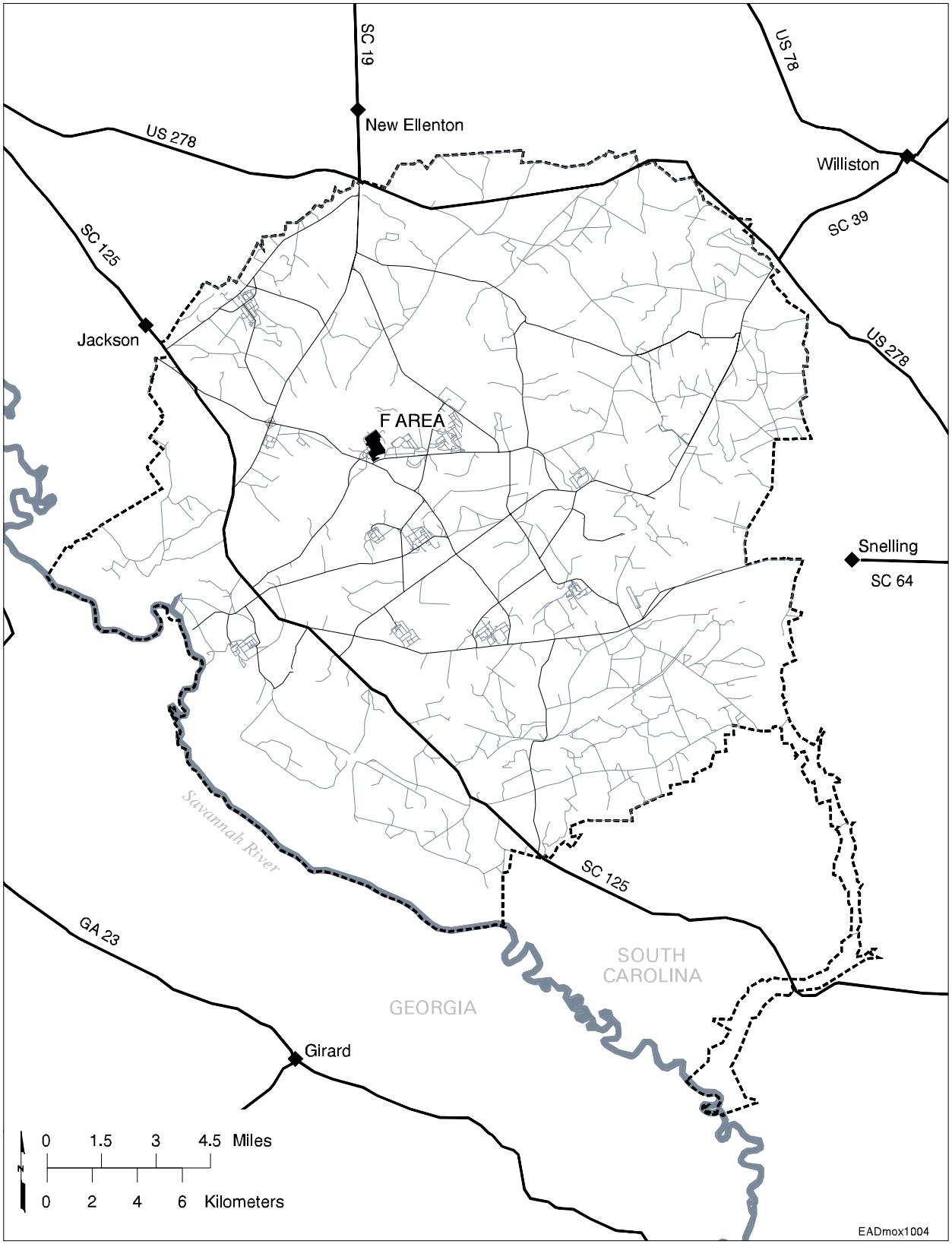


Figure 3.8. Roadways in the vicinity of the SRS.

Savannah River to connect with the Bobby Jones Expressway in Georgia to complete a loop around Augusta. The third improvement project may not be completed before the start of the MOX facility construction. It involves the completion of SR 118 that will add new segments to complete a by-pass around the city of Aiken (DCS 2002).

Railroad infrastructure at the SRS consists of 103 km (64 mi) of track for deliveries of coal and large structural components (DOE 1999). Rail service to the SRS is provided by the Norfolk Southern Corporation and CSX Transportation.

3.8.5 Site Safety Services

The SRS provides a fire department with facilities at three locations, using 12-hour shifts to provide continuous fire protection. The firefighters and officers are members of the SRS Hazardous Materials Response and Rescue Team. The Fire Department is supported by a fleet of 20 vehicles. The fleet includes six pumpers, a pumper-tanker, a tanker, and an aerial platform ladder truck (DCS 2002). Other emergency vehicles include a light-duty rescue vehicle, a mini-pumper for grass fires, an emergency response vehicle, a step van and trailer for hazardous materials response, and two boats for waterway spill response and control (DOE 1999).

The SRS has an integrated site emergency response organization. This organization provides infrastructure to support all SRS operations, local South Carolina and Georgia emergency response teams, and national or international emergency response teams when necessary.

3.9 Waste Management

This section discusses the waste management process that is in place at the SRS. This information would serve as the baseline for determining any additional impacts to waste management systems at the SRS from facility construction and operations. Human health impacts of current waste management practices are included in the discussion of SRS emissions presented in Section 3.10. Potential human health impacts from wastes generated by the proposed action are addressed in Section 4.3.1.

Current waste generation rates and inventories at the SRS are presented in Table 3.6. Waste management practices at the SRS include minimization, characterization, treatment, storage, transportation, and disposal of waste generated from ongoing site activities. Waste minimization at the SRS is accomplished through source reduction, recycling, and employee participation in pollution prevention programs. Total solid waste volumes have decreased by 70% since 1991.

The types of waste currently managed at the SRS are high-level waste (HLW), transuranic (TRU) waste, mixed TRU waste, low-level waste (LLW), mixed LLW, hazardous waste, and nonhazardous waste. The first five types contain radioactive material. Of the seven waste types currently managed at the SRS, HLW would not be generated by the proposed MOX

Table 3.6. Current waste generation rates and inventories at the SRS[a]

Waste type	Generation rate (m^3/yr)	Inventory[b] (m^3)
TRU[c]		
Contact handled	171	6,034
Remotely handled	0.6	1
LLW	8,195	1,616[d]
Mixed LLW		
RCRA	61	7,717
TSCA[e]	<1	3
Hazardous	74	1,416
Nonhazardous		
Liquid	416,100	NA[f]
Solid	6,670	NA

[a]Sources for estimates presented in this table are: DOE (1997) for TRU waste, LLW, and mixed LLW; DOE (1996) for hazardous and nonhazardous solid waste; and Sessions (1997) for nonhazardous liquid waste.

[b]Inventory projections were as of end of fiscal year 1996 for those presented in DOE (1997).

[c]Includes mixed TRU waste.

[d]LLW is disposed of on-site at the SRS. The estimated inventory shown is less than the generation rate (for FY1996) because it represents only LLW that had not been disposed of as of the end of FY 1996.

[e]TSCA = Toxic Substances Control Act.

[f]NA = not applicable; nonhazardous wastes are not held in long-term storage.

facility, the PDCF, or the WSB. The proposed MOX facility would generate a liquid high-alpha-activity waste that would be further processed, resulting in the generation of TRU waste and LLW (DCS 2002).

The TRU wastes generated at the SRS include contaminated equipment, protective clothing, and tools. Most of these wastes are stored on concrete pads that are not covered with soil. TRU waste generated before 1986 is stored on five concrete pads and one asphalt pad that have been covered with approximately 1.2 m (4 ft) of soil. TRU waste generated since 1986 is stored on 13 concrete pads that are not covered with soil. These storage pads are located in the Low-Level Radioactive Waste Disposal Facility, which is located in E-Area (DOE 1995). In 1996, it was decided to vent and purge all buried drums; this process was completed in 1999

(Arnett and Mamatey 2000b). A facility to prepare TRU waste for treatment and to certify TRU waste for disposal at the Waste Isolation Pilot Plant (WIPP) is planned. In the interim, drums that are certified for shipment to WIPP will be stored on concrete pads in E-Area.

Liquid and solid LLW types are treated at the SRS. Aqueous LLW streams undergo filtration, reverse osmosis, and ion exchange at the F- and H-Area effluent treatment facility to remove the radionuclide contaminants. The treated effluent is discharged to Upper Three Runs Creek.

Waste Types

Transuranic (TRU) waste: Refers to radioactive waste that contains more than 100 nanocuries per gram (nCi/g) of alpha-emitting isotopes with atomic numbers greater than 92 and half-lives greater than 20 years. Such waste results primarily from the fabrication of plutonium weapons and plutonium-bearing reactor fuel. Generally, little or no shielding is required.

Low-level waste (LLW): Refers to radioactive waste that is not classified as HLW, TRU, or SNF.

Hazardous waste: Refers to nonradioactive waste materials defined by the Resource Conservation and Recovery Act (RCRA) as hazardous wastes. These wastes are considered to pose potential hazard to human health when improperly treated, stored, disposed of, or otherwise managed because of their quantity, concentration, and physical and chemical characteristics. (Note: hazardous waste mixed with low-level [radioactive] waste or TRU waste is referred to as mixed low-level waste or mixed TRU waste, respectively.)

Treatment residuals are eventually immobilized with grout for on-site disposal. Solid LLW is categorized into four groups: low-activity wastes (those that radiate less than 0.002 Sv/h [200 mrem/h] at 5.1 cm [2 in.] from the unshielded container); intermediate-activity wastes (those that radiate greater than 0.002 Sv/h [200 mrem/h] at 5.1 cm [2 in.]); intermediate-activity tritium waste (intermediate-activity waste with more than 3.7×10^{11} Bq [10 Ci] of tritium per container); and long-lived waste (waste contaminated with long-lived isotopes that exceed the waste acceptance criteria [WAC] for on-site disposal) (DCS 2002). Wastes in the first three categories are stored and disposed of in vaults, and wastes in the fourth category are placed in a waste storage building until treatment and disposal technologies are developed. Located in the E-Area, the vaults are below-grade concrete structures, and the storage building is a metal structure on a concrete pad. Disposal facilities at the SRS are projected to meet solid LLW disposal capacity needs for the next 20 years.

Mixed LLW is stored in various tanks and buildings located in the A-, E-, M-, N-, and S-Areas of the SRS. The current mixed waste program at the SRS primarily involves the safe storage of these wastes until treatment and disposal facilities become available. A site treatment plan (WSRC 2000b) for mixed wastes has been developed, as required by the Federal Facility Compliance Act, that specifies treatment technologies or technology development schedules for all SRS mixed waste. During 1999, plans for all mixed LLW were met in accordance with the site treatment plan (Arnett and Mamatey 2000b).

Hazardous waste is managed at the SRS either by accumulating the waste at the generating facility for a maximum of 90 days or storing it in RCRA-permitted hazardous waste storage buildings or on interim storage pads located in the B- and N-Areas. Most of the waste is shipped off-site to commercial RCRA-permitted facilities. In 1999, 297 m^3 (10,490 ft^3) of

hazardous waste was shipped off-site to commercial disposal facilities (Arnett and Mamatey 2000b).

The treatment of nonhazardous wastewater at the SRS has been centralized since 1994 with the completion and operation of the 4.1 million-L/day (1.1 million-gal/day) Central Sanitary Wastewater Treatment Facility. This facility treats sanitary wastewater by an extended aeration activated sludge process that separates the wastewater into clarified effluent and sludge.

The collection, hauling, and disposal of solid sanitary waste at the SRS is privatized, and the waste is sent to the Three Rivers Landfill southwest of the B-Area. Other nonhazardous waste consists of scrap metal, powerhouse ash, domestic sewage, scrap wood, construction debris, and used railroad ties. These wastes are disposed of by means appropriate to their nature.

3.10 Human Health Risk

Human health can be adversely affected by radioactive and hazardous chemical contaminants in the environment. This section discusses how humans can become exposed to these materials, the potential effects of this exposure, potential human receptors considered in this EIS, and the existing conditions at the SRS and the surrounding area. Methods used to estimate the potential for injuries or fatalities among workers are also discussed.

3.10.1 Hazard Exposure Pathways

3.10.1.1 Pathways for Human Exposure to Radiation and Radioactivity

Radioactivity released from the SRS reaches the environment and people in a variety of ways. The routes that radioactive materials follow to get from an SRS facility to the environment and then to people are called pathways. The primary human exposure pathways for these releases are discussed below:

- *Inhalation exposure pathway*: Individuals in the path of airborne emissions would receive a dose from breathing in the radioactive material. Some of this material also deposits on the ground and over time may become resuspended in the air, at which time it may also be inhaled.

- *Direct radiation from contaminated soil:* Material that is deposited on the ground from passing airborne emissions becomes an external exposure source of direct radiation.

- *Immersion in radioactive clouds*: Individuals in the path of radioactive airborne emissions would receive an external dose during immersion in the passing “cloud” of material.

- *Ingestion exposure pathway*: Radioactive materials can be transported through a variety of routes into the human diet. Airborne radioactive material may deposit directly on food crops or animal feed crops, resulting in potential exposure from human ingestion of the food crops or indirectly from ingestion of contaminated animal products. Material deposited on farmland may also be taken up through the roots by human and animal food crops. Material deposited on surface water or land may reach groundwater. Contaminated surface water or groundwater could be used for irrigating crops or direct consumption by humans. Contaminated surface water could also result in contamination of aquatic species, such as fish, which could subsequently be consumed by humans.

One important pathway of radioactive material released from the SRS in the form of particulate matter is the airborne pathway. After being discharged from a stack, the radioactive particulate matter will be carried by wind downwind of the facility, where it will either be inhaled by individuals or settle on the ground. Radioactivity in the soil will cause direct radiation exposures in individuals located near contaminated soil. Soil contamination may also be resuspended into the air by the wind and then inhaled farther downwind. Food produced on farmlands with contaminated soil will also contain this radioactivity. Precipitation runoff from downwind soil will carry radioactivity to local surface waters, such as lakes, rivers, and streams. Finally, radioactivity in surface water may accumulate in fish or other aquatic life that can be consumed by humans.

The DOE has determined the critical types of radioactivity and pathways for radioactive materials released from SRS operations. Tritium and cesium-137 are the primary contributors to doses to members of the public. The major pathways for tritium released into air were through breathing air and eating food, whereas the major pathway for tritium and cesium-137 released into site streams were through drinking river water and eating fish from the river (DOE 1999). Pathways or routes by which radioactive material moves through the environment to

Radiation and Radioactivity

Radioactivity or *radioactive decay* is the process by which unstable atoms emit *radiation* to reach a more stable state.

Radiation is the movement of energetic particles or waves through matter and space. Radiation comes from radioactive material or from equipment such as x-ray machines. Radiation may be either ionizing radiation or non-ionizing radiation.

Ionizing radiation is radiation that has enough energy to cause atoms to lose electrons and become ions. For example, the radioactive decay of plutonium produces radiation that can ionize matter (e.g., tissue).

Radiation dose is the quantity of radiation energy that is deposited in a material. The radiation dose to humans is measured in units of sieverts (Sv). The unit of rem is also used. One sievert is equal to 100 rem.

Collective dose is the sum of the individual doses received in a given period of time by a specified population. The unit of collective dose is person-sieverts, or person-rem.

reach humans can be complex. For example, contaminants can settle on grass that is eaten by cows that produce milk that is consumed by humans. The meat of the cows can also be consumed by humans. Another example, more relevant to the SRS, would be game animals that consume contaminated vegetation and then are eaten by humans. A detailed discussion of the many pathways at the SRS is presented in the annual environmental report (Arnett and Mamatey 2001b).

3.10.1.2 Pathways for Human Exposure to Chemicals

Humans can also be exposed to nonradioactive chemicals released to the environment. The DOE has determined that the critical chemicals among those released from SRS operations to the environment are arsenic and benzene (Arnett and Mamatey 2000b). Exposures may occur primarily through inhaling pollutants released to air, drinking contaminated groundwater or surface water, ingesting contaminants in foodstuffs grown in contaminated soil or irrigated with contaminated groundwater, or ingesting contaminated soil.

3.10.1.3 Physical Hazards

Although not attributable to releases of contaminants to the environment, there is a risk of injuries and fatalities from physical hazards for construction and operation workers at any facility. The U.S. Bureau of Labor keeps statistics on the annual number of injuries and fatalities by industry type. Where possible, these statistics have been used to estimate the extent of physical hazard risk for the no-action and proposed action alternatives.

3.10.2 Receptors

Effects of radiation and chemical exposures for the no-action and proposed action alternatives during normal operations were estimated by first calculating the doses to relevant receptors. The analyses considered three groups of people: (1) members of the public, (2) SRS employees, and (3) facility workers. For purposes of this DEIS, these three groups are defined as follows:

- *Members of the Public:* Individuals who live and work outside the SRS within 80 km (50 mi) of the proposed facilities:
  - Might be exposed to trace amounts of radioactive materials released to the environment through exhaust stacks.
  - Could receive radiation and chemical exposures primarily through inhalation of material in the air, external radiation from deposited radioactive material, and ingestion of contaminated food.

- *SRS Employees:* Individuals employed at the SRS who are not workers at the proposed MOX facility, the PDCF, or the WSB. SRS employees include those workers assigned radiological work at other nuclear facilities within the SRS boundary, as well as those who are not assigned radiological work, such as cafeteria workers or persons in administrative positions:

  - Might be exposed to direct radiation from radioactive materials (although at a great distance) and to trace amounts of plutonium or uranium released to the environment through site exhaust stacks.

  - Could receive radiation and chemical exposures primarily through inhalation of material in the air and external radiation from radioactive material deposited on the ground.

  - Work-related physical hazard risks are present.

  - Estimate of impacts to transient population groups (soda machine vendors, etc.) are bounded by impacts to this group.

- *Facility Workers:* Individuals who work at the proposed MOX facility, the PDCF, or the WSB and who receive a radiation dose in the course of employment in which the assigned duties of the individuals involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation:

  - Might be exposed to direct gamma radiation emitted from radioactive materials, such as depleted uranium compounds.

  - Could receive small radiation doses from inhaling uranium, plutonium, or other radionuclides compared with the direct radiation doses resulting from enclosed processes; ventilation controls would be used to inhibit airborne emissions in facilities.

  - Would be protected by a dosimetry program to control doses below the maximum regulatory limit of 0.05 Sv/yr (5 rem/yr) for workers (10 CFR 20.1201).

  - For chemical exposures, facility workers are addressed under separate regulations (e.g., Occupational Safety and Health Act [OSHA]); their exposures are not quantitatively addressed in this DEIS. However, physical hazards (i.e., risks of injury and fatality) are addressed for both construction and operations workers.

Impacts to a maximally exposed individual (MEI) were also evaluated. The MEI is a hypothetical person who, because of proximity, activities, or living habits, could receive the highest possible dose of radiation or of a hazardous chemical from a given event or process. For members of the public, potential locations for an MEI would be at the site boundary, the closest possible public access points near the operations under consideration. For SRS employees not directly

involved in facility operations, MEI locations are considered at distances of 100 m (330 ft) or more from a facility. An MEI for radiation exposure is not always considered for facility workers because these workers are monitored, and their exposure is expected to be kept as low as reasonably achievable (ALARA), with workers being rotated into and out of relatively higher exposure job functions. In such cases, an average worker dose was estimated.

3.10.3 Baseline Radiological Dose and Risk

The radiological baseline in the vicinity of the SRS includes background radiation, man-made (anthropogenic) sources, and radiation from ongoing SRS operations. Background radiation comes from natural sources, such as cosmic radiation and naturally occurring radioactive material, and from anthropogenic sources that cannot be controlled, such as global fallout from nuclear testing or nuclear accidents. Anthropogenic sources, including consumer products (e.g. television sets and smoke detectors) and medical procedures, account for additional exposure. Human exposure to radiation is measured in units of sieverts (Sv). Background radiation levels result in a national annual average individual exposure of approximately 3.0 mSv (300 mrem), with an additional 0.60 mSv (60 mrem) from other anthropogenic sources. A more detailed breakdown of these sources is presented in Table 3.7.

What Is a Sievert?

A sievert is a unit of radiation dose. The effects of radiation exposure on humans depend on the kind of radiation received, the total amount absorbed by the body, and the tissues involved. A sievert (Sv) is calculated by a formula that takes these three factors into account. Another common unit of radiation dose is the rem (1 Sv = 100 rem). The U.S. average individual radiation dose is about 0.0036 Sv (0.36 rem) or 3.6 millisievert (mSv) [360 millirem (mrem)] from natural background and anthropogenic sources.

Radiation from SRS operations is estimated by analyzing monitoring data. The SRS has an extensive radiological monitoring network both on- and off-site to assess the effects of site operations on air, surface water, groundwater, soil, terrestrial and aquatic food products, and local game animals. These routine environmental surveillance activities include monitoring airborne and liquid effluent discharges from their points of origin at each operating facility on the SRS to determine compliance with applicable exposure standards. The results of the effluent monitoring and environmental surveillance and the potential radiation doses to members of the public in surrounding areas from those effluents are published annually by the Environmental Monitoring Section of Westinghouse Savannah River Company (e.g., Arnett and Mamatey 2001b).

Airborne emissions from the SRS operations for 2000 are summarized in Table 3.8. Liquid releases for 2000 are summarized in Table 3.9. The estimated off-site radiation doses from both airborne and liquid releases were below all applicable radiation exposure standards for humans and aquatic organisms (Arnett and Mamatey 2001b). The estimated exposures and the applicable standard for each exposure are summarized in Table 3.10. The estimated all-pathway dose to an MEI was 0.0018 mSv (0.18 mrem), which is 0.18% of the DOE's 1.0 mSv (100-mrem) all-pathway dose standard for annual exposure. For an NRC-licensed facility, such

Latent Cancer Fatality (LCF)

What it is: The primary adverse health effect from the low-level radiation doses received from proposed MOX facility, PDCF, or WSB operations and potential accidents would be the possible induction of latent cancer fatalities (LCFs). LCFs are a measure of the expected number of additional cancer deaths in a population (or people dying of cancer) as a result of exposure to radiation. Death from cancer induced by exposure to radiation may occur at any time after the exposure takes place. However, latent cancers would be expected to occur in a population from one year to many years after the exposure takes place. To place the significance of these additional LCF risks from exposure to radiation into context, the average individual has approximately 1 chance in 4 of dying from cancer (LCF risk of 0.25).

How it is calculated: The U.S. Environmental Protection Agency has suggested (Eckerman et al. 1999) a conversion factor that for every 100 person-Sv (10,000 person-rem) of collective dose, approximately 6 individuals would ultimately develop a radiologically induced cancer. If this conversion factor is multiplied by the individual dose, the result is the individual increased lifetime probability of developing an LCF. For example, if an individual receives a dose of 0.00033 Sv (0.033 rem), that individual's LCF risk over a lifetime is estimated to be 2×10^{-5}. This risk corresponds to a 1 in 50,000 chance of developing a LCF during that individual's lifetime. If the conversion factor is multiplied by the collective (population) dose, the result is the number of excess LCFs. Because these results are statistical estimates, values for expected LCFs can be, and often are, less than 1.0 for cases involving low doses or small population groups. If a population group collectively receives a dose of 50 Sv (5,000 rem), which would be expressed as a collective dose of 50 person-Sv (5,000 person-rem), the number of potential LCFs experienced from within the exposure group is 3. If the number of LCFs estimated is less than 0.5, on average, no LCFs would be expected.

Table 3.7. Sources and contributions to the U.S. average individual radiation dose[a]

Source	Effective dose equivalent [mSv/yr (mrem/yr)]
Natural background radiation	
Cosmic radiation	0.27 (27)
Rocks and soil (external)	0.28 (28)
Internal to body	0.40 (40)
Radon (internal/inhalation)	2.0 (200)
Subtotal	≈2.95 (≈295)
Man-made background radiation	
Weapons test fallout	<0.01 (<1)
Consumer products	0.10 (10)
Medical	
Diagnostic X-rays	0.39 (39)
Nuclear Medicine	0.14 (14)
Subtotal	≈0.64 (≈64)
Total	≈3.60 (≈360)

[a]*Source*: Modified from Arnett and Mamatey (2001b) and NCRP (1987).

Table 3.8. Radioactive atmospheric releases from SRS operations for 2000

Radionuclide	Curies[a]	Radionuclide	Curies[a]
Gases and Vapors		***Particulates (cont.)***	
H-3 (oxide)	3.24×10^{4}	Eu-152	4.13×10^{-5}
H-3 (elem.)	1.24×10^{4}	Eu-154	1.64×10^{-5}
H-3 total	4.48×10^{4}	Eu-155	4.02×10^{-6}
C-14	1.33×10^{-1}	Hg-203	2.23×10^{-10}
Kr-85	5.28×10^{4}	Ra-226	1.74×10^{-5}
I-129	1.71×10^{-3}	Ra-228	2.74×10^{-5}
I-131	6.96×10^{-6}	Ac-228	1.80×10^{-6}
I-133	1.18×10^{-4}	Th-228	5.76×10^{-7}
		Th-230	1.74×10^{-5}
Particulates		Th-232	2.58×10^{-6}
Cr-51	1.21×10^{-4}	Th-234	1.04×10^{-4}
Co-57	3.26×10^{-7}	Ba-133	5.4×10^{-10}
Co-58	1.27×10^{-4}	U-233	1.50×10^{-8}
Co-60	8.60×10^{-4}	U-234	3.98×10^{-4}
Ni-59	4.17×10^{-13}	U-235	1.80×10^{-5}
Ni-63	5.09×10^{-6}	U-236	4.16×10^{-11}
Zn-65	2.23×10^{-5}	U-238	5.20×10^{-4}
Sr-89,90	3.89×10^{-3}	Np-237	2.26×10^{-10}
Zr-95	1.68×10^{-5}	Pu-238	3.59×10^{-4}
Zr-85	1.07×10^{-9}	Pu-239	2.05×10^{-3}
Nb-94	3.95×10^{-10}	Pu-240	1.99×10^{-7}
Nb-95	1.13×10^{-4}	Pu-241	4.09×10^{-6}
Tc-99	8.75×10^{-5}	Pu-242	7.03×10^{-9}
Ru-103	4.23×10^{-5}	Am-241	1.46×10^{-4}
Ru-106	1.04×10^{-5}	Am-243	6.02×10^{-6}
Sb-124	5.63×10^{-10}	Cm-242	4.47×10^{-7}
Sb-125	5.34×10^{-5}	Cm-244	7.68×10^{-5}
Sn-113	6.20×10^{-10}	Cm-245	1.04×10^{-13}
Sn-126	6.45×10^{-14}	Cm-246	3.98×10^{-6}
Cs-134	1.31×10^{-4}	Ar-39	3.30×10^{-5}
Cs-137	8.15×10^{-3}	Na-22	7.90×10^{-11}
Ce-141	4.16×10^{-5}	Mn-54	1.30×10^{-10}
Ce-144	1.44×10^{-4}	Se-79	4.47×10^{-9}
Pa-233	2.23×10^{-10}		
Pr-144	3.68×10^{-13}	Alpha	7.35×10^{-4}
Pr-144m	4.43×10^{-15}	Beta-Gamma	3.57×10^{-2}
Pm-147	1.30×10^{-5}		

[a]One curie (Ci) equals 3.7×10^{10} becquerels (Bq). One Bq equals one disintegration per second (dps).

Source: Modified from Arnett and Mamatey (2001b).

Table 3.9. Radioactive liquid releases from SRS operations for 2000 (including direct and seepage basin migration releases)

Radionuclide	Curies[a]
H-3	5.34×10^{3}
Sr-90	5.44×10^{-2}
Co-60	1.62×10^{-3}
I-129	7.82×10^{-2}
Cs-137	8.81×10^{-2}
U-234	2.87×10^{-5}
U-235	6.18×10^{-6}
U-238	1.97×10^{-4}
Pu-238	2.21×10^{-5}
Pu-239	1.68×10^{-5}
Am-241	1.19×10^{-5}
Cm-244	7.01×10^{-6}
Alpha	1.96×10^{-2}
Beta-Gamma	4.44×10^{-2}

[a]One Ci equals 3.7×10^{10} Bq.

Source: Modified from Arnett and Mamatey (2001b).

as the proposed MOX facility, a dose limit of 1.0 mSv/yr (100 mrem/yr) from operations for an individual member of the public is also applicable (10 CFR Part 20.1301).

Workers at the SRS with the potential to be exposed to external radiation or to inhale airborne radioactivity take part in a monitoring program in accordance with 10 CFR 835 ("Occupational Radiation Protection"). In 2000, 3,382 SRS workers had a measurable dose with a combined total effective dose equivalent (TEDE) of 1.632 person-sievert (person-Sv) (163.2 person-rem) for an average TEDE of 0.00048 Sv (0.048 rem) (DOE undated).

The risk associated with low-levels of radiation exposure is the development of cancer. A conservative assumption in this regard is that any amount of radiation may pose some risk for causing cancer and hereditary effect, and that the risk is higher for higher radiation exposures. A linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and the occurrence of cancer. This dose-response model suggests that any increase in dose, no matter how small, results in an incremental increase in risk. For the purposes of this DEIS, the risk of a latent cancer fatality (LCF) is taken to be 0.06 LCF per person-Sv (0.0006 LCF per person-rem). (See the text box on page 3-49 for a discussion on LCFs.) This LCF risk factor is a gender- and age-averaged value that accounts for differences between male and female receptors from infancy through old age living in the United States

Table 3.10. Estimated radiation exposures to the public from SRS emissions in 2000

Pathway/receptor	Dose	Standard
Air		
Maximally exposed individual [mSv (mrem)]	0.0004 (0.04)	0.10 (10)[a]
Collective population [person-Sv (person-rem)]	0.023 (2.3)	NA[b]
Liquid		
Maximally exposed individual [mSv (mrem)]	0.0014 (0.14)	0.04 (4)[c]
Collective population [person-Sv (person-rem)]	0.039 (3.9)	NA
Total		
Maximally exposed individual [mSv (mrem)]	0.0018 (0.18)[d]	1.0 (100)[e]
Collective population [person-Sv (person-rem)]	0.062 (6.2)[d]	NA

[a]Set by the EPA in "National Emission Standards for Hazardous Air Pollutants–Radionuclides," 40 CFR 61 Subpart H, December 15, 1989.

[b]NA = not applicable.

[c]Adopted from the EPA in DOE Order 5400.5 as set forth in "National Primary Drinking Water Standards," 40 CFR Part 141.11, July 9, 1976.

[d]Sum of the air and liquid pathways.

[e]All pathway dose standard from DOE Order 5400.5.

Source: Arnett and Mamatey (2001b).

(Eckerman et al. 1999). While female receptors were estimated to have a slightly higher LCF rate than males, and infants a higher LCF rate than adults, the use of this risk factor for estimating collective LCF risks to the public in this DEIS should provide a reasonable average based on current understanding of radiological effects in humans. On the other hand, the collective LCF risks to the facility workers and SRS employees evaluated in this EIS may be conservative (overestimated) because the more susceptible receptors, such as infants, considered in determining the LCF risk factor are not present in the SRS employee population.

3.10.4 Baseline Chemical Exposure and Risk

3.10.4.1 Chemical Risk Assessment Background

As stated in Section 3.10.2, human exposure to nonradioactive chemicals in air, water, or soil may occur through ingestion, inhalation, or contact with skin. Methods used to assess hazards associated with chemical exposures may simply involve a comparison of concentrations in air, water, or soil with health-risk based standards or guidelines available from state and federal agencies (see *SRS Baseline Risks* below). More detailed assessments estimate the extent of

human exposure due to a particular source and compare that exposure with benchmark levels for noncarcinogenic risks ("hazard index" approach) or benchmarks for carcinogenic risks.

In estimating either noncancer risks (that is, noncancer adverse health outcomes, such as liver damage or developmental impairment) due to chemical exposures or increased lifetime cancer risk, the first step is to estimate the chemical concentration in air, water, and/or soil, either present from natural sources or attributable to anthropogenic sources. The concentration estimate is combined with an estimate of the human intake level to produce a chemical-specific daily intake estimate. (The intake level is usually from the upper end of the expected range of

Concepts in Estimating Risks from Exposures to Chemicals in Air, Water, and Soil

Reference Dose: Intake level of a chemical that is very unlikely to have noncancer adverse effects; measured in units of milligrams per kilogram of body weight per day (mg/kg-d).

Hazard Quotient: a comparison of the estimated intake level or dose of a chemical in air, water, or soil with its reference dose; expressed as a ratio.

Example: If 5 parts per billion (0.005 mg/L) benzene is in groundwater used for drinking and 2 L is ingested daily by a 70-kg (150-lb) person over a period of 10 years, then
Intake = (0.005 mg/L × 2 L/day)/70 kg = 0.00014 mg/kg-d
The reference dose for chronic ingestion of benzene is 0.0003 mg/kg-d.
The benzene hazard quotient is 0.00014/0.0003 = 0.5. This hazard quotient is less than 1, indicating that the exposure is unlikely to cause adverse noncancer health effects.

Hazard Index: The sum of hazard quotients for all chemicals to which an individual is exposed. Used as a screening tool, a hazard index of less than 1 indicates that adverse health effects are unlikely. However, a hazard index of greater than 1 does not necessarily mean adverse health effects will occur, because different chemicals may react differently in the human body (that is, they may have different, nonadditive kinds of toxicity).

Slope Factor: an upper-bound estimate of a chemical's probability of causing cancer over a 70-year lifetime, based on the extent of intake during the exposure period and given in units of inverse intake [$(mg/kg\text{-}d)^{-1}$ or 1/(mg/kg-d)]. For a carcinogen, different slope factors often apply for oral and inhalation exposures.

Increased Lifetime Cancer Risk: an upper-bound estimate of the likelihood that an individual will develop cancer as a result of exposure to a cancer-causing chemical. It is the product of the intake level and the slope factor.

Example: benzene is also a cancer-causing chemical with an oral slope factor of up to 0.055 $(mg/kg\text{-}d)^{-1}$.

Assuming 5 parts per billion (0.005 mg/L) in water and calculating intake as above, but averaging over a lifetime of 70 years, the increased lifetime cancer risk for benzene ingestion would be:

0.00014 mg/kg-d x 0.055 $(mg/kg\text{-}d)^{-1}$ x 10-yr exposure/70-yr lifetime = 0.0000011 (also can be stated as 1.1×10^{-6} or 1.1 in 1 million).

This increased risk level would be considered to be negligible. It is at the lower end of the risk range of 0.000001 (10^{-6}, or 1 in 1 million) to 0.0001 (10^{-4}, or 1 in 10,000) which generally does not require mitigating actions.

possible intakes in order to make sure risk estimates take individuals who have unusually high intakes into account). Estimated intakes are compared with chemical-specific reference doses or cancer slope factors. The reference doses and cancer slope factors are developed by the EPA for many commonly used chemicals and are based on a broad range of toxicological data. See the text box for further information on risk estimation procedures.

3.10.4.2 SRS Chemical Baseline Risks

Public water supplies in the vicinity of the SRS are monitored and regulated to be in compliance with health-based federal standards, and remediation programs are underway at the SRS to control exposure to and eliminate areas of soil contamination. Therefore, the most important potential exposure pathway for workers and the general public would be through inhalation of contaminants released to air from ongoing SRS operations.

The SRS has approximately 200 regulated sources of air emissions. In 1991, the SCDHEC established Air Pollution Control Regulation 61-62.5, Standard No. 8, to regulate hazardous or toxic air pollutant emissions. To demonstrate compliance with this standard, the SRS completed an air emissions inventory and air dispersion modeling for all site sources in 1993, as summarized in Arnett and Mamatey (2001b). An update to the modeling was submitted in 1998 (Dukes 1998). The modeling effort provides estimates of maximum ambient concentrations at the SRS boundary due to SRS emission sources for about 200 toxic or hazardous air pollutants. The estimated maximum concentrations of the toxic air pollutants generally did not exceed SCDHEC standards. A few exceeded a zero standard, albeit with very low estimated ambient concentrations (see Table 3.11) (Dukes 1998).

To assess the potential for adverse human health impacts from ongoing SRS operations, the reported maximum ambient concentration estimates were also compared with health risk-based air concentrations developed by the EPA's Office of Air Quality Planning and Standards (OAQPS) (Smith et al. 1999). The modeled maximum ambient concentrations of several toxic pollutants exceeded or approached the health risk-based concentrations (see Table 3.11). It should be noted that these modeled exceedances may not be indicative of actual ambient concentrations, because the modeling effort assumed maximum permitted emission levels rather than actual emissions. However, emissions of the pollutants listed in Table 3.11 may require further investigation by the SRS to determine that ambient levels are not of concern with respect to human health impacts.

3.10.5 Baseline Physical Hazard Risks

Although worker physical hazard risks (i.e., risks of fatality or injury from on-the-job accidents) can be minimized when workers adhere to safety standards and use protective equipment as necessary, certain rates of accidents have been associated with all types of work. Risks can be calculated on the basis of historical industrywide statistics, as described below.

Table 3.11. Modeled site boundary ambient concentrations of select SRS toxic air pollutant (TAP) emissions in comparison with SCDHEC standards and EPA health risk-based guideline levels

Toxic air pollutant (TAP)	Number of SRS sources	SRS maximum modeled ambient concentration ($\mu g/m^3$)	SCDHEC standard ($\mu g/m^3$)	EPA guideline level ($\mu g/m^3$)[a]
TAPs with ambient level exceeding SCDHEC standard or EPA guideline level				
Arsenic	7	0.05	1.0	0.00023-0.023
Bis(chloromethyl)ether	1	0.002	0.03	2×10^{-5} to 2×10^{-3}
Hydrazine	5	0.06	0.5	0.0002-0.02
Manganese compounds	5	0.1	25	0.05
Nickel	75	0.48	0.50	0.2
Nitrogen mustard	1	0.00002	0	NA
Nitrophenol (p-)	3	0.002	0	NA
Nitrosophenol (p-)	3	0.00004	0	NA
TCDDs	1	0.00002	0	3×10^{-8} to 3×10^{-6}
Tetrachloroethylene	36	99	3,350	0.17-17
TAPs with ambient level between EPA Guideline 10^{-6} and 10^{-4} cancer risk level				
Benzene	118	4.6	150	0.13-13
Beryllium	7	0.009	0.01	0.00042-0.042
1,3-Butadiene	1	0.01	110.5	0.0036-0.36
Carbon tetrachloride	16	4.2	150	0.067-6.7
Chloroform	14	0.08	250	0.043-4.3
Dimethyl benzidine	1	0.002	NA	0.00038-0.038
Formaldehyde	15	0.15	7.5	0.077-7.7
Heptachlor	1	0.01	2.5	0.00077-0.077
Hexachlorobenzene	1	0.002	NA	0.0022-0.22
Methylene chloride	21	1.3	8,750	2.1-210
1,3-Propane sultone	1	0.004	NA	0.0014-0.14
Quinoline	1	0.004	NA	0.00029-0.029
2,4-Toluenediamine	1	0.004	NA	0.0009-0.09
Toxaphene	1	0.01	2.5	0.003-0.3
Trichloroethylene	38	23	6,750	0.5-50
TAPs with multiple sources and levels approaching EPA screening levels				
Hydrochloric acid	25	13.5	175	20
Mercury	88	0.033	0.25	0.3
Methyl-isobutyl ketone	25	11	2,050	80
Toluene	122	15	2,000	400
Xylene	119	69	4,350	430

[a]Where a range is given, the range corresponds to a 10^{-6} to 10^{-4} risk level (that is, the concentration that if inhaled for a lifetime would result in an increased individual risk of developing cancer of between 1 in 1 million and 1 in 10,000).

Sources: Dukes (1998); Smith et al. (1999, Table 2).

The expected annual numbers of worker fatalities and injuries for specific industry types are calculated on the basis of rate data from the Bureau of Labor Statistics, as reported by the National Safety Council (NSC 2001), and on the number of annual full-time equivalent (FTE) workers required for manufacturing activities. Employment at the SRS currently is 13,227 people (DCS 2001b). It is assumed that, in general, the types of activities required for these employees would be similar to those for the manufacturing industrial sector, so those fatality and injury rates are used to estimate annual risks. A rate of 3.3 fatalities per 100,000 FTEs and 4.6 injuries per 100 FTEs is used. On the basis of these rates, the estimated annual number of fatalities for SRS workers is less than 1 (specifically, 0.44) per year. The estimated number of injuries is 610 per year (includes only injuries resulting in lost workdays, not including the day of injury). These physical hazard risks represent the baseline risks for existing SRS operations.

3.11 Socioeconomics

This section discusses existing socioeconomic conditions in the vicinity of the SRS as they relate to the proposed facilities. The socioeconomic data presented for the SRS describe a regional economic area (REA) comprising 15 counties around the site (see Appendix D) and a region-of-influence (ROI) surrounding the site comprising 4 counties — Columbia and Richmond Counties in Georgia and Aiken and Barnwell Counties in South Carolina. The REA is used to assess the potential regional economic impacts of site activities, specifically impacts on employment and unemployment and on personal income. The REA constitutes a broad market area defined by economic linkages between the various sectors in the regional economy.

The ROI was defined on the basis of the current residential locations of full-time SRS workers directly involved in the SRS activities and encompasses the area in which most of these workers spend their wages and salaries. The ROI is used to assess the impacts of site activities on population, housing, community services, and community fiscal conditions. More than 90% of SRS workers currently reside in these counties (DCS 2001b). In the following sections, data are presented for each of the counties in the ROI.

3.11.1 Population

The population of the ROI was at 475,095 in 2000 (U.S. Bureau of the Census 2001) and was expected to reach 489,000 by 2001, as shown in Table 3.12. In 2000, 30% of the ROI total (142,552 people) resided in Aiken County (U.S. Bureau of the Census 2001), with 25,337 in the city of Aiken. Over the period 1990-2000, population in the ROI as a whole, in Aiken County, and in the city of Aiken grew slightly, with average growth rates of 1.4%, 1.7%, and 2.5%, respectively. Over the same period, population in South Carolina as a whole grew at a rate of 1.4%.

Table 3.12. ROI population statistics for selected years

Entity	1990[a]	2000[a]	Average annual growth rate (%), 1990-2000	2002 (projected)
GEORGIA				
Columbia County	66,031	89,288	3.1	95,000
Richmond County/City of Augusta	189,719	195,182	0.3	196,000
SOUTH CAROLINA				
Aiken County	120,991	142,552	1.7	147,000
City of Aiken	19,872	25,337	2.5	27,000
Barnwell County	20,293	23,478	1.5	24,000
ROI TOTAL	415,394	475,095	1.4	489,000
Georgia	6,478,216	8,186,453	2.4	8,580,000
South Carolina	3,486,703	4,012,012	1.4	4,130,000

[a]*Source:* U.S. Bureau of the Census (2001).

In 2000, 41% of the ROI population (195,182 persons) resided in the city of Augusta/ Richmond County, Georgia, with 19% (89,288) located in Columbia County, Georgia, and 5% (23,478) in Barnwell County, South Carolina (U.S. Bureau of the Census 2000). Growth in Augusta/Richmond County over the period 1990-2000 was slight at 0.3%, relatively high in Columbia County over the same period at 3.1%, and moderate in Barnwell County at 1.5%. Other incorporated places in the immediate vicinity of the SRS are Barnwell (population 5,035 in 2000), Blackville (2,973), Elko (212), Hilda (436), Jackson (1,625), New Ellenton (2,250), North Augusta (17,574), and Willston (3,307) (U.S. Bureau of the Census 2000).

3.11.2 Employment and Unemployment

Employment in the REA totaled 207,660 people in 2000 and was expected to reach 214,000 in 2002. Employment grew at an annual average rate of 1.6% between 1990 and 2000 (U.S. Bureau of the Census 1992, 2002). The economy of the REA is dominated by the trade and service industries, with these activities currently contributing almost 63% of all employment in the REA (see Table 3.13). The manufacturing sector is also a significant employer in the REA, with 27% of total REA employment. Employment at the SRS currently is 13,227 people (DCS 2001b).

Unemployment in the REA steadily declined during the late 1990s from a peak rate of 8.0% in 1993 to the current rate of 5.7% (see Table 3.14) (U.S. Bureau of Labor Statistics 2002). Unemployment in Georgia is currently at 4.7%, and the current rate in South Carolina is 5.7%.

Table 3.13. REA employment by industry, 2000

Sector	Employment	Percent of REA total
Agriculture[a]	6,250	3.0
Mining	877	0.4
Construction	11,399	5.5
Manufacturing	55,853	27.0
Transportation and Public Utilities	5,028	2.4
Trade	34,389	17.0
Finance, Insurance and Real Estate	7,783	3.7
Services	86,673	42.0
Other	193	0.1
Total	207,660	

[a]1997 data; U.S. Department of Agriculture (1999).

Source: U.S. Bureau of the Census (2002), except as noted.

3.11.3 Income

Personal income in the REA was almost $14.3 billion in 2000 and was expected to reach $15.2 billion in 2002. Personal income grew at an annual average rate of 1.8% over the period 1990-1999 (see Table 3.15). Personal income per capita in the REA also rose in the 1990s and was expected to reach $24,700 in 2002, compared with $22,278 at the beginning of the period.

Table 3.14. REA unemployment rates

Period	Rate (%)
REA	
1990-2000 average	6.7
2002 (current rate)[a]	5.7
Georgia	
1990-2000 average	5.0
2002 (current rate)[b]	4.7
South Carolina	
1990-2000 average	5.4
2002 (current rate)[b]	5.7

[a]Rate is for July 2002.

[b]Rate is for August 2002.

Source: U.S. Bureau of Labor Statistics (2002).

3.11.4 Housing

Total housing in Columbia County grew at an annual rate of 3.5% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 35,400 in 2001, reflecting the relatively high growth in county population. About 9,580 new units were added to the existing housing stock in the county between 1990 and 2000. On the basis of annual population growth rates, there were expected to be 2,340 vacant housing units in the county in 2002, with 420 expected to be rental units available to construction workers at the proposed facilities.

Total housing in the City of Augusta/Richmond County grew at an annual rate of 0.6% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 82,800 in 2002, reflecting the relatively slow growth in county population. Only 5,000 new units were added to

Table 3.15. REA personal income (2001 dollars)

Parameter	1990[a]	2000[a]	Average annual growth rate (%), 1990-2000	2002 (projected)
Total personal income ($ millions)	11,960	14,258	1.8	15,200
Personal income per capita ($)	22,278	23,099	0.6	24,700

[a]*Source*: U.S. Department of Commerce (2002).

the existing housing stock in the county between 1990 and 2000. On the basis of annual population growth rates, there were projected to be 8,440 vacant housing units in the county in 2002, with 3,550 of those expected to be rental units available to construction workers at the proposed facilities.

Total housing in Aiken County grew at an annual rate of 2.3% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 64,100 in 2002. Growth in the city of Aiken was 2.9% over this period, with 11,900 total housing units expected in 2002. Almost 12,700 new units were added to the existing housing stock in the county between 1990 and 2000, 2,830 of which were built in the city of Aiken. On the basis of annual population growth rates, there were expected to be 6,610 vacant housing units in the county in 2002, with 1,610 expected to be rental units available to construction workers at the proposed facilities.

Total housing in Barnwell County grew at an annual rate of 2.6% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 10,500 in 2002, reflecting the moderate growth in county population. About 2,300 new units were added to the existing housing stock in the county between 1990 and 2000. On the basis of annual population growth rates, there were projected to be 1,210 vacant housing units in the county in 2002, with 300 of those expected to be rental units available to construction workers at the proposed facilities.

Total housing in the ROI as a whole grew at an annual rate of 1.8% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 202,000 in 2002. About 31,600 new units were added to the existing housing stock in the county between 1990 and 2000. On the basis of annual population growth rates, there were projected to be 19,600 vacant housing units in the county in 2002, with 5,910 of those expected to be rental units available to construction workers at the proposed facilities.

3.11.5 Community Resources

Construction and operation of the proposed MOX facility, PDCF, and WSB would result in increased revenues and expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues would come primarily from state and local sales taxes associated with employee spending during construction and operation and local property taxes.

Table 3.16. City, county, and ROI housing characteristics[a]

Parameter	1990[b]	2000[c]	2002
GEORGIA			
Columbia County			
Owner occupied	17,322	25,557	27,100
Rental	4,519	5,563	5,900
Total unoccupied units	1,904	2,201	2,340
Total units	23,745	33,321	35,400
Richmond County/City of Augusta			
Owner occupied	38,762	42,840	43,100
Rental	29,913	31,080	31,300
Total Unoccupied Units	8,613	8,392	8,440
Total units	77,288	82,312	82,800
SOUTH CAROLINA			
Aiken County			
Owner Occupied	33,491	42,036	43,400
Rental	11,392	13,551	14,000
Total Unoccupied Units	4,383	6,400	6,610
Total units	49,266	61,987	64,100
City of Aiken			
Owner Occupied	5,130	6,804	7,140
Rental	2,619	3,483	3,660
Total Unoccupied Units	794	1,086	1,140
Total units	8,543	11,373	11,900
Barnwell County			
Owner Occupied	5,194	6,810	7,010
Rental	1,906	2,211	2,280
Total Unoccupied Units	754	1,170	1,210
Total units	7,854	10,191	10,500
ROI TOTAL			
Owner Occupied	99,673	123,902	128,000
Rental	49,250	54,016	55,200
Total Unoccupied Units	16,520	19,116	19,600
Total units	165,443	197,034	202,000

[a]Column entries may not add up due to independent rounding.

[b]*Source*: *U.S.* Bureau of the Census (1994).

[c]*Source*: U.S. Bureau of the Census (2001).

Additional revenues would be used to support additional local community services currently provided by each jurisdiction.

Construction and operation of the proposed facilities would result in increased demand for community services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Additional demands would also be placed on local medical facilities and physician services.

Tables D.1 and D.2 in Appendix D present information on current revenues and expenditures by the various local government jurisdictions in the ROI. Tables 3.17 and 3.18 present data on current employment and levels of service (number of employees per 1,000 population) for public safety, general local government services, and physicians. Tables 3.19 and 3.20 provide current staffing data for school districts and hospitals.

3.11.6 Traffic

Vehicular access to the SRS is provided from State Routes (SRs) 19, 64, 125, 781, and U.S. Highway 278, as shown in Figures 3.1 and 3.8. Highway 19 runs north from the site through New Ellenton towards Aiken; SR 64 runs in an easterly direction from the site towards Barnwell; SR 125 runs through the site itself in a southeasterly direction between North Augusta and Allendale, passing through Beech Island and Jackson. U.S. 278 also runs through the site, in a southeasterly direction between North Augusta and Barnwell. SR 781 connects U.S. 278 with Willston to the northeast of the site. The northern perimeter of the site is about 16 km (10 mi) from downtown Aiken. Table 3.21 shows average annual daily traffic (AADT) flows over these road segments, together with congestion level designations (levels of service). Levels of service designations were developed by the Transportation Research Board (1985) and range from A to F. Designations A through C represent good traffic operating conditions with some minor delays experienced by motorists; F represents jammed roadway conditions.

3.12 Aesthetics

Natural and man-made features give a landscape character and aesthetic quality. The character of a landscape is determined by the elements of form, line, color, and texture; each may influence the character of a landscape to a varying degree. The stronger the influence of any one or all of these elements, and the more visual variety that can successfully coexist in the landscape, the more aesthetic quality present in the landscape

3.12.1 General Description of the Site

The viewshed within the vicinity of the SRS consists principally of agricultural and forested land, with some residential and industrial development. The landscape is characterized mainly by wetland or forest on low mountains and hills with intermittent open land. Vegetation consists of

Table 3.17. Local public service employment (2001)

Part A: Georgia

	Columbia County		Grovetown		Harlem	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	147	1.8	17	2.8	7	3.9
Fire protection[b]	3	0	4	0.7	1	0.6
General	435	5.3	33	5.4	14	7.7
Total	585	7.2	54	8.9	22	12.1

	Augusta-Richmond County		Blythe		Hephzibah	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	357	1.8	1	1.4	4	1.0
Fire protection[b]	283	1.4	0	0	7	1.8
General	1,673	8.6	1	1.4	4	1.0
Total	2,313	11.9	2	2.8	15	3.9

	State of Georgia level of service[a,c]
Police protection	2.4
Fire protection[b]	1.1
General	52.0
Total	55.4

Part B: South Carolina

	Aiken County		Aiken		Jackson	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	131	1.4	54	2.1	4	2.5
Fire protection[b]	78	0.8	-[d]	-[d]	-[d]	-[d]
General	60	0.6	239	9.4	7	4.3
Total	269	2.8	347	13.7	11	6.8

	New Ellenton		North Augusta		Wagener	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	4	1.8	48	2.7	3	3.5
Fire protection[b]	-[d]	-[d]	6	0.3	-[d]	-[d]
General	5	2.2	125	7.1	5	5.8
Total	9	4.0	179	10.2	8	9.3

Table 3.17. (Cont.)

	Barnwell County		Barnwell		Blackville	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	26	2.1	13	2.6	8	2.7
Fire protection[b]	-[d]	-[d]	3	0.6	1	0.3
General	150	12.3	22	4.4	11	3.7
Total	176	14.5	38	7.6	20	6.7

	Williston		State of South Carolina level of service[a,c]
	Number	Level of service[a]	
Police protection	9	2.7	2.5
Fire protection[b]	1	0.3	0.8
General	12	3.6	54.9
Total	22	6.7	58.2

[a]Level of service represents the number of employees per 1,000 persons in each jurisdiction.

[b]Does not include volunteers.

[c]2000 data.

[d]Police and fire services are provided by a combined department.

Sources: Aiken County: Powell (2001); Barnwell County: Aguilar (2001); Columbia County: J. Johnson (2001); Edgefield County: Harling (2001); Richmond County: Colliander (2001); City of Aiken: Rideout (2001); City of Jackson: S. Johnson (2001); Town of New Ellenton: Bledsoe (2001); City of North Augusta (2000); Town of Wagener: Salley (2001); City of Barnwell: Vargo (2001); Town of Blackville: McDonald (2001); Town of Williston: Fowler (2001); Town of Grovetown: Kent (2001) and Capatillo (2001); Town of Harlem: Moore (2001); City of Augusta (1999); Town of Blythe (2000); Town of Hephzibah (2000); U.S. Bureau of the Census (2000).

hardwood forests in the low-lying areas and wetland forests, with oak and pine forests on higher ground.

3.12.2 Description of the Location of the Proposed Facilities

Various concrete industrial buildings and other structures, administrative and support buildings, and parking areas are located within the F-Area at the SRS. The largest structures are approximately 30 m (100 ft) high, with some stacks and towers reaching 60 m (200 ft) high. All of the industrial and administrative areas are brightly lit at night and are visible when approached on SRS access roads. The industrial and other developed areas in the vicinity of F-Area, including utility corridors, are generally consistent with a Bureau of Land Management visual resource management (VRM) Class IV designation (activities that lead to major modification of the existing character of the landscape). The remainder of the site fits a VRM

Table 3.18. Local physicians data (1997)

County	Number of physicians	Level of service[a]
Georgia		
Columbia County	324	4.0
Richmond County	1,189	6.1
South Carolina		
Aiken County	190	1.4
Barnwell County	14	0.6

[a]Level of service represents the number of physicians per 1,000 persons in each county.

Source: American Medical Association (1999).

Table 3.19. Local school district data (2001)

School district	Number of teachers	Student-to-teacher ratio[a]
South Carolina		
Aiken County	1,486	17.0
Barnwell County		
School District 19	80	14.4
School District 29	70	14.9
School District 45	183	15.3
State total	44,967	15.2
Georgia		
Columbia County	1,064	17.0
Richmond County	2,200	16.0
State total	89,561	16.0

[a]The number of students per teacher in each school district.

Sources: Ferriter (2001); Georgia Department of Education (2000).

Table 3.20. Local medical facility data (2001)

Hospital	Number of staffed beds	Occupancy rate (%)[a]
Aiken Regional Medical Centers	245	56
Barnwell County Hospital	33	37
Georgia Regional Hospital at Augusta	196	79
Medical College of Georgia Hospital	446	56
Select Specialty Hospital	17	NA
St. Joseph Hospital	151	48
University Hospital	553	50
Walton Rehabilitation Institute	58	78
ROI Total	1,699	-

[a]Percent of staffed beds occupied.

Source: SMG Marketing Group Inc. (Copyright 2001, used with permission).

Table 3.21. Average annual daily traffic (AADT) in vicinity of the SRS (2000)

Road segment[a]	Traffic volume (AADT)	Level of service[b]
SR 125 in the vicinity of Jackson	13,400	B
U.S. 278 between SR 302 and Barnwell county line	5,400	A
SR 19 in the vicinity of New Ellenton	13,900	B
SR 781 between U.S. 278 and U.S. 78	2,700	A
U.S. 278 to SR 37	2,500	A
SR 64 between SR 20 and Barnwell	6,900	A
SR 125 between SR 17 and Martin	2,100	A

[a]SR = state route (highway); U.S. = U.S. highway.

[b]Level of service designations as developed by the Transportation Research Board (1985). Levels range from A to F, with A representing the best traffic operating conditions and F representing jammed roadway conditions.

Source: McCoy (2001), except as noted.

Class III (hosting activities which at most only moderately change the existing character of the landscape) or IV designation (DOI 1986a,b).

The closest publicly accessible viewing location is from State Highway 125, about 6 km (4 mi) to the southwest. Public view of F-Area is restricted by the heavily wooded terrain between Route 125 and the site.

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4 ENVIRONMENTAL CONSEQUENCES

4.1 Introduction

This draft environmental impact statement (DEIS) evaluates the potential impacts of the construction, operation, and decommissioning of the Mixed Oxide Fuel Fabrication Facility (the proposed MOX facility) proposed for construction at the Savannah River Site (SRS). Operation of the proposed MOX facility would also require the construction of two support facilities, the Pit Disassembly and Conversion Facility (PDCF) and the Waste Solidification Building (WSB).

Construction of the facilities would involve site preparation, including the clearing and grading of land, realignment of electrical utilities, and addition of access roads. After site preparation, the remaining construction activities would involve excavation for the foundation and erection of the buildings, connection of SRS utilities to the facilities, and final landscaping. Details of the construction and operational impacts are provided in Sections 4.3 and Appendix H. Operational impacts would include routine facility emissions, waste management, and potential accidents. The impacts of the transportation of the MOX feed materials, the fresh MOX fuel, and spent MOX fuel are discussed collectively with the transport of transuranic (TRU) waste generated by MOX fuel production in Section 4.4.

Once the fresh MOX fuel was manufactured and transported, it would be irradiated in authorized nuclear reactors as part of the power generation process. Following irradiation, the spent fuel would be temporarily stored at the reactor sites until shipped to a final disposal repository. The potential indirect impacts for the use of MOX fuel in a nuclear reactor are discussed in Section 4.4.

An initial evaluation of projected decommissioning impacts is provided in Section 4.3.6. However, the exact nature and scope of these impacts are uncertain because only present-day technologies are considered, and decommissioning of the facilities would occur well into the future.

In addition to considering the proposed action, this DEIS, in Section 4.2, considers the no-action alternative should the U.S. Nuclear Regulatory Commission (NRC) either not authorize construction of the proposed MOX facility, or not license its operation. Under the no-action alternative, the surplus plutonium would continue to be stored at its current storage locations.

As stated in Section 1.4.2, this chapter presents significant or more important environmental impacts of the proposed action and no-action alternative. Impacts considered to be less significant are presented in Appendixes G and H. The technical areas discussed in this chapter include human health, air quality, surface water and groundwater, waste management, and decommissioning. Impacts from potential accidents at the proposed MOX facility, the PDCF, and the WSB are discussed in Section 4.3.5. Environmental justice is discussed in detail in Section 4.3.7. In addition, transportation impacts are discussed in detail for the proposed action in Section 4.4.1.

Human health impacts include potential exposure to radiological and chemical materials via pathways associated with air, water, soil, and the food chain. Air quality impacts relate to compliance with National Ambient Air Quality Standards (NAAQS) from emissions of chemical pollutants. Surface and groundwater impacts relate to capacity effects from using these waters and to potential changes in quality of these waters. Waste management impacts relate to the types and quantities of both radiological, hazardous, and nonhazardous wastes generated and how those wastes would be handled. Generally technical terms used in this chapter are defined and discussed in Chapter 3. In those cases, the reader is referred back to specific areas of Chapter 3.

4.2 Impacts of the No-Action Alternative

4.2.1 Introduction

As described in Section 2.1, the no-action alternative would be a decision by the NRC not to approve the proposed MOX facility. If such a decision is made, the 34 MT (37.5 tons) of weapons-useable fissile nuclear materials would remain in storage at DOE sites. The impacts of the continued storage of surplus plutonium would be essentially the same as those discussed under the no-action alternative of the *Surplus Plutonium Disposition Final Environmental Impact Statement* (SPD EIS) (DOE 1999a, Section 4.2) and are summarized in the following sections.

It is possible that limited new construction would be required at one or more sites to upgrade surplus plutonium storage conditions. For example, previous analyses assumed that surplus pits[1] at the Pantex site in Texas would be moved from Zone 4 to Zone 12, but DOE decided to leave the surplus pits in Zone 4 for long-term storage (DOE 2002a). If new construction is required to accommodate continued storage, the impacts of that construction would be addressed under a separate environmental review required by the DOE regulations for implementation of the National Environmental Policy Act (NEPA) (*Code of Federal Regulations* Title 10, Part 1021 [10 CFR 1021]).

The SPD EIS discusses plans to build an Actinide Packaging and Storage Facility (APSF) at the SRS and to move SRS surplus plutonium to that facility for continued storage (DOE 1999a). After publication of the SPD EIS, the APSF project was canceled. Surplus plutonium at the SRS continues to be stored in existing facilities. It should also be noted that the potential impacts of construction and operation of the proposed MOX facility (as summarized in Section 4.3) would be avoided by implementation of the continued storage alternative. The impacts of continued storage are presented in the following sections.

The DOE is currently working to close the RFETS by the year 2006. Such a closure entails the shipment of all radioactive waste and special nuclear materials, including the surplus plutonium, to off-site locations. Storage of the RFETS surplus plutonium at other DOE sites currently

[1] A pit is the core element of a nuclear weapon's "primary" or fission component.

storing surplus plutonium is expected to result in a long-term reduction of radiological exposure to workers and the public. For example, approximately 6 MT (6.6 tons) of plutonium dioxide is expected to be shipped from the RFETS to the SRS (Roberson 2002). Storage of the additional plutonium material during normal operations was not estimated to result in any additional significant impacts to noninvolved workers and the public (DOE 2002c). The eventual removal and return of the shipping containers was estimated to result in a dose of no greater than 1 mrem/yr to an MEI of the public (DOE 2002c). Thus the cumulative risks from the no-action alternative presented in Table 4.1, which includes the RFETS, are expected to bound the risks that the surplus plutonium will contribute to other DOE storage sites following shipment from the RFETS.

4.2.2 Human Health Risk

4.2.2.1 Radiological Risk

The radiological doses and risks for members of the public are shown in Table 4.1 for all ongoing activities at each of the storage sites; radiological doses and risks from maintaining the surplus plutonium are portions of the totals. The doses are less than 2% of doses associated with natural background (see Section 3.10.3 and Table 3.7 for information on background radiation).

The average annual dose to facility workers maintaining the surplus plutonium inventories at the storage sites is also shown in Table 4.1. The maximum individual worker dose for the sites (3.2 mSv/yr [320 mrem/yr] at Pantex) is 16% of the administrative limit set by DOE (DOE 1999b) and 6% of the radiological limit of 50 mSv/yr (5,000 mrem/yr) as specified in 10 CFR 835, “Occupational Radiation Protection.”

4.2.2.2 Chemical Exposure and Risk

Health risks from exposure to hazardous chemicals used in ongoing operations at the storage sites within the DOE complex were estimated in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a, Appendix M) (these risks are also summarized in the SPD EIS [DOE 1999a]). The estimated baseline cancer risks for the storage sites include inhalation exposures to all carcinogens measured from site point emission sources. Surplus plutonium storage would account for only a small portion of the total exposures from ongoing operations at the various DOE sites. For members of the public, the estimated increased lifetime cancer risks from continued operations at all the storage sites were estimated to be lower than or within the risk range of 1×10^{-6} to 1×10^{-4} (the target used by the EPA to determine whether mitigation actions are needed [EPA 1990; see Section 3.10.4]). Except for LLNL, the hazard index (HI) for members of the public was also less than 1 in every case (an HI of less than 1 indicates no or negligible noncancer health risk; see Section 3.10.4). The general public HI for LLNL was estimated as 1.1, narrowly exceeding the noncancer health risk screening criterion. For the site employee populations, the

Table 4.1. Radiological impacts from continued plutonium storage in current locations[a,b]

Site	Annual population dose within 80 km in 2030 [person-Sv (person-rem)]	Expected number of fatal cancers in population from 50 years of storage[c]	Annual dose to the public MEI [mSv (mrem)]	Public MEI 50-year fatal cancer risk[c]	Average worker dose [mSv/yr (mrem/yr)]
Hanford	4.7×10^{-4} (4.7×10^{-2})	1×10^{-3}	4.1×10^{-6} (4.1×10^{-4})	1×10^{-8}	2.5 (250)
INEEL	7.6×10^{-7} (7.6×10^{-5})	2×10^{-6}	1.4×10^{-7} (1.4×10^{-5})	4×10^{-10}	0.26 (26)
Pantex	6.3×10^{-8} (6.3×10^{-6})	2×10^{-7}	1.8×10^{-10} (1.8×10^{-8})	5×10^{-13}	3.2 (320[d])
SRS	2.9×10^{-6} (2.9×10^{-4})	9×10^{-6}	6.8×10^{-8} (6.8×10^{-6})	2×10^{-10}	2.5 (250)
LLNL	6.7×10^{-5} (6.7×10^{-3})	2×10^{-4}	3.1×10^{-6} (3.1×10^{-4})	9×10^{-9}	2.5 (250)
LANL	0.027 (2.7)	8×10^{-2}	6.5×10^{-2} (6.5)	2×10^{-4}	2.5 (250)
RFETS[e]	1.0×10^{-3} (0.10)	3×10^{-3}	4.8×10^{-3} (0.48)	1×10^{-5}	2.5 (250)

[a]The population doses and cancer risks are from all ongoing activities at each site. The worker doses are for workers involved in surplus plutonium continued storage activities.

[b]MEI = maximally exposed individual, INEEL = Idaho National Engineering and Environmental Laboratory, SRS = Savannah River Site, LLNL = Lawrence Livermore National Laboratory, LANL = Los Alamos National Laboratory, RFETS = Rocky Flats Environmental Technology Site.

[c]Latent cancer fatalities are calculated by multiplying dose by the Federal Guidance Report (FGR) 13 health risk conversion factor of 0.06 fatal cancer per person-Sv (6×10^{-4} fatal cancer per person-rem) (Eckerman et al. 1999).

[d]This is the dose for workers involved in gasket replacement activities projected to occur over a period of 10 years; the dose for other storage workers at Pantex would be 1.16 mSv/yr (116 mrem/yr).

[e]Closure of the RFETS is planned for 2006. As discussed in Section 4.2.2.1, the risks presented here are expected to bound the impacts on storage of the RFETS surplus plutonium at other DOE storage sites.

Source: DOE (1999a, Section 4.2.4, based on data in DOE 1996a).

noncancer HI values for all sites except the SRS and LLNL were less than 1; the value for the SRS was 1.2, and the value for LLNL was 2.4. Estimated cancer risks from ongoing operations for employees at several sites (i.e., INEEL, SRS, LANL, RFETS) also exceeded EPA's tolerable risk range, although none was greater than 10^{-3}.

The emissions data used as the basis for the HI values and cancer risks from all ongoing operations at the storage sites are several years old. The methods used to estimate the HI values and cancer risks are generally conservative (assuming such things as the public receptor present at the site boundary for 24 hours per day), resulting in overestimates of actual exposure. Furthermore, only a small portion of the total exposures from site emissions would be from plutonium storage activities. Therefore, although it is possible on the basis of the cited data that members of the public (for LLNL) or on-site employees (for several sites) might

experience adverse health impacts as a result of exposures from ongoing plutonium storage operations, it is more likely that actual exposures would be less than those that would result in adverse health impacts.

4.2.2.3 Physical Hazards

The number of full-time employees required to maintain continued storage of the excess plutonium at the various sites was not given in the SPD EIS (DOE 1999a). Therefore, it is not possible on the basis of available information to estimate the annual number of fatalities and injuries that would be associated with continued plutonium storage under the no-action alternative.

4.2.2.4 Facility Accidents

The potential for accidental release of plutonium from storage vaults is much lower than for release from MOX fuel fabrication, which involves numerous operations. In the SPD EIS (DOE 1999a), the health risks of beyond-design-basis earthquake events on plutonium storage facilities were reported for the off-site population. Of the DOE sites evaluated, a high value of 0.4 latent cancer fatality (LCF) was reported for the 80-km (50-mi) off-site population at INEEL (see Section 3.10.3 for LCF definition). For a maximally exposed individual (MEI) member of the public, an explosive airplane crash at Pantex was estimated to result in an LCF probability of 0.04.

There is no known use of hazardous chemicals required for the continued storage of the surplus plutonium at the various storage sites. Therefore, accidental release of hazardous chemicals during continued storage would not be expected.

4.2.3 Air Quality

The SPD EIS (DOE 1999a) summarized ambient concentrations of criteria pollutants (carbon monoxide [CO], nitrogen dioxide [NO_2] , particulate matter with a diameter of 10 :m or less [PM_{10}], and sulfur dioxide [SO_2]) at each storage site from total site contributions, including plutonium storage operations. With one exception, the total site contributions were in compliance with applicable standards. At LLNL, however, the estimated maximum 1-hour ambient concentration of NO_2 was 2.5 times higher than the State of California standard. Because plutonium storage operations do not generate appreciable quantities of NO_2, continued storage of the plutonium would not change the impacts of ongoing operations on air quality at LLNL.

4.2.4 Hydrology

The annual water usage and wastewater discharges for all ongoing activities at each of the storage sites are shown in Table 4.2. Water use and wastewater generation for maintaining the surplus plutonium storage are small portions of the totals. No impacts to surface or ground-water resources from continued storage are anticipated beyond those of existing activities.

4.2.5 Waste Management

For all the storage locations, wastes generated by activities required to maintain continued storage of surplus plutonium would be a portion of the existing waste generation rates and are not anticipated to change appreciably. Continued storage should not have a major impact on waste management activities at any of the sites.

4.3 Impacts of the Proposed Action

This section presents the direct impacts of the proposed action. As discussed in Section 2.2, the proposed action is for NRC to authorize DCS to construct and later operate the proposed MOX facility at the SRS to convert 34 MT (37.5 tons) of surplus plutonium to MOX fuel. Section 4.3.1 presents the estimated impacts to human health. Sections 4.3.2 and 4.3.3 cover potential impacts to air and water, respectively. Waste management impacts (Section 4.3.4), potential accident impacts (Section 4.3.5), and environmental justice impacts (Section 4.3.7) were also evaluated. The scope of the proposed action includes decommissioning of the proposed facilities (Section 4.3.6).

Table 4.2. Annual water usage and wastewater discharges for the sites of continued plutonium storage

Site	Water requirement (million L/yr)[a]	Wastewater discharge (million L/yr)
Hanford	13,511/195	246
INEEL	0/7,570	540
Pantex	0/249	141
SRS	127,000/13,247	700
LLNL	NA[b]	NA[b]
LANL	0/5,760	693
RFETS	439/0	130

[a]Surface water/groundwater.

[b]NA = not available.

Source: DOE (1996a, Section 4.2).

As discussed in Section 1.4.1, the technology option to substitute sand filters for the proposed high-efficiency particulate air (HEPA) filters was identified during the scoping process. Discussions of the differences in impacts between sand filters and HEPA filters are summarized in Section 4.3.8.

Construction of the proposed MOX facility is assumed to occur over a 5-year period. Construction of the WSB is assumed to occur during the same 5-year period; whereas construction of the PDCF is assumed to begin 2 years after the construction start for the other facilities (DCS 2002c).

DCS plans to submit an application in October 2003 for a 20-year license to possess and use special nuclear material to manufacture MOX fuel. The actual operation period may be 10 to 14 years, with the additional time needed for facility startup, testing, and decommissioning prior to license termination. For purposes of evaluating operational impacts, a 10-year period was assumed for processing the 34 MT (37.5 tons) of surplus plutonium. That period is based on the facility design for a maximum annual throughput of 3.5 MT (3.9 tons) of plutonium dioxide. If the actual period of operation is greater than 10 years because the actual throughput is less than the maximum facility design capacity, the annual impacts would be less, but they would occur over a longer time period.

The following sections present potential impacts on human health, air quality, hydrology, waste management, and environmental justice. A discussion of the impacts in other technical areas is presented in Appendix H.

4.3.1 Human Health Risk

4.3.1.1 Radiological Risk

4.3.1.1.1 Construction

The construction workers for the proposed MOX facility, the PDCF, and the WSB, like other workers at the SRS, would be subject to exposure to baseline radiation from other SRS activities. However, no additional radiological impacts to the construction workers, to existing SRS workers, or members of the public off-site are expected from the construction activities because no surface contamination is present.

Although radioactive contamination is present in the groundwater underlying the Old F-Area Seepage Basin and the proposed MOX facility, the primary movement of this contamination is expected to follow the direction of the groundwater flow. This direction is toward the north-northwest, where the groundwater discharges to Upper Three Runs Creek (WSRC 1995), away from the proposed facilities. Another possible source of exposure of the construction workers would be any radioactively contaminated soil in the area disturbed by construction activities. An exploration and sampling program across the project site, however, did not identify any

radioactive contaminants (DCS 2000b). Soil would be further sampled for radioactive contamination before excavation begins at the site. If contamination was found, potential exposures and health impacts to the construction workers would be assessed.

4.3.1.1.2 Operations

Radiological impacts to human health from normal operations would result from releases to the environment and direct exposure of facility workers to sources of radiation (see description in Section 3.10). The impacts were evaluated for three receptor groups (facility workers, SRS employees, and members of the public).

All radiological impacts were assessed in terms of committed dose and associated health effects. The dose calculated was the total effective dose equivalent (TEDE) (10 CFR Part 20), which is the sum of the deep dose equivalent (DDE) from exposure to external radiation and the 50-year committed effective dose equivalent (CEDE) from exposures to internal radiation. Details of the dose calculations are provided in Appendix E. The DDE is the dose equivalent at a tissue depth of 1 cm and applies to external whole-body exposure. The CEDE is the dose equivalent to organs or tissues that is received over a 50-year period following the intake of radioactive material.

For each of the receptor groups, doses were estimated for the group as a whole (population or collective dose) and for an MEI. The MEI was defined as a hypothetical person who — because of proximity, activities, or living habits — could receive the highest possible dose. The MEI for SRS employees and members of the public usually was assumed to be at the location of the highest on-site or off-site air concentrations of contaminants, respectively — even if no individual actually worked or lived there. Under actual conditions, all radiation exposures and releases of radioactive material to the environment are required to be ALARA, a practice that has as its objective the attainment of dose levels as far below applicable limits as is practical, taking into account social, technical, economic, and public policy considerations. Annual estimated radiological impacts from normal operations of the proposed MOX facility, the PDCF, and the WSB are provided in Table 4.3.

Facility Workers

MOX facility: Facility workers during normal operations were estimated to receive an annual collective dose of 0.15 person-Sv (15 person-rem). Approximately 0.12 person-Sv (12 person-rem) would be from external exposure and the remaining 0.03 person-Sv (3 person-rem) from internal exposure. The resulting health effects were calculated to be approximately 0.009 LCF/yr. On average, the facility workers' dominant exposure pathway would be external exposure. However, the MEI dose of approximately 0.017 Sv/yr (1.7 rem/yr) with a fatal cancer risk of 1 chance in 1,000 (0.001) was estimated from inhalation exposure. The facility worker estimates were based on operational experience from a similar facility, as discussed in Appendix E.

Table 4.3. Annual estimated radiological impacts to facility workers, SRS employees, and the public from normal operations at the proposed facilities

Receptor	PDCF Dose [person-Sv (person-rem)]	PDCF Latent cancer fatalities/yr[a]	MOX facility Dose [person-Sv (person-rem)]	MOX facility Latent cancer fatalities/yr[a]	WSB Dose [person-Sv (person-rem)]	WSB Latent cancer fatalities/yr[a]
Collective population						
Facility workers	1.97 (197)	0.1	0.15 (15)	0.009	0.50 (50)	0.03
SRS employees (13,295)[b]	0.00014 (0.014)	8×10^{-6}	9.8×10^{-5} (0.0098)	6×10^{-6}	–[c]	–
Public (1,042,000 persons off-site)	0.0067 (0.67)	0.0004	0.00033 (0.033)	2×10^{-5}	–	–

	PDCF Dose [Sv (rem)]	PDCF LCF risk[d]	MOX facility Dose [Sv (rem)]	MOX facility LCF risk[d]	WSB Dose [Sv (rem)]	WSB LCF risk[d]
Maximally exposed individual						
Facility worker	0.020 (2.0)	0.001	0.017 (1.7)	0.001	0.020 (2.0)	0.001
SRS employee (225 m to the ENE)	2.5×10^{-7} (2.5×10^{-5})	1×10^{-8}	1.9×10^{-7} (1.9×10^{-5})	1×10^{-8}	–	–
Public (9,720 m to the NNW)	2.3×10^{-8} (2.3×10^{-6})	1×10^{-9}	2.1×10^{-9} (2.1×10^{-7})	1×10^{-10}	–	–

[a]Latent cancer fatalities are calculated by multiplying dose by the Federal Guidance Report (FGR) 13 health risk conversion factor of 0.06 fatal cancer per person-Sv (6×10^{-4} fatal cancer per person-rem) (Eckerman et al. 1999).

[b]*Source:* Birch (2001).

[c]Impacts from the WSB are included in the proposed MOX facility results.

[d]For annual individual exposure estimates, number represents the lifetime risk of fatality from a radiologically induced cancer.

PDCF: Average annual worker exposures are expected to remain below 0.005 Sv/yr (0.5 rem/yr), the SRS guideline. For 393 workers, an annual collective dose should not exceed 1.97 person-Sv (197 person-rem) with the potential for 0.1 LCFs/yr of operation. The maximum annual exposure to a single facility worker is expected to be maintained less than the DOE administrative limit of 0.02 Sv/yr (2 rem/yr) (DOE 1994). Such an exposure has an expected lifetime risk of developing a fatal cancer of approximately 0.001 (1 chance in 1,000).

WSB: Average annual worker exposures are expected to remain below 0.005 Sv/yr (0.5 rem/yr), the SRS guideline. For 100 workers, an annual collective dose should not exceed 0.50 person-Sv (50 person-rem) with the potential for 0.03 LCFs/yr of operation. The maximum annual exposure to a single facility worker is expected to be maintained at less than the DOE administrative limit of 0.02 Sv/yr (2 rem/yr). Such an exposure has an expected lifetime risk of developing a fatal cancer of approximately 0.001 (1 chance in 1,000).

SRS Employees

MOX facility and WSB: Normal operations were estimated to result in an annual collective SRS employee dose of 9.8 x 10^{-5} person-Sv/yr (9.8 x 10^{-3} person-rem/yr), which corresponds to approximately 6 x 10^{-6} LCF/yr. The MEI dose was found to occur at a location 225 m (738 ft) east-northeast of the proposed MOX facility stack location. The MEI was estimated to receive a dose of 1.9 x 10^{-7} Sv/yr (1.9 x 10^{-5} rem/yr), which results in an annual fatal cancer risk of 1 x 10^{-8} (1 chance in 100 million).

PDCF: Normal operations were estimated to result in an annual collective dose of 0.00014 person-Sv (0.014 person-rem) to the SRS employee population, resulting in an estimated 8 x 10^{-6} LCFs/yr of operation. An MEI located 225 m (738 ft) east-northeast of the facility stack location was estimated to receive an annual dose of 2.5 x 10^{-7} person-Sv (2.5 x 10^{-5} person-rem). The resulting lifetime latent cancer fatality is approximately 1 x 10^{-8} (1 chance in 100 million).

Members of the public

Operation of the facilities is considered to have an insignificant impact on members of the public. Maximally exposed individuals of the public were estimated to receive exposures that are about 10,000 times less than that received from the baseline radiological exposures as discussed in Section 3.10.3.

MOX facility and WSB: For members of the public, operations were estimated to result in an annual collective population dose of 3.3 x 10^{-4} person-Sv/yr (3.3 x 10^{-2} person-rem/yr), which is about 1.4% of the estimated dose received by the public from air emissions from the SRS for the year 2000 (0.023 person-Sv [2.3 person-rem]), as discussed in Section 3.10. The number of expected annual LCFs from operations was estimated to be 2 x 10^{-5}. The MEI location was determined to be at the SRS fenceline, 9,720 m (31,890 ft) north-northwest of the proposed

MOX facility stack location. An MEI at this location would receive an estimated annual dose of 2.1×10^{-9} Sv/yr (2.1×10^{-7} rem/yr). This dose corresponds to an annual fatal cancer risk of 1×10^{-10} and is 0.5% of the estimated dose received by the public MEI from air emissions from the SRS for the year 2000 (4×10^{-7} Sv [4×10^{-5} rem]), as discussed in Section 3.10.

PDCF: Normal operations were estimated to result in an annual collective population dose of 0.0067 person-Sv (0.67 person-rem) that corresponds to approximately 0.0004 LCFs/yr of operation. Thus, the average member of the public would receive a dose of approximately 6.4×10^{-9} Sv (6.4×10^{-7} rem), with an expected lifetime risk of developing a fatal cancer of 4×10^{-10} (1 chance in 2.5 billion). The pubic MEI was estimated to receive an individual dose of 2.3×10^{-8} Sv (2.3×10^{-6} rem) that has an expected lifetime fatal cancer risk of 1×10^{-9} (1 chance in 1 billion).

4.3.1.2 Chemical Exposure and Risk

4.3.1.2.1 Construction

The potential airborne emissions of criteria pollutants (a group of air pollutants for which federal ambient standards exist) from construction of the proposed MOX facility and supporting facilities are summarized in Section 4.3.2.1. Emissions of toxic air pollutants during construction would be very low (less than 1 kg/yr (2 lb/yr) [DCS 2002a]) and would not result in adverse health impacts. The potential ambient concentrations of criteria pollutants at or beyond the SRS boundary resulting from facility construction emissions were modeled. The estimated incremental criteria pollutant levels varied between 0.01% and 7% of the applicable ambient standard levels (see Table 4.5 in Section 4.3.2.1). The incremental annual concentration of $PM_{2.5}$ from construction of the facilities would be 0.24% of the ambient standard. However, the maximum measured annual average concentration of $PM_{2.5}$ in the vicinity of the SRS is already at 144% of the standard. The new primary ambient standard $PM_{2.5}$ level is based on the potential to cause adverse health impacts. Therefore, although the proportion of $PM_{2.5}$ that would be contributed to the annual average level by construction of the proposed facilities would be very small, measures to further minimize particulate emissions (and the potential for adverse health impacts) would be taken wherever possible.

Wastewater generated during construction would be transported to the SRS Central Sanitary Waste Treatment Facility for treatment (DCS 2002a). No adverse impacts from human exposure to contaminants in wastewater effluents are expected from the construction of the facilities.

Hazardous wastes generated during construction would be shipped off-site to permitted commercial recycling, treatment, and disposal facilities. Exposure to hazardous materials used during construction (e.g., paints, solvents) could be kept to a minimum by following good engineering practices, such as ensuring good ventilation and cleaning up small chemical spills as soon as they occur.

If soil contamination from past site activities exists in the construction area for the proposed facilities, construction workers doing excavation work could be exposed, primarily through inhalation or incidental soil ingestion. At this time, however, available data are insufficient to determine whether subsurface soil contamination is present in the proposed construction area. Groundwater contamination exists below the site of the proposed facilities. However, the soils overlying the aquifer are not expected to be contaminated. The project site is located at the northern boundary of the main processing facility in the F-Area. Historically, the site proposed for facility construction has been used as a disposal area for excavated soil from F-Area construction projects (Wike 2000). Remediation of contaminated soil in the Old F-Area Seepage Basin located just northwest of the facility site was completed in 2000 (DCS 2002a). It is expected that subsurface soil in the construction area would be sampled and analyzed for chemical contaminants before excavation work began. If contamination was found, the potential for exposures and health impacts to construction workers would be evaluated.

4.3.1.2.2 Operations

During operations, the proposed MOX facility would use about 30 chemicals for processing, mostly for aqueous polishing to remove impurities from the plutonium (DCS 2002a; Table 3-2); the chemicals would include dodecane, hydrazine, hydrogen peroxide, hydroxyl amine nitrate, nitric acid, nitrogen, nitrogen tetroxide, and tributyl phosphate. The WSB would use three chemicals for waste processing: aluminum nitrate, nitric acid, and sodium hydroxide (DCS 2002a; Table G-2). Operation of the PDCF would require about 15 processing chemicals, including nitrogen, chlorine, sulfuric acid, phosphoric acid, and aluminum sulfate (DOE 1999a; Table E-7). At all three facilities, the chemicals would generally be stored in liquid or compressed gas form. After these chemicals were used in operations, resulting wastes would be recycled through the systems or disposed of at appropriate licensed facilities for hazardous or radioactive waste. The facilities would not discharge any process liquid directly to the environment.

Facility workers: For normal operations, inhalation exposures and risks for facility workers (those working at the proposed MOX facility and related facilities) are difficult to estimate. This is due, in part, to the large amount of uncertainty associated with estimating airborne chemical concentrations in various rooms of the facilities. For this reason, quantitative estimates of risks to facility workers from inhalation of substances emitted during facility operations were not developed for this DEIS. However, the workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable occupation exposure limits. In addition, health risks from occupational exposure through all pathways would be minimized by using enclosed operations (e.g., gloveboxes) to the extent possible.

SRS employees and the public: SRS employees and members of the public could be exposed to chemicals emitted to air, water, or soil from the proposed MOX facility, the PDCF, and the WSB.

In general, the chemicals involved in processing at the three facilities would be used in small amounts, have low volatilities[2], and/or have low toxicities. On the basis of information that emissions of hazardous chemicals from all three facilities to air and water would be negligible (Sections 4.3.2 and 4.3.3), no hazard index or increased cancer risk estimates were made for SRS employees and the public. Adverse impacts to SRS employees and the public from exposure to air or water emissions from the facilities would not be expected. Two process chemicals from the proposed MOX facility requiring special consideration, hydrazine and uranium dioxide, are discussed below.

Hydrazine would be used in the aqueous polishing process to separate plutonium from the solvent. Hydrazine is highly reactive and corrosive; it is a carcinogen and a reproductive hazard. The maximum anticipated on-site inventory of hydrazine would be 600 L (160 gal); annual use would be 2,630 L (700 gal). In the Reagent Storage Building, hydrazine would be kept in sealed containers. Prior to use in the aqueous polishing process, the hydrazine would be mixed with nitrogen (that is, “blanketed with nitrogen”) to minimize the potential for unwanted side reactions. As discussed in Section 3.10.4.2 and Table 3.11, although SRS sitewide hydrazine emissions do not result in exceedance of the ambient level specified in the South Carolina Department of Health and Environmental Control (SCDHEC) standard, the existing emissions may result in exceedance of federal EPA health-risk-based air guideline concentrations. During permitting of the proposed MOX facility, demonstration that operational hydrazine emissions would be limited to very low levels that would not cause adverse health impacts to members of the public or SRS employees would be conducted.

During the fuel fabrication process, purified plutonium would be mixed with depleted uranium dioxide powder. The health risk from plutonium exposure is dominated by the radiological risk, whereas the health risk from uranium exposure is dominated by the chemical risk (i.e., possible damage to the kidney). The radiological health risk from plutonium emissions during operations of the proposed MOX facility and related facilities is addressed above in Section 4.3.1.1.2.

In the proposed MOX facility, uranium powder would be processed in closed containers located in gloveboxes to confine contamination to inaccessible areas and keep occupational exposures within specified guideline and standard levels (DCS 2002a). Air exhaust from gloveboxes would be equipped with HEPA filters to collect particulate emissions. Operation of the facility would generate less than 1 g of uranium emissions annually (see Table E.1). These uranium emissions would result in negligible exposures and chemical health risks for SRS employees and the public.

[2] A chemical with a “low volatility” does not readily change from a liquid to a gas at a relatively low temperature (e.g., near room temperature).

4.3.1.3 Physical Hazards

4.3.1.3.1 Construction

As with any construction project, there would be occupational hazards to construction workers at the proposed MOX facility and related facilities. Occupational hazards were estimated by using the same method as was discussed in Section 3.10.5 for baseline physical hazards. The annual fatality and injury rates for construction activities used were as follows: 13.6 fatalities per 100,000 full-time workers and 4.2 injuries per 100 full-time workers (NSC 2001). On the basis of this methodology, the annual number of fatalities was calculated to be less than 1 for all facilities, assuming peak year employment (see Table 4.4). The estimated annual number of injuries was about 40 per year for each facility. The injuries included in these numbers are those resulting in lost workdays, not including the day of injury.

4.3.1.3.2 Operations

Occupational hazards associated with normal operations at the proposed MOX facility and related facilities were estimated by the same method discussed in Section 3.10.5; impacts are summarized in Table 4.4. Annual fatality and injury rates used were as follows: 3.3 fatalities per 100,000 full-time workers and 4.6 injuries per 100 full-time workers (NSC 2001). Annual fatality and injury rates for the manufacturing sector were used because that sector was assumed to be the most representative for operational work at the proposed facilities. The annual number of fatalities was estimated to be less than 1 for all facilities. The estimated number of injuries was 18 per year of operation for the proposed MOX facility and the PDCF, and 5 per year for the WSB (includes only injuries resulting in lost workdays, not including the day of injury).

4.3.2 Air Quality

This section presents the maximum potential air quality impacts associated with construction and operation of the proposed MOX facility, the PDCF, and the WSB. Air quality impacts associated with construction and operation of the facilities were assessed by determining the concentrations of pollutants in the air caused by emissions associated with the facilities and comparing those concentrations with generally accepted measures of air quality impact, typically standards set by regulatory agencies. Two types of standards exist. Incremental standards set maximum concentrations that cannot be exceeded by emissions from sources associated with a facility or facilities. Total standards set maximum concentrations that cannot be exceeded by total emissions from both sources associated with a facility or facilities and other nearby sources, such as existing SRS sources.

Determining the air quality concentrations involves three steps. First, the emissions of the sources associated with a facility or facilities are calculated. Next, the incremental concentrations caused by these emissions are determined with an air quality model that uses emissions and meteorological data to estimate concentrations at various locations. To

Table 4.4. Annual physical hazard impacts from normal operations[a]

Facility	Peak year construction FTEs[b]	Annual operations FTEs[b]	Projected annual fatalities-construction	Projected annual fatalities-operations	Projected annual injuries-construction	Projected annual injuries-operations
MOX facility	950	400	0.13	0.013	40	18
PDCF	1,024	400	0.14	0.013	40	18
WSB	1,000	100	0.14	0.003	42	5

[a]Fatality estimates of less than 0.5 should be interpreted as “no expected fatalities.” Construction of each of the facilities is projected to require 3 to 5 years. The duration of operations is estimated as 10 years.

[b]Full-time equivalent employees; the numbers of FTEs were obtained from DCS (2002a) for the proposed MOX facility and the WSB, and from DOE (1999a) for the PDCF.

determine a total concentration, the impacts of other sources not associated with a facility or facilities must be added to the incremental concentrations. The impacts of these other sources are determined either by additional modeling or by selecting a measured background concentration representative of the impacts of the sources not modeled. Finally, the incremental concentrations due to a facility or facilities alone or the total concentrations due to a facility or facilities and other sources are compared against appropriate measures of impact.

In this analysis, incremental impacts of construction activities and operations were determined separately using the Industrial Source Complex Short Term (ISCST3) air quality model (EPA 1995). (Appendix F provides additional detail on the calculations of emissions and the assumptions and data used in the model.) The ISCST3 model is recommended by the EPA for modeling construction activities and operations. The meteorological data used in modeling came from Athens, or Atlanta, Georgia, and Columbia, South Carolina, nearby locations where meteorological data are recorded. The maximum modeled pollutant concentrations were selected to represent the impact of construction activities or operations.

The impacts of other sources were taken into account by adding two additional concentrations to the facility maximum: an SRS maximum concentration for other sources at the SRS (SRS maxima) and a background concentration representing the overall impact of non-SRS sources. The total concentrations were then compared with the applicable ambient standards given in Table 3.3. Facility maxima were compared with the incremental PSD standards to provide another measure of impact.

The background concentrations are those used by the State of South Carolina to evaluate air quality impacts. The SRS environmental staff modeled the maxima in support of its air permit process (SCDHEC 2001). These SRS maxima are based on the assumption that all permitted sources operate at their fully permitted limits; thus these values are conservative estimates of SRS impacts. In addition, for a given pollutant and averaging time, maximum values associated with the proposed action and other SRS facilities are unlikely to occur at the same locations. Adding them together for comparison with the corresponding standard adds additional conservatism to the procedure.

A slightly different procedure was used to evaluate potential impacts of $PM_{2.5}$. Implementation of the $PM_{2.5}$ standard has been delayed, and states have not developed plans for attaining it. SRS maxima and background values were not available for $PM_{2.5}$. Background values were taken as the maximum measured concentration[3] in the vicinity of the SRS and were added to the modeled facility maxima for comparison with applicable standards. Background concentrations also were not available for air toxics and are generally considered negligible. Therefore, for air toxics, the sum of the facility maximum concentration and the SRS maxima was taken to be the total concentration for comparison with ambient standards.

[3] The maximum annual average was used for the annual background, and the maximum 98th percentile was used for the 24-hour standard. Compliance with the 24-hour $PM_{2.5}$ standard is based on the 98th percentile values being below the standard level.

4.3.2.1 Construction

The earth-moving activities during the construction period for the proposed MOX facility and the WSB will not overlap the earth-moving activity period for the PDCF. The impacts presented below assume simultaneous construction of the proposed MOX facility and the WSB and were found to exceed the impacts from construction of the PDCF. The impacts presented are, therefore, considered to be bounding for construction activities.

During construction, emissions of criteria pollutants (see Section 3.4.2), total suspended particulates (TSP), and volatile organic compounds (VOCs) would include fugitive dust emissions from earthmoving activities, fugitive dust emissions from the concrete batch plant, and exhaust emissions from diesel-powered construction equipment and from worker and delivery vehicles. The emissions associated with constructing the proposed MOX facility and the WSB are listed in Table 4.5. The tabulation does not include emissions of lead, a criteria pollutant. The phaseout of lead in gasoline has led to a significant reduction in lead levels throughout the country. Appendix F summarizes the emission factors and assumptions used in estimating construction emissions.

Fugitive dust emissions would be the emissions of principal concern during construction of the facilities. Dust from construction activities and exhaust from diesel construction equipment would be emitted within the limited area of the construction site. Other vehicles used by construction workers and for deliveries would emit exhaust along various roadways around the site, and this dispersal would reduce the impacts of these emissions relative to emissions from the limited construction area. Therefore, only fugitive dust emissions from construction activities and operation of the concrete batch plant and exhaust emissions from construction equipment were analyzed for the construction phase.

The results of the impact analysis for construction of the proposed MOX facility and the WSB, including the total concentration and its individual components (i.e., the modeled facility maximum, the SRS maximum, and the background concentration) are presented in Table 4.6. As noted above, the totals are conservative in that they overestimate the likely concentrations. Comparison of the total concentrations with applicable ambient standards provides a measure of the impact of construction.

Annual maxima would occur 10.7 to 9.5 km (5.9 to 6.7 mi) west northwest of the proposed MOX facility site. Short-term maxima would occur 9.5 to 10.4 km (5.9 to 6.5 mi) west or west northwest of the site except for the 1-hour CO maximum, which would occur 20.6 km (12.8 mi) to the southeast.

The total TSP concentration would be close to, but still less than, the maximum value allowed by the applicable standard. Most of this TSP concentration would be due to existing sources; the TSP concentration from facility construction would be at most only 0.06% of the standard. Expected PM_{10} ambient levels would not exceed standards, and the concentrations from construction of the facilities would be equivalent to, at most, 5.0 and 0.05% of the 24-hour and annual PM_{10} standards, respectively.

Table 4.5. MOX facility and WSB construction emissions[a,b,c]

	Construction fugitive dust[d]		Concrete batch plant		Construction equipment exhaust	
Pollutant	**Annual (kg/yr)**	**Hourly (g/h)**	**Annual (kg/yr)**	**Hourly (g/h)**	**Annual (kg/yr)**	**Hourly (g/h)**
TSP	121,000	59,200	5,670	2,730	5,580	2,680
PM_{10}	36,900	17,800	1,640	790	5,580	2,680
$PM_{2.5}$	18,500	8,880	850	409	5,580	2,680
CO	0	0	0	0	25,600	12,300
NO_2	0	0	0	0	67,600	32,500
SO_2	0	0	0	0	6,510	3,130
VOC	0	0	0	0	6,550	3,150

[a]See Appendix F for details on emission calculations.

[b]Hourly values are based on a construction schedule of 8 hours per day, 5 days per week, 52 weeks per year.

[c]The proposed MOX facility and the WSB are assumed to be constructed at the same time. The construction of the PDCF is expected to occur outside the timeframe for construction of the other two facilities.

[d]Calculations assume that water is applied to control dust, resulting in a 50% reduction in emissions, and that emissions from earth-moving activities occur over a 9-month period.

Construction activities would contribute at most 4.3% of the 24-hour standard level for $PM_{2.5}$ and would not be expected to contribute to concentrations above the standard level. However, even without impacts associated with the proposed action, maximum measured levels of $PM_{2.5}$ in the vicinity of the SRS already exceed the annual standard. Facility construction activities could contribute another 0.070% of the standard level. This very small increase would be temporary, ceasing with the completion of heavy construction operations.

The CO, SO_2, and NO_2 construction emissions would be from construction equipment exhaust. Concentrations from these emissions would amount to at most 0.29% of any ambient standard level and would not contribute to concentrations in excess of a standard level.

4.3.2.2 Operations

DCS has proposed to treat exhausts from the proposed MOX facility with (at a minimum) a two-stage HEPA filter system to remove radioactive materials before the exhaust is discharged to the atmosphere.

Table 4.6. Maximum air quality impacts during construction of the facility

Pollutant	Averaging time	Pollutant concentration (: g/m^3) Facility maximum[a]	SRS maximum[b]	Background[b]	Total[c]	Ambient standard[d]	Percent of standard Total concentration	Facility maximum	Receptor location[e] Distance [km (mi)]	Direction
TSP	Annual	0.045	46.6	28	74.6	75	99.5	0.061	10.7 (6.7)	WNW
PM_{10}	24 hours	7.5	97.0	41	145.5	150	97.0	5.0	10.4 (6.5)	WNW
	Annual	0.023	6.9	19	25.9	50	51.8	0.047	10.7 (6.7)	WNW
$PM_{2.5}$	24 hours	2.8	f	28	30.8	65	47.4	4.3	10.4 (6.5)	WNW
	Annual	0.011	f	21.5	21.5	15	143	0.070	10.7 (6.7)	WNW
CO	1 hour	40	262.7	10,100	10,400	40,000	26	0.10	20.6 (12.8)	SE
	8 hours	8	67.4	6,800	6,880	10,000	69	0.08	9.5 (5.9)	WNW
SO_2	3 hours	3.7	1,171.3	50	1,225	1,300	94	0.29	9.6 (6.0)	W
	24 hours	0.83	337.2	18	356	365	98	0.23	9.5 (5.9)	WNW
	Annual	0.006	27.1	4	31	80	39	0.008	9.5 (5.9)	WNW
NO_2	Annual	0.063	17.32	9	26	100	26	0.06	9.5 (5.9)	WNW

[a]Maximum concentration due to facility construction, modeled with ISCST3 model.

[b]Based on SCDHEC (2001).

[c]Sum of facility maximum, SRS maximum, and background.

[d]South Carolina and Georgia standards are the same as NAAQS except for TSP, which is a South Carolina standard.

[e] Location of facility maximum from center of proposed MOX facility site.

[f]SRS maxima and background levels are not available for $PM_{2.5}$. Values for background are the maximum annual average and maximum 98 percentile 24-hour average values measured in the vicinity of the SRS.

The introduction to Section 4.3.2 provides a short discussion of the method used to assess air quality impacts. Sections 4.3.1 and 4.3.5 discusses the human health impacts of routine and accidental chemical and radiological releases to the air. In addition to the emissions discussed in this section, the facilities also would emit the radionuclides listed in Table E.1.

For purposes of this analysis, it was assumed that the proposed MOX facility, PDCF, and WSB would operate at the same time. While this may not always be the case, the combined analysis bounds the air quality impacts from normal operations.

The emissions from operation of the facilities are summarized in Table 4.7. It is expected that all these facilities would use electric boilers; there would be no emissions associated with production of hot water or steam. Air pollutants associated with the MOX process would be emitted from the stack located toward the eastern end of the proposed MOX facility. Nonradiological emissions from this stack would be limited to NO_2 from the aqueous polishing process. There would be no process emissions from the PDCF (DOE 1999a, Table G-59). Particulates from the cementation process in the WSB would be reduced by more than 90% before being released through two stacks.

Emissions from emergency and standby diesel-powered generators and storage of diesel fuel have been considered. Emergency and standby generators and associated fuel storage facilities would be located at each of the three facilities and would emit criteria pollutants, TSP, VOCs, and air toxics (see Table 4.7). The tabulated process VOCs would result from the storage of diesel fuel and would be small because of the low volatility of diesel fuel.

Air Toxics

Air toxics, also known as hazardous air pollutants, are substances judged to have adverse impacts on human health when present in the ambient air. The EPA and some states have issued lists of substances regulated as air toxics. The specific substances listed and the types of regulations applied differ among jurisdictions.

Parking lots and access roads would be paved to minimize fugitive dust emissions. Vehicle combustion emissions would be released along various roadways around the site, and this dispersal would reduce emission impacts compared with the emissions from the emergency/standby generator diesels. Only the process emissions from the facilities and diesel generators were modeled to evaluate emissions for the operations phase.

The results of the impact analysis for normal operations, including the total concentration and its individual components — the modeled facilities maxima, the SRS maximum, and the background levels — are presented in Table 4.8. As noted above, the totals are conservative in that they overestimate the likely total concentration. Impacts during normal operations were estimated by assuming that all three facilities were operating simultaneously. For short-term concentrations of 24 hours or less, emergency generators were assumed to operate 24 hours per day to simulate an extended power loss. For annual averages, the generators and process sources were modeled with emissions appropriate to their expected schedules (see Appendix F). Comparison of the total modeled concentrations with applicable ambient standards provides a measure of the potential impact of normal facility operations on air quality.

Table 4.7. MOX, PDCF, and WSB operations emissions[a]

Pollutant[b]	Process[c] Annual (kg/yr)	Process[c] Hourly (g/h)	Emergency generators[d] Annual (kg/yr)	Emergency generators[d] Hourly (g/h)
TSP	6.00	463	713	3,930
PM_{10}	3.00	234	653	3,490
$PM_{2.5}$	0.90	70.2	612	3,280
SO_2			1,344	13,100
CO			2,950	22,700
NO_2	10,500	30,700	24,200	224,000
VOCs[d]	1.40	0.155	940	8,350
Chlorine	15.0	1.71		
Acetone	2.9	9.75		
Benzene			6.36	58.4
Toluene			2.30	21.2
Xylenes			1.58	14.5
Propylene			22.9	210
Formaldehyde			0.647	5.95
Acetaldehyde			0.207	1.90
Acrolein			0.065	0.594
Naphthalene			1.07	9.80
Total PAHs[e]			1.74	16.0

[a]See Appendix F for details on emission calculations.

[b]Except for PAHs, directly emitted criteria pollutants, their precursors, and federally listed air toxics are included. Naphthalene is both an air toxic and a component of PAH.

[c]Hourly emissions assume continuous operation 24 hours per day, 7 days per week.

[d]Process emissions are from storage of diesel fuel.

[e]PAHs = polycyclic aromatic hydrocarbons.

Sources: DCS (2002a,c,d); DOE (1999a).

Except for annual $PM_{2.5}$, the total concentrations are all less than the concentrations stipulated in the corresponding standards, and the three facilities would contribute concentrations equivalent at most to 1.9% (for 3-hour SO_2) of the corresponding standard. Given the conservative overestimation in the SRS maxima, ambient levels above the standards would not be expected. Even without the impacts associated with the proposed action, maximum measured levels of annual $PM_{2.5}$ in the vicinity of the SRS already exceed the standard concentration. Facility operations would contribute only another 0.009% of the $PM_{2.5}$ annual standard.

The concentrations of toxic air pollutants and total polycyclic aromatic hydrocarbons (PAHs) associated with emissions from emergency and standby generators are all calculated to be less than 0.03% of the South Carolina standards.

Table 4.8. Maximum air quality impacts during operation of the proposed facilities

Pollutant	Averaging time	Concentration (: g/m^3) Facility maximum[a]	SRS maximum[b]	Background[b]	Total[c]	Ambient standard[d]	Percent of standard Total concentration	Facility increment	Receptor location[e] Distance (km [mi])	Direction
TSP	Annual	0.0016	46.6	28	74.6	75	99.5	0.002	16.5 (10.2)	NE
PM_{10}	24 hours	1.22	97.0	41	139	150	93.0	0.82	9.6 (6.0)	W
	Annual	0.0014	6.9	19	25.9	50	52	0.002	16.5 (10.2)	NE
$PM_{2.5}$	24 hours	1.14	–[f]	28	29.1	65	45	1.8	9.5 (5.9)	WNW
	Annual	0.0013	–[f]	21.5	21.5	15	143	0.009	16.5 (10.2)	NE
NO_2	Annual	0.060	17.3	9	26.4	100	26	0.060	16.5 (10.3)	NE
SO_2	3 hours	25	1,171.3	50	1,246	1,300	96	1.9	9.6 (6.0)	W
	24 hours	5.4	337.2	18	361	365	99	1.5	9.5 (5.9)	WNW
	Annual	0.0030	27.1	4	31.1	80	39	0.004	16.8 (10.4)	NE
CO	1 hour	102	262.7	10,100	10,460	40,000	26	0.25	9.7 (6.0)	NW
	8 hours	23	67.4	6,800	6,890	10,000	69	0.23	9.7 (6.0)	NW
Benzene	24 hours	0.021	4.6	NA[g]	4.6	150	3.1	0.01	9.5 (5.9)	WNW
Toluene	24 hours	0.008	14.6	NA	14.6	2,000	0.7	0.0004	9.5 (5.9)	WNW
Xylene	24 hours	0.005	69	NA	69.0	4,350	1.6	0.0001	9.5 (5.9)	WNW
Propylene	24 hours	0.079	NA	NA	NA	NA	NA	NA	9.5 (5.9)	WNW
Formaldehyde	24 hours	0.002	0.15	NA	0.152	7.5	2.0	0.03	9.5 (5.9)	WNW
Acetaldehyde	24 hours	0.0007	<0.01	NA	0.011	1,800	<0.001	<0.0001	9.5 (5.9)	WNW
Acrolein	24 hours	0.0002	<0.01	NA	0.010	1.25	0.82	0.02	9.5 (5.9)	WNW
Naphthalene	24 hours	0.004	<0.01	NA	0.014	1,250	0.001	0.0003	9.5 (5.9)	WNW
Chlorine	24 hours	0.0003	0.04	NA	0.04	75	0.054	0.0004	10.8 (6.7)	N
Acetone	24 hours	0.002	NA	NA	NA	NA	NA	NA	9.8 (6.1)	W
Total PAH	24 hours	0.006	<0.01	NA	0.016	160	<0.010	0.004	9.5 (5.9)	WNW

[a]Maximum concentration due to normal facility operations, modeled using ISCST3 model (EPA 1995).

[b]SCDHEC (2001) for criteria pollutants; Dukes (1998) for air toxics.

[c]Sum of facility maximum, SRS maximum, and background.

[d]South Carolina and Georgia standards are same as NAAQS for PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO. The TSP standard and the air toxic standards are South Carolina standards.

[e]Location of facility maximum from center of the proposed MOX facility site.

[f]SRS maxima and background levels are not available for $PM_{2.5}$ and acetone. Values for $PM_{2.5}$, background are the maximum annual average and maximum 98 percentile 24-hour average values measured in the vicinity of the SRS.

[g]NA = not available.

Comparing the incremental facility concentrations with Prevention of Significant Deterioration (PSD) increments (see Table 4.9) provides another perspective on operational impacts even when a PSD analysis is not required. As the table shows, maximum concentrations for 3-hour and 24-hour averaging times would all be less than 6.0% of the PSD Class II increments for SO_2 and PM_{10}. These two pollutants are emitted by the emergency generators, not the processes, and the concentration estimates assume all generators at all three facilities operate continuously. For annual averages, the maximum concentrations would all be less than 0.02% of the PSD Class II increments.

Prevention of Significant Deterioration (PSD)

The NAAQS establish maximum pollutant levels that should not be exceeded. The PSD program limits the deterioration of existing air quality in areas with air cleaner than the NAAQS. The program establishes a baseline level of air quality and specifies increments that cap the increases in pollutant levels above that baseline. The program applies to sulfur oxides, PM_{10}, and nitrogen dioxide emitted by major new or modified sources. Smaller increments apply in special areas such as national parks (Class I areas) than in other areas (Class II areas).

Class I PSD increments were compared with the concentrations expected to be experienced at the closest receptor location to the Cape Romain National Wildlife Refuge, the nearest PSD Class I area. This receptor location is 51 km (32 mi) from the site, near the maximum distance at which the ISCST3 model can reliably estimate concentrations. All concentration increments were less than 6.3% of the Class I increments. Concentration increments attributable to the three facilities would be even lower at Cape Romain, located about 160 km (100 mi) from the site.

Concentrations of lead and ozone were not modeled. Facility operations would not emit lead. Ozone is formed by photochemical reactions of precursors (including NO_2 and VOCs) in the atmosphere. Contributions of individual sources to ozone formation cannot be quantified accurately. As shown in Tables 3.1 and 4.7, ozone precursor emissions from facility operations would be a small percentage of the four-county totals, about 0.2% and 0.01% for NO_2 and VOCs, respectively. The impact of facility operations on ozone concentrations in the area would be negligible.

Table 4.9. Comparison of maximum concentration increments and PSD increments[a]

Pollutant	Averaging time	Maximum increment (: g/m^3)	PSD increment (: g/m^3) Class I	PSD increment (: g/m^3) Class II	Percent PSD II increment
SO_2	3 hours	25	25	512	4.88
	24 hours	5.4	5	91	5.93
	Annual	0.0030	2	20	0.02
NO_2	Annual	0.060	2.5	25	0.24
PM_{10}	24 hours	1.22	8	30	4.07
	Annual	0.0014	4	17	<0.01

[a]Class I increments apply only in Class I areas. An appropriate comparison is made in the text.

Under the Clean Air Act (CAA), federal actions in nonattainment and maintenance areas must demonstrate that they conform to the applicable state implementation plan (SIP). The SRS is located in an attainment area for all NAAQS and is not covered by a maintenance plan. Thus, the requirement to demonstrate conformity with the SIP would not apply to the proposed MOX facility, PDCF, and WSB. At some time in the future, EPA will issue conformity regulations for the new NAAQS for ozone and $PM_{2.5}$. Those regulations could impose requirements to demonstrate conformity with the SIP on the proposed MOX facility, PDCF, or WSB.

4.3.3 Hydrology

4.3.3.1 Surface Water

4.3.3.1.1 Construction

The estimated annual average water use for constructing the proposed MOX facility is 125 million L (33 million gal) (DCS 2002a). An additional 12 million L/yr (3.2 million gal/yr) of water would be needed for constructing the PDCF (DOE 1999a), and 2 million L/yr (0.5 million gal/yr) of water would be needed for constructing the WSB. Because surface water would not be used for supplying this water, there would be no impacts to surface water levels or flows. No direct releases of contaminated effluent are planned for construction operations. Sanitary waste would be collected with a combination of portable toilets and semipermanent facilities connected to the SRS Central Sanitary Waste Treatment Facility. All wastewater would be treated in the sitewide treatment system, which has sufficient hydraulic and organic capacity to treat the flows expected from construction activities (DCS 2002a).

During construction, surface water quality could, however, be impacted by contaminated runoff from sources such as accidental oil or diesel fuel spills and sediment from disturbed areas and from construction materials stockpiled in areas that are exposed to precipitation. Two areas of concern identified in the Scoping Comments (see Appendix I) are Upper Three Runs Creek, which would receive runoff water from the affected area via nearby unnamed tributaries, and the Savannah River, which receives water from Upper Three Runs Creek. To comply with South Carolina standards for storm-water management and sediment reduction, detention ponds would be built at strategic locations as part of the SRS construction program. These detention ponds would be designed to control the release of storm-water runoff at a rate equal to or slightly less than that of the predevelopment stage. Good engineering practices, as required by the SCDHEC (see Chapter 6), such as the use of siltation fences or straw bales to control sediment and runoff, would be followed during construction, and a sediment control plan would be developed for areas exceeding 2 ha (5 acres) that are disturbed by construction (DCS 2002a). Therefore, impacts to surface water quality from construction activities are expected to be insignificant. Similarly, impacts from accidental releases of contaminants such as gasoline, oil, diesel fuel, or paint during construction are expected to produce negligible impacts on surface water quality because cleanup activities would be prompt and thorough, as required in

the facility's Spill Prevention Control and Countermeasures Plan. This plan would be developed by DCS to meet EPA regulations (40 CFR Part 112).

4.3.3.1.2 Operations

Normal operations of the proposed MOX facility would utilize 9.1 million L (2.4 million gal) of water per year (DCS 2002a). An additional 48 million L/yr (12.7 million gal/yr) of water would be needed for operating the PDCF, and 19 million L/yr (5 million gal/yr) of water would be needed for operating the WSB, but none of this water would be from surface water resources. Therefore, there would be no impacts to surface water levels or flows. There would be no direct impacts to surface water quality because no direct releases of contaminated effluent are planned. Nonhazardous wastewater would be treated, if necessary, and discharged to the F-Area process sewer system that connects to the SRS Effluent Treatment Facility (ETF).

Storm-water runoff from the proposed MOX facility, the PDCF, and the WSB would be controlled under existing NPDES storm-water permits. These permits would limit potential contaminants to safe concentrations, and compliance with the permit conditions would ensure that any surface water impacts were insignificant.

4.3.3.2 Groundwater

4.3.3.2.1 Construction

During construction, the groundwater system beneath the SRS would be directly affected by additional pumping from existing wells because groundwater would be the only source of water used for construction activities. Annual groundwater use at F-Area currently totals 374 million L (98.8 million gal) (DCS 2002a). The combined capacity of the four deep wells in the F-Area is about 4.2 billion L/yr (1.1 billion gal/yr). This water is withdrawn from the Crouch Branch Aquifer, which is uncontaminated in the F-Area. For an average water demand of 139 million L/yr (37 million gal/yr) (DCS 2002a), construction activities for the proposed MOX facility, the PDCF, and the WSB would increase water use in F-Area by about 37%. The projected total water use for F-Area (513 million L/yr [136 million gal/yr]) would be about 12% of total capacity of the existing wells in F-Area. Impacts to groundwater supplies from construction of the proposed facilities would, therefore, be insignificant.

In addition to impacts from groundwater use, impacts during construction (e.g., grading and excavating) could also occur because groundwater beneath the proposed MOX facility site is contaminated (Section 3.2.2). Impacts from this contamination would not be measurable because the deepest construction activities would occur at least 9.1 m (30 ft) above the zone of groundwater contamination (DCS 2002a). Because direct releases of contaminated effluent to groundwater during construction are not planned, there would be no direct impacts to groundwater quality. Groundwater quality, however, could still be indirectly affected by accidental releases of contaminated effluents and infiltration of contaminated runoff. However,

these impacts are expected to be negligible because appropriate good engineering practices would be implemented during construction, detention basins would be used to control runoff, and any spills would be promptly and thoroughly cleaned up as required under the facility Spill Prevention Control and Countermeasures Plan.

4.3.3.2.2 Operations

During normal operations, groundwater would be the only source of water used for the facilities, and the groundwater system beneath the SRS would be directly impacted by additional pumping that would deplete the resource. Operation of the proposed MOX facility would require 9.1 million L/yr (2.4 million gal/yr), the PDCF would require 48 million L/yr (12.7 million gal/yr), and the WSB would require 19 million L/yr (5 million gal/yr) (DCS 2002a). These impacts would be insignificant because the total water use, 76 million L/yr (20 million gal/yr), represents about 20% of the current use at F-Area for all facilities (374 million L/yr [98.8 million gal/yr]), and the total projected withdrawal of 450 million L/yr (119 million gal/yr) represents about 11% of the existing F-Area capacity (4.2 billion L/yr [1.1 billion gal/yr]).

Groundwater quality would not be affected because there would be no discharges (either shallow or deep) to underlying aquifers. During the scoping process, several commenters expressed concerns about potential contamination of groundwater resources by plutonium. Because no direct releases of contaminated effluent to the groundwater are planned during normal operations of the proposed facilities and because the facilities would not use settling or holding basins as part of the wastewater treatment system, there would be no direct impacts to groundwater quality (DCS 2002a).

4.3.4 Waste Management

4.3.4.1 Construction

In the 5-year period that is assumed to be required for construction of the facilities, no HLW, TRU waste, LLW, or mixed LLW would be expected to be generated at the facilities. No hazardous or radiologically contaminated soil is expected to be generated (DCS 2002a).

Hazardous (liquid) wastes that would be generated would be similar to those expected during the construction of any industrial facility. Examples of these wastes include liquids (such as motor oil), batteries, and other machinery-related products, cleaning products, and other chemicals (such as insecticides and pesticides). Approximately 77 m^3/yr (100 yd^3/yr), 50 m^3/yr (65 yd^3/yr), and 35 m^3/yr (46 yd^3/yr) of hazardous waste is estimated to be generated during construction of the proposed MOX facility, the PDCF, and the WSB, respectively. These wastes would be managed in accordance with the hazardous waste management practices in place at the SRS. The current practice includes accumulating the waste at the generating facility (which in this case would be in the F-Area) for a maximum of 90 days as necessary, and

packaging such wastes in U.S. Department of Transportation (DOT)-approved containers to ship off-site to permitted commercial recycling, treatment, or disposal facilities.

Nonhazardous liquid and solid wastes would also be generated during the construction of the facilities. The estimated additional liquid and solid waste volumes that would be generated from construction of the proposed MOX facility are 178 m^3/yr (47,000 gal/yr) and 8,410 m^3/yr (11,000 yd^3/yr), respectively; the PDCF construction would produce an estimated 5,300 m^3/yr (1,400,000 gal/yr) and 120 m^3/yr (157 yd^3/yr) of nonhazardous liquid and solid wastes, respectively. Construction of the WSB is estimated to generate 21,000 m^3/yr (5,550,000 gal/yr) of liquid and 2,200 m^3/yr (2,880 yd^3/yr) of solid nonhazardous waste. The generated liquid and solid wastes would be managed consistent with SRS waste management practices (see Section 3.9).

The impact of the facilities construction waste on SRS waste management capacities would be insignificant. The hazardous waste that would be generated would be shipped off-site to permitted facilities. The impacts at these permitted facilities from the proposed MOX facility, PDCF, and WSB wastes are expected to be within the bounds of the evaluations performed for the waste facilities. The nonhazardous liquid waste generated by the facilities would constitute a moderate to small percentage of the SRS's capacity for treatment and disposal (about 10%). Nonhazardous solid wastes are packaged in conformance with standard industrial practice and shipped to commercial or municipal facilities for recycling or disposal. Estimates for waste volumes that would be generated during construction of the facilities are presented in Table 4.10.

4.3.4.2 Operations

Consistent with waste management practices at the SRS, all wastes generated from operations of the facilities would be transferred from the F-Area to the appropriate facilities or areas elsewhere within the SRS for subsequent treatment, storage, or disposal. The period of operation is expected to be about 10 years.

The aqueous polishing process would generate a liquid high-alpha-activity waste that would be processed at the WSB. A pipeline would be constructed to receive and transport waste from the proposed MOX facility and PDCF to the WSB. Three liquid waste streams (americium, excess acid, and solvent regeneration alkaline wash) from the proposed MOX facility would be combined into the high-alpha-activity waste. A stripped uranium waste stream would be transferred as a separate waste to the WSB. These two wastes would be batch-transferred through separate double-walled stainless steel pipelines to the WSB. The wastes would be collected in the waste receipt area of the WSB. This area would be equipped with separate collection tanks for each waste type, with capacities to hold waste volumes generated for a period of 6 weeks at a time.

Following receipt at the WSB, the high-alpha-activity waste would be reduced in volume by evaporation, and the still bottoms would be neutralized with sodium hydroxide. The distillate

Table 4.10. Waste volumes from the construction of the facilities compared with waste management capacities at the SRS

Waste type	Estimated MOX facility construction waste[a] (m^3/yr)	Estimated PDCF construction waste[b] (m^3/yr)	Estimated WSB construction waste[a] (m^3/yr)	SRS capacity[c] Characterization or treatment (m^3/yr)	SRS capacity[c] Storage (m^3)	SRS capacity[c] Disposal (m^3)
TRU	–[d]	–[d]	–[d]	1,720	34,400	168,500[e]
LLW	–[d]	–[d]	–[d]	17,830	NA[f]	30,500
Hazardous[g]	77	50	35	17,830	5,170	NA[h]
Nonhazardous						
Liquid	178	5,300	21,000	276,000	NA[h]	NA[h]
Solid	8,410	120	2,200	NA[h]	NA[h]	NA[h]

[a]The construction period for the proposed MOX facility is assumed to be 5 years; the construction period of the PDCF is assumed to be 3 years. The construction period of the WSB is assumed to be 5 years. Source of estimates: DCS (2002a).

[b]Source of estimates: DOE (1999a).

[C]Storage and disposal capacity estimates presented represent total capacity at the SRS. Sources of estimates: DOE (1999a).

[d]No radioactive waste would be generated by facility construction.

[e]Value represents limit for TRU waste at the WIPP.

[f]Not applicable since LLW is planned for on-site disposal.

[g]Hazardous waste that would be generated is less than 1% of the treatment and about 14% of the storage capacity at the SRS. Source of hazardous waste estimates: DCS (2002a).

[h]Not applicable because waste is planned for off-site disposal.

would be sent to the SRS ETF as LLW, and the neutralized bottoms would be blended with cement to produce a solid TRU waste matrix similar to that accepted for disposal at WIPP.

The stripped uranium waste would also be reduced in volume by evaporation, with the distillate sent to the SRS ETF as LLW. The uranium that remains in the residue portion would be blended with cement to produce a solid LLW matrix suitable for disposal at SRS or an approved outside facility, consistent with waste management practices at SRS.

TRU, low-level, hazardous, and nonhazardous (both liquid and solid) wastes are expected to be generated by operation of the proposed MOX facility. About 1,900 m^3 (2,480 yd^3) of TRU waste is expected to be generated from the proposed MOX facility for an assumed 10-year operational period. This volume represents approximately 11%, 6%, and 1% of the site's treatment, storage, and disposal capacities, respectively (see Table 4.11). About 180 m^3 (235 yd^3) of TRU waste is expected to be generated for an assumed 10-year operational period of the PDCF. This volume represents approximately 1% of the site's treatment capacity and less than 1% of the site's storage and disposal capabilities (see Table 4.11). About 3,100 m^3 (4,100 yd^3) of TRU waste is expected to be generated from the WSB for the assumed 10-year operational period. This represents 18%, 9%, and 2% of the site' treatment, storage, and disposal capacities, respectively.

The combined volume of TRU waste that would be generated per year of operations from the three facilities amounts to about 30% of the site's TRU waste treatment capacity. Further, these volumes of TRU waste contribute about 16% to the site's overall storage capacity and about 3% of the disposal capacity at WIPP. These percentages indicate a moderate to low impact to waste management of TRU waste at SRS, including disposal at WIPP. The DOE has a national program for the management and disposal of defense-related TRU waste. Subsequently, waste acceptance criteria (WAC) for receipt of TRU waste at WIPP have been established for contact-handled TRU (CH-TRU) waste. The TRU wastes generated from the proposed MOX facility, the PDCF, and the WSB are expected to be in this category. The WAC that must be met for CH-TRU waste to be transported to, managed at, and disposed of at WIPP address container properties, radiological properties, physical properties, chemical properties, and data package contents. The generator facilities are required to transmit characterization, certification, and shipping data to WIPP before shipping waste.

The proposed MOX facility is expected to generate 1,460 m^3/yr (385,800 gal/yr) of liquid LLW. The WSB is expected to generate 890 m^3/yr (235,000 gal/yr) of liquid LLW. These waste streams would be collected and sampled to ensure that it meets the acceptance criteria for the SRS ETF. After treatment in the ETF, the effluent would be discharged to Upper Three Runs Creek consistent with permit discharge limitations.

Solid LLW generated during the operation of the facilities would be packaged, certified, and accumulated at the F-Area before transfer to the appropriate SRS facilities for on-site treatment and disposal. About 1,020 m^3 (1,340 yd^3), 600 m^3 (780 yd^3), and 1,750 m^3 (2,280 yd^3) of solid LLW are expected to be generated from the proposed MOX facility, the PDCF, and the WSB respectively, over the assumed 10-year period of facility operation. The LLW generated at the facilities would represent about 2% of the capacity for treatment at the Consolidated

Table 4.11. Waste volumes from operation of the facilities compared with waste management capacities at the SRS

Waste type	Estimated MOX facility operational waste[a] (m^3/yr)	Estimated PDCF operational waste[b] (m^3/yr)	Estimated WSB operational waste[a] (m^3/yr)	SRS capacity[c] Characterization or treatment (m^3/yr)	SRS capacity[c] Storage (m^3)	SRS capacity[c] Disposal (m^3)
TRU[c]	190	18	310	1,720	34,400	168,500[d]
LLW[e]	1,562	60	1,065	17,830	NA[f]	30,500
Hazardous/mixed[g]	12	1	90[h]	17,830	5,170	NA[i]
Nonhazardous						
Liquid	16,600	25,000	55,000	276,000	NA[i]	NA[i]
Solid	1,340	1,800	850	NA[i]	NA[i]	NA[i]

[a]The facilities are assumed to be in operation for a 10-year period. Therefore, the total waste volume that would need to be managed would be 10 times the estimates shown. Sources for estimates: DCS (2002a) and DOE (1999a).

[b]Storage and disposal capacity estimates presented represent total capacity at the SRS. Sources of estimates: DOE (1999a).

[c]The combined values of TRU waste that would be generated from the three facilities is estimated to be approximately 30% and 16% of the treatment and storage capacity, respectively, at the SRS. The generated TRU waste is approximately 3% of the disposal capacity at WIPP.

[d]Value represents limit for TRU waste at the WIPP.

[e]Includes estimates for liquid and solid LLW. Solid LLW generated from the MOX facility and WSB is estimated to be about 272 m^3/yr (362 yd^3/yr). Liquid LLW generated is estimated to be about 2,350 m^3/yr (620,800 gal/yr). The volume presented for the PDCF represents solid LLW.

[f]Not applicable since LLW is planned for on-site disposal, not storage.

[g]Hazardous waste that would be generated is less than 1% of the treatment and storage capacity at the SRS. Source of hazardous waste estimates: DCS (2000a).

[h]Volumes for hazardous, liquid and solid nonhazardous waste for WSB obtained by subtracting PDCF volumes from values in Table 5-15C of DCS (2002a).

[i]Not applicable because off-site disposal of waste is planned.

Incineration Facility and approximately 11% of the disposal capacity at the Low-Activity Waste Vaults. The additional waste should not affect the LLW management system at the SRS.

Hazardous wastes generated at the SRS are packaged at the generating facility for treatment and storage at either on-site or off-site facilities and disposal at off-site permitted facilities. If treatment and disposal are assumed to be on-site, the expected wastes volumes from the proposed MOX facility, the PDCF, and the WSB would represent less than 1% of the capacities of the Consolidated Incineration Facility and of the hazardous waste storage buildings (see Table 4.10). The facilities waste should not affect the SRS hazardous waste management system.

Nonhazardous solid wastes generated would be packaged and transported in accordance with standard industrial practices. Recyclable waste would be sent off-site with the remaining waste, which would be primarily solid sanitary waste, to the Three Rivers Landfill for disposal.

Nonhazardous liquid wastes would be treated before being discharged to the F-Area sanitary sewer system, which connects to the SRS Central Sanitary Wastewater Treatment Facility. The wastes of this type expected to be generated by operations of the proposed MOX facility, the PDCF, and the WSB are estimated to be about 35% of the capacity of the Central Sanitary Wastewater Treatment Facility. These additional wastes are not expected to have a significant impact on the nonhazardous liquid waste management system at the SRS.

Wastes that would be generated and the impacts from such wastes were identified as concerns during scoping. The estimated waste generation rates from the operation of the facilities are presented in Table 4.11. The operation of the facilities would have a small impact on the SRS waste management system. Impacts are bounded by existing evaluations presented in previous environmental impact statements (DOE 1995, 1997a). Potential impacts to facilities located off the SRS are bounded by the evaluations performed for those facilities.

4.3.5 Accident Impacts

This section discusses hypothetical accidents that could occur at the proposed facilities (the MOX facility, the PDCF, and the WSB), and the estimated maximum impacts that such accidents could produce. Table 4.12 lists the various accidents considered, and Tables 4.13, 4.14, and 4.15 list the estimated radiological impacts on SRS employees, the collective off-site public, and the maximally exposed member of the public, respectively. Table 4.16 lists the potential impacts of accidental chemical releases from the proposed facilities. This section describes the potential accident impacts in more detail and includes a discussion of impacts on local groundwater quality that could result from accidental releases.

4.3.5.1 Accidents Considered

4.3.5.1.1 Proposed MOX Facility

To obtain a possession and use license, DCS is required under 10 CFR Part 70, Subpart H, to perform an integrated safety analysis (ISA) to identify the hazards of the proposed MOX facility in a systematic and comprehensive manner. As an initial part of that process, DCS has completed a safety assessment that identified the following types of events that could lead to releases to the environment — natural phenomena, loss of confinement, internal fire, explosion, load handling events, external man-made events, criticality, direct radiation exposure, and chemical releases (DCS 2002a).

With respect to natural phenomena, DCS has shown that flooding does not pose a credible threat to the proposed MOX facility. For the remainder of the credible natural phenomena events, which include extreme winds, earthquakes, tornadoes, external fires, rain, snow, ice, and lightning, the applicant has committed to design criteria and standards that would prevent accidents associated with these hazards. For this reason, the effects of accidents caused by these phenomena are not described in this DEIS.

External man-made events were also considered in DCS's hazard evaluation. These events include hazards from nearby facilities or vehicles. These hazards may include industrial facilities, military facilities, chemical facilities, nearby SRS facilities, pipelines, automobiles, and aircraft. A screening evaluation by DCS determined that credible external man-made events will not significantly impact facility operations (DCS 2002a). For this reason, the effects of accidents caused by such events are not described in this DEIS.

Direct radiation hazards generally arise from radioactive material or other sources that emit penetrating gamma or neutron radiation. The radioactive material that would be used in the proposed MOX facility produces mostly alpha radiation, which is not as penetrating and is a less significant direct radiation hazard, but could cause adverse health effects when inhaled. As a result, there would be no accidents at the proposed MOX facility that would produce a direct radiation hazard to the public. In addition, other than a criticality event, there would be no accidents that would produce a direct radiation exposure hazard for an SRS employee.

The events for which accident consequences were evaluated in this DEIS are internal fire, explosion, load handling event, criticality, and chemical releases. The methods employed to analyze accident consequences were based on conservative assumptions and were intended to provide a comprehensive, bounding analysis for all potential events up to and including design basis accidents.

Accidents were classified into likelihood categories on the basis of qualitative estimates (DCS 2002a, 2001). The likelihood categories were defined as follows:

- Not Unlikely – Event may occur during the facility's lifetime.
- Unlikely – Event is not expected to occur during the facility's lifetime, but may be considered credible.
- Highly Unlikely – Event originally classified as "not unlikely" or "unlikely" to which sufficient controls have been applied to further reduce its likelihood to an acceptable level.

A short description of each event evaluated for the accident risk assessment is given in Table 4.12. Additional details of the assessment methodology are provided in Appendix E.

4.3.5.1.2 Pit Disassembly and Conversion Facility

A wide range of accident scenarios was considered previously for the PDCF (DOE 1999a). Potential accidents from both man-made and natural phenomena were considered. The potential accidents evaluated for this DEIS were taken from DOE (1999a) and are listed in Table 4.12.

4.3.5.1.3 Waste Solidification Building

A procedure similar to those used for the proposed MOX facility and the PDCF was used to identify potential accidents at the WSB. Those accidents considered to be credible were evaluated (DCS 2002a). A description of the accidents is presented in Table 4.12.

4.3.5.2 Radiological Human Health Risk

For exposures to depleted uranium, the health impacts would be expected to be dominated by the chemical toxicity of the compounds rather than by their radiological effects. A lethal exposure from the chemical toxicity of uranium (resulting from kidney failure), would occur with an internal radiation dose of about 0.01 Sv (1 rem) (over a lifetime), a dose that is not considered to have any significant radiation health effects.

Receptors: Radiation doses and health risk effects were calculated for SRS employees and the public. General definitions of these receptor groups are given in Section 3.10.2.

For radiological hazards, the dose consequences to facility workers and SRS employees following an accident would generally be dominated by the 50-year committed effective dose equivalent from radioactive material inhaled immediately following the event. For the purposes of analyses in this DEIS, this period of inhalation is assumed to last 8 hours. This exposure

Table 4.12. Accidents evaluated for the proposed facilities

Facility / accident	Description
Proposed MOX facility	
Internal fire	A fire was postulated to occur in a storage location for polished plutonium dioxide powder (the PuO_2 Final Dosing Unit). The frequency of this event is considered to be unlikely or lower because multiple failures are required for this event to occur.
Explosion	A hypothetical explosion event was postulated to occur in an aqueous polishing process cell and involved the maximum material at risk in any process cell. Simultaneous failure of the design features and administrative controls resulting in an explosion and the subsequent release of radioactive materials is highly unlikely.
Load handling	The load-handling event postulated to produce the largest radiological consequences was a drop event involving the glovebox in the Jar Storage and Handling Unit. This glovebox would contain jars of plutonium powder. The frequency associated with this event is estimated to be unlikely or lower since multiple failures would be required for this event to occur.
Criticality	A criticality hazard arises whenever fissionable materials (e.g., uranium-235 or plutonium-239) are present in sufficient quantities to attain a self-sustaining fission chain reaction under optimal conditions. Thus, a generic hypothetical criticality event was evaluated.
PDCF	
Fire	The bounding fire accident was assumed to occur in a plutonium glovebox. Against procedure, a flammable cleaning liquid was assumed to be taken into the glovebox used for blending plutonium powder. The liquid is inadvertently spilled and ignited, involving all of the gloves.
Explosion	Multiple equipment failures and operator errors were postulated to result in the ignition of a hydrogen and oxygen gas mixture in an inert-atmosphere glovebox. The resulting explosive pressure was assumed to damage the glovebox windows but insufficient to compromise the building HEPA filtration system.
Leak or Spill	A forklift or other heavy vehicle running over a package of plutonium dioxide was postulated as the most catastrophic leak or spill. A portion of the released oxide becomes airborne and is filtered by the HEPA filtration system before entering the environment.
Criticality	A criticality involving plutonium dioxide powder was postulated because the PDCF handles amounts in excess of that required for such an accident. However, facility design and procedures are intended to preclude such an occurrence. No specific scenario was identified other than multiple failures due to human error.

Table 4.12. Continued

Facility / accident	Description
Earthquake	During an earthquake event, the PDCF was expected to maintain its structural integrity, and the major safety systems, including building confinement and HEPA filtration, were assumed to continue to function. It was conservatively assumed that loose plutonium powder in gloveboxes would be resuspended and result in some minor spills.
Tritium release	Tritium contamination of parts in a glovebox was assumed to be released during a major glovebox fire. The formation of tritiated water vapor is postulated to occur, and the resulting vapor is released through the building ventilation system.
WSB	
Fire	The bounding fire accident was postulated to be an area fire in the low-activity and effluent processing sections of the WSB. As a result of structural damage to the facility, thousands of gallons of unprocessed low-activity waste, low-activity bottoms, low-activity overheads, effluent bottoms, and effluent overheads are released.
Explosion	The bounding explosion accident was postulated to be the result of the ignition of hydrogen gas in the High-Activity Evaporator. Hydrogen accumulation from waste material left in the evaporator after shutdown and eventual ignition was assumed. Such an accident could only occur because of human error or multiple safety device failures.
Loss of confinement	A facility-wide spill of all material in the building was considered due to natural phenomena or an external event. Only the high-activity waste was considered in the source term for this accident because the low-activity waste would add only a slight increase in dose (DCS 2002a).

pathway would dominate the dose (except in the case of criticality accidents) because it is assumed that direct exposure to contaminated areas following an accident can be effectively limited. In addition, no food is grown on the SRS, so the consumption of contaminated food is not included in the dose for facility workers or SRS employees. Criticality accidents involve radionuclides, other than uranium or plutonium, that pose a higher direct radiation hazard than do inhalation or ingestion.

Unlike SRS employees, members of the public could reasonably be expected to be exposed to both contaminated soil and food for some time beyond the early phase of emergency response. The scoping process identified concerns about the impacts from accidents, and commenters requested that the worst-case impacts be presented. Whether an individual would be exposed to contaminated soil and food would depend upon the specific protective actions that the applicant and government agencies might take following the accident. If protective actions were taken, the component of dose attributable to exposure to contaminated soil and consumption of contaminated food would be effectively mitigated. However, the actions that would be taken cannot be predicted at this time, so both the early phase and unmitigated intermediate and late phase consequences (corresponding to one year of exposure to the contaminated environment) are provided in this DEIS.

Population doses were calculated for up to a distance of 80 km (50 mi) from the release point for 10 downwind distances and 16 wind directions. Radiation doses were calculated for the following receptors for accident conditions:

- *SRS employee MEI:* For the purposes of the accident consequence assessment, an employee on the SRS at the point of maximum air concentration located close to, but outside, the facility's protected area fence (at least 100 m [330 ft] or more from the accident location). Exposure pathways assessed were inhalation exposure and direct radiation from the passing cloud of airborne radioactive material (cloudshine) released by the accident. A period of 8 hours of direct radiation exposure from deposited radioactive material on the ground (groundshine) following the accident was also considered.

- *SRS employee population:* All employees on the site located more than 100 m (330 ft) from the accident location outside the facility. The same exposure pathways as evaluated for the SRS employee MEI were evaluated for the collective SRS employee population.

- *Off-site MEI:* A hypothetical individual member of the public living off-site and receiving the maximum exposure from accidental releases. For the purposes of the accident consequence assessment, this individual was assumed to be located at the SRS boundary. A short-term exposure period, involving the same exposure pathways assessed for the SRS employees, and a 1-year exposure period were evaluated. The 1-year exposure evaluation included the short-term exposures, but it also included a 1-year exposure, not 8 hours, to groundshine and a 1-year ingestion exposure to contaminated food grown locally. Contaminated crops were not

assumed to be condemned; all locally grown food was assumed to have been consumed.

- *General population:* All members of the public within an 80-km (50-mi) radius of the site where the accident might occur. Short-term and 1-year impacts to the general population were assessed on the basis of the same exposure pathways as for the public, or off-site, MEI.

During an accident, facility workers might be subject to severe physical and thermal (fire) forces and could be exposed to releases of chemicals and radiation. The risk to the facility workers would be very sensitive to the specific circumstances of each accident and would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical and thermal forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. Quantitative facility worker accident impacts are not provided in this DEIS. For most events, the applicant has conservatively assumed that consequences to the facility worker MEI would exceed the applicable performance requirements in 10 CFR 70.61 and has identified preventive or mitigative features in the facility's design basis in order to meet the performance requirements. However, it is recognized that worker injuries and fatalities would be possible from chemical, radiological, thermal, and physical forces if an accident did occur.

Impacts: Estimated radiological impacts from the four hypothetical accident scenarios considered are presented in Tables 4.13, 4.14, and 4.15 and are discussed below. While the consequences of many of these accidents are significant, the likelihood of significant accidents will be very low (highly unlikely) through the use of safety systems discussed in DCS's Construction Authorization Request. Thus, the overall risk of significant accidents is now considered to be low.

SRS employee population: SRS employees were assumed to be unshielded from the passing plume of airborne radioactivity released during an accident. The impacts for the collective SRS employee population given in Table 4.13 were estimated for inhalation and external radiation exposure. External radiation exposure consisted of cloudshine and groundshine. Groundshine exposure was evaluated for 8 hours following an accident and was negligible, less than approximately 0.02% of the total dose, in all cases. The impacts presented in Table 4.13 are the highest potential impacts to the SRS employee population and were found to occur in the direction of the major F-Area facilities, toward the south-southwest. The dominant exposure pathway was inhalation for all accidents except for the hypothetical criticality events. For those hypothetical criticality events, exposure to cloudshine was estimated to account for 70 to 85% of the collective dose; the remaining dose was estimated to result from inhalation.

The SRS employee MEI was estimated to receive a maximum dose, 0.68 Sv (68 rem), from the explosion event at the proposed MOX facility. This dose was from the inhalation pathway. For this dose, the chance of developing a latent fatal cancer was estimated to be 0.04 (about 1 chance in 25). SRS employee MEI impacts for all accidents considered are presented in Table 4.13.

Table 4.13. Estimated human health radiological impacts to SRS employees from hypothetical facility accidents

	SRS employee MEI			SRS employee population		
Facility/accident	**Dose [Sv (rem)]**	**Chance of LCF[a]**	**Major exposure pathway**	**Dose [person-Sv (person-rem)]**	**Chance of LCF[a]**	**Major exposure pathway**
Pit Disassembly and Conversion Facility						
Criticality	0.00070 (0.070)	4×10^{-5}	External	0.027 (2.7)	0.002	External
Earthquake	4.0×10^{-5} (0.0040)	2×10^{-6}	Inhalation	0.0099 (0.99)	0.0006	Inhalation
Explosion	0.00033 (0.033)	2×10^{-5}	Inhalation	0.081 (8.1)	0.005	Inhalation
Fire	1.2×10^{-6} (0.00012)	7×10^{-8}	Inhalation	0.00030 (0.030)	2×10^{-5}	Inhalation
Leak/spill	4.0×10^{-7} (4.0×10^{-5})	2×10^{-8}	Inhalation	0.00010 (0.010)	6×10^{-6}	Inhalation
Tritium release	0.026 (2.6)	0.002	Inhalation	7.9 (790)	0.5	Inhalation
Proposed MOX Facility						
Criticality	0.023 (2.3)	0.001	External	1.6 (160)	0.1	External
Explosion	0.68 (68)	0.04	Inhalation	170 (17,000)	10	Inhalation
Internal fire	0.026 (2.6)	0.002	Inhalation	6.7 (670)	0.4	Inhalation
Load handling	0.0010 (0.10)	6×10^{-5}	Inhalation	0.26 (26)	0.02	Inhalation
Waste Solidification Building						
Fire	0.022 (2.2)	0.001	Inhalation	4.6 (460)	0.3	Inhalation
Hydrogen explosion	0.093 (9.3)	0.006	Inhalation	20 (2,000)	1	Inhalation
Loss of confinement	0.040 (4.0)	0.002	Inhalation	8.9 (890)	0.5	Inhalation

[a]Latent cancer fatalities are calculated by multiplying dose by the FGR 13 health risk conversion factor of 0.06 fatal cancer per person-Sv (6×10^{-4} fatal cancer per person-rem) (Eckerman et al. 1999). Values are rounded to one significant figure.

Table 4.14. Estimated human health radiological impacts to the collective off-site public from hypothetical facility accidents

Facility/accident	Short-term exposure: Dose [person-Sv (person-rem)]	Short-term exposure: Fatalities (LCFs)[a]	Short-term exposure: Major exposure pathway	1-year exposure: Dose person-Sv (person-rem)]	1-year exposure: Fatalities (LCFs)[a]	1-year exposure: Major exposure pathway
Pit Disassembly and Conversion Facility						
Criticality	0.053 (5.3)	0.003	External	0.063 (6.3)	0.004	Ingestion
Earthquake	0.024 (2.4)	0.001	Inhalation	0.069 (6.9)	0.004	Ingestion
Explosion	0.20 (20)	0.01	Inhalation	0.57 (57)	0.03	Ingestion
Fire	0.00075 (0.075)	5×10^{-5}	Inhalation	0.0021 (0.21)	0.0001	Ingestion
Leak/spill	0.00023 (0.023)	1×10^{-5}	Inhalation	0.00070 (0.070)	4×10^{-5}	Ingestion
Tritium release	19 (1,900)	1	Inhalation	6,100 (610,000)	400	Ingestion
Proposed MOX Facility						
Criticality	1.2 (120)	0.07	External	4.4 (440)	0.3	Ingestion
Explosion	400 (40,000)	20	Inhalation	1,200 (120,000)	70	Ingestion
Internal fire	16 (1,600)	1	Inhalation	48 (4,800)	3	Ingestion
Load handling	0.63 (63)	0.04	Inhalation	1.9 (190)	0.1	Ingestion
Waste Solidification Building						
Fire	11 (1,100)	0.7	Inhalation	11 (1,100)	0.7	Inhalation
Hydrogen explosion	49 (4,900)	3	Inhalation	140 (14,000)	8	Ingestion
Loss of confinement	22 (2,200)	1	Inhalation	63 (6,300)	4	Ingestion

[a]Latent cancer fatalities are calculated by multiplying dose by the FGR 13 health risk conversion factor of 0.06 fatal cancer per person-Sv (6×10^{-4} fatal cancer per person-rem) (Eckerman et al. 1999). Values are rounded to one significant figure.

Table 4.15. Estimated human health radiological impacts to the maximally exposed member of the public from hypothetical facility accidents

Facility/accident	Short-term exposure			1-year exposure		
	Dose [mSv (mrem)]	Chance of LCF[a]	Major exposure pathway	Dose [mSv (mrem)]	Chance of LCF[a]	Major exposure pathway
Pit Disassembly and Conversion Facility						
Criticality	0.0030 (0.30)	2×10^{-7}	External	0.0069 (0.69)	4×10^{-7}	Ingestion
Earthquake	0.00051 (0.051)	3×10^{-8}	Inhalation	0.0010 (0.10)	6×10^{-8}	Ingestion
Explosion	0.0042 (0.42)	3×10^{-7}	Inhalation	0.0084 (0.84)	5×10^{-7}	Ingestion
Fire	1.6×10^{-5} (0.0016)	9×10^{-10}	Inhalation	3.2×10^{-5} (0.0032)	2×10^{-9}	Ingestion
Leak/spill	5.1×10^{-6} (0.00051)	3×10^{-10}	Inhalation	1.1×10^{-5} (0.0011)	6×10^{-10}	Ingestion
Tritium release	0.41 (41)	2×10^{-5}	Inhalation	29 (2,900)	0.002	Ingestion
Proposed MOX Facility						
Criticality	0.092 (9.2)	6×10^{-6}	External	0.35 (35)	2×10^{-5}	Ingestion
Explosion	8.7 (870)	0.0005	Inhalation	18 (1,800)	0.001	Ingestion
Internal fire	0.34 (34)	2×10^{-5}	Inhalation	0.69 (69)	4×10^{-5}	Inhalation/ingestion
Load handling	0.013 (1.3)	8×10^{-7}	Inhalation	0.027 (2.7)	2×10^{-6}	Inhalation/ingestion
Waste Solidification Building						
Fire	0.24 (24)	1×10^{-5}	Inhalation	0.31 (31)	2×10^{-5}	Inhalation
Hydrogen explosion	1.1 (110)	7×10^{-5}	Inhalation	2.1 (210)	1×10^{-4}	Inhalation/ingestion
Loss of confinement	0.44 (44)	3×10^{-5}	Inhalation	0.91 (91)	5×10^{-5}	Ingestion

[a]Latent cancer fatalities are calculated by multiplying dose by the FGR 13 health risk conversion factor of 0.06 fatal cancer per person-Sv (6×10^{-4} fatal cancer per person-rem) (Eckerman et al. 1999). Values are rounded to one significant figure.

Members of the public: As discussed above, impacts to the public were assessed for a short-term period immediately following the accident and for a 1-year exposure period following the accident that includes the short-term exposures. With the exception of nuclear criticality accident events, inhalation was the dominant exposure pathway for the public in the short term. Maximum inhalation doses would occur to the west-northwest of the SRS and would be more than 100 million times any external exposure. For the 1-year exposure to the public, the ingestion pathway was the dominant exposure pathway. The highest potential 1-year ingestion dose would be to the north of the SRS. Inhalation would account for the remainder of the dose except in the case of the criticality accidents where external exposure and inhalation make up the balance of the dose. Further details of the accident risk analysis are given in Appendix E.

The hypothetical explosion accident at the proposed MOX facility was estimated to result in the largest short-term exposure. An estimated collective dose of 400 person-Sv (40,000 person-rem) was projected to be received by a population of approximately 309,900 persons extending out to 80 km (50 mi) to the west-northwest of the proposed MOX facility. The average individual dose was projected to be approximately 1.3 mSv (130 mrem), about one-third the value an individual would receive on an annual basis from existing natural and man-made sources in the SRS vicinity. However, persons living closer to the accident location would receive a higher dose on average as discussed below for the hypothetical public MEI. The collective population dose received from this accident is estimated to have a risk of an additional 20 LCFs in the affected population.

The largest 1-year collective population dose was estimated to be 6,100 person-Sv (610,000 person-rem) from a hypothetical tritium release from the PDCF. This impact was calculated for winds blowing toward the north, where 84,200 people reside. However, only 6.6 person-Sv (660 person-rem) of this dose results from tritium inhalation. The remainder of the dose is attributable to ingestion of contaminated food. For the purposes of this DEIS, all contaminated food that would be grown in the affected area is assumed to be eaten. Because the amount of contaminated food exceeds the amount that would be consumed by persons living within the affected area, it is further assumed that some of the contaminated food would be shipped out of the region and consumed by persons living outside the region. Therefore, the collective dose estimated above includes doses to persons both within the affected area and outside the region. As shown in Table 4.15, the public MEI was estimated to receive a dose of 0.029 Sv (2.9 rem) for this hypothetical accident, based on individual consumption rates presented in Appendix E. Assuming that all 84,200 persons received the MEI dose, which would be an overestimate of the dose, the corresponding collective dose would be about one-third of the total collective dose estimated above. Therefore, the people living within the affected area would receive less than one-third of the collective dose estimated above.

As discussed below, no interdiction of contaminated food was assumed in the analysis of doses to the public during the 1-year post-accident exposure period. The current FDA recommendations (FDA 1998) include a protective action guide (PAG) of 5 mSv (0.5 rem) committed effective dose equivalent (CEDE) and 50 mSv (5 rem) committed dose equivalent to a individual tissue or organ, whichever is more limiting. These intervention levels of dose are radiation doses at which protective actions should be considered. The maximum public MEI dose of 0.029 Sv (2.9 rem) would exceed the FDA PAG of 5 mSv (0.5 rem) CEDE.

Impacts were assessed for an MEI living at the SRS boundary for both short-term and 1-year exposures. In both cases, maximum impacts were found to occur to a hypothetical individual located 9,070 m (5.6 mi) northwest of the facilities. As shown in Table 4.15 , the highest estimated dose to the public MEI was 8.7 mSv (870 mrem) in the short term from inhalation exposure from a hypothetical explosion accident at the proposed MOX facility. The maximum 1-year exposure accident impacts were estimated to result from the hypothetical tritium release from the PDCF. An exposure of 29 mSv (2,900 mrem) was estimated, with 0.41 mSv (41 mrem) from the inhalation pathway and the remainder from the ingestion pathway. The resulting health effects for the public MEI in the short term and after 1 year were estimated to be a chance of contracting a latent fatal cancer over their lifetime of 0.0005 (1 chance in 2,000) and 0.002 (about 1 chance in 500), respectively.

Should an accident occur, potential nearby receptors would be the most vulnerable immediately after the event because they might not be aware of the accident and might not receive notification in time to take protective actions. However, those individuals farther from an accident would be more likely to receive notification in time and would be in a position to reduce doses by taking protective actions. The consequences reported here assume that no protective actions are taken. Protective actions include sheltering or evacuation in the short-term and the banning of locally grown food in the long-term. Further, the results presented here are based on the assumption that an accident occurs immediately before harvest. This is a conservative assumption because the direct deposition of radioactivity on crops would cause the highest ingestion exposures. In addition, this analysis assumes that individuals are not sheltered during the accident and passing of the radioactive plume. Thus, the estimated accident impacts presented in this DEIS are considered to bound future possible outcomes.

The radiological risks of accidents described in this DEIS are considered to be low because either the likelihood of these accidents would be significantly diminished, or sufficient controls would be applied to ensure the dose consequences are much lower than those presented here. The requirements to reduce the risk of accidents that could result in high consequences are contained in the NRC's regulations in 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," and the DOE’s 10 CFR Part 830 "Nuclear Safety Management." In order to obtain a license to possess and use special nuclear material from the NRC, for example, the applicant must show that the risk of each credible high-consequence event is limited through the use of engineered controls, administrative controls, or both. Pursuant to this and other performance requirements, mitigation measures identified in Chapter 5 of this DEIS include those controls identified by the applicant to reduce the risks of potential accidents.

4.3.5.3 Chemical Human Health Risk

An analysis of potential impacts from accidental chemical releases was conducted. The analysis considered maximum inventories of stored chemicals at the proposed facilities and each chemical’s physical characteristics (e.g., volatility) and its toxic concentration levels. Liquid storage containers with the largest chemical inventories were assumed to be punctured (e.g., by a forklift), resulting in a spill of the entire chemical contents of the container on an outdoor concrete surface. For conservatism, it was assumed that the spill would occur onto an

impervious surface from which evaporation could occur, rather than onto a soil surface where absorption would limit evaporation. Evaporation from the chemical pool was assumed to be of limited duration, not more than an hour, because of rapid mitigative response. The Areal Locations of Hazardous Atmospheres (ALOHA, Version 5.2.3) model (Reynolds 1992) was used with the aid of a liquid pool evaporation algorithm to assess the downwind consequences of such bounding-case spills. An assessment of the accidental release of uranium dioxide powder was also included.

For each release, potential impacts to two populations were evaluated — the off-site general public and SRS employees. For the SRS employee evaluation, a wind speed of 2.2 m/s (4.9 mph), F atmospheric stability class, and a temperature of 25.8EC (78.5EF), was determined to represent the site-specific 95th percentile concentration. This was established on the basis of the ARCON 96 model chi/Q value (ratio of concentration to emissions) estimated at a distance of 100 m (330 ft) from the release. For the off-site general public evaluation, the bounding conditions were determined to be a wind speed of 1.3 m/s (3.0 mph), F atmospheric stability class, and a temperature of 25.8EC (78.5EF), representing site-specific, 95th percentile nighttime bounding meteorology. The 95th percentile meteorology was assumed to be a reasonable approximation of conditions that would produce the 95th percentile concentration consistent with the ARCON 96 estimate at 100 m (330 ft). Details on the modeling assumptions are provided in Appendix E.

The criteria levels used to assess potential exposures were temporary emergency exposure limits (TEELs) adopted by the DOE Subcommittee on Consequence Assessment and Protective Action (SCAPA) (Craig 2002). Several TEEL concentration values are available for each chemical (see text box on page 4-45). For the purposes of this analysis, modeled exposures of SRS employees (assumed to be located 100 m [330 ft] from the release location) to levels greater than TEEL-3 for any chemical were defined as high consequence, and levels less than TEEL-3 but greater than TEEL-2 were defined as moderate consequence. The assessment for the off-site general public differed slightly, as discussed below.

The distance from the release location to the SRS boundary (the nearest location for potential exposures of the general public) is 8.2 km (5.1 mi). Since the ALOHA model restricts release durations to 1 hour, the ambient air concentration at that location could not be readily obtained (the concentrations for downwind distances at times exceeding 1 hour are not directly provided in the ALOHA model). Because plume travel time exceeded 1 hour (i.e., the ALOHA limit) for all of the evaporative spill scenarios considered, the estimated site boundary concentration was obtained by extrapolation methods (see Appendix E). To assess impacts to the general public, site boundary concentrations greater than TEEL-2 levels for any chemical were defined as high consequence, and levels less than TEEL-2 but greater than TEEL-1 were defined as moderate consequence. In addition, the maximum distances from the release point to which chemical TEEL-1 and TEEL-2 air concentrations could extend were estimated using the ALOHA model.

Two release scenarios, one involving nitrogen tetroxide and the other involving chlorine, were modeled as pressurized releases. The HGSYSTEM model (Post 1994a,b; Hanna et al. 1997) was used to simulate pressurized jet releases for punctured containers and the downwind dispersion of the released material. As was done with the ALOHA model for the evaporative

Temporary Emergency Exposure Limits (TEELs)

TEEL-1: The maximum concentration in air below which it is believed that nearly all individuals could be exposed for up to one hour *without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor*.

TEEL-2: The maximum concentration in air below which it is believed that nearly all individuals could be exposed for up to one hour *without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action*.

TEEL-3: The maximum concentration in air below which it is believed that nearly all individuals could be exposed for up to one hour *without experiencing or developing life-threatening health effects*.

dispersion cases, all model runs accounted for the influence of dense vapor cloud behavior on downwind dispersion in releases determined to exhibit this behavior.

The results of the assessment are summarized in Table 4.16. No accidental releases would result in concentrations exceeding TEEL-1 levels beyond the site boundary. Impacts from these spills on the general public would be negligible. For all spills, impacts could be minimized with rapid emergency response actions by nearby workers. This response would include quick mitigative action to cover the spill and to minimize evaporation and downwind transport. For workers, impacts would be moderate or high for spills involving chlorine, nitrogen tetroxide, hydrazine hydrate, or nitric acid. Specific response actions covered under the existing SRS Emergency Response Plan (SRS 2001), including remaining indoors (i.e., sheltering in place) and evacuating (e.g., including rapid evacuation of all nonemergency workers to an upwind location and into designated buildings), would be implemented to minimize worker exposures to spills involving hazardous chemicals of this type. The SRS Emergency Response Plan may be revised to address specific hazards that are not covered in the existing plan subsequent to safety analysis reviews required under DOE chemical safety standards or orders (e.g., DOE-STD-3009-94, DOE Order 420.1).

4.3.5.4 Hydrology

During the scoping process, a concern was raised about groundwater contamination through existing deep boreholes. There are 11 deep boreholes at the SRS. The closest deep borehole is located north of the unnamed tributary that is just north of the proposed MOX facility (see Figure 3.3). Impacts to the groundwater from the proposed facilities have been evaluated. The deep boreholes were determined not to be a credible path by which materials from the proposed facilities could contaminate groundwater, and there would be no discharges to groundwater. Surface spills from the facilities that might travel toward the deep boreholes would be intercepted by the unnamed tributary. Accidental releases that might possibly reach

Table 4.16. Potential impacts of accidental chemical releases[a]

Chemical name	Form and concentration[b]	Maximum storage amount per container (gal)[c]	TEEL-1 (mg/m^3)	TEEL-2 (mg/m^3)	TEEL-3 (mg/m^3)	Modeled concentration at 100 m (mg/m^3) and impacts[d]	Modeled concentration at site boundary (mg/m^3)[d]	Maximum distance to TEEL-1 (km) and impacts[e]	Maximum distance to TEEL-2 (km) and impacts[e]
Proposed MOX facility									
Hydrazine hydrate	L, 35%	126	0.04	0.04	0.04	2.3	0.03[f]	6	6
Hydrazine/Sodium Hydroxide	L, 0.16 N	384	0.6	6	40	0.01	0.001	0.06	0.02
Hydrazine/Hydroxyl amine nitrate	L, 0.15 M	627	0.6	6	40	1.7	0.076	0.86	0.23
Hydrogen peroxide	L, 35%	55	12.5	60	125	0.2	0.008	0.08	0.03
Hydroxylamine nitrate	L, 1.9 M	200	15	26	125	1.5	0.068	0.21	0.15
Nitric acid	L, 13.6 N	161	2.5	15	200	1.7	0.090	0.62	0.22
Nitric acid	L, 2.1 N	1,321	2.5	15	200	6.7	0.319	1.2	0.41
Nitrogen tetroxide[g]	L, pres., 100%	240	15	15	75	1,600	5.10	4.1	4.1
Tributyl phosphate	L, 100%	126	6	10	300	1.7	0.075	0.23	0.18
Uranium dioxide[h]	S, 100%	37,500 kg	0.6	1	10	0.39	2×10^{-6}	< 8.6	< 8.6
Waste Solidification Building									
Nitric Acid	L, 50% (7.9 M)	500	2.5	15	200	20	0.88	2.0	0.67
Pit Disassembly and Conversion Facility									
Chlorine[g]	L, pres., 100%	240	3	7.5	60	500	2.2	6.9	3.9

[a]Assessment excluded chemicals that would be stored at volumes less than 38 L (10 gal), having low toxicity, defined as a TEEL-1 value of greater than or equal to 15 mg/m^3, or having low volatility (vapor pressure less than 1 Pa). Meteorological conditions assumed were F stability, 1.3 and 2.2 m/s wind speed (for site boundary and 100-m calculations, respectively), and 78.5EF. Sources of chemical use data: proposed MOX facility: DCS (2002b); WSB: DCS (2002a, Appendix G); PDCF: SPD EIS (DOE 1999a, Table E-7).

[b]L = liquid; S = solid; M = molar (moles/L); NA = not applicable; pres: pressurized; 13.6 moles of HNO_3 weighs 0.857 kg, 1.9 moles of hydroxylamine weighs 0.182 kg.

[c]To convert from gallons to liters, multiply by 3.8.

[d]The assumed nearest distance to an SRS employee is 100 m; concentrations greater than TEEL-2 indicate moderate impacts; concentrations greater than TEEL-3 indicate high impacts.

[e]The assumed nearest distance to off-site general public is 8.2 km; the distance to the site boundary; concentrations greater than TEEL-1 indicate moderate impacts; concentrations greater than TEEL-2 indicate high impacts.

[f]Estimated value.

[g]Chlorine and nitrogen tetroxide releases modeled using the HGSYSTEM model, Wake submodule.

[h]The 95th percentile relative air concentration at 100 m was estimated using ARCON96 as used in Section 4.3.3.1 and detailed in Appendix E, Section E.2.1.

the groundwater would flow in the shallow groundwater aquifer and discharge to Upper Three Runs Creek.

Because accidental releases to surface water would be quickly remediated as required by the facility's Spill Prevention Control and Countermeasures Plan, impacts would be negligible. Materials released by leaks or ruptures of vessels and piping used to store and transfer process chemicals and liquid radioactive waste could affect surface water and groundwater. Bulk process chemicals would be stored and chemical mixtures would be prepared in the Reagent Processing Building. DCS has identified a number of chemical process safety controls to prevent significant spills or other accidents that would have the potential to significantly affect the human environment. These measures include administrative controls over segregation and separation of incompatible chemicals, concentration controls on specific reagents, and a process safety instrumentation and control system to measure and control process conditions to ensure safety limits are not exceeded.

Groundwater quality could be indirectly impacted by accidental releases of contaminated effluents or hazardous stored liquids and infiltration of contaminated runoff. Such impacts, however, are expected to be negligible because of adherence to guidelines established in existing National Pollutant Discharge Elimination System (NPDES) permits and prompt cleanup of any spills as required under the facility's Spill Prevention Control and Countermeasures Plan. Storage vessels for liquid wastes would be located in the Aqueous Polishing Building.

A rupture of the low-level liquid radioactive waste transfer line could release wastewater containing radioactivity at concentrations up to the ETF waste-acceptance criteria levels. DCS, however, has committed to liquid containment features, including containment basins below storage tanks that hold contaminated liquids (stainless-steel-lined floors and portions of walls would be used to create basins in the tank room of the Aqueous Polishing Building) and double-wall pipe and a leak detection system for the transfer line.

The WSB would be connected to the proposed MOX facility and PDCF by two stainless steel double-walled pipelines for transfer of stripped uranium wastes and the high-alpha-activity wastes. The waste streams that constitute the high-alpha-activity waste stream include the americium stream, the alkaline wash stream, and the excess acid stream. The combined volumes of these streams would be about 83,270 L/yr (22,000 gal/yr) (DCS 2002a). The stripped uranium stream would average about 161,000 L/yr (42,530 gal/yr) during normal operations and 175,000 L/yr (46,000 gal/yr) during start-up. The stripped uranium stream would contain only 1% uranium-235 to avoid issues of criticality. To minimize the probability of a pipe failure, both of these waste streams would be transported in double-walled stainless steel pipes. In addition, the pipes would be designed to withstand the effects of a design-basis earthquake and other natural phenomena. If either of these lines ruptured, impacts to surface water or groundwater would be small because of the small quantities of waste involved in the transfer and prompt and thorough cleanup required under the SRS Spill Prevention Control and Countermeasures Plan.

4.3.5.5 Waste Management

Wastes that may be generated from the accident scenarios discussed in this DEIS are expected to be similar in type and of volumes that would be within the bounds of the capacities at the SRS for waste management. Potential impact to the waste management system at the SRS is expected to be minimal.

4.3.6 Deactivation and Decommissioning

4.3.6.1 Introduction

License termination is considered the final stage of the licensing process for an NRC-licensed facility. License termination entails deactivation and decommissioning of the facility as part of the termination process. Decommissioning involves the removal of the facility safely from service and reduction of residual radioactivity to a level that permits release of the property for unrestricted use. Termination of the MOX facility license would be governed by 10 CFR 70.38. Decommissioning of the proposed MOX facility would be conducted in accordance with criteria of 10 CFR 20 Subpart E (Radiological Criteria for License Termination). The PDCF and WSB may not be decommissioned after completion of MOX facility operations, but they are included in this evaluation to bound the analysis.

DCS plans to deactivate the proposed MOX facility and request NRC to terminate the license once the facility's mission for disposition of excess plutonium is completed (DCS 2002a). This plan is based on the contract between DOE and DCS that calls for DCS to deactivate the proposed MOX facility and place it in a safe-shutdown condition once operations have ended. In addition, the supporting DOE-owned and -operated support facilities, the PDCF and the WSB, would also require decommissioning once the surplus plutonium mission was completed. The ultimate fate of the facilities would then become the responsibility of DOE. DOE may choose to reuse or decommission the facilities once the surplus plutonium mission has been completed. DOE will make a decision on when and how to decommission the facilities.

Deactivation

Deactivation is the process of removing a facility from operation and placing it in safe-shutdown condition for an extended period of time. Deactivation would involve:

- Removal of unused plutonium and uranium feedstock, process chemicals, and loose surface contamination;
- Depressurization of all facility systems; and
- Sealing of gloveboxes and ventilation systems.

Currently, it is difficult to determine the possible final disposition of the facilities following the completion of their intended mission. The proposed MOX facility would be owned by DOE and operated by DCS under the terms of the DOE-DCS contract and scope of work. The course of decommissioning and future use of all three facilities would depend largely on DOE decisions that would be made at some future date as the facilities approached the end of their operating

lives. Although impacts of decommissioning the facilities were not included in the ER (DCS 2002a), the scoping process did identify decommissioning as a significant issue; therefore, the potential impacts of decommissioning the facilities are presented below.

Decommissioning

Decommissioning is the process of decontaminating and dismantling the facilities following deactivation and returning the site to an end state that meets the prescribed regulatory criteria. Decommissioning would involve:

- Chemical decontamination,
- Physical decontamination of equipment, structures, and materials (e.g., disassembly of equipment and enclosures and removal of materials), and
- Removal of structures and restoration of the site to a prescribed end state.

4.3.6.2 Decommissioning Process

Options for decommissioning nuclear facilities are discussed generically in NRC's *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities* (NUREG/CR-0586 [NRC 1988]). As stated in that document, it is the objective of the NRC to conduct decommissioning as an end point of the license termination process.

Other options, such as safe storage, deferred decommissioning, or restricted release, could have been evaluated. However, for safe storage and deferred decommissioning, the doses to workers during decommissioning would be greater because of the decay of transuranic radionuclides (e.g., plutonium-241 and plutonium-238). That is, the radioactivity in a facility would increase because of the in-growth of daughter products. Restricted release was not considered at this time because the "base case" for decommissioning under 10 CFR Part 20, Subpart E, would be unrestricted release. DCS would need to provide additional justification to support a request for restricted release, which at this point in the project would be speculative.

On the basis of the EIS on decommissioning of nuclear facilities (NRC 1988), it is assumed that the decommissioning process for the facilities would include 2 years of preparation and planning, followed by actual decommissioning activities. In general, decommissioning planning would be conducted during the last 2 years of normal plant operation. During that time, detailed plans and procedures would be prepared, a decommissioning staff would be trained, safety and environmental reports would be prepared (if necessary), and effluent control system modifications would be started.

Work would begin immediately following facility shutdown. Chemical decontamination would be followed by physical decontamination of most plant areas, including disassembly of equipment and enclosures and removal of resulting materials, such as structural components. These materials would be packaged and transported off-site as waste. The main facility and service system (e.g., decommissioning equipment and accessories) would be removed last. Some buildings, such as the Administration Building at the proposed MOX facility might not require any decommissioning prior to release for unrestricted use.

4.3.6.3 Decommissioning Impacts

4.3.6.3.1 Radiological Impacts

Because of the uncertainties involved in future operation of the facilities, most of the specific information needed to assess actual decommissioning impacts would depend on the actual operating history of the facilities. Because of the lack of a full-scale MOX facility, PDCF, and WSB, the analysis conducted for this DEIS has been extrapolated from the generic information provided in NRC's final generic EIS for a small mixed oxide fuel fabrication plant (NUREG/CR-0129; NRC 1979) and from NUREG/CR-0586 (NRC 1988). The extrapolation is based on a comparison of the size of the facilities as represented by the total area covered (square meters or square feet) by the MOX Fuel Fabrication Building plus the PDCF and the WSB. The objective of this analysis is to obtain baseline information pertaining to the radiological impact associated with decommissioning activities. Thus, the radiological impact from the proposed MOX facility was estimated to be about 28 times that in the NRC's generic EIS. Given the uncertainties in the decommissioning activities that would be undertaken at the proposed facilities in the future, this assumption provides a reasonable estimate of the decommissioning impacts. The radiological impacts associated with decommissioning are presented in Table 4.17.

Table 4.17. Summary of radiological impacts from routine facility decommissioning

Exposure	Dose[a] [person-Sv (person-rem)]
Occupational	
Deactivation[b]	6.3 (630)
Decommissioning	19 (1,900)
Transportation[c]	0.99 (99)
Total	27 (2,700)
Public	
Deactivation	8.2×10^{-9} (8.2×10^{-7})
Decommissioning	1.8×10^{-7} (1.8×10^{-5})
Transportation[c]	1.2 (120)
Total	1.2 (120)
Grand total	28 (2,800)

[a]Doses are rounded to two significant figures.

[b]Assumed to follow the same preparation process for long-term custodial care (NRC 1998).

[c]Assumes 686 shipments. Estimated from single shipment risks for TRU waste shipments from the SRS to WIPP presented in Monette et al. (1996).

4.3.6.3.2 Nonradiological Impacts

Geology and Soils. Soils covered by buildings and paved surfaces would be reclaimed to support the designated vegetation type after decommissioning. Soil treatments, including grading, disking, and fertilizer applications, would be used following removal of concrete foundations of structures and asphalt from paved parking areas. The movements of trucks and other vehicles involved in removing concrete and major facility components during decommissioning might result in soil compaction in localized areas. The use of chisel plows or other equipment might be required to loosen the soil in areas where compaction was severe. Depending on the final engineering design for the facility sites, some earth moving might

be needed. Soils in the storm-water retention area might be moved and/or graded to prevent erosion and to enhance establishment of plant species on areas to be revegetated. Attempts would be made to grade the area to fit with the existing topography of this portion of F-Area at the time of decommissioning.

Hydrology. The types of impacts to surface and groundwater during decommissioning of the facilities would be similar to those occurring during construction. Water would be used for dust suppression when necessary and might be needed during planting until vegetation becomes established. Runoff from areas being graded after the removal of concrete or asphalt would be minimized through use of silt fences or straw bales to control erosion. No impacts are anticipated to groundwater during decommissioning activities. Impacts to surface water during decommissioning would be small because of the measures employed to control runoff.

Air Quality and Noise. The types of air quality impacts expected during decommissioning of the facilities would be similar to those anticipated during facility construction. Vehicles used during decommissioning might create fugitive dust during dry conditions at the SRS. Fugitive dust would be controlled by watering during these periods. As described in Section 4.3.2.1, impacts to air quality would be small.

Noise associated with dismantling and removal of facility structures from F-Area and the SRS would be localized and temporary. Impacts of noise would be similar to those generated by initial construction of the facility (see Section H.2.1 in Appendix H) and would be small.

Ecology. Assuming that full decommissioning occurs and DCS removes the facilities and allows restricted use of the facility areas on the SRS, the following ecological impacts could occur. Although decommissioning plans may call for removal of facility structures, other areas designed to support operations may not be changed. The 4.5 ha (11.0 acres) occupied by the relocated 115-kV power line would remain in use as the power line continued to provide electricity to other F-Area facilities. Also, the 2.0 ha (5.0 acres) of new roads and road upgrades would remain. The 0.6 ha (1.5 acres) occupied by the storm-water basin might also be retained for that use. If storm-water control was not necessary, this area could provide wetland and pond habitats. The remaining areas located within the fenced boundaries of the facilities and along the pipeline rights-of-way could be revegetated. Revegetation goals could include establishing landscaped lawn around buildings, grass and forb species (e.g., similar to the vegetated conditions on the existing spoils pile area within the proposed location for the proposed MOX facility area), or evergreen and mixed forest habitats. The choice of treatment would depend upon the restricted use planned for the area in the future.

During decommissioning activities, wildlife would be affected in a manner similar to what would occur during construction (see Section H.3.1.1.2 in Appendix H). Impacts would primarily be disturbance and displacement caused by noise and human presence. Following decommissioning, a potentially diverse wildlife community could reoccupy the facility areas. Reforestation of the areas would be the most productive for wildlife, while use of the area for new facilities would be least productive for wildlife.

On the basis of the assessment of impacts to ecological resources during construction of the proposed facilities (Section H.3.1, Appendix H), the impacts of decommissioning are expected to be minor.

Land Use. The F-Area is classified as developed/industrial land. Construction of the proposed facilities is consistent with this classification and the SRS Long Range Comprehensive Plan (DOE 2000b). Decommissioning of the facility site for unrestricted use at SRS would not interfere with current uses or anticipated future uses of the F-Area. Lands in adjacent areas on the SRS managed by the U.S. Forest Service would not be adversely affected by decommissioning activities.

Cultural and Paleontological Resources. Decommissioning is not likely to affect any archaeological sites, historic structures, or traditional cultural properties at the proposed project site. Mitigation measures to avoid impacts during construction of the facility at one prehistoric archaeological site that is eligible for listing on the *National Register of Historic Places* (NRHP) are described in Section H.5.1.1 (Appendix H). Prior to decommissioning, a plan would be developed by DOE describing actions that would be taken to avoid or protect any known or new archaeological sites discovered in areas likely to experience surface disturbance or impacts from runoff because of decommissioning activities. The plan would also address other impacts of decommissioning workers such as unauthorized pedestrian traffic or vehicular activity in the vicinity of known sites or eligible sites. If the mitigation measures described in Section H.5.1.1 are implemented during decommissioning, the impacts to cultural resources could be avoided or minimized.

Nonradiological Impacts of Transportation. Decommissioning would require the transport of demolished structures and components to on-site or off-site disposal areas. The transport of structural materials and components would be along existing SRS roads and local South Carolina highways and would not require new roadway construction. Vehicular traffic on the SRS and local roadways related to decommissioning activities is not expected to affect traffic volume or traffic flow patterns on local roads.

Waste Management. The demolition of the facilities would generate solid waste in the form of structural materials such as concrete and steel and contaminated facility components. The quantities and classification of waste types cannot be determined at this time, but the handling and disposal of wastes produced during decommissioning would comply with all regulatory requirements.

Socioeconomics. The types of impacts to socioeconomic and community resources during the decommissioning of the facilities would be similar to those occurring during their construction. The number of workers expected to be needed for decommissioning is about the same as for construction. Socioeconomic impacts from construction are described in Section H.7.1 (Appendix H). No adverse impacts are anticipated to local communities relative to housing demand for workers or community services from decommissioning activities. Assuming that they would have sufficient notice of the completion of decommissioning impacts, local communities should be able to plan for the loss of revenue generated by the work force. The projected costs of decommissioning are discussed below.

Decontamination and Decommissioning Costs. Uncertainties surrounding the precise nature of activities and, consequently, the magnitude of the cost associated with decommissioning of the proposed MOX facility have meant that no direct estimates of these costs have been made to date. However, estimates have been made on the basis of the costs of decommissioning efforts for a similar facility at the Rocky Flats Environmental Technology Site (RFETS) in Colorado (DCS 2001). Facilities currently being decommissioned at RFETS have supported activities that are broadly similar to those likely to take place in a MOX fuel fabrication facility and in the associated aqueous polishing facility. These activities at RFETS have included the manufacture of plutonium weapons components, including casting and machining in dry gloveboxes, and the recovery of plutonium from plutonium residue in "canyon" rooms. On the basis of the volume and types of wastes generated during the decommissioning of those buildings, estimates of the direct costs of decommissioning of the proposed MOX facility and related facilities are about $363 million (FY 2001 dollars).

In addition to the direct costs of the facilities, a number of indirect costs would also be incurred. These costs include site security, residue and fuel deactivation and removal, environmental programs, project management, and costs associated with borrowing funds to finance the project (DCS 2001). Significant contingency allowances would also have to be included.

On the basis of data gathered from other, similarly large nuclear fuel cycle-related projects, it can be concluded that the indirect costs are likely to be roughly approximate to the direct costs of construction and operation. It has also been estimated that decommissioning costs of similar projects are equivalent to about 80% of project capital cost (DOE 1995). Design and construction costs for the MOX, PDCF, and WSB facilities, including contingency, are estimated to be $1,830 million (NNSA 2002). Using both approaches, the total decommissioning cost for the three facilities would, therefore, lie in the range of $730 million to $1,464 million (2001 dollars).

4.3.7 Environmental Justice

4.3.7.1 Introduction

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (Volume 59, page 7629 of the *Federal Register* [59 FR 7629]), issued by President Clinton on February 11, 1994, requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

The analysis of the potential impacts of the no-action and proposed action alternatives on environmental justice at the SRS uses demographic data from the 2000 census to describe the minority composition of the area around the SRS and data from the 1990 census to describe the distribution of the low-income population in the vicinity of the SRS. At this time, 2000

census data on the low-income population are not available at the appropriate level of geographic detail required for a full analysis. The definitions of minority and low-income population groups as used in this analysis are as follows:

- **Minority.** Beginning with the 2000 census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origin. Persons are included in the minority category if they classify themselves as belonging to any of the following racial groups: Hispanic, Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander. In addition, persons who classify themselves as being of multiple racial origin may choose up to six racial groups as the basis of their racial origins. The "minority population" therefore incorporates all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as not of Hispanic origin and as White or "Other Race" (U.S. Bureau of the Census 2001).

- **Low-Income.** Individuals who fall below the poverty line are classified as low-income. The poverty line takes into account family size and age of individuals in the family. In 1999, for example, the poverty line for a family of five with three children below the age of 18 was $19,882 in annual income. For any given family below the poverty line, all family members are considered as being below the poverty line for the purposes of analysis (U.S. Bureau of the Census 2001).

Data on minority and low-income populations are available at the county, census tract, block group, and block level. To fully evaluate the potential environmental justice impacts of the proposed action alternative, the distribution of minority and low-income populations was analyzed at the census block group level. The analysis was based on guidelines for environmental justice analyses described in *Environmental Review Guidance for Licensing Actions Associated with NMSS Programs* (NRC 2001). An 80-km (50-mi)-diameter buffer zone around F-Area at the SRS was used as the basis for the analysis so as to include potential adverse human health or socioeconomic impacts related to the construction and operation at the SRS that might occur at greater distances than have been used in other analyses. On the basis of information received during scoping meetings at the site, a larger area was also used to address the concern that any accidental releases to the environment would also have the potential to affect fishing resources that might be used for subsistence by low-income and minority population groups some distance downstream of the site (see Appendix I). Accidental chemical and radiological releases, for example, have the potential to affect minority and low-income population groups located some distance from the site, depending on the size and nature of potential releases and on meteorological conditions. The actual extent of any such effects would depend on the magnitude and nature of any release at the site.

Block group level data for minority and low-income populations for all block groups within 80 km (50 mi) of F-Area are shown in Table 4.18. Data for each population group are compared with the state minority and low-income totals.

Table 4.18. Minority and low-income population characteristics at the SRS

Parameter	Within 80-km buffer, Georgia	Within 80-km buffer, South Carolina
Ethnic or racial origin		
White	225,136	242,652
Hispanic or Latino	9,863	8,184
Black or African American	157,757	145,808
American Indian or Alaska Native	955	1,320
Asian	6,293	1,701
Native Hawaiian or other Pacific Islander	328	66
Two or more races	4,856	3,081
Other Race	573	271
Total minority	180,052	160,160
Percent minority	44.4%	39.7%
State percent minority	37.2%	33.8%
Low income		
Total low-income population	61,834	60,819
Percent low-income	16.8%	16.3%
State percent low-income	13.0%	14.1%

Source: U.S. Bureau of the Census (2001).

Guidelines for performing environmental justice reviews described in NRC's NUREG-1748 (NRC 2001) suggest that disproportionate effects on minority and low-income populations should be considered if the minority or low-income populations in block groups are more than 20 percentage points higher than the state level, or where the local minority or low-income population exceeds 50%. Using data in Table 4.18, adding 20 percentage points to the state average would mean that disproportionate effects on minority populations should be considered if the percentage of minorities in a block group is greater than 57.2% in Georgia and 53.8% in South Carolina. However, according to the guidelines, any block group where the minority population is more than 50% should also be considered. Disproportionate effects on low-income populations should be considered if the percentage of the low-income persons in a block group is greater than 34.7% in Georgia and 35.4% in South Carolina. Block groups with more than 50% of the population categorized as low income would also be considered.

Figures 4.1 and 4.2 show the census block groups for the 80 km (50 mi) buffer zone area. The shaded areas are those block groups where minority and low-income individuals is 20 percentage points higher than the state average, or greater than 50 percent of the total population in the block group."

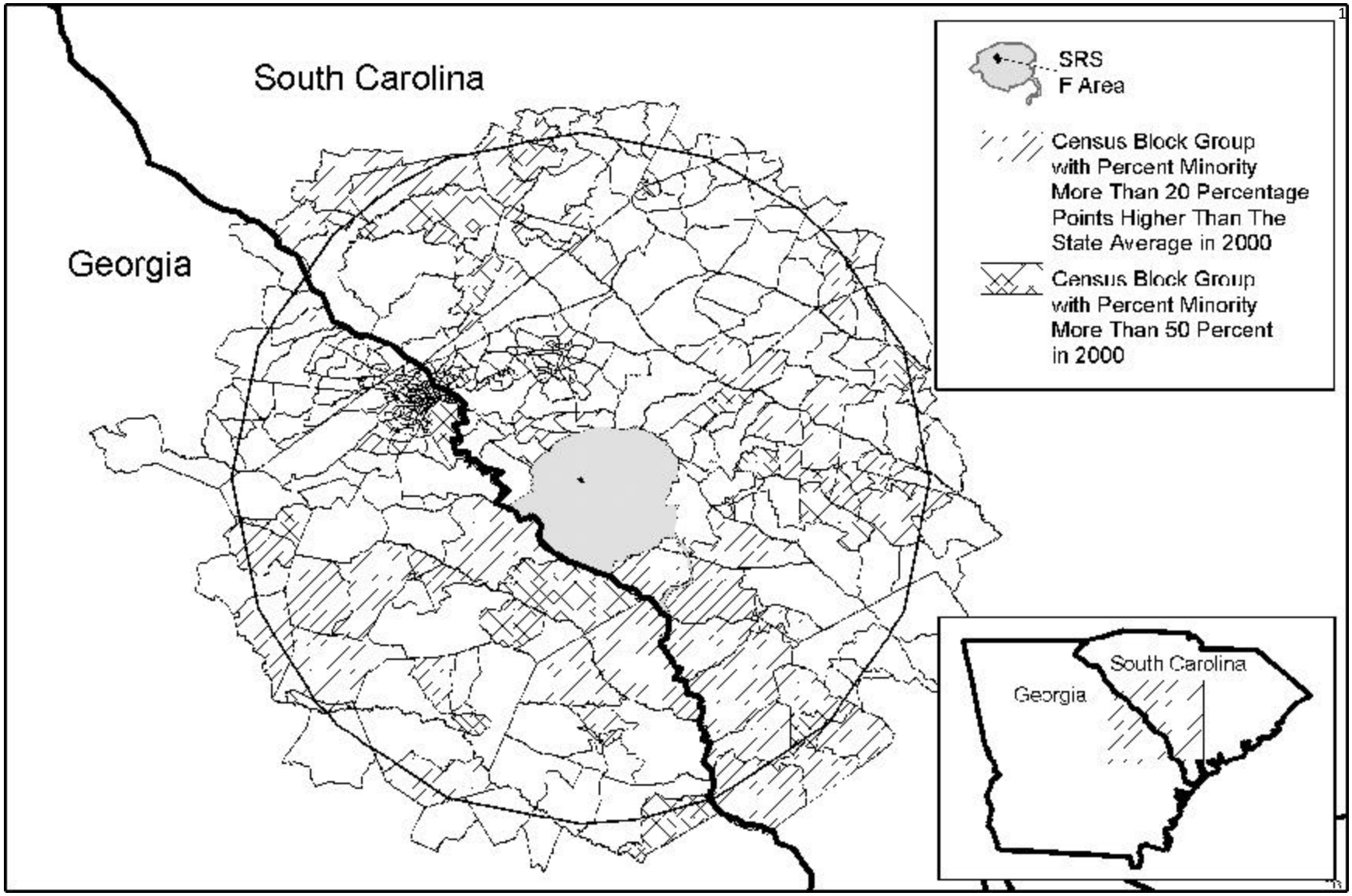

Figure 4.1. Minority population concentration in census block groups within an 80-km (50-mi) radius of the SRS F-Area (*Source:* U.S. Bureau of the Census 2001).

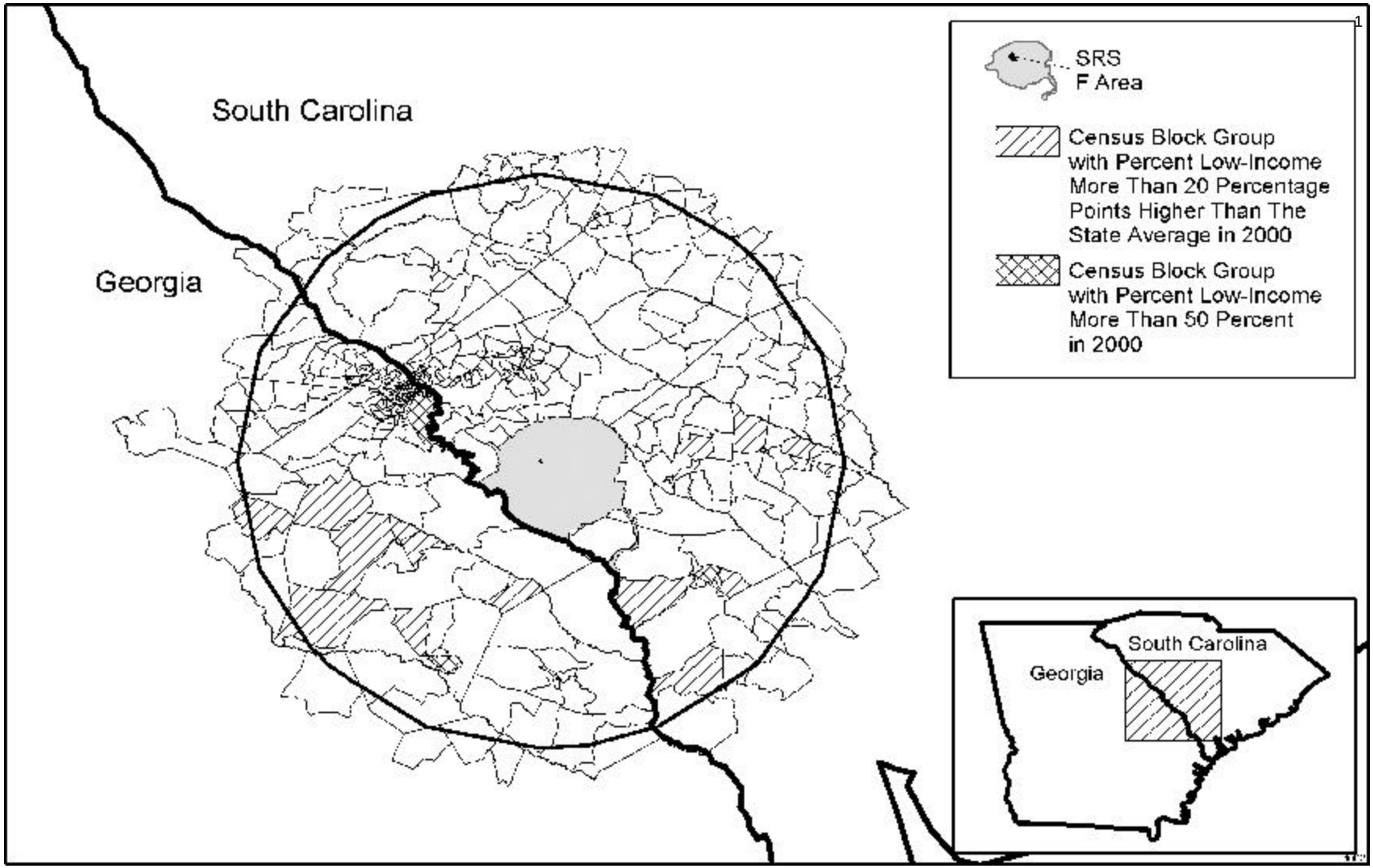

Figure 4.2. Low-income population concentration in census block groups within an 80-km (50-mi) radius of the SRS F-Area (*Source:* U.S. Bureau of the Census 2002)

4.3.7.2 Impacts of the No-Action Alternative

For all the storage sites, radiological and nonradiological risks from continued storage of surplus plutonium would be small regardless of the racial and ethnic composition of the populations surrounding the sites, and independent of the economic status of individuals constituting the populations. Continued storage would have no disproportionately high and adverse effects on minority or low-income populations.

4.3.7.3 Impacts of the Proposed Action

4.3.7.3.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction. Chemical exposure would be limited to toxic air pollutants released at levels below applicable standards and would not result in any high adverse health impacts. Because the health impacts on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts on the minority and low-income population would not be significant.

4.3.7.3.2 Routine Operations

Radiological impacts to the general public during routine operation of the proposed facilities would be minimal and would not cause any adverse health impacts. The facilities are expected to produce an annual latent cancer risk of approximately 1 in 3 billion for the MEI member of the public. The annual collective dose to members of the public living and working within 80 km (50 mi) of SRS associated with the facilities is expected to produce an LCF risk of approximately 0.0004 or less. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations are expected to occur. Because the health impacts of routine operations on the general public would be negligible, there would be no disproportionately high adverse impact on low-income or minority population groups within the 80-km (50-mi) assessment area.

4.3.7.3.3 Accidents

A tritium release at the proposed PDCF facility has the potential for causing up to 400 latent cancer fatalities in the area surrounding SRS. However, it is highly unlikely that such an accident would occur. Therefore, the risk to any population, including low-income and minority communities, is considered to be low. In the unlikely event of a tritium release at the PDCF or an explosion at the proposed MOX facility, the communities most likely affected would be minority or low income, given the demographics within 80 km (50 mi) of the proposed MOX facility.

In the event that accidents producing significant contamination occurred, appropriate measures would be taken to ensure that the impacts to low-income and minority populations would be minimized (see Section 5.2.11). The extent to which low-income or minority population groups would be affected would depend on the amount of material released and the direction and speed at which airborne material was dispersed from the facility by the wind. Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release would be to the population located to the west-northwest of SRS, while the greatest one-year risk would be to population groups residing to the north of the site because of the prevailing wind direction. Airborne releases following an accident would likely have a larger impact area than would an accident that released contaminants directly onto the soil surface. A surface release entering local streams could temporarily interfere with subsistence activities by low-income and minority populations located within a few kilometers downstream of SRS.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control use of high health risk areas would reduce the potential impact to local residents.

4.3.7.3.4 Decommissioning

Impacts of decommissioning are not expected to disproportionally affect low income or minority populations in the SRS vicinity. A detailed analysis of impacts would be prepared by DOE in a NEPA document specifically on decommissioning and site closure if plans call for full decommissioning of the facilities. Important elements of the environmental analysis in the DOE NEPA document would likely address the disposal process and locations of disposal sites for structural materials and facility components resulting from decommissioning.

4.3.8 Sand Filter Technology Option

Sand filters are air filtration systems used to prevent the release of radioactive material from nuclear facilities to the atmosphere. In a sand filter, the airborne radioactive material is forced through large beds of stone, gravel, and sand that capture and retain radioactive material. Filtered air is discharged to the atmosphere from a nearby stack.

As discussed in Sections 1.4.1 and 2.2.5, the use of sand filters was identified during the EIS scoping process as a potential substitute for final high-efficiency particulate air (HEPA) filters. Differences in impacts between sand filters and HEPA filters are discussed below. Specifically, this section presents the impacts to human health, air quality, hydrology, waste management, potential accident impacts, and facility decommissioning.

Relative to radiological impacts during routine operations, those human receptors who would be affected by such a change would be the proposed MOX facility workers, SRS employees, and the public. However, the differences in emissions between the two filter types is not significant. Thus, the impacts presented in Section 4.3.2.2 on routine operational impacts from the

proposed MOX facility to SRS employees and the public would hold for both sand filters and the proposed HEPA filters. In the case of the proposed MOX facility workers, exposure would occur from maintenance activities during normal operations. Monitoring to ensure adequate performance would be required for both filter types. However, HEPA filters, unlike sand filters, would require periodic replacement in addition to monitoring (Orr 2001). The additional exposure in the case of HEPA filters would be minimized with the use of a bag-in/bag-out system (one that isolates the filters from personnel and the environment during replacement) and the maintenance of practices to limit releases of radioactivity to levels as low as reasonably achievable (ALARA) (Orr 2001).

With regard to chemical risks, the difference in chemical removal efficiency between HEPA filters and sand filters is small. Therefore, the impacts presented in Section 4.3.2.2 would be representative for either filter type.

Because air quality impacts associated with the proposed MOX facility would be dominated by the emission of gaseous chemical compounds, and neither HEPA filters nor sand filters are effective for gases, sand filters do not present a clear advantage over HEPA filters. Air quality impacts would be mitigated by other off-gas treatment systems associated with the proposed action.

If sand filters were chosen over HEPA filters at the proposed MOX facility, excavation would be needed for the filter foundations. Excavation is not expected to extend to a depth likely to encounter groundwater. The depth of the sand filter would depend on spatial configuration and topography at the specific site selected for the filter. A surface area of 3,162 m^2 (33,650 ft^2) would be required for the sand filter (Orr 2001). Operation of a sand filter at the proposed MOX facility would not impact groundwater resources. The filter would be covered to prevent precipitation from enhancing recharge of the underlying aquifers and would have a concrete wall and bottom.

The impact to waste management practices at the SRS was also evaluated with regards to the type of air filters that could be used during proposed MOX facility operations. The waste volume and associated disposal costs from routine operations using HEPA filters versus use of sand filters are compared in Table 4.19. TRU waste and LLW would be generated if HEPA filters were used, and primarily TRU waste would be generated if sand filters were used. The waste volumes generated from either type of filter would be within the SRS capacity for treatment, storage, and disposal of TRU waste and LLW and, therefore, should have minimal impact to the SRS waste management program.

Relative to radiological impacts resulting from accidents, sand filters may provide a larger margin of safety for SRS employees and the public. Two of the four accidents evaluated, the internal fire event and the explosion event, have the potential to damage HEPA filters. If the major vent duct work itself remained intact for these accidents, filter efficiency would not be lost if sand filters were used, and the impacts for the internal fire event and the explosion event could be approximately 100 times lower than the impacts presented for HEPA filters in Section 4.3.5. (Appendix E presents more information on the amount of radioactivity released

Table 4.19. Comparison of waste volume and disposal cost for HEPA and sand filters

Parameter	HEPA filter	Sand filter
Waste amount	2,178 filters	9,543 m^3
Disposal cost[a]	$9,333,000	$8,411,750
Type of waste	TRU, LLW	TRU

[a]Estimated disposal cost for HEPA filters is based on the number of filters required, while the cost for the sand filters is based on total volume of sand and rock requiring disposal.

from each accident considered.) DCS has committed to a strategy of making explosions highly unlikely if they could result in high consequences to SRS employees and members of the public. By preventing explosions, DCS would prevent impaired function of the facility HEPA filters. Further, DCS would maintain safety controls in the proposed MOX facility that would either prevent fires, or for some areas, ensure that fires are contained to single fire areas that would limit the amount of radioactive material involved a fire. Where fires are limited to fire areas, DCS would ensure that the facility HEPA filters would continue to function in the high temperature and soot environment created by the bounding fire.

The decommissioning impacts described in Section 4.3.6 were based on the proposed use of HEPA filters. However, if a sand filter was used, there is the possibility that it could be left in place, incurring little additional decommissioning work. Otherwise, there could be significant impacts, such as economic costs and human health risks, from excavating the contaminated material and possibly transporting and disposing of significant amounts of low-level or transuranic waste, depending on the level of contamination (Orr 2001).

In conclusion, the technology option to install sand filters would not clearly result in lower net environmental impacts than the use of HEPA filters. By selecting sand filters, DCS could reduce environmental impacts in the areas of human health risk to facility workers and accident mitigation. However, controls on HEPA filter change-out and a DCS safety strategy to prevent accidents that would challenge HEPA filter function provide an equivalent reduction of impacts.

4.4 Indirect Impacts

4.4.1 Transportation

This assessment is based on the transportation assessment presented in the NRC's NUREG-0170 report (NRC 1977). Since that assessment was conducted, computer models and basic assumptions have been refined, but the overall approach to estimating transportation impacts has remained the same.

4.4.1.1 Scope of the Analysis

The technical approach for estimating transportation risks involves use of several computer models and databases. For assessment of normal transport, risks were calculated for the collective populations of all potentially exposed individuals, as well as for an MEI receptor. Potentially exposed populations include those persons living and working along the transport route, those present at vehicle stops, and those on the road near the shipment. The accident assessment included consideration of the probabilities and consequences of a range of possible transportation-related accidents, including low-probability accidents that have high consequences, and high-probability accidents that have low consequences. The details of the transportation analysis are provided in Appendix C. Transportation impacts are presented in Section 4.4.1.2.

Transportation concerns raised during the scoping process for this DEIS (see Appendix I) included the impacts of transporting MOX feed materials (depleted uranium hexafluoride [UF_6] and the surplus plutonium metal) transport. As discussed below, impacts from the transportation of depleted uranium and surplus plutonium metal (pit material) feed materials were analyzed. Impacts of transporting the plutonium dioxide from the proposed PDCF to the proposed MOX facility are not considered because of the short distance involved and the absence of public roads in this area (DCS 2002a). The NRC intended to evaluate truck and rail transportation impacts of shipping fresh MOX fuel from the SRS. However, this DEIS evaluated only truck shipments of such fuel because of the added security provided through the use of the SafeGuards Transporter, as described in Appendix C, Section C.2.3.

The transportation risk assessment conducted for operation of the proposed MOX facility involved estimating the potential human health risks during transport of feed and waste materials associated with the MOX fuel fabrication process. The risk assessment also considered the risks associated with the transport of the MOX fuel following fabrication.

Transport of the depleted uranium feed materials analyzed included shipment of depleted UF_6 from Portsmouth, Ohio, to Wilmington, North Carolina, and depleted uranium dioxide (UO_2) from Wilmington to the proposed MOX facility at the SRS. Assessment of the transport of plutonium pit material considered shipments from existing storage sites to the SRS. Of the 34 MT (37.5 tons) of plutonium expected to be processed into MOX fuel, 7.3 MT (8.0 tons) would be initially available at the SRS site. Under a separate action (DOE 2002a), approximately 6 MT (6.6 tons) of surplus plutonium is to be shipped from RFETS to SRS (Roberson 2002), which currently has 1.3 MT (1.4 tons) (DOE 1996a). The proposed action would therefore require the shipment of another 26.7 MT (29.4 tons) of plutonium, approximately 21.3 MT (23.4 tons) of which is expected to come from the Pantex Plant in Texas. This DEIS analyses the transportation impacts of the Pantex shipments and the remaining 5.4 MT (5.9 tons) of plutonium whose origins are not yet determined. However, the remaining plutonium would come from storage at other DOE sites. For the purposes of this DEIS, the analysis assumed that the remaining 5.4 MT (5.9 tons) of plutonium would come from the Hanford Site, the plutonium storage site farthest from the SRS. Thus, the actual transportation impacts are expected to be lower than those presented here because some plutonium from closer storage

sites is expected to be used. Impacts of shipping transuranic (TRU) waste from the WSB to the Waste Isolation Pilot Plant (WIPP) in New Mexico were evaluated.

Additionally, the DEIS evaluates the impacts of shipping all the fresh MOX fuel from the SRS to a surrogate commercial nuclear plant. The fresh MOX fuel is expected to be used in reactors in the eastern to midwestern portion of the United States. For purposes of impact assessment, a midwestern site was chosen for the surrogate nuclear plant because such a location maximizes the distances necessary to transport the fuel, thus providing conservative estimates of potential impacts. A surrogate nuclear power plant was chosen because no licensed nuclear plant has applied to NRC for authority to use MOX fuel. Thus, the impacts presented here are expected to bound the impacts for future shipments of fresh MOX fuel.

For all shipments, risks were estimated for truck transport for both normal (incident-free) and accident conditions. In both cases, “vehicle-related” and “cargo-related” impacts were evaluated.

Vehicle-related risks result simply from moving any material from one location to another, independent of the characteristics of the cargo. For example, increased levels of pollution from vehicular emissions during normal conditions may affect human health. Similarly, accidents during transportation may cause fatalities from physical trauma.

Cargo-related risk, on the other hand, refers to risk attributable to the characteristics of the cargo being shipped. The radiological cargo-related risks from the transportation of depleted uranium, surplus plutonium, fresh MOX fuel, and TRU waste would be caused by exposure to ionizing radiation. Exposures to radiation occur during both normal transportation and during accident conditions. In the case of the depleted uranium materials considered, cargo-related risks also include chemical hazards during accident conditions.

The risks from exposure to hazardous chemicals during transportation-related accidents can be either acute (result in immediate injury or fatality) or latent (result in cancer that would present itself after a latency period of several years). The acute health end point — potential irreversible adverse effects — was evaluated for the assessment of cargo-related population impacts from transportation accidents. Accidental releases during transport of the uranium compounds (UF_6 and UO_2) were evaluated quantitatively. The analysis of UF_6 effects included consideration of the formation of hydrogen fluoride (HF) from the reaction of UF_6 with moisture in the air. Chemical health effects from transportation of plutonium compounds were not assessed because the radiological impacts are far greater than any chemical impacts.

Unlike the case for radiological exposure, the acute chemical effects evaluated were assumed to exhibit a threshold nonlinear relationship with exposure; that is, some low level of exposure can be tolerated without inducing a health effect. To estimate risks, chemical-specific concentrations were developed for potential irreversible adverse effects. All individuals exposed at these levels or higher following an accident were included in the transportation risk estimates. In addition to acute health effects, the cargo-related risk of excess cases of latent cancer from accidental chemical exposures could be evaluated. However, none of the chemicals that might be released in any of the transportation accidents involving UF_6, UO_2,

plutonium, or the MOX fuel would be carcinogenic. As a result, no predictions for excess chemically induced latent cancers are presented in this assessment for accidental chemical releases.

4.4.1.2 Transportation Impacts

The estimated exposures and the associated human health effects are discussed in this section and summarized in Table 4.20.

4.4.1.2.1 Routine Transportation

Radiological risks during routine transportation would result from the potential exposure of people to low levels of external radiation near a loaded shipment. U.S. Department of Transportation (DOT) and NRC regulations — 49 CFR Part 173.441 (*Radiation Level Limitations*) and 10 CFR Part 71.47 (*External Radiation Standards for All Packages*) — were set to maintain these external radiation levels at a value considered to be protective of the public. The maximum allowable external dose rate is 0.1 mSv/h (10 mrem/h) at 2 m (6.5 ft) from the outer lateral sides of the transport vehicle. In this analysis, the external dose rates expected are approximately 0.0024 mSv/h (0.24 mrem/h), 0.0076 mSv/h (0.76 mrem/h), 0.048 mSv/h (4.8 mrem/h), and 0.040 mSv/h (4.0 mrem/h) at 1 m (3.3 ft) for the UF_6, UO_2, MOX fuel, and TRU waste shipments, respectively (Biwer et al. 1997; DCS 2001; DOE 1997b). Since the regulatory maximum is approximately 0.14 mSv/h (14 mrem/h) at a distance of 1 m (3.3 ft), the external dose rates from the depleted uranium shipments, the MOX fuel shipments, and the TRU waste shipments are expected to be less than 6%, 35%, and 30% respectively, of that regulatory maximum. For this analysis, the external dose rate for the shipments of plutonium metal were set to the regulatory maximum, but it is expected that the dose rate from these shipments would actually be similar to those for the fresh MOX fuel and TRU waste.

Combined total exposures of 4.1 person-Sv (410 person-rem) and 2.5 person-Sv (250 person-rem) were estimated for the public and the transportation crews, respectively, from all shipments. The resulting expected LCFs are 0.3 and 0.2, respectively (see Table 4.20). These impacts to the public would be insignificant because the exposure would be spread out over several years among all the people along the transportation routes. The plutonium shipments from Pantex to the PDCF had the highest average individual dose to the public, 0.0025 mSv (0.25 mrem), estimated from a total collective dose of 1.47 person-Sv (147 person-rem) spread over 576,597 persons along the route. Thus, the routine radiological impacts to the public for the entire shipping campaign would be negligible, an average member of the public would receive only 0.07% or less of the value for exposure to background radiation in one year.

For an MEI member of the public (defined as being located 30 m [98 ft] away from a shipment passing at a speed of 24 km/h [15 mph] [Neuhauser and Kanipe 1992]), the greatest radiological risk would be from the plutonium metal shipments, as shown in Table 4.21. In this case, a risk of 6×10^{-10} (a chance of less than 1 in 1 billion) of contracting a fatal cancer is

Table 4.20. Total collective population transportation risks

Parameter	Depleted UF_6	Depleted UO_2	Pu metal	TRU waste	MOX fuel	Total campaign
Origin site	Portsmouth, Ohio	Wilmington, N.C.	Storage sites	WSB	MOX facility	
Destination site	Wilmington, N.C.	MOX facility	PDCF	WIPP	surrogate reactor	
Shipment summary						
Shipments	110	60	430	350	598	1,548
Distance [km (mi)]	103,000 (63,900)	26,500 (16,500)	1,130,000 (705,000)	854,000 (531,000)	1,280,000 (798,000)	3,400,000 (2,114,000)
Population impacts						
Cargo-related[b]						
Radiological Impacts						
Dose risk [person-Sv (person-rem)]						
Routine crew	0.0061 (0.61)	0.0045 (0.45)	0.72 (72)	0.54 (54)	0.93 (93)	2.2 (220)
Routine public						
Off-link	0.00044 (0.044)	0.00013 (0.013)	0.12 (12)	0.022 (2.2)	0.038 (3.8)	0.18 (18)
On-link	0.0011 (0.11)	0.00035 (0.035)	0.35 (35)	0.068 (6.8)	0.094 (9.4)	0.51 (51)
Stops	0.0045 (0.45)	0.0018 (0.18)	1.7 (170)	0.36 (36)	0.34 (34)	2.4 (240)
Total	0.0060 (0.60)	0.0022 (0.22)	2.2 (220)	0.45 (45)	0.48 (48)	3.1 (310)
Accident[c]	0.0025 (0.25)	0.00049 (0.049)	6.3×10^{-4} (0.063)	0.068 (6.8)	0.16 (16)	0.23 (23)
Latent cancer fatalities[d]						
Crew	0.0004	0.0003	0.04	0.03	0.06	0.1
Public	0.0005	0.0002	0.1	0.03	0.04	0.2
Chemical Impacts						
Irreversible adverse effects[e]	1.3×10^{-7}	0	NA	NA	NA	1.3×10^{-7}
Vehicle-related[f]						
Emission fatalities	0.04	0.008	0.3	0.2	0.6	1
Accident fatalities	0.003	0.0012	0.028	0.02	0.029	0.081

[a]NA = not applicable.

[b]Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the waste material.

[c]Accident dose risk is a societal risk and is the product of accident probability and accident consequence.

[d]Latent cancer fatalities are calculated by multiplying dose by the FGR 13 health risk conversion factor of 0.06 fatal cancer per person-Sv (6×10^{-4} fatal cancer per person-rem) (Eckerman et al. 1999).

[e]Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds is estimated to result in fatality of approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

[f]Vehicle-related impacts are impacts independent of the cargo in the shipment.

Table 4.21. Routine single-shipment impacts to a maximally exposed individual[a]

Shipment type	Dose [mSv (mrem)]	Risk of developing a latent fatal cancer
Depleted UF_6	2.3×10^{-7} (2.3×10^{-5})	1×10^{-11}
Depleted UO_2	3.7×10^{-7} (3.7×10^{-5})	2×10^{-11}
Pu metal	1×10^{-5} (1×10^{-3})	6×10^{-10}
MOX fuel	1.5×10^{-6} (1.5×10^{-4})	9×10^{-11}
TRU waste	2.4×10^{-6} (2.4×10^{-4})	1×10^{-10}

[a]Individual is located 30 m (98 ft) from a passing shipment traveling at 24 km/h (15 mph).

0.0003% of the value for an annual exposure to background radiation. However, the value for potential exposure to multiple shipments would be correspondingly higher. For example, if the same MEI were present for three shipments of depleted UO_2, that individual would receive a dose of approximately 1.1×10^{-6} mSv [$3 \times (3.7 \times 10^{-7}$ mSv)].

For transportation crew members, the largest estimated single shipment dose to one transportation crew member was 0.0013 Sv (0.13 rem) for shipments of plutonium from the Hanford Site to the PDCF. In this case, the risk of contracting a fatal cancer is 1 in 13,000.

A total of 1 latent fatality was estimated from vehicle emissions for the entire shipping campaign. Thus, approximately 1 fatality might be expected from vehicle emissions. This vehicle-related impact is insignificant because the proposed action truck travel on U.S. highways for the entire shipping campaign, 3,400,000 km (2,114,000 mi) as shown in Table 4.20, is only 0.0016% of similar truck travel on an annual basis in the United States, 217,550,000,000 km (135,179,000,000 mi) (BTS 2002).

4.4.1.2.2 Accident Impacts

The total radiological collective population accident dose risk to the public from all shipments was estimated to be 0.23 person-Sv (23 person-rem). The resulting estimated LCFs are 0.01 for the entire shipping campaign.

Chemical impacts would be negligible; only 1.3 x 10^{-7} irreversible adverse effect from depleted UF_6 shipments is expected for the entire shipping campaign. As discussed in Appendix C (Section C.2.6), this value corresponds to approximately 1 x 10^{-9} fatality.

Total fatalities from direct physical trauma as a result of accidents were estimated to be 0.081. Thus, no fatalities are expected from accidents for the entire shipping campaign.

4.4.1.3 Highly Enriched Uranium

As described in Section 2.2.2.2, highly enriched uranium (HEU) is a by-product of the plutonium pit disassembly process. This recovered HEU would be shipped to the Y-12 facility at the Oak Ridge Reservation for declassification, storage, and eventual disposition. The transportation risks for these shipments were analyzed and included in estimates presented in the SPD EIS for transport of all radioactive material associated with the conversion of 33 MT (36.4 tons) of plutonium to MOX fuel as part of Alternative 3 (see Table L-6 in DOE 1999a). The total radiological transportation risks for Alternative 3 were 0.024 and 0.038 LCFs expected for transportation workers and the public, respectively. Thus, the transportation risks for the HEU shipments are considered to be insignificant because they represent only a small portion of an insignificant impact.

4.4.1.4 Spent MOX Fuel

Transportation of the spent MOX fuel to a final disposal site would be required after irradiation in a commercial nuclear reactor. The types of transportation risks posed would be the same as those considered above for the uranium and plutonium feed materials, the fresh MOX fuel, and the TRU waste. These risks include the radiological cargo-related risks from routine transport and hypothetical accidents and the vehicle-related risks, such as traffic accident fatalities and potential latent fatalities from vehicle emissions.

Estimating specific transportation risks for the spent MOX fuel is premature at this time because of the uncertainty in the actual location of both the commercial reactors that would be used for irradiation of the fresh MOX fuel and the final disposal site. As discussed in Section 4.4.1.1, the actual commercial reactors that would be used to irradiate the fresh MOX fuel are not yet known. The only disposal site currently under consideration in the United States is the proposed geologic repository at Yucca Mountain in Nye County, Nevada (DOE 2002d). For purposes of complying with NEPA requirements, it is assumed that spent MOX fuel would eventually be shipped to the proposed Yucca Mountain repository. However, the DOE's application for a license to operate the Yucca Mountain repository has not yet been submitted to the NRC. There is no assurance that the DOE's application, if submitted, would be approved.

On a per kilometer traveled basis, the routine radiological and vehicle-related transportation risks for spent MOX fuel would be similar to those estimated in this DEIS for fresh MOX fuel, plutonium metal, or TRU waste. The transportation risks of commercial SNF and spent MOX

fuel transport in particular were estimated in DOE's EIS concerning disposal of SNF and high-level waste at Yucca Mountain (DOE 2002d). In the mostly legal-weight truck scenario, approximately 53,000 truck shipments were estimated to result in approximately 12 LCFs to workers, 3 LCFs to the public, and 5 traffic fatalities. A rough estimate of the transportation risks of the spent MOX fuel can be obtained based on average shipment risks calculated from these results to show that no fatalities would be expected. Shipment of all the spent MOX fuel, approximately 598 shipments assuming three assemblies per cask, might be expected to result in approximately 0.1 worker LCFs, 0.03 public LCFs, and 0.056 transportation fatalities. Actual impacts would be lower or higher depending on the actual shipment distances relative to the average in the Yucca Mountain EIS (DOE 2002d). Thus, no significant impacts would be expected because the estimated risks are only a very small fraction of the radiological and vehicular risks to which the public are exposed to on a routine basis as discussed in Section 4.4.1.2.1.

4.4.2 Conversion of Uranium Hexafluoride to Uranium Dioxide

As discussed in Section 1.2.2, it is assumed that the conversion of uranium hexafluoride to uranium dioxide would take place at the General Electric Company (GE) facility in Wilmington, North Carolina. The impacts of the general conversion process are described in the environmental assessment for the last license renewal of that facility (NRC 1977). At that time, the GE facility was using the ammonium diuranate (ADU) process and was planning to begin using a new dry conversion process (DCP). The ADU process is a "wet" process that has higher impacts than the DCP. The GE facility currently uses the DCP. The environmental assessment includes a discussion of the impacts from both the ADU process and DCP. Therefore, it is believed that the impacts summarized below would bound impacts from the conversion process if another facility was ultimately selected.

No measurable impacts have been observed to the air, surface water, or vegetation due to releases from the GE facility. Impacts to the shallow groundwater aquifer have occurred. The GE facility produces gaseous, liquid, and solid effluent streams. Gaseous effluents are controlled by the use of HEPA filters and scrubbers permitted by the State of North Carolina, as necessary. Liquid effluents are controlled by the use of treatment systems and wastewater retention basins designed to reduce the concentration of contaminants prior to discharge. Solid wastes are managed through segregation, recycling, off-site disposal, and incineration. Discharges are permitted and are monitored to ensure compliance with permit requirements. Impacts to a hypothetical MEI and to the collective population are summarized in Table 4.22.

4.4.3 MOX Fuel Use

This section evaluates on a generic basis the impacts of using MOX fuel in reactors. The evaluation summarizes DOE site-specific analyses in Section 4.28 and Appendix K.7 of the SPD EIS (DOE 1999a). The NRC will perform its own site-specific NEPA analyses in evaluating any license amendment applications it may later receive seeking authorization to use

Table 4.22. Comparison of human exposure for ammonium diuranate (ADU) and dry conversion processes (DCP)

Pathway/receptor	ADU dose	DCP dose
Air		
Maximally exposed individual [mSv/yr (mrem/yr)]	0.001 (0.1)	0.0005 (0.05)
Collective population [person-Sv (person-rem)]	0.0009 (0.09)	0.00045 (0.045)
Liquid		
Maximally exposed individual [mSv/yr (mrem/yr)]	0.007 (0.7)	0.001 (0.1)
Collective population [person-Sv (person-rem)]	NA[a]	NA
Total		
Maximally exposed individual [mSv/yr (mrem/yr)]	0.008 (0.8)	0.00015 (0.15)
Collective population [person-Sv (person-rem)]	0.0009 (0.09)	0.00045 (0.045)

[a]Not applicable because liquid effluent in the river quickly dilutes to background levels; therefore, the collective dose impact is negligible.

MOX fuel. In order for any specific commercial reactor to use MOX fuel, an amendment to a 10 CFR Part 50 license, issued by the NRC, would be required.

Impacts resulting from both normal operations and postulated accidents were evaluated. For purposes of this analysis, it was assumed that up to 40% of the fuel assemblies in a generic reactor would contain MOX fuel and that the remaining assemblies would contain the type of low-enriched uranium (LEU) fuel now used by commercial reactors. The impacts resulting from the use of MOX fuel in such a hybrid reactor core were estimated and compared with the impacts that would result from the use of a reactor core containing only LEU fuel.

The impacts from normal operations would be the same whether the reactor core contained 40% MOX fuel or 100% LEU fuel. The public surrounding such a generic reactor was estimated to receive a collective dose in the range of 0.057 person-Sv/yr (5.7 person-rem/yr) to 0.203 person-Sv/yr (20.3 person-rem/yr). The estimated number of annual LCFs produced by such a dose would be less than 0.01. No individual would be expected to receive more than 0.0073 mSv/yr (0.73 mrem/yr) due to reactor operations under normal conditions. These doses are a small fraction of the annual average background dose. For comparison, as discussed in Section 3.10, the average annual natural background radiation dose to an individual in the United States is 3.6 mSv (360 mrem).

The SPD EIS (DOE 1999a) also analyzed potential MOX fuel use impacts from both postulated design-basis and beyond-design-basis accidents. The impacts were estimated in terms of both the consequences (the impacts that would result if the accident occurred) and risks (taken to be the consequences multiplied by the probability of occurrence of the accident). The risk was estimated over a 16-year campaign. The risk, over the entire 16-year period, of a latent cancer fatality associated with design-basis accidents to the public surrounding a reactor using all LEU fuel ranged from 2.19×10^{-4} to 8.98×10^{-4}. The change in risk of a latent cancer fatality associated with a reactor using 40% MOX fuel ranged from about 6% lower to 3% greater. For beyond-design-basis accidents, the campaign risk of a latent cancer fatality to the public surrounding a reactor using all LEU fuel ranged from 0.144 to 5.25×10^{-5}. The change in risk

of a latent cancer fatality associated with a reactor using 40% MOX fuel ranged from about 7% lower to 14% greater.

Some of the beyond-design-basis accidents were estimated to cause prompt fatalities in the highly unlikely event that they occurred. The change in the number of prompt fatalities due to the use of MOX fuel was estimated to range from 0 to 28 additional fatalities (815 versus 843 in the worst accident).

Impacts of transporting fresh MOX fuel to reactors is presented in Section 4.4.1.2.1, and impacts of transporting spent MOX fuel to a geologic repository is presented in Section 4.4.1.4. The impacts of disposing of the MOX fuel is included in the FEIS for Yucca Mountain (DOE 2002d).

4.5 Cumulative Impacts

Cumulative Impacts

Cumulative impacts are potential impacts when the proposed action is added to other past, present, and reasonably foreseeable future actions.

This section assesses potential cumulative impacts of construction and operation of the proposed MOX, PDCF, and WSB facilities. Cumulative impacts are distinguished from the direct and indirect impacts of these facilities, which are discussed in Sections 4.3 and 4.4 and Appendix H. Direct effects are caused by the proposed action and occur at the same time and place. Indirect effects are caused by the proposed action and occur later in time or are farther removed in distance but are still reasonably foreseeable.

Cumulative impacts were determined by adding the expected impacts of past, present, and reasonably foreseeable future actions to the projected direct and indirect impacts of the proposed MOX, PDCF, and WSB facilities. The impacts of construction and normal operations of the proposed facilities were evaluated for each impact area and are presented in Section 4.3. The impacts of past and present actions were determined from site environmental reports and other available documents (e.g., recent EISs). Reasonably foreseeable future actions include among others, those that would occur if the proposed MOX facility is built and operated, and include actions to be undertaken by the DOE as part of its surplus plutonium disposition program. The impacts of reasonably foreseeable future actions were taken from recently published NEPA analyses. Although the cumulative impact analysis focused on impacts at the SRS and vicinity (Section 4.5.1), an evaluation of cumulative impacts of off-site transportation activities is also included (Section 4.5.2).

4.5.1 Cumulative Impacts at the SRS

A review was conducted of past, present, and reasonably foreseeable future activities on the SRS. Past impacts were included in the cumulative impact assessment only if the residual effects of past actions are still in existence (e.g., past land use changes that are still in effect).

Past impacts that have come and gone (e.g., operational impacts of decommissioned facilities) were not included in the cumulative impact assessment. The impacts of present activities and residual past activities at the SRS were determined from annual environmental reports that document the results of ongoing monitoring activities (e.g., Arnett and Mamatey 2001), as well as descriptions of the SRS baseline conditions in various recent DOE EISs. The impacts of past and present activities at the SRS are described qualitatively for each impact area in Chapter 3.

Nuclear facilities within an 80-km (50-mi) radius of the SRS include Georgia Power's Vogtle Electric Generating Plant across the river from the SRS; Chem-Nuclear Inc., a commercial low-level waste burial site just east of the SRS; and Starmet CMI, Inc. (formerly Carolina Metals), located southeast of the SRS, which processes uranium-contaminated metals. Radiological impacts from the operations of the Vogtle Electric Generation Plant, a two-unit commercial nuclear power plant, are small, but they are included in this cumulative impact analysis. The South Carolina Department of Health and Environmental Control Annual Report (SCDHEC 1995) indicates that operation of the Chem-Nuclear Services facility and the Starmet CMI facility do not noticeably affect radiation levels in air or liquid pathways in the vicinity of the SRS.

The counties surrounding the SRS host numerous industrial facilities (e.g., Bridgestone Tire, textile mills, paper product mills, and manufacturing facilities) with permitted air emissions that cumulatively affect regional air quality. South Carolina Electric and Gas Company's Urquhart Station, a three-unit, 250-megawatt, coal- and natural-gas-fired steam electric plant, is located near the SRS in Beech Island, South Carolina. All of these facilities contribute to ambient air quality at the SRS and thus are included within the SRS baseline used in the analysis of cumulative air quality impacts.

A number of construction and operating permits for industrial facilities in Aiken, Barnwell, Allendale, and Edgefield Counties have recently been filed with the South Carolina Department of Health and Environmental Control Bureau of Air Quality. No new permits have been applied for in Augusta-Richmond, Columbia, and Burke Counties in Georgia. In addition, a number of road projects are planned in the area. These include relatively minor improvements in the Aiken and North Augusta, South Carolina, areas that are part of the Augusta Regional Transportation Study and would take place in 2003 through 2007. Additional road projects in the area include improvements to a 13-km (8-mi) portion of US 78 from Montmorenci, South Carolina, to Windsor, South Carolina (to the east of Aiken), and the extension of I-520 across the Savannah River into North Augusta. This latter project would take place in 2006 through 2009.

Construction of new facilities and roads would result in short-term air quality impacts and would only contribute to the cumulative impact of MOX facilities if the construction period of facilities overlapped with the MOX construction or operational period. Impacts to air quality resulting from operations of new facilities and roads would result in changes to regional air quality as represented by the SRS baseline in Table 4.23. It is difficult to adequately predict the contribution of these facilities and roads to cumulative air quality impacts with the information

Table 4.23 Estimated cumulative impacts to air quality from MOX, PDCF, and WSB facility operations and other activities at the SRS[a]

Source	Pollutant concentrations (: g/m^3)								
	TSP, annual	PM_{10}		NO_2, annual	SO_2			CO	
		24 h	annual		3 h	24 h	annual	1 h	8 h
SRS baseline[b, c]	74.6	138	25.9	26.3	1,246	355	31.1	10,363	6,867
MOX facility, PDCF, and WSB	0.002	1.2	0.001	0.06	25	5.4	0.003	102	23
SNF management[d]	0.02	0.1	0.02	3.4	1.0	0.1	0.02	9.8	1.3
HEU disposition[e]	0.05	0.01	0.01	0.01	0.7	0.3	0.02	0.1	0.07
Tritium extraction facility[f]	0.0002	0.01	0.00009	0.006	0.09	0.001	0.00009	3.6	0.5
Plutonium residues[g]	0.0	0.0	0.0	0.04	0.0	0.0	0.0	0.0	0.0
Salt processing[h]	0.001	0.07	0.001	0.03	0.4	0.05	0.0005	18.0	2.3
Tank closure[i]	0.005	0.08	0.004	0.03	0.2	0.04	0.002	1.2	0.3
Total concentration (: g/m^3)	74.7	139.5	25.9	29.8	1,248.7	361.1	31.1	10,497.4	6,898.8
MOX, PDCF, and WSB contribution (%)	0.00	0.9	0.00	0.19	2.0	1.5	0.01	1.0	0.3
NAAQS (: g/m^3)	75	150	50	100	1,300	365	80	40,000	10,000
% of standards	99.6	93.0	51.9	29.8	96.1	98.9	38.9	26.2	69.0

[a]Maximum predicted off-site cumulative ground-level concentrations of nonradiological pollutants.

[b]SRS baseline includes the impacts of existing SRS facilities (SRS maximum) and regional emissions (background) from Table 4.8.

[c]Includes Defense Waste Processing Facility operations.

[d]*Source:* DOE (2000c).

[e]*Source:* DOE (1996b).

[f]*Source:* DOE (1999c).

[g]*Source:* DOE (1998).

[h]*Source:* DOE (2001) using maximum impact alternative.

[i]*Source:* DOE (2002b).

available. All facilities would require permitting, and this permit process would take into consideration regional air quality NAAQS compliance.

Reasonably foreseeable future actions at the SRS were identified by reviewing recent NEPA documents for the site. A brief synopsis of future projects at the SRS that are considered in the cumulative impact analysis is presented in the following paragraphs:

- *Final Defense Waste Processing Facility Supplemental Environmental Impact Statement,* DOE/EIS–0082–S (DOE 1994). The Defense Waste Processing Facility (DWPF) has been constructed at the SRS and is currently processing sludge from SRS HLW tanks. However, SRS baseline data do not include the impacts of all planned DWPF operations, including the processing of salt solution from these tanks. Therefore, the cumulative impact analysis includes some effects of DWPF in the impacts of past and present activities and some in the impacts of reasonably foreseeable future actions.

- *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement,* DOE/EIS-0240 (DOE 1996b). The cumulative impact analysis incorporates an alternative at the SRS that would blend highly enriched uranium to 4% low-enriched uranium as uranyl nitrate hexahydrate (61 FR 40619; August 5, 1996).

- *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy at the Rocky Flats Environmental Technology Site,* DOE/EIS-0277 (DOE 1998). DOE plans to process certain plutonium-bearing materials currently being stored at the Rocky Flats Environmental Technology Site (RFETS) (64 FR 8068; February 18, 1999, and 66 FR 4803; January 18, 2001). These materials are plutonium residues and scrub alloy remaining from nuclear weapons manufacturing operations. DOE has decided to ship certain residues from the RFETS to the SRS for plutonium separation and stabilization. The separated plutonium would be stored at the SRS pending disposition decisions. Environmental impacts from using the F-Canyon to chemically separate the plutonium from the remaining materials at the SRS are included in the cumulative impact analysis.

- *Final Environmental Impact Statement for the Construction and Operation of a Tritium Extraction Facility at the Savannah River Site,* DOE/EIS-0271 (DOE 1999c). DOE plans to construct and operate a facility at the SRS to extract the tritium from commercial light-water reactor targets and targets of similar design (64 FR 26369; May 14, 1999). The proposed action and alternatives would provide tritium extraction capability to support either reactor or accelerator tritium production. Environmental impacts from the maximum processing option in the EIS are included in the cumulative impact analysis.

- *Surplus Plutonium Disposition Final Environmental Impact Statement,* DOE/EIS-0283 (DOE 1999a). The SPD EIS analyzed implementation of DOE's disposition strategy for surplus plutonium. The decision to site the facilities to implement this strategy at the SRS (as described in 65 FR 1608, January 11, 2000) is the basis for the proposed action analyzed in this EIS. The SPD EIS was used in some cases to determine the impacts of the Pit Disassembly and Conversion Facility for inclusion in the cumulative impact analysis.

- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement,* DOE/EIS-0279 (DOE 2000c). The selected alternative in the Record of Decision (ROD) for the Spent Nuclear Fuel Management EIS is to prepare for disposal of about 97% by volume (about 60% by mass) of the aluminum-based fuel considered in the EIS (48 MT [53 tons] heavy metal), using a melt and dilute treatment process (65 FR 48224; August 7, 2000). The impacts of this process are included in the cumulative impact analysis. The remaining 3% by volume (about 40% by mass) would be managed using conventional processing in existing SRS chemical separation facilities. As part of the preferred alternative, DOE will develop and demonstrate the melt and dilute technology. Following development and demonstration of that technology, DOE will begin detailed design, construction testing, and startup of a new treatment and storage facility to combine with a new dry storage facility. The spent nuclear fuel will remain in existing wet storage until treated and will then be placed in dry storage.

- *Savannah River Site High-Level Waste Tank Closure Final Environmental Impact Statement,* DOE/EIS-0303 (DOE 2002b). DOE evaluated three alternatives for tank closure. All of these alternatives would start after bulk waste removal. DOE decided (as described in 67 FR 53784; August 19, 2002) to implement the preferred alternative identified in the EIS (i.e. stabilize tanks and fill with grout). The impacts of this alternative are presented in this cumulative impact analysis.

- *Savannah River Site Waste Management Final Environmental Impact Statement,* DOE/EIS-0217 (DOE 1995). This EIS provides a basis for the selection of a sitewide approach to managing present and future (through 2024) wastes generated at the SRS. These wastes would come from ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs. The EIS evaluated the treatment of wastewater discharges in the Effluent Treatment Facility, F- and H-Area Tank Farm operations and waste removal, and construction and operation of an HLW evaporator in the H-Area Tank Farm. In addition, it evaluated the Consolidated Incineration Facility (CIF) for the treatment of mixed waste, including incineration of benzene waste from the in-tank precipitation (ITP) process. (The CIF has suspended operations and the ITP process is to be replaced by an alternative evaluated in DOE 2001.) The first ROD stated that DOE would configure its waste management systems according to the moderate treatment alternatives described in the EIS (60 FR 55249; October 30, 1995). The second ROD (62 FR 27241; May 9, 1997) was deferred regarding treatment of mixed waste to ensure consistency with the *Approved Site Treatment Plan* (WSRC 2000). The Waste Management EIS is relevant to the assessment of cumulative impacts because it provides the baseline forecast of waste generation from operations, environmental restoration, and decontamination and decommissioning. This forecast was updated in 1999 (Halverson 1999).

- *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel,* DOE/EIS-0306 (DOE 2000d). DOE plans to treat all spent nuclear fuel from the Experimental Breeder Reactor-II (EBR-II) and sodium-bonded spent nuclear fuel at Argonne National Laboratory-West (ANL-W) (located at INEEL) (65 FR 56565, September 19, 2000). Fermi-1 sodium-bonded spent nuclear fuel will be stored

pending a decision on alternative treatments. DOE does not plan to implement any of the alternatives proposed for the SRS. However, some of the impact projections from other EISs (e.g., cumulative waste generation from the High-Level Waste Tank Closure EIS; DOE 2000a) include impacts at the SRS from sodium-bonded spent nuclear fuel, and these impacts were excluded from the cumulative impact analysis.

- *Savannah River Site Salt Processing Alternatives Final Supplemental Environmental Impact Statement,* DOE/EIS-0082-S2 (DOE 2001). A process to separate the high-activity and low-activity waste fractions in high-level waste solutions is planned to replace the in-tank precipitation process assessed in the Defense Waste Processing Facility EIS (DOE 1994). The Salt Processing EIS evaluates four alternatives: small tank precipitation; ion exchange; solvent extraction; and direct disposal in grout. The proposed MOX facility cumulative impact analysis includes maximum impacts of the solvent extraction process as selected in the DOE ROD for this project (66 FR 201, p. 52752, October 17, 2001).

- *Draft Environmental Assessment for the Construction and Operation of the Highly Enriched Uranium Blend-Down Facilities at the Savannah River Site,* DOE/EA-1233 (DOE 2000e). DOE plans to construct and operate a low-enriched uranium (LEU) loading station and modifications to the existing high-enriched uranium (HEU) blend-down facilities. The process will convert off-specification HEU (60% uranium-235) to less than 20% uranium-235 for use as commercial fuel. The environmental assessment (EA) for this facility indicated that impacts would be either negligible or unmeasurable. A Finding of No Significant Impact was issued on November 3, 2000.

The DOE recently announced its intention to prepare a supplemental programmatic EIS on stockpile stewardship and management of a modern pit facility (67 FR 184, p. 59577, September 23, 2002). The EIS would be prepared to aid in the decision to proceed with development of the pit facility and where such a facility would be located. A tiered, project-specific EIS would be prepared if a decision were made to proceed with development of a pit facility, and that EIS would evaluate the impacts of construction and operation of that facility. SRS is one of five sites that are considered reasonable alternatives for the pit facility. Although the impacts of construction and operation of a pit facility at SRS would contribute to cumulative impacts at the site, the project is not sufficiently developed to enable a meaningful analysis at this time. An analysis of the cumulative impacts of the pit facility at SRS would be included in the supplemental programmatic EIS and, if SRS was chosen as the preferred site for such a facility, the tiered project-specific EIS.

For all impact areas but employment, it was conservatively assumed that the impacts of past, present, and future activities would occur simultaneously. In reality, there would be less overlap of impacts in time (e.g., the impacts of some projects would be declining during the operational life of the facility), and cumulative impact, therefore, actually would be less than is presented here. Impacts to the MEI were also determined using a conservative approach that assumed the same MEI would be exposed to all concurrent actions (see Section 4.3.1.1.2 for the location of MEI for the proposed MOX facility). In reality, the MEIs for different activities vary and are dependent on the location of the activity (Simpkins 2000).

4.5.1.1 Cumulative Impacts of the MOX, PDCF, and WSB Facilities

Cumulative impacts of the facilities at the SRS were evaluated in detail for (1) air quality; (2) human health; (3) waste generation; (4) resource use (land, electricity, and water); and (5) employment. These impacts were evaluated on the basis of the anticipated effects of facility construction and normal operations (as presented in Section 4.3) and the potential for contributions to existing cumulative impacts on the SRS. The analysis focused primarily on normal facility operations over an assumed 10-year operating period. Construction impacts were considered in the cumulative impact analysis only with respect to the amount of land developed, because other construction impacts would be too short-lived to contribute substantially to cumulative impacts to any resources. Additionally, standard mitigation practices employed during construction (e.g., dust control measures, erosion control) would likely reduce these impacts to negligible levels.

Topics Evaluated and Impact Criteria Used in the Cumulative Impact Analysis

- ***Air quality:*** % NAAQS for criteria pollutants.
- ***Human health:*** Radiological dose to off-site MEI, off-site population, and SRS workers and resultant latent cancer fatalities.
- ***Waste generation:*** Generation rate of various waste types.
- ***Resource use:*** Amount of land developed relative to total SRS area; amount of electricity and water used relative to existing SRS capacity.
- ***Employment:*** Number of jobs at the SRS.

Impacts to water quality, geologic resources, ecological resources, aesthetic and scenic resources, and cultural resources are not treated explicitly in the cumulative impact analysis because direct and indirect impacts to these resources are expected to be negligible (see Sections 4.3 and Appendix H). Facility operations would not contribute to the cumulative impacts of SRS activities on water quality because no liquid effluent would be discharged to surface water or groundwater from normal facility operations. No impacts are anticipated to aesthetic and scenic resources because the facilities would be visually consistent with surrounding SRS industrial facilities and would not be visible from off-site. Impacts to geologic, ecological, and cultural resources are expected to be minimal and would be limited to the immediate vicinity of the facilities (which would be located on a partially developed site), thus reducing the potential for cumulative impact. Any cumulative impacts to these resources would be proportional to the cumulative impact projected for land development at the SRS.

Cumulative impacts to air quality were evaluated for five pollutants — TSP, PM_{10}, NO_2, SO_2, and CO. Normal operations of the MOX, PDCF, and WSB facilities would result in small contributions (2% or less) to cumulative concentrations of these air pollutants (see Table 4.23). For four air pollutants (annual total suspended particulates, 24-hour PM_{10}, 3-hour SO_2, and 24-hour SO_2), the cumulative total concentrations would be above 90% of the NAAQS and, therefore, approaching noncompliance. However, even without the contributions from operations of the proposed facilities, the cumulative totals for these four pollutants would be above 90% of the NAAQS. Although the cumulative total concentration of $PM_{2.5}$ could not be determined because information was not available for many of the future actions considered here, the SRS region is currently well above the annual ambient standard (see Table 4.8). The

facilities would contribute a negligible amount of $PM_{2.5}$ (0.009% of the annual standard) and only when emergency generators were used. It should be noted that all of the air quality analyses are based on very conservative assumptions (e.g., maximum concentrations for all facilities), and it is not likely that NAAQS exceedances would occur at the SRS.

During normal operations, the contribution of the MOX, PDCF, and WSB facilities to cumulative radiological dose to the public would be small (3% or less of total dose; see Table 4.24). The cumulative dose to an MEI would increase by 0.04% as a result of facility operations. The estimated risk of a latent cancer fatality resulting from cumulative dose to the MEI is extremely small (4×10^{-7}). The estimated number of latent cancer fatalities resulting from cumulative collective dose to the off-site population is 0.02. These very small numbers mean that statistically, radiological doses from plant operations would not be expected to cause any latent cancer fatalities in the off-site population.

Cumulative collective dose to workers at SRS would increase approximately 11% as a result of MOX, PDCF, and WSB facility operations. The number of expected latent cancer fatalities among workers resulting from cumulative dose (that resulting from dose contributions from the SRS baseline, the proposed action, and other reasonably foreseeable future actions) is 1.3. For most types of waste, facility operations would contribute relatively small volumes to the cumulative waste generation volumes at the SRS (see Table 4.25), and existing waste treatment facilities at the SRS have sufficient capacity to treat this cumulative total (see Section 4.3.4.2). The largest proportionate increase would be in the amount of TRU waste (approximately 24% increase).

The cumulative impacts of the facilities to land development, electricity usage, and groundwater usage at the SRS would be quite small and well within existing SRS capacity (see Table 4.24). Construction of the facilities would result in a slight increase (1.9%) in the amount of developed land at the SRS, but the cumulative amount of developed land on the SRS would remain quite small (3.8% of the total site). Facility operations would use 186,000 MWh/yr of electricity (3.7% of SRS capacity). Cumulative electricity demand resulting from facility operations and all existing and planned actions would be only 13% of SRS capacity. Facility operations would use 76 million L/yr (20.1 million gal/yr) of groundwater (0.02% of SRS capacity). Cumulative groundwater demand would be only 2.4% of SRS capacity.

Determination of the cumulative impacts of facilities construction and operation on the SRS workforce is complicated by the fact that employment is not expected to be constant during the life of the facility and other existing and planned actions at the SRS discussed in the beginning of Section 4.5.1. The analysis presented here considered the timelines of workforce projections for the SRS baseline and reasonably foreseeable future actions and the year in which the workforce would be highest. The results of these conservative analyses are presented in Table 4.26. Overall, employment at the SRS has decreased from 22,070 in September 1993 to 14,193 in September 2000. Projections indicate that site employment will continue to decline to approximately 10,000 by 2010 (DOE 1999c). Facility construction would result in a peak workforce of 1,000 in 2005. Facility operations would support 480 workers annually (3.2% of the total projected for the SRS).

Table 4.24. Estimated annual cumulative radiological dose and latent cancer fatalities resulting from MOX, PDCF, and WSB facility operations and other activities at the SRS

	Dose to maximally exposed individual[a]				Collective dose to off-site population				Collective dose to workers	
Source	Air pathway (rem)	Liquid pathway (rem)	Total dose (rem)	Latent cancer fatalities[b]	Air pathway (person-rem)	Liquid pathway (person-rem)	Total dose (person-rem)	Latent cancer fatalities[b]	Total dose (person-rem)	Latent cancer fatalities[b]
SRS baseline[c]	4.0×10^{-5}	1.4×10^{-4}	1.8×10^{-4}	1.1×10^{-7}	2.3	3.9	6.2	3.7×10^{-3}	163	0.1
MOX, PDCF, and WSB	2.5×10^{-6}	–[d]	2.5×10^{-6}	1.5×10^{-9}	0.70	–[d]	0.7	4.2×10^{-5}	257	1.5×10^{-1}
SNF management[e]	1.5×10^{-5}	5.7×10^{-5}	7.2×10^{-5}	4.3×10^{-8}	0.6	0.2	0.8	4.5×10^{-4}	55	3.3×10^{-2}
HEU disposition[f]	2.5×10^{-6}	–[d]	2.5×10^{-6}	1.5×10^{-9}	0.2	–[d]	0.2	9.6×10^{-5}	11.3	6.8×10^{-3}
Tritium extraction facility[g]	2.0×10^{-5}	–[d]	2.0×10^{-5}	1.2×10^{-8}	0.8	–[d]	0.8	4.6×10^{-4}	4.0	2.4×10^{-3}
Plutonium residue management[h]	5.7×10^{-7}	–[d]	5.7×10^{-7}	3.4×10^{-10}	0.006	–[d]	0.006	3.7×10^{-5}	7.6	4.6×10^{-3}
Defense waste processing facility[i]	1.0×10^{-6}	–[d]	1.0×10^{-6}	6.0×10^{-10}	0.07	–[d]	0.07	4.2×10^{-5}	118	7.1×10^{-2}
Salt processing[j]	3.1×10^{-4}	–[d]	3.1×10^{-4}	3×10^{-9}	18.1	–[d]	18.1	1.1×10^{-2}	29	1.7×10^{-2}
DOE complex miscellaneous components[k]	4.4×10^{-6}	4.2×10^{-8}	4.4×10^{-6}	2.7×10^{-11}	0.007	2.4×10^{-4}	0.007	4.3×10^{-6}	2	1.2×10^{-3}
Tank closure[l]	2.5×10^{-8}	–[d]	2.5×10^{-8}	1.5×10^{-11}	0.0014	–[d]	0.0014	8.4×10^{-7}	1,600	1.0
Vogtle Nuclear Power Plant[m]	5.4×10^{-7}	5.4×10^{-5}	5.5×10^{-5}	3.3×10^{-8}	0.04	0.003	0.05	2.7×10^{-5}	–[d]	–[d]
Total	4.0×10^{-4}	2.5×10^{-4}	6.5×10^{-4}	3.9×10^{-7}	22.7	4.1	26.8	1.6×10^{-2}	2,247	1.3
MOX, PDCF, and WSB contribution to total (%)	0.6	0.00	0.04	0.04	3.0	0.00	2.6	2.6	11.4	11.4

See next page for footnotes.

Table 4.24. Continued

[a]The MEIs for different facilities for the same pathway and the MEIs for different pathways for the same facility are likely to be different individuals. Therefore, simple addition of doses for all MEIs to estimate the total MEI dose is not accurate, but it is shown here to be conservative, (i.e., to present impacts that are overestimates of what would actually happen).

[b]Latent cancer fatalities are calculated by multiplying dose by the FGR-13 health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (Eckerman 1999).

[c]SRS baseline includes the impacts of existing facilities and the residual impacts of past activities. Values are from Arnett and Mamatey (2001).

[d]Less than minimum reportable levels.

[e]*Source:* DOE (2000c); SNF = spent nuclear fuel.

[f]*Source:* DOE (1996b).

[g]*Source:* DOE (1999c).

[h]*Source:* DOE (1998).

[i]*Source:* DOE (1994).

[j]*Source:* DOE (2001).

[k]*Source:* DCS (2002a).

[l]*Source:* DOE (2002b).

[m]*Source:* NRC (1996)

Table 4.25. Estimated cumulative waste generation at the SRS resulting from operation of the MOX, PDCF, and WSB facilities and other activities at the SRS

Source	Total waste generation over 30-year period (m^3)				Annual waste generation	
	High-level waste	Low-level waste	Hazardous-mixed waste	Transuranic waste	Nonhazardous solid waste (m^3)	Nonhazardous liquid waste (L)
SRS baseline[a, b]	14,000	120,000	3,900	6,000	6,670	4.2×10^8
MOX, PDCF, and WSB facilities[c]	0	26,870	220	5,180	3,990	9.7×10^7
Salt processing[d]	45,000	920	56	0	–[e]	Negligible
Environmental restoration and D&D activities[d]	0	62,000	6,200	0	NA[f]	NA
Other future actions[g, h]	129,490	21,750	4,013	10,100	4,105	2.2×10^7
Total	189,000	232,440	14,396	21,370	14,765	5.3×10^8
MOX, PDCF, and WSB contribution to total (%)	0.0	11.6	1.5	24.2	9.1	3.1

[a]SRS baseline includes the impacts of existing facilities and the residual impacts of past activities.

[b]High-level, low-level, hazardous-mixed, and transuranic waste volumes from DOE (2001); nonhazardous solid and liquid waste volumes from DCS (2002a).

[c]Total waste generation was determined by multiplying the annual generation rates (from Table 4.11) by 10 years, the operational period of these facilities.

[d]*Source:* DOE (2001).

[e]Value presented in DOE (2001) as 61 metric tons/yr.

[f]NA = not available.

[g]30-year waste generation volumes include life-cycle waste associated with DWPF operations (DOE 1994), HLW tank closure (DOE 2002b), SNF management (DOE 2000c), Tritium Extraction Facility (DOE 1999c), plutonium residues (DOE 1998), HEU disposition (DOE 1996b), commercial light water reactor waste, and weapons components that could be processed at the SRS. Values presented were derived from values provided in DOE (2001), but were adjusted to remove the contribution from SPD facilities (presented separately here) and sodium-bonded SNF management, which no longer involves SRS operations.

[h]Nonhazardous waste volumes include waste generated by activities associated with HEU disposition (DOE 1996b), Tritium Extraction Facility (DOE 1999c), DWPF operations (DOE 1994), and HLW tank closure (DOE 2002b).

Table 4.26. Estimated cumulative impacts to resource use and employment from MOX, PDCF, and WSB facility operations and other activities at the SRS

	Land area		Electricity		Groundwater		Employment	
Source	Developed area (acres)	% Total SRS area	Average annual usage (MWh/yr)	% Total SRS capacity	Average annual usage (L/yr)	% Total SRS capacity	Number of workers	% SRS total
SRS baseline[a]	7,241[b]	3.7	411,000	7.9	1.7×10^{10}	4.7	13,227	87.3
MOX, PDCF, and WSB facilities	123	0.06	610,000	11.7	1.5×10^{8}	0.04	509	3.4
SNF management[b]	0	0.00	15,800	0.3	2.1×10^{8}	0.06	520	3.4
HEU disposition[c]	0	0.00	5,000	0.1	1.9×10^{7}	0.005	125	0.8
Tritium extraction facility[d]	3	0.002	20,600	0.4	NA[e]	NA	400	2.6
Plutonium residue management[f]	0	0.00	1,329	0.03	1.6×10^{7}	0.005	NA	NA
Defense waste processing facility[g]	105	0.05	32,000	0.6	NA	NA	60	0.4
Salt processing[h]	0	0.00	24,000	0.5	1.2×10^{7}	0.003	220	1.5
Tank closure[i]	0	0.00	0	0.0	8.7×10^{6}	0.002	85	0.6
Total	7,472	3.8	1,119,729	21.7	8.3×10^{9}	4.8	15,146	100.0

[a]SRS baseline includes the impacts of existing facilities and the residual impacts of past activities.

[b]*Source:* DOE (2000c); SNF = spent nuclear fuel.

[c]*Source:* DOE (1996b).

[d]*Source:* DOE (1999c).

[e]NA = not available.

[f]*Source:* DOE (1998).

[g]*Source:* DOE (1994).

[h]*Source:* DOE (2001).

[i]*Source:* DOE (2000a).

4.5.1.2 Cumulative Impacts of the No-Action Alternative

The no-action alternative would be a decision by the NRC not to approve the proposed MOX facility. Because all the surplus plutonium would remain at the DOE sites, the facilities planned for processing this surplus plutonium at the SRS — the proposed MOX facility, PDCF, and the WSB — would not be constructed. Since none of the surplus plutonium from other DOE sites would be stored at the SRS, none of the projected impacts of these facilities (as presented in Section 4.5.1.1) would occur.

4.5.2 Cumulative Impacts of Transportation

Cumulative impacts of transportation were estimated by adding the contributions from four sources:

- Historical shipments of spent nuclear fuel and radioactive waste;
- Reasonably foreseeable future actions involving the transportation of radioactive materials;
- Spent fuel shipments to a geological repository at Yucca Mountain, Nevada;
- General transportation of radioactive materials not related to any particular action; and
- Transportation of surplus plutonium and depleted uranium to the SRS and of fresh MOX fuel from the SRS to a surrogate Midwest nuclear power plant.

Estimates of contributions from the first four sources to the collective occupational dose and dose to the general population were summarized in the EIS for a geological repository at Yucca Mountain (DOE 2002d). These estimates are presented in Table 4.27. The future SNF shipments listed in Table 4.27 include potential spent MOX fuel shipments to the repository. The shipment risks from spent MOX fuel are similar to those for typical SNF. Therefore, these risks are expected regardless of the fuel type, normal LEU or MOX, that will be used in existing nuclear power plants in the future. The estimated dose resulting from the proposed action is similar to that resulting from historical shipments of spent nuclear fuel and radioactive waste, 100 times smaller than that resulting from reasonably foreseeable future actions and 1,000 times less than general transportation. The contribution to cumulative occupational and general population dose associated with the proposed action is expected to be insignificant.

Table 4.27. Estimated cumulative transportation impacts of facility operations and shipment of radioactive materials from other sources (1943 to 2048)

Category	Collective occupational dose [person-Sv (person-rem)]	Latent cancer fatalities	Collective dose to the general population [person-Sv (person-rem)]	Latent cancer fatalities
Historical shipments[a]	3.3 (330)	0.2	2.3 (230)	0.1
Reasonably foreseeable future actions[a]	197 (19,670)	12	498 (49,770)	30
Spent fuel shipments to geologic repository[a]	88 (8,800)	5	16 (1,600)	1
General transportation (1943 to 2048)[a]	3,300 (330,000)	198	2,900 (290,000)	174
MOX shipments	2.2 (220)	0.1	3.33 (333)	0.2
Total	3,590.2 (359,020)	215	3,419.3 (341,933)	205

[a]*Source:* DOE (2002d).

4.6 Cost-Benefit Analysis

4.6.1 Introduction

This section compares the costs and benefits of the proposed action with the costs and benefits of the no-action alternative. The cost-benefit analysis sets forth the various environmental impacts (both negative and positive) of the proposed action, and the economic costs and benefits of building and operating the proposed MOX facility, the PDCF, and the WSB. Costs and benefits are assessed at both the national and regional levels. At the national level, the overall costs of proposed MOX facility construction and operation are compared with the benefits of plutonium supply reduction. The benefits to national security from plutonium supply reduction are substantial, but these benefits are not quantifiable in terms of dollars and cents.

The national benefits associated with the proposed action that are quantifiable include project expenditures during construction and operation of the proposed MOX facility, the PDCF, and the WSB. Various sectors in the national economy would provide the materials, equipment, and services needed to build and operate these facilities. Another national benefit of the proposed action would be the generation of additional supplies of electricity. However, this analysis does not assign a specific economic value to the electricity that would be generated by the irradiation of MOX fuel.

There would also be regional costs and benefits associated with construction and operation of the proposed MOX facility. At the regional level, excluding costs and benefits that cannot be quantified, the proposed MOX facility would produce an overall net benefit of $1,840 million (see Table 4.28).

4.6.2 National Costs and Benefits

The primary national benefit of construction and operation of the proposed MOX facility would be a reduction in the supply of weapons-grade plutonium available for unauthorized use. Once the plutonium component in MOX fuel has been irradiated in commercial nuclear reactors, the isotopic composition of the plutonium would be more proliferation resistant. Moreover, since the plutonium would then be part of the resultant high-level nuclear waste, the plutonium would no longer be available for other uses. Compared with the no-action alternative — in which the weapons-grade plutonium would continue to be stored at several existing DOE locations — converting surplus plutonium into MOX fuel and irradiating it better ensures its security, since it would reduce the number of locations where the various forms of plutonium are stored (DOE 1997a). Converting surplus weapons-grade plutonium into MOX fuel is thus viewed as better ensuring that weapons-usable material would not be obtained by rogue states and terrorist groups. Implementing the proposed action would promote the above nonproliferation objectives.

For the no-action alternative, although the costs and benefits of continued storage of plutonium in the present DOE locations are not re-evaluated in this analysis, these issues are discussed in the SPD EIS (DOE 1999a). Continued storage of plutonium by the DOE at its present locations would not be expected to produce additional latent cancer fatalities (LCFs). Annual LCFs of approximately 0.002 in the surrounding population of the storage sites were estimated. The annual collective dose to members of the public (i.e., those living and working within 80 km [50 mi] of the SRS) produced by routine operation of the proposed MOX facility would be expected to result in an LCF rate of approximately 0.0004/yr or less. Therefore, continued storage would result in higher annual impacts.

The national costs associated with the proposed action are the total life-cycle costs, which include research and development and pre-capital costs, design and construction costs, operating costs, deactivation costs, and contingency costs. Decommissioning costs are not included given the uncertainty surrounding their magnitude. The total cost of the proposed action is estimated to be $3,850 million (in 2001 dollars), with $2,155 million to cover the cost of the proposed MOX facility and $1,695 million for the PDCF and WSB (NNSA 2002). A significant item included in the estimated total cost of the proposed facilities is the credits associated with the value of the MOX and HEU fuel. These items amount to $964 million over the life of the project (NNSA 2002).

4.6.3 Regional Costs and Benefits

The various quantifiable costs and benefits of the proposed MOX facility in the REA are identified in Table 4.28. Costs and benefits are presented for construction and operation, including decommissioning, over a 20-year project life. On balance, the proposed MOX facility would provide a net benefit (total benefits minus total costs) to the REA. The net benefit of the proposed MOX facility would be approximately $1,840 million. Sections 4.6.3.1 and 4.6.3.2 provide a more detailed description of the costs and benefits of the proposed MOX facility.

4.6.3.1 Regional Costs

Both potential internal and external costs are included in the assessment. Potential external costs include both long-term and short-term costs. The most significant long-term external cost associated with the proposed action is the potential impact that an accident at the proposed PDCF would produce. As set forth in Table 4.14, a major glovebox fire (tritium release) at the PDCF could cause up to 400 latent cancer fatalities (LCFs) in the area surrounding SRS. At the proposed MOX facility, the highest-consequence event there would be an explosion, which could cause up to 70 LCFs in the area surrounding SRS.

Although the probability of occurrence of such accidents is very low, if those accidents did occur, the people living within 80 km (50 mi) of the SRS would likely be affected by these severe accidents at these proposed facilities. The extent to which the surrounding population would be affected would depend on the amount of material released and the direction and speed at which airborne material was dispersed by wind conditions at the time of the accident. While the overall risk to the surrounding population would be very low (since the probability of severe accidents occurring would be very low), the greatest short-term risk of exposure would be to population groups located to the west-northwest of SRS, while the greatest one-year risk would be to population groups located north of SRS.

Routine operation of the proposed facilities is expected to produce an annual latent cancer risk of about 1 in 3 billion for the maximally exposed member of the public. The annual collective dose (associated with the facilities) to members of the public living and working within 80 km (50 mi) of SRS is expected to produce an LCF risk of approximately 0.0004 or less.

No adverse impacts from chemical exposure of workers at the proposed facilities are anticipated. Less than one fatality and approximately 410 worker injuries are expected during the 10-year operating period of the proposed facilities.

Routine proposed facilities operations are expected to produce insignificant impacts to air quality and would not exceed any ambient air quality standards for criteria pollutants at SRS. Maximum levels of $PM_{2.5}$ in the vicinity of SRS already exceed the applicable levels, and facility construction would create an additional 0.07% of the present standard; facility operations would contribute 0.009%.

Table 4.28. Summary of project costs and benefits in the REA (in millions of 2001 dollars, except where noted)

Item	MOX facility[a]
Costs	
Internal costs	
Construction	6
Operation	2
Short-term external costs (construction)	
Housing shortages	2% of vacant rental housing units would be required
Overcrowding in local public facilities	Minimal
Inflation	Minimal
Noise and congestion	Minimal
Water and sewage systems	Minimal
Long-term external costs (operations)	
Housing values	Less than 1% of vacant owner occupied housing would be required
Cost of providing public services	Less than 1% increase in revenues would be required
Deterioration in recreational values	Minimal
Restrictions to water and land	Minimal
Aesthetic values	Minimal
Cultural and historical sites	Minimal
Total REA costs	8
Benefits	
Total tax revenues	110
Economic activity in the REA	
Construction	
Annual average employment	980 jobs
Total income	350
Total regional product	720
Operations	
Annual average employment	1,310 jobs
Total Income	610
Total regional product	1,130
Other benefits	
Enhancement of recreational values	Minimal
Increased knowledge of the environment	Minimal
Total REA benefits	1,850
Net REA benefit	+1,840

[a]Data may not add to totals because of independent rounding.

Water consumption during MOX facility operations would be about 11% of the F-Area groundwater capacity. Impacts to surface water are not expected during facility operations.

Waste management systems at SRS would not be adversely affected by wastes generated by the proposed facilities. Adequate storage capacity and handling procedures are in place at SRS to process hazardous wastes generated during both construction and operation. Nonhazardous liquid and solid wastes would not adversely affect the Central Sanitary Waste Treatment Facility.

Other long-term external costs would include the potential impact of the proposed MOX facility, PDCF, and WSB (proposed facilities) on deterioration in recreational values, access restrictions to water or land (including any income lost), aesthetic impacts, impacts on local cultural and historical sites, decreased housing values, and the increased cost of providing local public services.

No impacts to recreational values, local aesthetic quality, or local water or land access would be expected from the proposed facilities. The location of the proposed facilities is close to the center of the SRS, and no recreation opportunities are currently available to the public in the vicinity. The proposed facilities would not change the industrial nature of the F-Area, and since the closest viewing location is about 8 km (5 mi) to the south, no changes in aesthetic quality would be expected (see Appendixes G and H). Construction of the facilities would occur on land already owned by the federal government and would have no impact on water or land access.

Impacts to housing values or to the cost of providing local public services are unlikely because of the relatively small number of long-term new residents that would be expected to move into the REA from elsewhere. Sufficient local housing is likely to be available to absorb new residents. Only 2% of vacant rental housing would be needed for workers during construction and less than 1% of vacant owner-occupied housing would be needed during operations. Changes in local public expenditures to maintain existing levels of public services would likely be small, with less than five additional local public service employees likely to be required (see Appendixes G and H).

Short-term external costs include the contribution of the proposed facilities to housing shortages; local inflation, noise, and congestion; impacts on the local water supply and sewage systems; and crowding in local public schools, hospitals, and other local public facilities.

The proposed facilities would not produce any significant costs in the REA at the SRS in the short term. Sufficient vacant rental units would be available in the REA for use by construction workers, and sufficient owner occupied units would be available to operations employees (see Section G.2.7 in Appendix G). Inflation in prices in the local area is not likely because much of the equipment, materials, and services required would be specialized, and a significant portion would be obtained from outside the REA. Material and equipment expenditures assumed to be made locally would not likely push local industries to capacity, and no labor shortages would be likely. Any construction and managerial positions not filled from within the

local labor market would be taken by workers moving to the area from other labor markets in the southeastern United States (see Appendixes G and H).

Noise and congestion from construction activities for the proposed facilities would likely be minor. Additional traffic generated during construction and operation would be unlikely to cause any additional traffic congestion on the major road segments surrounding the site, given the relatively small incremental increase in traffic from the proposed action (see Appendix H). Relatively small utility requirements would mean that no impacts would be expected on the local water supply and sewage systems. Local public schools, hospitals, and other local public facilities are not expected to suffer any overcrowding because of the relatively small number of new residents expected during the construction and operation under the proposed action (see Appendix H).

Internal costs are the life-cycle costs of design, construction, and operation of the project borne by the federal government. The internal costs of the proposed action in the REA are approximated using a cost localization factor that apportions total life-cycle project costs on the basis of the ratio of REA population to total national population. Internal costs apportioned to the REA using this method are small, amounting to $8 million for the proposed action.

4.6.3.2 Regional Benefits

The potential benefits of construction and operation of the proposed facilities include economic benefits — such as employment, income, and gross regional product — and various additional potential benefits — such as enhancement of recreational values, environmental enhancement in support of the protection of wildlife and wildlife habitat, and increased knowledge of the environment.

The measurement of the local employment and income economic benefits is based on the use of regional economic multipliers. These multipliers capture the indirect (off-site) effects of on-site activities associated with construction and operation.

To estimate employment benefits, life-cycle cost estimates were used (NNSA 2002) in association with data on the relationship between direct and indirect (off-site) employment benefits associated with construction and facility operations at the SRS. Those data were taken from the SPD EIS (DOE 1999a; see Appendix F, Section 9.2 for more information on the methodology used). By using direct (on-site) facilities employment data taken from the ER (DCS 2002a) as the basis for calculation, the indirect employment impacts during the construction and operation of the proposed facilities were estimated by application of the direct-to-indirect employment multiplier for the project at the SRS from the SPD EIS. The direct impacts of no action were estimated by using the relationship between total annual cost during construction and operation and direct employment for the proposed action. Indirect impacts were then estimated by application of the direct-to-indirect employment multiplier for a proposed MOX facility at the SRS from the SPD EIS (DOE 1999a).

The impacts on regional income of construction and operation were estimated by using employment impact estimates together with average regional income multipliers for the REA taken from IMPLAN regional economic data (MIG Inc. 2001). IMPLAN input-output economic accounts show the flow of commodities to industries from producers and institutional consumers. The accounts also show consumption activities by workers, owners of capital, and imports from outside the region. The IMPLAN model contains 528 sectors representing industries in agriculture, mining, construction, manufacturing, wholesale and retail trade, utilities, finance, insurance and real estate, and consumer and business services. The model also includes information for each sector on employee compensation; proprietary and property income; personal consumption expenditures; federal, state, and local expenditures; inventory and capital formation; and imports and exports.

The benefits of the proposed facilities to the economy of the REA would be significant (see Table 4.28). In the peak year of construction, 1,820 workers would be required for the proposed action. On average, 1,000 jobs would be created for the proposed facilities. During operations, 1,260 workers would be required in each year. The facility would also contribute significantly toward personal income within the REA. The proposed facilities would produce $350 million in income over the construction period and $610 million during operations (see Appendix H).

No taxes are paid by the federal government (income, property, or sales taxes), and contractors constructing and operating a facility on behalf of the federal government are currently exempt from local sales taxes in Georgia and South Carolina. Although local tax revenues, primarily state income and sales tax revenues, paid by federal government employees, contractors, and their employees would increase, the increase would be relatively small. During both construction and operation, the proposed facilities would produce approximately $110 million in tax revenues in the REA.

The gross regional product (GRP) provides the best measure of the overall benefits of both alternatives to the economy of the REA. The GRP is the sum of value added in the production of all goods and services in a year and measures the overall level of economic activity in the REA. The proposed facilities would produce $1,850 million in GRP in the REA over the entire life of the project.

4.7 Resource Commitment

Construction of the proposed facilities would result in some impacts that cannot be avoided. Impacts may be irreversible if the future uses of the resource are limited. This section addresses unavoidable, irreversible, and irretrievable impacts of constructing and operating the facility and the relationship between short-term uses of F-Area and the SRS for the facility and long-term productivity. A summary of unavoidable impacts is presented in Table 4.29.

Table 4.29. Unavoidable impacts of constructing and operating the proposed facilities

Resource	Unavoidable impacts
Geology and soils	• Construction excavation work may result in release of contaminated materials
Surface water	• Potential impacts to surface water quality by release of sediment, contaminated runoff, or accidental release of oil or construction equipment fuel
Air quality	• Incremental releases of $PM_{2.5}$ of 0.07% and 0.009% of proposed annual standard for construction and operations. The SRS currently exceeds proposed $PM_{2.5}$ standard level.
Ecology	• Initial loss of 50.0 ha (123.4 acres) of woodland and grassland habitat in F-Area. Over 30 ha (75 acres) would be landscaped following construction.
Land use	• A worst-case accident at the facility could result in minor land use impacts outside of the SRS
Cultural and paleontological resources	• Construction would directly affect two prehistoric archaeological sites that are eligible for listing on the *National Register of Historic Places*
Waste management	• Small impact to waste management system at the SRS • Volumes of TRU and hazardous waste produced by facilities would represent 3% of the WIPP disposal capacity and 20% of the SRS storage capacity, respectively. • Nonhazardous liquids produced would be about 35% of the capacity of the CSWTF
Human health risk	• Annual radiological impacts to SRS employees and the public from exposure to radioactive air pollutants are expected to be small at 1×10^{-5} and 4×10^{-4} latent cancer fatalities/yr, respectively. • 610 lost workday injuries during 5-year construction period • 410 lost workday injuries during 10-year operations period
Socioeconomics	• Increase in employment of 0.1 of a percentage point during construction • In-migrating workers during construction and operations would require 2% and <1% of vacant housing in ROI

4.7.1 Unavoidable Adverse Environmental Impacts

Geology and Soils. Impacts to geology and soils from construction and operation of the proposed MOX facility, PDCF, and WSB are expected to be insignificant. Restoration work, consisting of final grading and revegetation, would reclaim over half of the 41.9 ha (103.5 acres) of land in the F-Area that would be disturbed during construction. The 41.9-ha (103.5-acre) disturbed area is assumed to include 2 ha (4.9 acres) for laydown area for constructing the PDCF, and 9.7 ha (24 acres) for a laydown area for constructing the WSB. Some land in the area would be permanently altered because of constructing buildings, roads, and parking lots. The proposed MOX facility would permanently alter 6.9 ha (17 acres) of land, the PDCF would permanently alter 1.2 ha (3 acres), and the WSB would permanently alter

about 2.5 ha (6.2 acres). Because soils in the affected areas are not unique within the SRS, and the permanently altered areas represent only about 7% of the land available in F-Area (160 ha [395 acres]) and only about 0.01% of the 80,292 ha (198,400 acres) of land area at SRS (DCS 2002a), overall physical impacts on soil would be insignificant.

The potential exists that accidental releases of contaminated material during construction and normal operations might adversely affect receiving soils. However, if good engineering practices were used and any accidental spills were cleaned up promptly and thoroughly, chemical impacts to soil would be insignificant.

Surface Water. Impacts to surface water are expected to be negligible. Because surface water would not be used to supply water for construction or operations, there would be no impacts to surface water levels or flows.

Surface water quality could potentially be impacted by sediment, contaminated runoff, and accidental releases. However, good engineering practices, compliance with existing NPDES permits, and prompt, thorough cleanup of accidental releases would help to ensure that impacts to surface water quality during construction and normal operations would be insignificant.

Groundwater. The groundwater system beneath the SRS would be directly affected (i.e., used) during construction and normal operations of the proposed facilities because it is the only source of water for these activities. However, the impact to existing F-Area groundwater supplies would be small. Projected total water use for the proposed and existing facilities in the F-Area represents about 11% of the existing capacity during normal operations and about 3.4% during the construction phase. There would be no releases to underlying aquifers.

No direct impacts to groundwater quality (as opposed to quantity) are expected from construction or normal operations; there would be no releases to underlying aquifers. Groundwater quality could be impacted by accidental releases of contaminated material. However, impacts are expected to be negligible because of good engineering practices, prompt and thorough cleanup of any spills, and adherence to NPDES permit requirements.

Air Quality. Emissions associated with the construction and normal operation of the proposed facilities would have a negligible effect on air quality. With the exception of $PM_{2.5}$, concentrations of pollutants would remain below standard levels. The background level of annual $PM_{2.5}$ is currently above the ambient standard; MOX construction and operations activities would contribute concentrations equivalent to 0.07% and 0.009%, respectively, of the annual standard. For both construction and normal operations, contributions of the proposed facilities to CO, SO_2, NO_2, VOCs, and PAH concentrations would be well below 1.0% of applicable standards.

Noise. Potential noise impacts from construction and operation of the proposed facilities should be negligible at all off-site locations.

Ecology. Impacts of construction on ecological resources would primarily result from the loss and alteration of up to 50.0 ha (123.4 acres) of habitat. The woodland and grassland habitats that would be impacted represent a small fraction of those types of habitats at the SRS. Overall, the adverse impacts related to construction are expected to be limited to the immediate project vicinity and should not affect the viability of any vegetation types or wildlife populations at the SRS.

Sediment and erosion control measures implemented during site preparation and construction should prevent impacts to surface waters, aquatic and wetland resources, and protected fish species. No federally listed species have been reported in the areas that will be disturbed by construction. The SRS has established habitat management areas for the federally and state-endangered red-cockaded woodpecker, but the proposed facilities would not be located within any of these areas.

No adverse impacts to ecological resources are expected from operations of the proposed facilities.

Land Use. Land use of the entire F-Area is currently classified as developed/industrial. Since the facilities would be industrial, no adverse effects to land use would result from their construction or routine operation. If an operational accident occurred, F-Area would remain in developed/industrial land use. A worst-case accident could result in minor impacts to lands outside of the SRS. Future F-Area land use is expected to remain developed/industrial.

Cultural and Paleontological Resources. Construction of the proposed facilities would directly affect two prehistoric sites that are eligible for listing on the NRHP. Data recovery plans have been implemented, excavation has been completed, and monitoring will be conducted during ground-disturbing construction activities. Five additional eligible sites are located in the vicinity of the construction area. Mitigation measures would be taken to ensure that these sites were not disturbed directly or indirectly by construction activities.

No historic structures, traditional cultural property, or fossil-bearing strata have been identified in the project area; therefore, there would be no MOX-related impacts to such resources during construction.

Routine operations are unlikely to affect archaeological resources. However, the potential exists that storm-water detention releases resulting from a heavy rainfall could cause erosion in the area of an eligible site. Periodic monitoring of this site may be required.

An operational accident might affect archaeological resources by restricting access to sites that require regular monitoring. Such an accident might also affect traditional plant resources that might be present on the SRS.

Transportation. The existing road network at the SRS can readily accommodate the additional traffic expected during construction. In addition, the increased construction traffic would have negligible impacts on noise and air emissions. For operations, the impacts of transportation of the uranium and plutonium metal feed materials to the SRS, shipping fresh MOX fuel to a

surrogate nuclear power plant site, shipping TRU waste to WIPP, and shipping spent MOX fuel were considered.

For routine transportation, the expected latent cancer fatalities from radiation exposure are 0.2 and 0.1 for the public and transportation crews, respectively. A total of 1 latent fatality was estimated from vehicle emissions. Thus, 1 fatality might be expected from routine transportation activities.

It is estimated that the radiological transportation risk from accidents is 0.01 latent cancer fatality over the course of the entire shipping campaign. Chemical impacts from accidents would be negligible: 1.3×10^{-7} irreversible adverse effect (approximately 1×10^{-9} fatality) from depleted UF_6 is expected for the entire shipping campaign. None of the chemicals that might be released in any transportation accident are known to be carcinogens.

Total fatalities from direct physical trauma from accidents were estimated to be 0.081. This value indicates that no fatalities are expected from accidents for the entire shipping campaign.

Infrastructure. Construction activities and normal operational activities are not expected to adversely impact current SRS infrastructures. Projected electrical power, water, and fuel needs are well within existing capacities. The existing infrastructure would require a coordinated upgrading to support all phases of the surplus disposition program at the SRS: the proposed MOX facility, PDCF, and the WSB.

Waste Management. The impacts of facility construction waste on existing SRS waste management capacities would be minimal. The types and volumes of wastes generated would be similar to those that would be expected during the construction of an industrial facility. These wastes would be managed in accordance with current SRS waste management practices. Hazardous waste would be shipped off-site to commercial RCRA permitted facilities. The nonhazardous liquid waste generated would represent less about 35% of the SRS capacity for treatment. Solid waste would be shipped to off-site facilities for recycling or disposal.

Wastes generated by facility operations would have a small impact on the waste management system at the SRS. Estimated volumes for TRU, low-level, and hazardous waste would represent about 3% and 20% of the WIPP storage capacity and SRS storage capacities, respectively. Nonhazardous liquid wastes generated by facility operations are estimated to be about 35% of the capacity of the Central Sanitary Wastewater Treatment Facility. Nonhazardous solid wastes would be shipped off-site for recycling or disposal.

Human Health Risk. Statistically, no fatalities are predicted during facility construction or normal operation phases of the facility. An estimated 610 lost workday injuries would occur over the 5-year construction period, 410 over the assumed 10-year operations period.

No radiological impacts or adverse health impacts from emissions of toxic air pollutants are expected during the construction phase of the proposed facilities, and no adverse impacts to SRS employees and the public from exposure to emissions of toxic air pollutants are expected during normal operations. Annual radiological impacts to SRS employees and the public for

exposure to air emissions from the proposed facilities are expected to be very small, approximately 1×10^{-5} and 4×10^{-4} LCF/yr, respectively.

Hydrazine is the only chemical, aside from the radionuclides, that would be used in MOX processing that is listed as a hazardous air pollutant under the Clean Air Act. During routine operations, off-gas treatment systems would be expected to keep hydrazine emissions to very low levels that would not cause adverse health impacts to the off-site public or noninvolved workers.

Socioeconomics. The potential socioeconomic impacts from constructing and operating the proposed facilities would be insignificant. The increase in the annual average employment growth rate would be less than 0.1 of a percentage point over the duration of construction; even less during the operation phase.

In-migration of 350 people during the peak construction year would have only a marginal effect on population growth requiring 2.0% of the available vacant rental housing units in the region of influence (ROI) for construction and less than 1% of the available vacant owner occupied housing units for facility operations.

There would be no significant impact on public finances or the need for additional local public service employees during construction or normal operation.

Minor impacts would occur to agriculture and commercial fishing as demand for their products increase during construction and normal operation. No significant impacts on agriculture and downstream fisheries are expected from facility operations.

Any impacts associated with the transportation of fresh MOX fuel, including impacts on property values, would be minimal.

Environmental Justice. There would be no unavoidable environmental justice impacts from routine operations.

Aesthetics. The addition of the proposed facilities would not adversely affect the overall aesthetics of the F-Area or the SRS. The size and appearance of facility structures would be similar to those of existing buildings adjacent to the F-Area and would maintain the industrial nature of the F-Area.

Cumulative Impacts. Cumulative impacts of normal operations of the proposed facilities at the SRS were evaluated for air quality, health and safety, waste generation, resource use, and employment. Cumulative impacts for water quality, geologic resources, ecological resources, aesthetic resources, and cultural and paleontological resources were not explicitly addressed because direct and indirect impacts to these resources are expected to be negligible.

Cumulative impacts to air quality from proposed facility operations are not expected to be significant. On the basis of conservative assumptions, facility operations are projected to contribute 2% or less to cumulative concentrations of criteria air pollutants.

During normal operations, the facilities' contribution to cumulative radiological doses to the off-site population would be low (11% of the total). A cumulative dose to a MEI would increase by 1.4%. No latent cancer fatalities are expected from the cumulative dose to the MEI or to the off-site population. Transportation of radioactive materials associated with facility operations would not contribute significantly to cumulative impacts (collective occupational dose, dose to the general public, and latent cancer fatalities).

For most types of waste, facility operations would contribute less than 10% to the cumulative waste volumes generated at the SRS; existing waste treatment facilities will be able to handle this cumulative total. The largest proportionate increase would be in the amount of TRU waste (9%).

The cumulative impacts of the proposed facilities to land development, electricity usage, and groundwater usage at the SRS would be quite small and well within existing SRS capacities.

Construction activities would result in a peak workforce of 1,000 in the peak construction year, or about 6% of the cumulative SRS employees. Facility operations would support 510 workers annually (3.7% of the total projected workforce for the SRS in 2007) and result in a cumulative total of 13,820 employees at the SRS in 2007.

4.7.2 Irreversible and Irretrievable Commitments of Resources

This section addresses the major irreversible and irretrievable commitments of resources associated with the no-action alternative and proposed action as described in Chapter 2. A commitment of a resource is irreversible when its primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources neither renewable nor recoverable for use by future generations.

The 23.6 ha (58.3 acres) within which the proposed MOX facility, PDCF, and WSB would be built and the estimated 15.5 ha (38.3 acres) needed for infrastructure upgrades (e.g., pipeline and powerline rights-of-way, storm-water basin, batch plant, and roads) would be precluded from other uses until the NRC license to operate the facility was terminated (i.e., about 20 years into the future). About 3.6 ha (8.9 acres) of mostly woodland vegetation surrounding the proposed MOX facility site border would require grading for facility construction. Existing habitats would be eliminated, and ecological succession that would typically lead to progression from grassland to woodland vegetation would not occur. Although ultimate decommissioning of the facility could result in removal of all structures and paved surfaces, it is unlikely that woodland habitat comparable in quality to that north and west of the F-Area could become reestablished in less than 50 to 70 years.

Construction and operation activities would involve use of materials that could not be recovered or recycled. Soil excavated to produce the cement used in concrete would be irretrievably lost. Concrete and steel represent the bulk of construction materials. Other major construction materials that would be irretrievably lost or difficult to recycle include aluminum, lumber, piping materials, and electric wires and cables (DCS 2002a).

Water would be used for dust suppression during construction. Except for the water chemically bound in the production of concrete, water needed for construction and operation would eventually be recycled through the atmosphere and surface waters for distribution elsewhere. Water used during operation would be treated and discharged to the environment. Water obtained from groundwater supplies would be replaced through natural recharges of local aquifers. An estimated 760 million L (201 million gal) of water would be needed during the 10-year operating life of the facilities. Construction water requirements would total about 695 million L (185 million gal). A list of resources that would be required for the proposed MOX facility is provided in Table 4.30.

Construction, operation, deactivation, and decommissioning of the project site would require a commitment of financial and human resources. Commitments of machinery, construction equipment vehicles, and fossil fuels (e.g., fuel oil and diesel oil) would be needed during the life of the project. None of these resources is expected to be in short supply in the vicinity of the SRS.

No valuable mineral resources are known to be present at the project site or immediate vicinity that could by affected by facility construction and operation security requirements in the F-Area.

4.7.3 Relationship between Short-Term Uses of the Environment and Long-Term Productivity

Short-term uses of the environment for the proposed action include (1) using a 23.6-ha (58.3-acre) area in F-Area for the proposed facilities, and (2) using an additional 15.5 ha (38.3 acres) of land for infrastructure upgrades and a process pipeline right-of-way needed to transport liquid high-level alpha waste from the proposed MOX facility. These uses would allow the U.S. government to fulfill its obligations in a September 2000 agreement with the Russian government to convert surplus weapons-grade plutonium no longer needed for defense purposes into MOX fuel for irradiation in nuclear reactors.

The proposed action would result in favorable short-term effects for the local economy, specifically for the nearby communities of Aiken and North Augusta, South Carolina, and Augusta, Georgia. These communities would benefit from the increase in income generated by direct jobs and workers in support industries in the SRS vicinity.

The use of 39.1 ha (96.6 acres) of land (up to 50.0 ha [123.4 acres] would be disturbed by construction) on the SRS for the facility is consistent with the SRS Long Range Comprehensive Plan (DOE 2000b) and use of the F-Area for processing nuclear materials. The proposed project would require clearing of up to 14.8 ha (36.4 acres) of woodland. Clearing would eliminate wildlife habitat in these woodlands. Infrastructure upgrades for electrical supply and additional roadways built for the proposed project would have long-term benefit to F-Area for ongoing and future projects. If DOE decides to decommission the proposed facilities and remove all structures and paved surfaces, the site could be reclaimed to woodland vegetation. Reclamation would require about 50 to 70 years to establish woodlands comparable in species composition to areas that would be cleared for construction.

Table 4.30. Irreversible and irretrievable commitments of resources for the proposed MOX, PDCF, and WSB facilities

Resource	Consumption
Construction[a]	
Electricity	85,500 MWh
Fuel oil	7.624 million L (1,960,000 gal)
Water	695 million L (185 million gal)
Concrete	149,300 m^3 (195,240 yd^3)
Steel	36,367 MT (40,100 tons)
Operations[b]	
Electricity	1,860,000 MWh
Water	380 million L (101 million gal)
Fuel oil	5,362,600 L (1,376,000 gal)
Plutonium	34 MT (37.5 tons)
Depleted uranium	665 MT (726 tons)
Argon	3.7 m^3 (129 million ft^3)
Argon-methane	103,930 m^3 (3.67 million ft^3)
Dodecane	29,144 L (7,700 gal)
Helium	96,570 m^3 (3.41 million ft^3)
Hydrogen	105,070 m^3 (3.71 million ft^3)
Hydrogen peroxide	20,060 L (5,300 gal)
Hydrazine (35%)	15,140 L (4,000 gal)
Hydroxylamine nitrate	348,220 L (92,000 gal)
Manganese nitrate	45.4 kg (100 lb)
Nitric acid	49,205 L (13,000 gal)
Nitrogen	45,310 million m^3 (1.6 billion ft^3)
Nitrogen tetroxide	37,380 million m^3 (1.32 million ft^3)
Oxalic acid dehydrate	40,363 kg (89,000 lb)
Oxygen	20,110 m^3 (710,000 ft^3)
Porogen	2,993 kg (6,600 lb)
Silver nitrate	1,088 kg (2,400 lb)
Sodium carbonate	1,995 kg (4,400 lb)
Sodium hydroxide (10M)	189 L (50 gal)
Tri-butyl phosphate	28,009 L (7,400 gal)
Zinc stearate	2,798 kg (6,170 lb)

[a]Consumption amounts are based on a 5-year construction period.

[b]Represents total volumes for the MOX and PDCF facilities.

[c]Consumption amounts are based on facility operations for an assumed 10-year period. The data on chemicals are only for the proposed MOX facility.

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5 MITIGATION

5.1 Introduction

This chapter presents means to mitigate adverse environmental impacts from the proposed action as required by 10 CFR 51, Appendix A. Federal policy on mitigation is specified in the Council on Environmental Quality (CEQ) regulations. Under 40 CFR 1500.2 (f), federal agencies shall to the fullest extent possible use all practicable means consistent with the requirements of the National Environmental Policy Act (NEPA) and other essential considerations of national policy to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions on the quality of the human environment. The CEQ regulations define mitigation to include the following:

- Avoiding the impact altogether by not taking a certain action or parts of an action;
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
- Compensating for the impact by replacing or providing substitute resources or environments.

5.2 Mitigation Measures

The NRC staff evaluated both proposed mitigation measures identified by DCS (2002) and additional measures that could reduce or eliminate adverse environmental impacts of the proposed action. Table 5.1 is a summary of the mitigation measures. A more detailed discussion of mitigation measures is presented for construction, normal operations, accidents, and deactivation and decommissioning, and is organized by technical areas approximately corresponding to the section headings of Chapter 3, Affected Environment.

5.2.1 Soils

Soils could be affected by construction activities, normal operations, activities associated with deactivation and decommissioning, and accidents. DCS has proposed various mitigation measures to address these potential impacts.

Table 5.1. Summary of DCS mitigation commitments and additional measures identified by NRC staff for reducing or avoiding impacts from the proposed action[a]

Technical area	Mitigation	Measures proponent
Soils and Hydrology	• Creation of foundations and building of structures for the proposed MOX facility, PDCF, and WSB (hereafter "the facilities") will be limited to the upper soil layers, thus minimizing impacts to groundwater.	DCS
	• Good engineering practices will be used during operation and construction to minimize chemical impacts to soils.	DCS
	• Soils on-site will be graded or moved to create a uniform elevation that would reduce soil erosion.	DCS
	• Sediment detention basins will be placed around the facilities during construction to control runoff.	DCS
	• Accidental spills during construction shall be promptly cleaned up as required by DCS's Spill Prevention Control and Countermeasures Plan.	DCS
	• A Sediment Control Plan will be developed prior to disturbance of areas exceeding 2 ha (5 acres).	DCS
	• Sanitary wastes generated during construction will be collected with a combination of portable toilets and semipermanent facilities connected to the Central Sanitary Waste Treatment Facility.	DCS
	• Good engineering practices, such as the use of straw bales or siltation fences adjacent to areas disturbed during construction, will be used to control sediment and limit runoff to Upper Three Runs Creek.	NRC
	• The proposed MOX facility storm-water prevention plan shall be consistent with the existing SRS storm-water and erosion management practices.	DCS
	• Regular monitoring of the double-walled liquid high-alpha waste pipeline will be conducted to detect leaks.	DCS
Air Quality and Noise	• Dust suppression measures such as watering will be used during construction to reduce fugitive dust emissions by at least 50%.	DCS
	• Particulate emissions from the silo hopper and concrete mixer used during the cementation process to construct the WSB shall be reduced by 90%.	DCS

Table 5.1. Continued

Technical area	Mitigation	Measures proponent
Ecology	• Prior to construction, sites will be surveyed for plants and nests of migratory birds. To ensure compliance with the Migratory Bird Treaty Act and to provide additional protection for other bird species of concern (e.g., raptors), the following steps should be taken: (1) obtain a list from the Department of the Interior of migratory birds protected by the Act; (2) determine if protected migratory birds or their nests exist in the areas to be cleared for the proposed action; and (3) if protected birds or their nests or eggs are present, consult with the Department of the Interior for the appropriate precautions to be taken. This consultation should be undertaken as far in advance of construction as practicable.	NRC
	• Consultation and coordination with state and federal natural resource and wildlife agencies shall be conducted prior to any site disturbances to ensure that all potential sensitive species (including candidate and listed species) are protected to the maximum extent possible.	NRC
	• Environmental supervisors shall be present during vegetation clearing to ensure that impacts are held to a minimum.	NRC
	• Construction crews shall receive environmental briefings as appropriate to alert them to specific areas of concern (e.g., possible harassment and other adverse impact to wildlife species during the construction period) and to explain the reasons for such concern.	NRC
	• The loss of the existing storm-water basin near the southern boundary of the proposed site would be compensated for by construction of a new basin that would provide more viable aquatic habitat.	DCS
	• Measures shall be taken to protect trees not selected for removal. Any trees or other landscape features accidentally scarred or damaged should be replaced.	NRC
	• Reclamation plans shall be developed for laydown areas and other construction areas that will not be occupied by structures, parking lots, or roads. Reclamation will include removal of all temporary construction features, stabilization of soils, and reseeding with appropriate plant species.	NRC
	• Access roads will be sited on previously disturbed areas where possible to minimize sensitive vegetation removal.	DCS
	• The right-of-way for the 610-m (2,000-ft) pipeline to convey liquid high-alpha-activity waste and stripped uranium waste for the proposed MOX facility and PDCF to the WSB will be less than 7.6 m (25 ft) wide and thus minimizes vegetation removal.	DCS

Table 5.1. Continued

Technical area	Mitigation	Measures proponent
Land Use	• No mitigation measures are needed to reduce impacts of the proposed action on land use.	
Cultural and Paleontological Resources	• Monitoring of ground-disturbing construction activities will be conducted for the two directly affected eligible archaeological sites to complete obligations set forth in the data recovery plan for sites.	NRC/DOE
	• Awareness training will be conducted for workers so they do not disturb eligible archaeological sites.	NRC
	• Restrictions will be established regarding where heavy machinery is allowed.	NRC
	• Periodic monitoring of nearby eligible archaeological sites will be conducted to check for possible erosion.	NRC/DOE
	• Additional mitigation measures, such as avoidance agreements, will be determined in consultation with the SCSHPO.	NRC/DOE
Infrastructure	• Road upgrades for ingress and egress of the proposed MOX site will be conducted in existing traffic rights-of-way.	DCS
Waste Management	• No mitigation measures are needed to reduce impacts of the proposed action on the SRS waste management system.	
Human Health Risk	• The radiation exposure of radiographers will be monitored or badged during construction.	DCS
	• The radiography contractor will follow the contractor's existing NRC or agreement-state license in evaluating and monitoring radiographer exposure.	DCS
	• Radiation doses to workers during construction will be kept to a minimum by using administrative limits and ALARA programs, including worker rotations.	DCS
	• Construction workers will be protected from inadvertent chemical and radiological exposures by soil testing and analysis prior to excavation to ascertain that levels of inorganic and/or organic chemicals in soils would not present a health hazard during construction activities.	NRC
	• Exposures of facility workers during operations will be kept to a minimum through (1) use of engineering controls to keep airborne chemical concentrations below applicable occupational exposure limits, and (2) use of enclosed operations to the extent possible.	DCS

Table 5.1. Continued

Technical area	Mitigation	Measures proponent
Human Health Risk (cont.)	• During licensing of the proposed MOX facility, DCS should demonstrate that the offgas treatment system will limit hydrazine to very low levels that would not cause adverse health impacts to members of the public or SRS employees.	NRC
	• To minimize adverse effects to facility and SRS workers in the event of an accidental release of a process chemical, DCS shall add appropriate revisions to the SRS Emergency Response Plan for chemicals identified as presenting moderate or high risks to workers (as identified in Section 4.3.5.3).	NRC
	• DCS will appropriately train SRS workers stationed close to the proposed MOX facility and related facilities on actions to take both to prevent chemical accidents and in response to accident situations.	NRC
Socioeconomics	• No mitigation measures are necessary to reduce impacts to socioeconomic factors.	
Environmental Justice	• DCS should work closely with SRS to implement procedures to protect low-income and minority groups in the event of an accidental chemical or radiological release from the proposed MOX facility that impacts areas beyond the SRS boundary.	NRC
	• DCS should conduct focused public information campaigns to provide important information to low-income and minority groups/communities. Included in these campaigns would be descriptions of existing monitoring programs, and information on the nature, extent, and likelihood of any airborne release from the facility. The campaigns would also include a description of the relevant risks associated with the proposed MOX facility and MOX fuel transportation programs. These campaigns should include information on sheltering and other protection strategies that may be needed, including detailed descriptions of any evacuation procedures that may be required.	NRC
	• DCS should provide public information to local agencies and groups representing low-income or minority groups on existing soil or groundwater contamination monitoring programs and the nature, extent, and likelihood of surface release. Key information would include the extent of any likely damage to drinking water supplies and subsistence resources, and the relevant preventative measures that may be taken.	NRC

Table 5.1. Continued

Technical area	Mitigation	Measures proponent
Environmental Justice (cont.)	• Meet with local communities providing emergency response services and other emergency facilities to discuss additional measures to ensure that the low-income and minority population in their jurisdictions are located and fully prepared in the event that sheltering or evacuation procedures are required. In addition to public information campaigns targeting low-income and minority groups, this would include the development of spatial databases providing information on the location of low-income and minority populations, local resources available to emergency response agencies, and any evacuation routes that might be required.	NRC
Aesthetics	• No mitigation measures are necessary to reduce aesthetic impacts of the proposed action.	

[a]The mitigation measures are commitments made by DCS that were identified in the ER (DCS 2002) and additional recommendations/requirements identified by the NRC staff in its review of the proposed action. Proponent refers to the organization that identified the mitigation.

As part of the overall mitigation strategy, the site selected for the proposed MOX facility, PDCF, and WSB (the facilities) is located in an area in which the soils are not unique to the SRS, and there are no soils classified as prime farmlands. To a great extent, the impacts of construction on soils would be mitigated by the installation of sediment detention basins that would catch and hold runoff water. These detention ponds would be situated in strategic locations and would be designed to control the release of storm-water runoff at a rate equal to or slightly less than that of the predevelopment conditions. In addition, following good engineering practices as required by the DCS Spill Prevention Control and Countermeasures Plan, such as covering hazardous material and cleaning up spills as soon as they occur, would mitigate the consequences of construction.

During normal operations, there would be no planned direct discharges of water to the soil, and stack emissions of contaminated particulates would be filtered. These mitigation measures would minimize adverse impacts to the soil.

During deactivation and decommissioning, impacts could once again occur to soils through mobilization of contaminants by water or wind. Mitigation activities for this phase of the project would be the same as those outlined for construction.

Accidents during the lifetime of the facilities could also adversely impact soils. Mitigation activities for accidents would include prompt and thorough cleanup to prevent long-term impacts to soils and surface water from contamination by chemicals deposited downwind of the facilities.

5.2.2 Hydrology

Surface water resources could be adversely affected by construction of the facilities. The principal mitigation actions for surface water resources include eliminating any direct discharges to the ground or surface water (such as the tributaries to Upper Three Runs Creek or Fourmile Branch) and installation of sediment detention basins. Sanitary wastes would be collected with a combination of portable toilets and semipermanent facilities connected to the SRS Central Sanitary Wastewater Treatment Facility (CSWTF). All wastewater would be treated in the sitewide treatment system prior to release under existing NPDES permits. Good engineering practices would also be followed to mitigate the effects of potentially contaminated runoff water. Some of these activities include the use of siltation fences or straw bales to control sediment and runoff, and a sediment control plan would be developed for the site. Impacts from accidental releases of contaminants such as gasoline, oil, diesel fuel, and paint used during construction would be mitigated by prompt and thorough cleanup activities as required by the DCS Spill Prevention Control and Countermeasures Plan. This plan would be developed by DCS to meet EPA regulations (40 CFR Part 112).

As with surface water, groundwater could be adversely affected during construction of the facilities. Because the capacity of the existing wells in the F-Area are sufficient to meet the needs of the project, no mitigation is required. However, construction could directly impact groundwater quality if any of the buildings or structures extended below the surface of the groundwater. This direct impact would be mitigated by selecting a site in which the groundwater is deeper than any of the anticipated construction, as is the case for the proposed site. Groundwater could also be indirectly impacted by infiltration of contaminated surface water. These impacts would be mitigated by following appropriate good engineering practices, such as cleaning up any construction spills promptly and thoroughly as required under the DCS Spill Prevention Control and Countermeasures Plan.

During normal operation of the facilities, surface water would not be used. Therefore, no mitigation activities would be required for surface water flows or volumes. Although no direct discharges to surface water are planned, surface water quality could be impacted by runoff of contaminated water from surface spills. The primary mitigation activity for surface water quality is eliminating all releases of contaminated effluent. Nonhazardous wastewater would be treated, if necessary, and discharged to the F-Area process sewer system that connects to the SRS Effluent Treatment Facility. Storm-water runoff from the facility would be controlled under existing NPDES permits. These permits would limit potential contaminants to safe levels, thereby mitigating any impacts.

Water for normal operations would be obtained from F-Area wells. Because the quantity of water required for operations is within the capacity of the existing wells, no mitigation activities would be required. Also, there would be no direct releases to underlying aquifers. However, the quality of groundwater could be affected indirectly by receipt of contaminated surface water. No direct quality impacts would occur because no direct releases to groundwater are planned and the facilities would not use settling or holding basins as part of the wastewater treatment system. Operation of a sand filter would not directly impact groundwater because the filter would be covered to prevent infiltration and it would have a concrete wall and bottom.

Deactivation and decommissioning could also impact water resources at the site. These impacts would be mitigated by using the methods discussed above for construction.

Accidents could impact surface water and groundwater directly and indirectly. Impacts to surface water would primarily be indirect. These impacts would be produced by contaminated runoff from spill areas. Mitigation would be accomplished by prompt and thorough cleanup. Direct impacts to groundwater could occur if there were a failure in the liquid high-alpha activity waste stream that would be transported through an underground pipeline from the proposed MOX facility's Aqueous Polishing Area to the WSB. Failure of a stripped uranium pipeline from the proposed MOX facility to the WSB or a pipeline transporting low-level liquid radioactive waste from the WSB to the SRS ETF also could directly impact groundwater in the F-Area. These impacts would be mitigated by using double-wall construction for the pipe, performing regular monitoring of the system to detect leaks, and developing contingency plans to remediate any spills promptly and thoroughly.

5.2.3 Ecology

Construction of the proposed MOX, PDCF, and WSB facilities and associated infrastructure would disturb up to 50.0 ha (123.4 acres) of land in the F-Area of the SRS. The location of the facilities would mitigate many of the construction impacts to ecological resources. The site selected for the facilities would be largely in previously disturbed or developed locations, and there are no designated wetlands or Carolina bays within the areas to be disturbed. For example, a portion of the construction activities for the proposed MOX facility would take place on a former spoils pile used for previous F-Area construction, and most of the PDCF/WSB facilities would be located within "facility" land (e.g., landscaped areas). Also the new, widened, and realigned roads would be located within previously cleared rights-of-way. In addition, the facilities would not be located within either the red-cockaded woodpecker management area or its supplemental management area.

Best management practices for soil erosion and sediment control, such as using straw bales to limit runoff, watering the site to control fugitive dust, and constructing sediment detention ponds, would be used to prevent runoff and dust from entering sensitive habitats and nearby streams (e.g., unnamed tributaries to Upper Three Runs Creek), and direct construction disturbance would be avoided. Prior to construction, the proposed facility sites would be surveyed for nests of migratory birds in accordance with the Migratory Bird Treaty Act, and preconstruction surveys and consultations with the U.S. Fish and Wildlife Service and the South Carolina Department of Natural Resources would be conducted to ensure that impacts on any sensitive animal and plant species (e.g., the smooth coneflower) living in or near F-Area or rights-of-way would be insignificant. Some possible mitigative measures include avoiding species and their habitats entirely or just during critical time (e.g., during breeding season) or relocating sensitive species away from areas likely to be disturbed. These mitigation strategies would be coordinated with appropriate state and federal regulatory agencies as part of the consultation process.

Following construction, the cleared and graded areas not covered with facilities, parking lots, or roads would be landscaped. This landscaping would provide habitat for some wildlife species, mitigating the loss of habitat from constructing the facilities.

During normal operation of the proposed MOX facility, the major mitigation factor would be the elimination of all direct releases of wastewater to the environment with the exception of the HVAC condensate. The HVAC condensate would be from cooled external air and would be uncontaminated. It would be discharged to the environment through the storm-water system. Storm-water would be collected and routed through the existing SRS NPDES permitted outfalls, and sanitary wastewater would be treated in the sitewide treatment system. The storm-water basin and associated drainage ditches would provide habitat for a number of species. Use of scrubbers and filters would mitigate release of airborne contaminants that could adversely impact ecological resources.

Impacts of deactivation and decommissioning would be mitigated by using the same methods described for construction, particularly those for erosion and sediment control.

Accidents could also impact ecological resources at the facilities. These impacts would be produced primarily by contaminated runoff water entering sensitive habitat. These impacts would be mitigated by initiating prompt and thorough cleanup to reduce the likelihood of bioaccumulation and biomagnification in the food chain. Additional impacts could occur through air emissions from an accident. Prompt cleanup would also be used to mitigate these adverse impacts, if necessary.

5.2.4 Air Quality

During construction of the facilities, emission of criteria pollutants (CO, NO_2, and SO_2), TSP, and VOCs would require mitigation. Of these, suspended particles would be the principal concern. Suspended particles could be produced by fugitive dust from earthmoving activities, fugitive dust from the concrete batch plant, and exhaust emissions from diesel-powered construction equipment and from worker and delivery vehicles. Most of this dust would be generated within the construction site; dust created along roadways in the SRS would be naturally mitigated by dispersal. Air pollution impacts from suspended particles would be mitigated by applying, as appropriate, standard dust control practices, such as watering or sweeping roads and watering exposed areas.

During normal operations, air quality impacts would be produced by process emissions, testing of emergency diesel generators, trucks moving materials and wastes, and employee vehicles. These impacts would be mitigated by using at least a two-stage HEPA filter system (or sand filter) to remove radioactive particulates prior to discharge of process exhaust air to the atmosphere and by using internal scrubbers to reduce gas concentrations. Parking lots and access roads would be paved to minimize the emission of fugitive dust during normal operations.

Mitigation activities for deactivation and decommissioning would be similar to those used for construction. These strategies would be primarily aimed at reducing fugitive dust.

In the event of an accident, adverse impacts to the air would be mitigated by using the HEPA (or sand) filters and prompt and thorough cleanup, if necessary.

5.2.5 Noise

Noise is unwanted sound that interferes with or interacts negatively with the human or natural environment. Construction of the facilities could adversely affect the level of noise. Mitigation of these adverse impacts would be realized by locating the facilities away from the SRS public boundary and sensitive receptors. The level of noise could also be a concern for federally listed or endangered species; however, none are known to occur in F-Area. Construction workers could also be adversely affected by the levels of noise. DCS would be required to implement appropriate hearing protection measures to mitigate impacts on workers. These measures include the use of standard silencing packages on construction equipment, administrative controls, engineering controls, and personal hearing protection devices.

During normal operations, noise would be produced by cooling systems, vents, motors, generators, material-handling equipment, employee vehicles, and truck traffic. Impacts of these noises on the public would be mitigated by the location of the facilities (about 8.7 km [5.4 mi] from the site boundary).

Operation workers could also be exposed to noise levels higher than the acceptable limits specified by the Occupational Safety and Health Administration (OSHA) in its noise regulation (29 CFR 1926.52). Appropriate mitigation programs would be implemented according to pertinent OSHA standards to minimize impacts on workers. These programs include the use of administrative control, engineering controls, and personal hearing protection devices.

Mitigation measures used during deactivation and decommissioning of the facilities would be similar to those employed for construction.

5.2.6 Infrastructure

Upgrades of roadways to and from the proposed MOX site will be conducted in existing traffic rights-of-way.

5.2.7 Waste Management

During construction, hazardous and nonhazardous wastes would be produced. Impacts of hazardous wastes would be mitigated by managing them in accordance with the hazardous waste management practices in place at the SRS. The current practices include accumulating the waste at the generating facility (F-Area) for a maximum period of 90 days or storing it in

RCRA-permitted hazardous waste storage buildings or on interim pads located in the B- and N-Areas. The wastes would be packaged in DOT-approved containers for off-site shipping to permitted commercial recycling, treatment, or disposal facilities. Impacts from nonhazardous liquid and solid wastes would be mitigated by managing them in accordance with site waste management practices. Nonhazardous wastewater would be treated at the CSWTF. At the SRS, solid sanitary waste handling and management is privatized. These wastes would be collected, hauled, and disposed of at the Three Rivers Landfill southwest of the B-Area. Other nonhazardous solid wastes, such as scrap metal, powerhouse ash, domestic sewage, scrap wood, construction debris, and used railroad ties, would be disposed of according to their nature.

Impacts of wastes generated during normal operations of the facilities would be mitigated consistently with waste management practices at the SRS. Wastes would be transferred from F-Area to the appropriate facilities or areas within the SRS for subsequent treatment, storage, or disposal. Potential impacts from the liquid high-alpha waste stream from the aqueous polishing process would be mitigated by transferring the wastes via a double-walled pipeline. A new tank would be constructed at the WSB so that the high-alpha-activity waste could be neutralized before being transferred to the F-Area HLW Tank Farm.

Impacts of low-level liquid wastes would be mitigated by appropriate collection, sampling, and treatment at the SRS ETF. After treatment, the waste would be pumped to the existing F-Area process sewer consistent with current practices at the SRS. Solid low-level wastes would be packaged, certified, and accumulated in the F-Area before transfer to the appropriate SRS facilities for on-site treatment and disposal.

Impacts of hazardous wastes generated during normal operation would be mitigated by packaging and either on-site or off-site treatment and disposal. Nonhazardous solid wastes would be packaged and transported in accordance with standard industrial practices. Nonhazardous liquid wastes would be mitigated by treatment before being discharged to the F-Area sanitary sewer system, which connects to the CSWTF.

During deactivation and decommissioning, impacts of generated wastes would be mitigated in the same ways as discussed above. Impacts of wastes produced by accidents would be mitigated by rapid and thorough cleanup and by following the prescribed SRS waste management practices.

5.2.8 Human Health Risk

During construction, workers could be adversely affected by exposure to soil or groundwater previously contaminated by radioactivity or chemicals. Impacts from contaminated soil would be mitigated by conducting further sampling of the soil for radioactive contamination before excavation begins at the site. The location of the proposed construction would mitigate the effects of contaminated groundwater because groundwater would not be encountered during the excavation process. In addition, workers would be monitored, as appropriate, to ensure that radioactive doses are maintained at levels as low as reasonably achievable.

To mitigate adverse impacts of fugitive dust on workers, standard dust suppression techniques, such as watering or sweeping of roads and watering exposed areas, would be implemented. Wastewater generated during construction would be transported to the CSWTF for treatment prior to release. This procedure would mitigate any adverse impacts.

Impacts from hazardous wastes generated during facility construction would be mitigated by appropriately packaging and shipping the material off-site for commercial recycling, treatment, or disposal. Exposure to hazardous materials such as paints and solvents would be mitigated by following good engineering practices, such as using good ventilation and cleaning up small spills promptly and thoroughly.

During construction, occupational hazards to workers would be mitigated by following OSHA guidelines.

During normal operations of the proposed MOX facility, workers could be impacted by exposure to internal and external radiation. These impacts would be mitigated by instituting monitoring, enforcing administrative limits, and developing ALARA programs that would include worker rotations. During normal operations, workers could also be impacted by chemical exposure. Health risks from occupational exposures through all pathways (i.e., inhalation, skin contact [dermal], and ingestion) would be mitigated by using enclosed operations (e.g., gloveboxes) as much as possible. In addition, workplace exposure to such chemicals as hydrazine that are used in the plutonium polishing process to separate plutonium from the solvent would be monitored to ensure that airborne concentrations within the facility were kept below the occupational exposure limit. Off-gas treatment systems would be used to limit hydrazine emissions to very low levels that would not cause adverse human health impacts.

During the fuel fabrication process at the proposed MOX facility, purified plutonium dioxide would be mixed with depleted uranium dioxide. Impacts from this process would be mitigated by performing the mixing in closed containers located in gloveboxes that would confine contamination to inaccessible areas. Air exhaust from the gloveboxes would be passed through HEPA filters to collect particulate emissions.

During normal operations, occupational hazards to workers would be mitigated by following OSHA guidelines.

The consequences of accidents (fire, explosion, load handling, and criticality) on human health would be mitigated by following SRS emergency procedures. For fires, key features would include installing fire barriers, minimizing combustibles and ignition sources, installing ventilation systems with fire dampers and HEPA filters, using nitrogen blanket systems, providing only qualified canisters and containers, incorporating fire suppression and detection systems, developing and following appropriate emergency procedures, providing worker training, and equipping and training local fire brigades. For explosions, the following mitigation devices would be available: scavenging air systems, hydrogen monitoring systems, temperature control systems, chemical addition and concentration control systems, sampling systems, process shutdown controls, operator training, and operations and maintenance procedures. Key mitigation features for load handling include load path restrictions, crane-operating

procedures, maintenance procedures, operator training, qualified canisters, reliable load-handling equipment, and ventilation systems with HEPA filters. Key mitigation features for criticality accidents include geometry, mass, and moderation controls.

Mitigation activities for the deactivation and decommissioning of the facilities would be essentially the same as those discussed for construction.

5.2.9 Cultural, Historical, and Paleontological Resources

Construction of the facilities would directly impact two prehistoric archaeological sites that are eligible for listing on *National Register of Historical Places.* There are no known fossil-bearing strata within the area of the project, and although there are about 400 historic sites or sites with historic components, none of them are located within the location of the proposed facilities.

Impacts of construction to two prehistoric archaeological sites have been mitigated in part through data recovery as described in a data recovery plan that was submitted and approved by the South Carolina State Historic Preservation Office (SCSHPO). Monitoring of these sites during construction activities is also part of the mitigation strategy.

Five additional eligible sites are located in the vicinity of the planned construction, but no direct impacts to these sites are expected. However, indirect impacts could still affect these sites. Possible mitigation activities for these indirect impacts include awareness training for workers so that they would not inadvertently disturb the sites, possible restrictions on where heavy machinery is allowed, and periodic monitoring to check for possible surface erosion or evidence of other impacts from an increase in F-Area activities (e.g., unauthorized pedestrian or vehicle activity at the archaeological sites). The need for an avoidance agreement for one site or additional mitigation activities for potential erosion at several of the sites would be determined in consultation with the SCSHPO.

Inadvertent discoveries of cultural resources could also occur during site construction. Mitigation of any adverse impacts to these sites would follow the guidelines of 36 CFR 800.11 (historic properties) and/or 43 CFR 10.4 (Native American human remains, funerary objects, objects of cultural patrimony, and objects that are sacred).

During normal operations, archaeological resources are unlikely to be affected. Therefore, no mitigation activities would be required.

Potential impacts of deactivation and decommissioning eligible archaeological sites or historic structures would have to be evaluated at the time of decommissioning. Mitigation measures would be determined in consultation with the SCSHPO.

5.2.10 Aesthetics

Construction, operation, and deactivation and decommissioning of the facilities' buildings would have a minimal effect on the scenic character of the surrounding area and would be consistent with the VRM Class IV designation of the area. The buildings would be low-rise structures with heights of less than 30 m (100 ft). This height would be similar to that of other buildings in the area. The tallest new structure would be a stack that is less than 30 m (100 ft) above the existing grade. Impacts of these buildings on visual resources would be mitigated by the presence of trees and rolling terrain that would effectively screen them from view, and the distance of the facility from the nearest publicly accessible viewpoints located on State Highway 125 and SRS Road 1, both approximately 6 km (4 mi) away.

5.2.11 Socioeconomics

Construction of the facilities would have a minor beneficial socioeconomic impact on the region. Therefore, no mitigation would be needed. Although the region should benefit from the construction, the peak demand for workers could adversely affect other construction activities in the area. These impacts would be mitigated by the short duration of the peak demand for workers (a few months). In addition, given that a majority of workers would be hired from the existing regional labor pool, impacts from worker relocation to area businesses, public services, and facilities would be mitigated.

Transportation impacts during construction would be primarily associated with construction labor. To minimize conflicts with other SRS activities, the work schedule would be coordinated and staggered with other SRS activities to minimize the number of vehicles entering and exiting the SRS during peak commuting periods.

Normal operations of the facilities would require approximately 480 new permanent positions and an additional 780 indirect jobs. Given the population and its rate of growth, no significant socioeconomic impacts are expected, and no mitigation would be required.

The impacts of deactivation and decommissioning of the facility would be similar to those for construction, and mitigation activities would be similar to those previously discussed. No mitigation of socioeconomic impacts would be required for accidents, unless residents were evacuated and prevented from quickly returning to their homes. Such impacts would be mitigated, to the extent possible, by rapid cleanup of the accident.

5.2.12 Environmental Justice

Various procedures might be used to protect low-income and minority groups in the event of an accidental chemical or radiological release from the facilities. These activities include development and implementation of the following:

- Focused public information campaigns to provide technical and environmental health information directly to low-income and minority groups, or to local agencies and representative groups; and

- Additional programs directed at local communities providing emergency response services and other emergency facilities to incorporate additional measures to protect low-income and minority populations.

Included in the public information campaigns would be descriptions of existing air and groundwater monitoring programs; the nature, extent, and likelihood of any future airborne or groundwater release from the facilities; and the likely characteristics of environmental and health impacts. Key information would include the extent of any likely damage to drinking water supplies and subsistence resources and the relevant preventive measures that may be taken. The campaigns would also include a description of the relevant risks associated with MOX-related transportation programs.

The additional programs under the second group of measures would ensure that the low-income and minority population in local government jurisdictions are located and fully prepared in the event that sheltering or other protection strategies may be required and would ensure that detailed descriptions of evacuation routes that may be used have been developed and distributed. In addition to public information campaigns targeting low-income and minority groups, these programs would include the development of spatial database programs for use by local emergency response planners. These databases would provide information on the locations of low-income and minority populations and the locations of relevant local resources available to emergency response agencies, and would have detailed descriptions of evacuation routes that might be required.

5.3 Reference for Chapter 5

DCS (Duke Cogema Stone & Webster) 2002. *Mixed Oxide Fuel Fabrication Facility Environmental Report, Revision 1 & 2*. Docket Number 070-03098. Charlotte, NC.

6 ENVIRONMENTAL REGULATIONS AND PERMITS

The proposed project would be subject to many federal, state, local, and other legal requirements, and a variety of permits, licenses, and approvals would have to be obtained. Many of these requirements are identified and their status summarized in Table 6.1. For items that are the responsibility of the facility owner or operator, Table 6.1 presents requirement status on the basis of information obtained from the environmental report (ER) (DCS 2002). No independent evaluation was made of the status of consents not discussed in the ER that are the responsibility of the facility owner or operator. For items that are the responsibility of the U.S. Nuclear Regulatory Commission (NRC), references are made to other sections of this environmental impact statement (EIS) that discuss their status.

Because of the early stage of project design, the information in Table 6.1 should not be considered comprehensive or binding. It may later be determined that the facility is subject to additional requirements that are not listed in Table 6.1 or qualifies for exemptions or exclusions from some requirements that are listed.

For ease of reference, the information in Table 6.1 has been divided into the following categories:

- Civilian Use of Nuclear Material,
- Air Quality Protection and Noise Control,
- Protection of Water Resources,
- Waste Management and Pollution Prevention,
- Biotic Resources,
- Cultural Resources,
- Transportation, and
- Other.

Table 6.1. Applicable environmental regulations and consents or activities

Responsible agency	Authority	Requirement	Status
Civilian Use of Nuclear Material			
NRC	Atomic Energy Act of 1954, as amended (AEA) (42 U.S.C. 2011 et seq.); 10 CFR Part 40	*Part 40 License* to receive, possess, use, and transfer depleted uranium	DCS has satisfied this requirement by specifying depleted uranium activities in the Construction Authorization Request for its Part 70 License (DCS 2001, Sections 1.2.2 and 1.2.3, and 2002a) .
NRC	AEA; 10 CFR Part 70	*Part 70 License* to receive, possess, use, and transfer plutonium	DCS has applied for this consent by filing a Construction Authorization Request and an Environmental Report with the NRC (DCS 2002b).
South Carolina Department of Health and Environmental Control (SCDHEC)	AEA; South Carolina (SC) Regulations R.61-63	*Radioactive Materials License* to receive, use, possess, transfer, and dispose of radioactive material, including depleted uranium	DCS has satisfied this requirement by applying for a Part 70 License from the NRC.
Air Quality Protection and Noise Control			
SCDHEC	Clean Air Act (CAA) Section 165 (42 U.S.C. 7475); SC Regulations R.61-62.5 Standard No. 7	*Prevention of Significant Deterioration (PSD) Permit* to construct and operate a new major stationary source of air pollution in an area that complies with National Ambient Air Quality Standards for carbon monoxide, lead, nitrogen dioxide, ozone, sulfur oxides, particulate matter with aerodynamic diameter less than or equal to 10 : m (PM_{10}), and $PM_{2.5}$	DCS has determined that gaseous emissions from the facility would not be enough to trigger the requirement for a PSD Permit (DCS 2002b, Section 7.2.1.1). Section 4.3.2.2 discusses impacts of facility operations on air quality.

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
SCDHEC	CAA, Title V, Sections 501 - 507 (42 U.S.C. 7661 - 7661f); SC Regulations R.61-62.70	*Title V Operating Permit* for a new or existing stationary source that is a major source; a source subject to National Emission Standards for Hazardous Air Pollutants (NESHAPs); a source subject to New Source Performance Standards (NSPS); or an affected source under the Acid Rain Program	DCS has determined that the quantity of criteria and hazardous air pollutants (other than radionuclides) expected to be emitted during facility operation would not be enough to trigger the requirement for a Title V Operating Permit (DCS 2002b, Section 7.2.1.1). Even so, DCS has initiated consultation with the SCDHEC and plans to submit any permit forms necessary to augment the existing Title V Operating Permit held by the DOE SRS (DCS 2002b, Section 7.2.1.1).
SCDHEC	CAA, Section 112 (42 U.S.C. 7412); 40 CFR Part 61; SC Regulations R.61-62.63	*Approval for Construction* of a new source or modification that is subject to NESHAPs	DCS has determined that the proposed facility would be subject to NESHAPs requirements in 40 CFR Part 61, Subpart H, which govern radionuclide emissions from all DOE-owned or DOE-operated facilities, whether or not they are licensed by the NRC. However, EPA Region IV and SCDHEC approved an alternate calculation methodology that exempted the facility from preparing an application for NESHAPs construction approval (DCS 2002b, Section 7.2.1.1). Section 4.3.2.2 discusses impacts on air quality during routine operation.
SCDHEC	CAA, Section 111 (42 U.S.C. 7411); 40 CFR Part 60; SC Regulations R.61-62.60	*Demonstration of Compliance* with applicable NSPS	DCS has determined that the facility would not trigger the requirement to comply with any NSPS (DCS 2002b, Section 7.2.1.1).

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
SCDHEC	CAA, Section 112(r) (42 U.S.C. 7412); 40 CFR Part 68, Subpart G; SC Regulations R.61-62.68	*Risk Management Plan* for any stationary source that has more than a threshold quantity of a regulated substance in a process	DCS has determined that a Risk Management Plan is not required because the projected quantities of regulated substances at the facility would not be greater than threshold levels (DCS 2002b, Section 7.1.2).
SCDHEC	SC Pollution Control Act (SC Code of Laws, 1976, as amended, Title 48, Chapter 1); SC Regulations R.61-62.1, Section II.A	*State Construction Permit* to construct, alter, or add to a source of air contaminants within South Carolina, if the emission limits imposed would be more restrictive than those imposed by other federal or state air permitting requirements	DCS plans to develop a Construction Emissions Control Plan and to submit standard permit application forms required by the SCDHEC in order to evaluate the applicability of all state air permitting requirements (DCS 2002b, Section 7.2.1.1).
NRC	CAA, Section 176 (42 U.S.C. 7506); 40 CFR Part 93, Subpart B	*Determination of Conformity* with applicable air quality implementation plans	No air quality implementation plans apply to the area where the facility is located.
Protection of Water Resources			
SCDHEC	Clean Water Act of 1977 (CWA) (33 U.S.C. 1251 et seq.); SC Regulations R.61-9	*National Pollutant Discharge Elimination System (NPDES) Permit for Storm Water Discharges during Construction* for discharges of storm water from any land disturbance activity affecting an area greater than 5 acres	DCS has determined that the facility construction activities would be covered by the South Carolina NPDES General Permit for storm-water discharges from construction activities within the state (Permit No. SCR100000), provided that a notice of intent, supported by a Storm Water Management Pollution Prevention Plan is filed before construction activities are initiated (DCS 2002b, Section 7.2.1.2). DCS plans to submit the notice of intent and required plans at the appropriate time.

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
SCDHEC	CWA (33 U.S.C. 1251 et seq.); SC Regulations R.61-9	*NPDES Permit for Storm Water Discharges from Industrial Activity Areas* for discharges of storm water from any facility or activity classified as "associated with industrial activity"	DCS has determined that the South Carolina NPDES General Permit for storm-water discharges from industrial activities within the state (Permit No. SCR000000) would cover runoff exposed to pollutants in an industrial activity area at the facility after construction is complete, provided that a notice of intent, supported by a Storm Water Management Pollution Prevention Plan, is filed (DCS 2002b, Section 7.2.1.2). DCS plans to submit the notice of intent and required plan at the appropriate time.
SCDHEC	CWA (33 U.S.C. 1251 et seq.); SC Regulations R.61-9	*NPDES Permit for Wastewater Discharges* for discharges to surface waters of wastewater from industrial facilities	DCS has determined that the facility would not require an NPDES permit of this type because no discharges of process wastewater are planned (DCS 2002b, Section 7.2.1.2).
SCDHEC	SC Pollution Control Act (SC Code of Laws, 1976, as amended, Title 48, Chapter 1); SC Regulations R.61-67	*State Construction Permit* to construct, alter, or add to wastewater treatment facilities within South Carolina	DCS has initiated consultation with the SCDHEC and at the appropriate time, plans to obtain a permit to construct the tie-in between the existing SRS Central Sanitary Waste Treatment Facility and the sanitary wastewater system from the facility (DCS 2002b, Section 7.2.1.3).

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
SCDHEC	SC Safe Drinking Water Act (SC Code of Laws, 1976, as amended, Title 44, Chapter 55); SC Regulations R.61-58	*Public Water System Construction Permit* for construction, modification, or expansion of any public water system	DCS has initiated consultation with the SRS Environmental Protection Department, which is responsible for compliance with SCDHEC requirements applicable to the existing drinking water systems at the SRS. DCS plans to obtain the necessary permit before construction begins on a tie-in between the existing SRS drinking water system and the facility drinking water system (DCS 2002b, Section 7.2.1.3).
SCDHEC	SC Safe Drinking Water Act (SC Code of Laws, 1976, as amended, Title 44, Chapter 55); SC Regulations R.61-58	*Public Water System Operating Approval* for placing a new, modified, or expanded public water system into service	DCS has initiated consultation with the SRS Environmental Protection Department, which is responsible for compliance with SCDHEC requirements applicable to the existing drinking water systems at the SRS. DCS plans to obtain the necessary operating approval before beginning operation of the tie-in between the existing SRS drinking water system and the facility drinking water system (DCS 2002b, Section 7.2.1.3).
U.S. Environmental Protection Agency (EPA)	CWA (33 U.S.C. 1251 et seq.); 40 CFR Part 112	*Spill Prevention Control and Countermeasures (SPCC) Plan* for any facility that could discharge oil in harmful quantities into navigable waters	DCS plans to prepare the required SPCC Plan (DCS 2002b, Section 7.2.1.2).
SCDHEC	CWA (33 U.S.C. 1251 et seq.); SC Regulations R.61-101	*State Water Quality Certification* certifying that the applicable state water quality standards will not be violated as a result of discharges to navigable waters by an activity authorized by a federal license.	DCS has initiated consultation with the SCDHEC regarding a determination of whether an NRC license requires a 401 Water Qualification Certification in accordance with SCDHEC regulations 61-101 (DCS 2003).

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
NRC; U.S. Army Corps of Engineers	CWA (33 U.S.C. 1251 et seq.); Executive Order 11988 (42 FR 26951; May 24, 1977) as amended by Executive Order 12148 (44 FR 43239; July 20, 1979)	*Floodplain Assessment* to evaluate the effects of issuing a Part 70 License on any floodplain	DCS has completed a floodplain assessment and incorporated its results into the design of the facility (DCS 2002b, Section 7.1.3 and Table 7-1). Section 3.3.1 discusses the results of the floodplain assessment.
U.S. Department of the Interior (National Park Service); NRC	Wild and Scenic Rivers Act, as amended (16 U.S.C. 1271 et seq.)	*Wild and Scenic Rivers Assessment* to ensure that issuing a Part 70 License will not result in activities that would adversely affect the values for which a river is being studied or has been designated as a wild and scenic river	DCS has determined that no river that is being studied or has been designated as a national wild and scenic river occurs within the SRS (DCS 2002b, Section 4.4.2.1).
U.S. Army Corps of Engineers	CWA (33 U.S.C. 1251 et seq.)	*Section 404 Permit* to discharge dredged or fill material into waters of the United States, including wetlands	DCS has determined that no wetlands are present on the facility site and that no other discharge of dredged or fill material into water of the United States would occur at the facility site (DCS 2002b, Section 4.6.2.2). Therefore, DCS has concluded that no Section 404 permit is required from the U.S. Army Corps of Engineers (DCS 2002b, Section 7.1.3 and Table 7-1).

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
Waste Management and Pollution Prevention			
EPA; SCDHEC	Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA) (42 U.S.C. 6901 et seq.), Subtitle C; SC Regulations R.61-79.262	*EPA Identification Number* to identify a hazardous waste generator	DCS has determined that the facility would generate small quantities of hazardous wastes. Therefore, DCS plans to file a notice of hazardous waste activity with EPA and obtain an EPA identification number when hazardous waste activities commence at the site (DCS 2002b, Section 7.2.1.4). Hazardous waste generated during facility operations is discussed in Section 4.3.2.4.
SCDHEC	RCRA, as amended by HSWA (42 U.S.C. 6901 et seq.), Subtitle C; SC Regulations R.61-79.270	*Hazardous Waste Facility Permit* for a facility that will store hazardous wastes beyond the allowed accumulation periods, treat hazardous wastes, or dispose of hazardous wastes	DCS has determined that the facility will not store hazardous waste beyond the allowed accumulation time. Also, DCS does not plan to treat or dispose of hazardous waste at the facility. Therefore, DCS has concluded that the facility would not require a hazardous waste facility permit (DCS 2002b, Section 7.2.1.4).
SCDHEC	RCRA, as amended by HSWA (42 U.S.C. 6901 et seq.), Subtitle I; SC Regulations R.61-92	*Underground Storage Tank Installation and Operation Permits* to install and operate an underground storage tank that will contain regulated substances, including petroleum products and other substances defined in Section 101(14) of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA)	DCS has initiated consultation with the SCDHEC regarding underground storage tanks for managing regulated substances at the facility and plans to obtain the necessary permits at the appropriate time (DCS 2002b, Section 7.2.1.4).

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
Biotic Resources			
NRC; U.S. Fish and Wildlife Service; South Carolina Department of Natural Resources; Georgia Department of Natural Resources	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.); Nongame and Endangered Species Conservation Act (SC Code of Laws, 1976, as amended, Title 50, Chapter 15); Endangered Wildlife Act of 1973 (Georgia Laws 1973, p. 932, et seq.); Wildflower Preservation Act of 1973 (Georgia Laws 1973, p. 333, et seq.)	*Threatened and Endangered Species Consultation* between the NRC, the U.S. Fish and Wildlife Service, and affected states to ensure that issuance of a Part 70 License is not likely to jeopardize the continued existence of any species listed at the federal or state level as endangered or threatened, or result in destruction of critical habitat of such species	DCS has obtained declarations from the U.S. Fish and Wildlife Service and the South Carolina Department of Natural Resources indicating that facility construction and operation would have no effect on threatened and endangered species under their jurisdictions (DCS 2002b, Sections 7.1.6 and 7.2.3).
Cultural Resources			
NRC; Advisory Council on Historic Preservation; South Carolina State Historic Preservation Officer	National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); Archaeological and Historical Preservation Act of 1974 (16 U.S.C. 469-469c-2); Antiquities Act of 1906 (16 U.S.C. 431 et seq.); Archaeological Resources Protection Act of 1979, as amended (16 U.S.C. 470aa-mm)	*Archaeological and Historical Resources Consultation* between the NRC and the State Historic Preservation Officer or Tribal Historic Preservation Officer before allowing federally licensed activities to proceed in an area where archaeological or historic resources might be located	DCS has determined that, while there are no historic sites located within the facility site, there are two prehistoric archaeological sites that are eligible for listing on the *National Register of Historical Places* (DCS 2002b, Section 4.8.2). Mitigation of these sites was completed during August 2002 (DCS 2002b, Table 7-1). Sections 3.7 and 4.3.7.8 describe the required consultations.

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
NRC	American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996); Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001, et seq.)	*Native American Resources Consultation* between the NRC and Native Americans to ensure that activities resulting from issuance of a Part 70 License have been designed to protect access to, physical integrity of, and confidentiality of Native American sites	DCS reports that consultation has been initiated with appropriate Native American groups to identify concerns about construction activities associated with a facility such as the MOX facility at the SRS (DCS 2002b, Section 4.8.4). Sections 3.7.3 and 4.2.6.3 discuss the status of this consultation.
Transportation			
U.S. Department of Transportation (DOT); NRC	Hazardous Materials Transportation Act, as amended by the Hazardous Materials Transportation Uniform Safety Act of 1990 and other acts (49 U.S.C. 1501, et seq.); Atomic Energy Act of 1954, as amended (42 U.S.C. 2011, et seq.); 49 CFR 172, 173, 174, 177, and 397; 10 CFR 71	*Packaging, Labeling, and Routing Requirements for Radioactive Materials*	At the appropriate time, DCS will comply with DOT and NRC requirements for packaging, labeling, and routing of radioactive materials. DCS has identified no specific permits, licenses, or approvals that will be required for transportation of materials to or from the facility.
Other			
NRC; U.S. Natural Resource Conservation Service	Farmland Protection Policy Act (7 U.S.C. 4201 et seq.); 7 CFR Part 658	*Prime Farmland Assessment* to consider alternatives to address the adverse effects on prime farmland of activities resulting from issuance of a Part 70 license	DCS has determined that none of the land on the facility site has been identified as prime farmland because the land is not available for agricultural production (DCS 2002b, Section 7.1.7 and Table 7-1).

Table 6.1. Continued

Responsible agency	Authority	Requirement	Status
NRC	National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.); 40 CFR 1500 - 1508; 10 CFR Part 51	*Environmental Impact Statement (EIS)* to evaluate the potential environmental impacts of a proposed major federal action that may significantly affect the quality of the human environment, and to consider alternatives to the proposed action	This DEIS meets the requirements of the NEPA.

References for Chapter 6

DCS (Duke Cogema Stone & Webster) 2001. *Construction Authorization Request for the Mixed Oxide Fuel Fabrication Facility.* Docket Number 070-03098. Charlotte, NC.

DCS 2002a. *Amended Construction Authorization Request for the Mixed Oxide Fuel Fabrication Facility*. Docket Number 070-03098. Charlotte, NC.

DCS 2002b. *Mixed Oxide Fuel Fabrication Facility Environmental Report*, *Revision 1 & 2*. Docket Number 070-03098. Charlotte, NC.

DCS 2003. "Duke Cogema Stone & Webster Mixed Oxide Fuel Fabrication Facility 401 Water Quality Certification." Letter from M.L. Birch (Manager, Environment, Safety and Health, DCS, Charlotte, NC) to Q. Epps (Section Manager, Water Quality Certification Standards and Wetlands, South Carolina Department of Health and Environmental Control, Columbia, NC). Jan. 15.

7 Glossary

7Q10 flow: The 7-day low flow, 10-year recurrence flow for a river. This flow is the lowest recorded over any 7 consecutive days within any 10-year period.

absorbed dose (*dose*[1]): The amount of energy deposited in any material by ionizing radiation. The unit of absorbed dose, the rad, is a measure of energy absorbed per gram of material.

accident: An unplanned sequence of events resulting in undesirable consequences, such as the release of radioactive or hazardous material to the environment.

accident risk: Risk based on both the severity of an accident (consequence) and the probability that the accident will occur. High-consequence accidents that are unlikely to occur (low probability) may pose a low overall risk. For purposes of comparison, accident risk is typically calculated by multiplying the accident consequence (for example, dose or expected fatalities) by the probability of the accident's occurring.

accident severity categories: A method of characterizing all the possible types of accident scenarios that might occur according to their likely outcome and the probability of occurrence. The *Nuclear Regulatory Commission* method, which is used in this environmental impact statement, divides the spectrum of accidents into eight categories. Category I accidents are the least severe but the most frequent; Category VIII accidents are very severe but very infrequent.

accident source term: The amount of radioactive or hazardous material released to the environment following an accident.

acute: Resulting in immediate impacts.

acute health endpoint: A human health impact involving immediate injury or fatality.

administrative outfall: An authorized liquid waste *outfall* that discharges no pollutants.

Advisory Council on Historic Preservation: Under the National Historic Preservation Act of 1966, the Council reviews federal undertakings that may affect historic structures, sites, or archeological artifacts. Second contact in sequential review that begins with the State Historic Preservation Officer.

An independent federal agency that serves as the chief policy advisor to the President and Congress on matters concerning historic preservation. Included on the 20 member Council are the heads of several federal agencies, including the Secretaries of the Interior and Agriculture.

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[1] Italicized words and phrases are entries in this glossary.

aerosol: Particles of solid or liquid matter that can remain suspended in air from a few minutes to many months, depending on the particle size and weight.

aerosolize: The process of converting a solid or a liquid into an airborne suspension of fine particles (an *aerosol*).

affected environment: For an environmental impact statement (EIS), a description of the existing environment covering information necessary to assess or understand the impacts. It must contain enough detail to support the impact analyses and must highlight environmentally sensitive resources (for example, floodplains, wetlands, threatened and endangered species, archeological resources).

aggregate: The sum total.

air pollutant: Any substance in air which could, if in high enough concentration, harm humans, other animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of matter capable of being airborne.

air quality: A measure of the quantity of pollutants, measured individually, in the air. These levels are often compared to regulatory standards.

Air Quality Control Region (AQCR): An interstate or intrastate area designated by the *U.S. Environmental Protection Agency* for the attainment and maintenance of *National Ambient Air Quality Standards*.

air quality standards: The legally prescribed level of constituents in the outside air that cannot be exceeded during a specific time in a specified area.

air toxics (hazardous air pollutants): Substances that have adverse impacts on human health when present in the *ambient air*.

ALARA (as low as reasonably achievable): An approach to keep radiation exposures (both to the workforce and the public) and releases of radioactive material to the environment at levels that are as low as social, technical, economic, practical, and public policy considerations allow. ALARA is not a dose limit; it is a practice whose objective is the attainment of dose levels as far below applicable limits as possible.

algorithm: A formula or set of steps used to solve a problem.

ALOHA model: A computer model used to assess the impacts of potential chemical releases.

alpha particle (a): A positively charged particle made up of two protons and two neutrons that is emitted in the radioactive decay of certain atoms. An alpha particle is identical to the nucleus of the helium atom. It is easily stopped by a sheet of paper. Since they cannot penetrate human skin, alpha particles are not considered an external exposure hazard. Alpha particles within the body can cause harm, however.

ambient: Undisturbed, natural conditions, such as ambient temperature; surrounding conditions.

ambient air: The surrounding atmosphere, usually the outside air, as it exists around people, plants and structures. It is not the air in immediate proximity to emissions sources.

Ambient Air Quality Standards: Regulations prescribing the levels of airborne pollutants that may not be exceeded during a specified time in a defined area.

American Indian Religious Freedom Act: States that the policy of the United States is to protect and preserve for American Indians their inherent rights of freedom to believe, express, and exercise the traditional religions of the American Indian, Eskimo, Aleut, and Native Hawaiians. These rights include, but are not limited to, access to sites, use and possession of sacred objects, and the freedom to worship through ceremony and traditional rites.

anthropogenic: Produced by human activities.

aqueous process: An operation involving chemicals dissolved in water.

aquifer: A geologic formation that can yield significant quantities of groundwater to wells and springs.

aquitard: A geologic unit that is not permeable enough to transmit significant quantities of water. Aquitards transmit water at a very slow rate to or from an adjacent aquifer.

Archaeological and Historic Preservation Act: A federal law directed at the preservation of historic and archaeological data that would otherwise be lost as a result of federal construction. It authorized the U.S. Department of the Interior to undertake recovery, protection, and preservation of archaeological and historic data.

Archaeological Resources Protection Act of 1979: A federal act protecting cultural resources on federally owned lands. This act requires a permit for archaeological excavations or the removal of any archaeological resources on public or Native American lands.

archaeological site: Any location where humans have altered the terrain or discarded *artifacts* during prehistoric or historic times.

artifact: An object produced or shaped by human beings and of archaeological or historical interest.

as low as reasonable achievable: See *ALARA*.

atom: The smallest unit of an element that is capable of entering into a chemical reaction and displays the properties of the element.

Atomic Energy Act of 1954: A federal law that created the Atomic Energy Commission, which later split into the *Nuclear Regulatory Commission* and the Energy and Research and Development Administration (ERDA). ERDA became part of the *Department of Energy* in 1977. This act encouraged the development and use of nuclear energy and research for the general welfare and the security of the United States. This act authorized the Nuclear Regulatory Commission (NRC) to regulate and license fuel fabrication facilities that seek to receive, possess, use, or transfer special nuclear material.

atomic number: The number of positively charged protons in the nucleus of an atom and the number of electrons on an electrically neutral atom.

attainment area: An area considered to have air quality as good as or better than the National Ambient Air Quality Standards for a given pollutant. An area may be in attainment for one pollutant and nonattaining for others.

attenuate: To lessen the magnitude or severity of an impact or effect.

background radiation: Radiation that is part of our natural world. It can originate from naturally occurring radioactive materials within the Earth and from outer space (cosmic sources). Background radiation also includes global fallout as it exists in the environment from the testing of nuclear explosive devices. Background radiation varies considerably with location.

becquerel (Bq): A unit used to measure radioactivity. One Becquerel is that quantity of a radioactive material that will have one transformation in one second. There are 3.7×10^{10} Bq in one *curie* (Ci).

beta particle (ß): Beta particles are electrons except they are not bound to an atom. They cannot travel far from their radioactive source (about one half inch in human tissue and a few yards in air).

beyond design basis accident: An accident generally with more severe impacts to on-site personnel and the public than a *design basis accident*. This accident is used for estimating the impacts of a facility or process.

bioaccumulation: The net accumulation of a chemical by an organism as a result of uptake from all routes of exposure.

biomagnification: The tendency of some chemicals to accumulate to higher concentrations at higher levels in the food chain through dietary accumulation.

biota: The plant and animal life of a region.

blackwater stream: A freshwater stream that has a dark color because of organic debris and tannin-containing compounds.

borrow material: Material such as soil or sand that is removed from one location and used as fill material in another location.

borrow pits: An excavated area from which earthy material has been removed, typically for construction purposes.

bound: To estimate or describe a lower or upper limit on a potential environmental or health consequence when uncertainty exists.

bounding: In the case of accident analysis, that which represents the maximum reasonably foreseeable event or impact.

breach: A general term referring to a hole in a cylinder or container. A breach may be caused by corrosion or by mechanical forces.

bryozoa: Bryozoa are microscopic aquatic animals that live in large colonies of interconnected individuals. Bryozoa are abundant in modern marine environments and are also an important part of the fossil record. They are commonly referred to as sea mats, moss animals, or lace corals.

calcareous sand: Sand containing calcium carbonate, calcium, or limestone; it is usually white or tan.

cancer: A group of diseases characterized by uncontrolled cellular growth. Increased incidence of cancer can be caused by exposure to radiation and some chemicals.

candidate species: Species for which substantial information is available to support proposing that they be added to the federal threatened and endangered species list.

CANDU (Canadian deuterium-uranium reactor): A heavy-water reactor that uses natural uranium as a fuel and heavy water as a *moderator* and a coolant.

canister: A container (generally stainless steel) into which immobilized radioactive waste is placed and sealed.

canopy: The upper forest layer of leaves consisting of the tops of individual trees whose branches sometimes cross each other.

canyon building: A term for a chemical separations plant, inspired by the building's long, high, narrow structure. Chemical separation is a process for extracting uranium and plutonium from dissolved spent nuclear fuel and irradiated targets.

capable fault: A *fault* is described as capable if it has had movement at or near the ground surface at least once within the past 35,000 years, or recurrent movement within the past 500,000 years.

capping: The process of installing a layer of clay or other impermeable material over the top of a closed landfill to prevent entry of rainwater and to minimize the escape of chemicals into the surrounding soil.

carbonate: Rocks and associated minerals that contain carbonate ion, as in calcium carbonate.

carbon monoxide (CO): A colorless, odorless gas that is toxic if breathed in high concentrations over an extended period. Carbon monoxide is a *criteria air pollutant*. One source of carbon monoxide is engine exhaust.

carcinogen: A substance that is capable of producing or inducing cancer.

cargo-related impacts: Transportation risks associated with the nature of the cargo itself.

Carolina bays: Closed, elliptical-shaped depressions capable of holding water. They are a type of *wetland*.

cask (for radioactive materials): A heavily shielded container that meets all applicable regulatory requirements for shipping *spent nuclear fuel* or *high-level waste*.

Category I Resources: Resources (for example, waters) defined by the U.S. Department of the Interior as unique and irreplaceable on a national or eco-regional basis.

Cenozoic: A geologic era dating from approximately 65 million years ago to the present. It is known as the age of mammals.

census blocks: Census blocks are defined by the U.S. Bureau of Census and are the smallest geographic unit for which the Census Bureau tabulates data. Blocks contain data from the 2000 Census of Population, including total population, population by race and ethnicity, age, marital status, population density and the number and composition of households, and information on housing unit types. Many blocks correspond to individual city blocks bounded by streets, but blocks – especially in rural areas – may include many square miles and may have some boundaries that are not streets. The Census Bureau established blocks covering the entire nation for the first time in 1990. Over 8 million blocks are identified for Census 2000.

census block groups: Census block groups are geographic entities consisting of groups of individual Census blocks. Census blocks are grouped together so that they contain between 250 and 550 housing units.

census tract: An area usually containing between 2,500 and 8,000 persons that is used for organizing and monitoring census data. The geographic dimensions of census tracts vary widely, depending on population density. Census tracts do not cross county borders.

clay: A rock or mineral fragment of any composition that is smaller than very fine silt grains, having a diameter of less than 0.00016 in. (1/256 mm).

Class II water source: Current and potential drinking water, as classified by the EPA.

Clean Air Act: A federal law that mandates and provides for the enforcement of air pollution control standards from various sources. Its purpose is to protect the health and welfare of the public by controlling air pollution.

closed canopy: A forest *canopy* that is dense enough that the tree crowns fill or nearly fill the canopy layer so that light cannot reach the forest floor directly.

cloudshine: The exposure pathway of direct external exposure from radioactive material suspended in air.

Code of Federal Regulations (CFR): A publication in codified form of all federal regulations in force.

collective dose: The sum of individual doses received by all those exposed to a specified source of radiation in a given period of time. (Also referred to as population dose.)

collective population risk: A measure of possible loss or injury in a group of people that takes into account the probability that the hazard will cause harm and the consequences of that event. The collective population risk does not express the risk to specific individual members of the population.

committed effective dose equivalent (CEDE): The sum of the committed dose equivalents to various tissues of the body, each multiplied by its weighting factor. It does not include contributions from external doses. Committed effective dose equivalent is expressed in units of rem and provides an estimate of the lifetime radiation dose to an individual from radioactive material taken into the body through either inhalation or ingestion.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (Superfund)**:** An act providing the regulatory framework for the *remediation* of past contamination from hazardous waste. If a site meets the act's requirements for designation, it is ranked along with other Superfund sites on the National Priorities List. This ranking is the U.S. Environmental Protection Agency's way of determining the priority of sites for cleanup.

conservative estimates: Conservative estimates lean on the side of pessimism and toward maximizing estimates of negative impacts.

consortium: A group (of companies) formed to undertake an enterprise beyond the resources of any one member.

contact-handled transuranic waste: Transuranic waste with a surface radiation dose rate not greater than 200 millirems per hour. It can be safely handled without any shielding other than that provided by the waste container itself.

conversion: An operation for changing material from one form, use, or purpose to another.

cooling water: Water circulated through a *nuclear reactor* or processing plant to remove heat.

cosmic radiation: Streams of highly penetrating, charged particles composed of protons, *alpha particles*, and a few heavier nuclei that bombard the earth from outer space. Cosmic radiation is part of the natural background radiation.

cost-benefit analysis: A formal quantitative procedure comparing costs and benefits of a proposed project or act under a set of preestablished rules.

Council on Environmental Quality: The President's Council on Environmental Quality (CEQ) was established by the enactment of *National Environmental Policy Act* (NEPA). The CEQ is responsible for developing regulations to be followed by all federal agencies in developing and implementing their own specific NEPA implementation policies and procedures.

criteria pollutants: Common air pollutants for which *National Ambient Air Quality Standards* have been established by the U.S. Environmental Protection Agency (EPA) under Title I of the *Clean Air Act*. Criteria *pollutants* include *sulfur dioxide*, *nitrogen oxides*, *carbon monoxide*, *ozone*, *particulate matter* (PM_{10} and $PM_{2.5}$), and *lead*. Standards for these pollutants were developed on the basis of scientific knowledge about their health effects.

critical habitat: Specific areas within the geographical range of an *endangered species* that is formally designated by the U.S. Fish and Wildlife Service under the Endangered Species Act as essential for conservation of the species.

criticality: A state in which a self-sustaining nuclear chain reaction is achieved.

cultural resources: *Archaeological sites*, architectural structures or features, traditional-use areas, and Native American scared sites or special use areas.

cumulative impacts: Potential impacts when the proposed action is added to other past, present, and reasonable foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

curie (Ci): The unit used to describe the intensity of radioactivity in a sample of material. A curie is equal to 37 billion disintegrations per second, which is approximately the activity of one gram of radium. It is also a quantity of any nuclide or mixture of nuclides having one curie of radioactivity.

D&D (deactivation and decommissioning): The removal of the facility safely from service and reduction of residual radioactivity to a level that permits release of the property to a specified end state.

decibel, A-weighted (dBA): A measurement of sound approximating the sensitivity of the human ear and used to characterize the intensity or loudness of sound.

deactivation: The process of removing a facility from operation and placing it in a safe and stable condition. Deactivation involves removal hazardous and radioactive materials.

decibel (dB): A standard unit for measuring sound-pressure levels based on a reference sound pressure of 0.0002 dyne per square centimeter. This is the smallest sound a human can hear. In general, a sound doubles in loudness with every increase of slightly more than 3 decibels.

decommissioning: The process of decontaminating and dismantling a facility following deactivation and returning the site to an end state that meets the prescribed regulatory criteria.

deep dose equivalent (DDE): The dose equivalent derived from external radiation at a depth of 1 cm in tissue.

deionized water: Water from which both negative and positive ions have been removed by an ion exchange process.

Department of Energy (DOE): A federal agency whose mission is to achieve efficiency in energy use, diversity in energy sources, a more productive and competitive economy, improved environmental quality, and a secure national defense. It was created in 1977.

depleted uranium: Uranium whose content of the isotope uranium-235 is less than 0.7%, which is the uranium-235 content of naturally occurring uranium.

depleted uranium hexafluoride (UF_6): A compound of *uranium* and fluorine from which most of the uranium-235 isotope has been removed.

dermal absorption: Entry of a substance into the body through the skin.

design basis accident: For nuclear facilities, an assumed abnormal event used to establish the performance requirements of structures, systems, and components that are necessary to keep the facility in a safe shutdown condition indefinitely, or to prevent or mitigate the consequences of such an event, so as to ensure that the public and operating staff are not exposed to radiation in excess of appropriate guideline values.

detention ponds: Engineered depressions in the land that contain storm-water runoff until it can slowly seep back into the ground or evaporate.

direct impact: An effect that results solely from the construction or operation of a proposed action without intermediate steps or processes. Examples include habitat destruction, soil disturbance, air emissions, and water use.

direct jobs: The number of workers required at a site to implement an alternative.

disposition: A process of use or disposal of materials that results in the remaining material being converted to a form that is substantially and inherently more *proliferation* resistant than the original form.

disproportionately high and adverse environmental impact: An adverse environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an environmental hazard with a risk or rate of exposure for a low-income or minority population that exceeds the risk or rate of exposure for the general population.

disproportionately high and adverse human health effect: Any effect on human health from exposure to environmental hazards that exceeds generally accepted levels of risk and affects low-income and minority populations at a rate that appreciably exceeds the rate for the general population.

dissolution: The chemical dispersal (dissolving) of a solid throughout a liquid medium.

dose (radiation dose): In a general sense, dose is a measure of the amount of energy from *ionizing radiation* deposited in a material. Dose is affected by the type of radiation, the amount of radiation, and the physical properties of the material itself. Radiation dose to humans is measured in units of *sieverts* (Sv) or *rem* (1 Sv = 100 rem).

drainage basin: An aboveground area of the Earth's surface that supplies the water to a particular stream.

ecology: The study of the interrelationships of organisms and their environment.

ecosystem: A group of organisms and their physical environment.

effective dose equivalent: The sum of the products of the dose equivalent to various organs or tissues and the weighting factors applicable to each of the body organs or tissues that are irradiated. This sum is a risk-equivalent value that can be used to estimate the risk of health effects to the exposed individual. The effective dose equivalent includes the *dose* from *radiation* sources internal and/or external to the body and is expressed in units of *rem* or *sievert*.

effluent: A gas or fluid discharged into the environment, treated or untreated. Most frequently, the term applies to wastes discharged to *surface waters*.

emissions: Substances that are discharged into the air.

endangered species: Any species (plant or animal) that is in danger of extinction throughout all or a significant part of its range. Requirements for declaring a species endangered are found in the *Endangered Species Act*.

Endangered Species Act of 1973: An act requiring federal agencies, with the consultation and assistance of the Secretaries of the Interior and Commerce, to ensure that their actions will

not likely jeopardize the continued existence of any endangered or threatened species or adversely affect the habitat of such species.

environmental impact statement (EIS): A document required of federal agencies by the *National Environmental Policy Act* for major proposals or legislation that will or could significantly affect the environment. It describes the positive and negative effects of the proposed and alternative actions.

environmental justice: The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no population of people should be forced to bear a disproportionate share of the negative environmental impacts of pollution or environmental hazards due to a lack of political or economic strength.

Environmental Protection Agency (EPA): A federal agency that is responsible for setting, or working with state and local governments, to set standards that help control and prevent pollution and minimize the potential health effects in areas of solid and hazardous waste, pesticides, water, air, drinking water, and toxic and radioactive substances. It was created in 1970.

Eocene: A geologic epoch early in the Cenozoic era, dating from approximately 56 to 34 million years ago.

epicenter: The point on the Earth's surface directly above the focus of an earthquake.

equivalent dose: The equivalent dose is a measure of the effect that radiation has on humans. It takes into account the type of radiation and the *absorbed dose*. Not all types of radiation produce the same effects. For example, when considering beta, x-ray, and gamma ray radiation, the equivalent dose (in rem) is equal to the absorbed dose (in rads). For alpha radiation, the equivalent dose is assumed to be 20 times the absorbed dose.

erosion: The removal and transport of materials by wind, ice, or water on the Earth's surface.

exposure: Contact of an organism with a chemical, radiological, or physical agent.

exposure pathways: A route or sequence of processes by which a radioactive or hazardous material may move through the environment to humans or other organisms. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route.

external exposure: Exposure to radiation or hazardous substance that originates from sources outside of the body.

facility: Any building, structure, system, process, equipment, or activity that fulfills a specific purpose on a site.

facility workers: Persons working at the *Mixed Oxide* Fuel Fabrication Facility who are directly involved with the handling of radioactive or hazardous materials.

fault (geologic): A fracture in rock along which movement of one side relative to the other has occurred.

fauna: Animals, especially those of a specific region, considered as a group.

Federal Facilities Compliance Act of 1992: A federal law that amended the *Resource Conservation Recovery Act* with the objectives of bringing all federal facilities into compliance with applicable federal and state hazardous waste laws, waiving federal sovereign immunity under those laws, and allowing the imposition of fines and penalties. The law requires the U.S. Department of Energy to submit an inventory of all its mixed waste and to develop a treatment plan for mixed waste.

FIREPLUME: A computer code used to evaluate atmospheric dispersion of contaminants in an airborne release plume.

fissile nuclear material: Nuclear materials that are fissionable by slow (thermal) neutrons. Fissile materials include uranium-233, uranium-235, and plutonium-239.

fission: The splitting of a heavy atomic nucleus into at least two nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or be induced by neutron bombardment.

floodplain: The lowlands adjoining inland and coastal waters and relatively flat areas, including, at a minimum, that area inundated by a 1% or greater-chance flood in any given year. The level area adjoining a river or stream that is sometimes covered by flood water. The base floodplain is defined as the 100-year (1%) floodplain.

flora: Plants, especially those of a specific region, considered as a group.

fly-ash: Small solid ash particles from the noncombustible portion of fuel that are small enough to escape with the exhaust gases.

forb: An herb other than grass.

fossil: An impression or trace of an animal or plant of past geologic ages that has been preserved in the Earth's crust.

fossil fuel: Natural gas, petroleum, coal, and any form of solid, liquid, or gaseous fuel derived from such materials for the purpose of creating useful heat.

Fujita Scale: The official classification system for tornado damage. The scale ranges from F0 (gale tornado, minor damage, winds up to 72 mph) to F6 (inconceivable tornado, winds 319-379 mph). F2 on the Fujita scale indicates a significant tornado causing significant damage.

fugitive dust: The dust released into the air from activities associated with construction, manufacturing, or vehicles operating on open fields or dirt roads. It is a subset of *fugitive emissions*.

fugitive emissions: Emissions that are not caught by a capture system. They are often caused by equipment leaks, evaporative processes, and windblown disturbances.

full-time equivalent (FTE): Equivalent to a full-time worker. For example, two people, each working half time, constitute one FTE.

gamma radiation (?): High-energy, short-wavelength electromagnetic radiation emitted from a radioactive nucleus during decay. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded by dense materials such as lead or uranium. Gamma rays are similar to X-rays, but are more energetic.

Gaussian model: An air dispersion model based on the assumption that the time-averaged concentration of a substance emitted from a point source has a Gaussian distribution about the mean centerline. A Gaussian distribution is represented by a symmetrical bell-shaped curve.

glauconitic sand: Sand that contains the mineral glauconite, which consists of a dull green earthy iron potassium silicate.

GENII: A computer software code used to evaluate dose from the migration of radionuclides introduced into the environment that may eventually affect humans through *ingestion*, *inhalation*, or direct radiation.

geologic repository: An underground facility intended for the disposal of nuclear waste. The waste is isolated by placing it in mined cavities in a continuous, stable geologic formation at depths typically greater than 300 m (984 ft).

geology: The science that deals with the study of the materials, processes, environments, and history of the Earth, including the rocks and their formation and structure.

glovebox: An airtight box used to work with hazardous material. It is vented to a closed filtering system, and has gloves attached inside to protect the worker.

gravitational acceleration (g): An acceleration equal to the Earth's gravitational acceleration at sea level (32 feet /second/second).

gross alpha: The total (or gross) radioactivity in a sample due to emission amount of *alpha particles.* It includes both naturally occurring and man-made radiation.

groundshine: Radiation from ground-deposited *radionuclides*.

groundwater: The supply of water found beneath the Earth's surface, usually in *aquifers*, which may supply wells and springs. Generally, all water contained in the ground.

grout: A cementing or sealing mixture of cement and water to which sand, sawdust, or other additives (sometimes waste) may be added. In terms of waste management practices, grouting is used to reduce the mobility of a waste material. In-situ grout is used to stabilize contaminated soil without having to remove it.

habitat: Area where a plant or animal lives.

half-life (radiological): The time in which half the atoms of a radioactive substance decay to another nuclear form. It varies for different radioisotopes from millionths of a second to billions of years.

hazard Index (HI): A measure of the noncancer risk involved in human exposure to a chemical substance. It is the sum of the *hazard quotients* for all chemicals to which an individual is exposed. A Hazard Index value of 1.0 or less means that no adverse human health effects (noncancer) are expected to occur.

hazard quotient (HQ): A comparison of the estimated intake level or dose of a chemical in air, water, or soil with its reference dose; expressed as a ratio.

hazardous waste: According to the *Resource Conservation and Recovery Act*, a waste that because of its characteristics may (1) cause or significantly contribute to an increase in mortality or an increase in serious irreversible illness, or (2) pose a substantial hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous wastes possess at least one of the following characteristics: ignitability, corrosivity, reactivity, or toxicity. Hazardous waste is nonradioactive.

headwaters: The source of a flowing body of water.

health risk conversion factors: Estimates of the expected number of health effects cause by exposure to a given amount of radiation. Health risk conversion factors are multiplied by the estimated radiation dose received by a given population in order to estimate the number of health effects expected to occur as a result of an exposure.

heavy combination trucks: Rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other and the tractor. They are typically used for shipping radioactive wastes.

herpetofauna: Reptiles and amphibians.

HGSYSTEM: A computer code used to assess hazardous chemical impacts.

high-efficiency particulate air (HEPA) filters: A filter designed to remove 99.97% of particles as small as 0.3 micrometers in diameter from a flowing air stream.

high-level (radioactive) waste (HLW): The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid. High-level waste contains a combination of *transuranic waste* and *fission* products in concentrations requiring permanent isolation. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

highly enriched uranium: Uranium enriched in the isotope uranium-235 to 20% or above, which thus becomes suitable for nuclear weapons use.

HIGHWAY: A transportation routing model.

historic structures: A standing structure that has historic significance.

human health risk: The likelihood that a given exposure or series of exposures will damage the health of individuals.

hydrazine: A highly reactive and corrosive chemical that is a *carcinogen* and a reproductive hazard. It is the only chemical that would be used in the MOX process that is listed as a hazardous air pollutant under the *Clean Air Act.*

hydrogen fluoride: A colorless, toxic, fuming, corrosive liquid or gas. It is produced when uranium hexafluoride (UF_6) comes in contact with water, such as humidity in the air. It is often a by-product when UF_6 is converted to another chemical form.

hydrology: The study of water, including groundwater, surface water, and rainfall.

ICRP (International Commission on Radiological Protection): An international body tasked with providing an overview of radiation standards and regulations and information to help standardize these regulations.

immobilization: A process used to stabilize waste, thus inhibiting its release into the environment.

impoundment: A natural or artificial body of water confined by a dam, dike, floodgate, or other barrier.

in attainment: In compliance with air quality standards. Areas that are in attainment have air quality that is as good as or better than specified in the *National Ambient Air Quality Standards* for a given pollutant. An area may be in attainment for one pollutant and nonattaining for others.

incremental impact: The impact due to an emission source (or group of sources) in isolation, without including background levels.

indirect impact: An effect that is related to, but removed from a proposed action by an intermediate step or process. An example would be surface-water quality changes resulting from soil erosion at construction sites.

indirect jobs: Jobs generated or lost in related industries within a *regional economic area* as a result of a change in direct employment.

infrastructure: The basic facilities, services, and utilities needed for the functions of an industrial facility or site. Transportation and electrical systems are part of the infrastructure.

ingestion: To take in by mouth. Material that is ingested enters the digestive system.

inhalation: Take in by breathing. Material that is inhaled enters the lungs.

in-migration: People moving into an area, in this case, the region of influence.

in situ: In its natural position or place.

invertebrates: Animals without a backbone (insects for example).

ion: An atom that has too many or too few electrons, causing it to have an electrical charge, and therefore, be chemically active.

internal exposure: The radiation dose to internal organs and tissues of the body from the ingestion or inhalation of radioactive contaminants in air, water, food, or soil.

ion exchange: A process that removes specific chemicals and radionuclides from a liquid stream (usually water) for the purposes of purification or decontamination. In this process, salts present as charged ions in water are attached to active groups on and in an ion exchange resin, and other ions are discharged into water allowing separation of the two groups of ions.

ionizing radiation: Radiation that has enough energy to remove electrons from atoms, causing them to become charged or ionized.

irradiate: Expose to some form of radiation, usually a nuclear reactor. Irradiated reactor components and fuel are subjected to neutron radiation and become radioactive themselves or produce *isotopes*.

ISCST3: Version 3 of the Short-Term Industrial Source Complex model. It was used to estimate potential air quality impacts from MOX facility construction and operation activities.

isotope: An atom of an element with a specific atomic number and atomic mass. Isotopes of the same element have the same number of protons (atomic number) but different numbers of

neutrons (atomic mass). For example, uranium-235 is an isotope of uranium with 93 protons and 143 neutrons; uranium-238 is an isotope of uranium with 92 protons and 146 neutrons.

kaolinitic clay: A fine, usually white *clay* that contains the mineral kaolinite, a hydrous silicate of aluminum.

L_{dn}: A 24-hour average sound level that gives additional weight to noise that occurs during the night (10:00 p.m. to 7:00 a.m.).

L_{eq}: For sounds that vary with time, L_{eq} is the steady sound level that would contain the same total sound energy as the time-varying sound over a given period.

L_{eq}(24): L_{eq} averaged over 24 hours.

Land Disposal Restrictions: Part of the Hazardous and Solid Waste Amendments to RCRA. They restrict land disposal of certain hazardous wastes; these wastes may be land disposed only if they meet specified treatment standards.

land use: A characterization of land surface in terms of its potential utility for various activities.

latent: Occurring some time (usually several years) after exposure.

latent cancer fatalities (LCF): Deaths resulting from cancer that has become active after a latent period following exposure to a cancer-causing agent. Latent cancer fatalities are similar to naturally occurring cancer and may be expressed at any time after the initial exposure.

latent cancers: Cancers that occur after a latency period of about 10 or more years from the time of exposure

latency period: The average period of time between exposure to an agent and the onset of a health effect.

latent fatalities (latent mortality): Fatalities that result from acute or chronic environmental exposures to hazardous substances or radiation but that do not occur immediately after exposure.

lead: A gray-white metal that is listed as a criteria air pollutant. Health effects from exposure to lead include brain and kidney damage and learning disabilities.

linear/no threshold hypothesis: A hypothesis that implies, in part, that even small doses of radiation cause some risk of inducing cancer, and doubling of the radiation dose would mean doubling of the expected number of cancers.

listed species: Species that are considered threatened or endangered.

loam: A soil consisting of an easily crumbled mixture of *clay*, *silt*, and sand.

low-enriched uranium (LEU): Uranium enriched in the isotope uranium-235, greater than 0.7% but less than 20% of the total mass. Naturally occurring uranium contains about 0.7% uranium-235, almost all the rest is uranium-238.

low-level (radioactive) waste: Waste that contains radioactivity and is not classified as *high-level waste*, *transuranic waste*, or *spent nuclear fuel*.

low-specific-activity (LSA) drum: A container, such as a 55-gallon drum, that is used to package low-*specific-activity* material. The depleted uranium considered in this EIS is low-specific-activity material.

macroinvertebrates: Small animals, such as larval aquatic insects, that are visible to the naked eye and have no vertebral column.

magnitude: A measure of the total energy released by an earthquake. It is commonly measured in numerical units on the *Richter scale*. Each unit is different from an adjacent unit by a factor of 30.

marsh: An area of low-lying wetlands dominated by grasslike plants.

maximally exposed individual: A hypothetical person who — because of proximity, activities, or living habits — could receive the highest possible dose of radiation or of a hazardous chemical from a given event or process.

meteorology: The science dealing with the atmosphere and its phenomena, especially as relating to weather.

metric ton: A unit of mass equal to approximately 1.1 short (U.S.) tons, or 2,200 pounds.

millirem (mrem): A unit of radiation exposure equal to one-thousandths of a *rem*.

Miocene: A geologic epoch of the *Cenozoic era* dating from approximately 24 to 5 million years ago.

mitigation: A series of actions implemented to ensure that projected impacts will result in no net loss of habitat value or wildlife populations. The purpose of mitigative actions is to avoid, minimize, rectify, or compensate for any adverse environmental impact.

mixed low-level (radioactive) waste: Low-level waste that also contains hazardous chemical components regulated under the *Resource Conservation Recover Act*.

mixed oxide: For the purposes of this EIS, a physical blend of uranium oxide and plutonium oxide.

mixed transuranic waste: Transuranic waste that also contains hazardous chemical components regulated under the *Resource Conservation and Recovery Act.*

mixed waste: Waste that contains both hazardous and radioactive components.

model: A conceptual, mathematical, or physical system obeying certain specified conditions, whose behavior is used to understand the physical system it is attempting to mimic. Models are often used to predict the behavior or outcome of future events.

moderator: A material (usually water, heavy water, or graphite) used in some nuclear reactors to slow down high-velocity neutrons, thereby increasing the likelihood of *fission*. Moderation controls are a factor in mitigating *criticality* accidents.

Modified Mercalli Intensity Scale: A measure of the perceived intensity of earthquake ground shaking, originally developed in Italy nearly a century ago. It includes 12 degrees of shaking from I (not felt by people) to XII (nearly total damage).

molar concentration: The amount of a substance dissolved per unit volume of solution.

National Ambient Air Quality Standards (NAAQS): Air quality standards established by the *Clean Air Act*, as amended. The primary NAAQS are intended to protect the public health with an adequate margin of safety; and the secondary NAAQS are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

National Emission Standards for Hazardous Air Pollutants (NESHAP): A set of national emission standards for listed hazardous pollutants emitted from specific classes or categories of new and existing sources. These standards were implemented in the *Clean Air Act* Amendments of 1977.

National Environmental Policy Act (NEPA) of 1969: A federal law constituting the basic national charter for protection of the environment. The act calls for the preparation of an environmental impact statement (EIS) for every major federal action that may significantly affect the quality of the human or natural environment. The main purpose is to ensure that environmental information is provided to decision makers so that their actions are based on an understanding of the potential environmental and socioeconomic consequences of a proposed action and the reasonable alternatives.

National Historic Preservation Act: A federal law providing that property resources with significant national historic value be placed on the *National Register of Historic Places*. It does not require permits; rather, it mandates consultation with the proper agencies whenever it is determined that a proposed action might impact a historic property.

National Pollutant Discharge Elimination System (NPDES): A federal permitting system controlling the discharge of effluents to surface waters of the United States and regulated through the *Clean Water Act*, as amended.

National Register of Historic Places (NRHP): A list of districts, sites, buildings, structures, and objects of prehistoric or historic local, state, or national significance. The list is maintained by the Secretary of the Interior.

nitrogen oxides (NO_x): The oxides of nitrogen, primarily nitrogen oxide (NO) and nitrogen dioxide (NO_2), that are produced in the combustion of fossil fuels. Nitrogen dioxide emissions constitute an air pollution problem, because they contribute to acid deposition and the formation of atmospheric ozone. Nitrogen oxides are *criteria air pollutants*.

noise: Any sound that is undesirable because it interferes with speech and hearing, is intense enough to damage hearing, or is otherwise annoying (unwanted sound).

Noise Control Act of 1972: A federal law directing all federal agencies to carry out programs in a manner that furthers the national policy of promoting an environment free from noise that jeopardizes health or welfare.

nonattainment area: The U.S. Environmental Protection Agency's designation for an air quality control region (or portion thereof) in which ambient air concentrations of one or more criteria pollutants exceed *National Ambient Air Quality Standards*.

normal operations: Conditions during which facilities and processes operate as expected or designed. In general, normal operations include the occurrence of some infrequent events that, although not considered routine, are not classified as accidents.

Notice of Intent: A notice that an environmental impact statement will be prepared and considered. It describes the proposed action and provides information on issues and potential impacts and invites comments and suggestions on the scope of the environmental impact statement.

nuclear power plant: A facility that converts nuclear energy into electric power. Heat produced in a *nuclear reactor* is used to make steam, which drives a turbine connected to an electric generator.

nuclear reactor: A machine in which a fission chain reaction is maintained for the purpose of irradiating materials or producing heat for the generation of electricity.

Nuclear Regulatory Commission (NRC): The NRC is an independent regulatory agency created out of the Atomic Energy Commission in 1975 to regulate civilian uses of nuclear material. It is responsible for ensuring that activities associated with the operation of nuclear power and fuel cycle plants and the use of radioactive materials in medical, industrial, and research applications are carried out with adequate protection of public health and safety, the environment, and national security.

Nuclear Waste Policy Act of 1982: The act that authorized federal agencies to develop a geologic repository for the permanent storage of *spent nuclear fuel* and *high-level radioactive waste.*

off-link population: Persons living or working within 0.8 km (0.5 mi) of each side of a transportation route.

Oligocene: A geologic epoch of the *Cenozoic era* dating from approximately 34 to 24 million years ago.

on-link population: Persons sharing a transportation route.

order of magnitude: A range of numbers extending from some value to 10 times that value. If, for example, a number is two orders of magnitude greater than another, it is 100 times greater.

organic compounds: A large group of chemical compounds containing mainly carbon, hydrogen, nitrogen, and oxygen. All living organisms are made up of organic compounds.

outfall: The discharge point of a drain, sewer, or pipe into a body of water.

oxide: A compound formed when an element (for example, plutonium) is bonded to oxygen.

ozone: A strong-smelling, reactive toxic chemical gas consisting of three oxygen atoms chemically attached to each other. It is the product of the photochemical process involving the sun's energy and ozone precursors, such as hydrocarbons and oxides of nitrogen. In the stratosphere, ozone protects the Earth from the sun's ultraviolet rays, but in lower levels of the atmosphere, ozone is considered an air pollutant and can cause irritation of the eyes and respiratory tract. Ozone is one of the criteria air pollutants specified under Title I of the *Clean Air Act* and is a major constituent of smog.

PM_{10}: Particulate matter with a diameter less than 10 µm (0.0004 inch). Particles less than this diameter are small enough to be breathed and could be deposited in the lungs. PM_{10} is one of the six criteria air pollutants specified under Title I of the *Clean Air Act.*

$PM_{2.5}$: Particulate matter with a diameter less than 2.5 µm (0.0001 inch). A standard for this material as a *criteria pollutant* has been defined but not yet implemented.

paleontology: The study of plant and animal life that existed in former geologic times, particularly through the analysis of *fossils*.

Paleocene: The earliest epoch in the *Cenozoic era*, dating from approximately 65 to 56 million years ago.

Paleozoic: The longest era of geologic time, dating from approximately 544 to 248 million years ago. Seed-bearing plants, amphibians, and reptiles first appeared in the Paleozoic era.

parameters: Data or values that are input to computer codes or equations. They are quantifiable or measurable characteristics like wind speed, temperature, pH, vehicular speed, duration of exposure, etc.

particulate matter (PM): Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions. The size of the *particulates* is measured in micrometers (:); a

micrometer is 1 millionth of a meter (0.000039 in.). Particle size is important because the *Environmental Protection Agency* has set standards for PM_{10} and $PM_{2.5}$ designed to protect human health and welfare. Particulate matter is a *criteria pollutant*.

particulates: Solid particles and liquid droplets small enough to become airborne.

Pascal (PA): A unit of measurement for pressure in the International System of Units (SI). 1 pascal = 0.0001450 pounds per square inch.

Pasquill atmosphere stability class: A classification scheme that describes the degree of atmospheric turbulence. Categories range from extremely unstable (A) to extremely stable (F). Unstable conditions promote the rapid dispersion of atmospheric contaminants and result in lower contaminant air concentrations compared with stable conditions.

permitted outfalls: *Outfalls* that are regulated by permits.

person-rem: A unit used to measure the radiation exposure to an entire group and to compare the effects of different amounts of radiation on groups of people; it is the product of the average dose equivalent (in *rem*) to a given organ or tissue multiplied by the number of persons in the population of interest.

person-sievert: A unit of radiation exposure. One person-*sievert* is equivalent to 100 person-rem.

person-year: The sum of the number of years each person in a study population is at risk; a metric used to aggregate the total population at risk, assuming that 10 people at risk for 1 year is equivalent to 1 person at risk for 10 years.

physiographic province: A region in which the landforms are similar in geologic structure and differ significantly from the landform patterns in adjacent regions.

physiographic regions: Geographic regions based on geologic setting.

pit: The core element of a nuclear weapon's fission component.

plasma arc cutting: Plasma arc cutting uses a high-velocity jet of electrically charged gas to cut metal at temperatures up to 50,000EF.

plume: The elongated pattern of contaminated air or water originating at a point source such as a smoke stack or a hazardous waste disposal area.

plutonium: A heavy, radioactive, metallic element with the atomic number 94. It is produced artificially in a reactor by the bombardment of uranium with neutrons and is used in the production of nuclear weapons. Weapons-usable plutonium consists mainly of plutonium-239.

point source: A source of effluents that is small enough in dimensions that it can be treated as if it were a point. A point source can be either a continuous source or a source that emits effluents only in puffs for a short time.

pollutant: Any material entering the environment that has undesired effects.

pollution: The addition of an undesirable agent to the environment in excess of the rate at which natural processes can degrade, assimilate, or disperse it.

pollution prevention: The use of any process, practice, or product that reduces or eliminates the generation and release of pollutants, hazardous substances, contaminants, and wastes, including those that protect natural resources through conservation or more efficient utilization.

polycyclic aromatic hydrocarbons (PAHs): Organic compounds that include only carbon and hydrogen with a fused ring structure containing at least two benzene (six-sided) rings. Some PAHs are potent human carcinogens. The combustion of organic substances is a common source of atmospheric PAHs.

Prevention of Significant Deterioration (PSD): A program used in development of permits for new or modified industrial facilities in an area that is already in attainment. The intent is to prevent an attainment area from becoming a *non-attainment area*. Allowable increases are lowest in Class I areas (national parks and wilderness areas); the rest of the country is subject to PSD II increments.

Price Anderson Act: First enacted into law in 1957, it limits the liability of the nuclear power industry in the event of an accident.

primary contact recreations: Activities such as swimming and diving where there is direct contact with the water.

prime farmland: Land with the best combination of physical and chemical characteristics for economically producing high yields of food, feed, forage, fiber, and oilseed crops with minimum inputs of fuel, fertilizer, pesticides, and labor. Prime farmland includes cropland, pastureland, rangeland, and forestland.

probable maximum flood: Flood levels predicted for hydrological conditions that maximize the flow of surface waters.

proliferation: The spread of nuclear, biological, and chemical capabilities and the weapons (e.g., missiles) capable of delivering them.

proprietary income: Income from self-employment.

protected species: Species that are protected by federal legislation, such as the Endangered Species Act or the Migratory Bird Treaty Act.

radiation: Energy radiated in the form of waves or particles through matter and space. Radiation comes from radioactive material or from equipment such as X-ray machines. Radiation may be either *ionizing radiation* or non-ionizing radiation.

radiation dose: See *dose*.

radioactive waste: Materials that are radioactive or are contaminated with radioactive materials and for which use, reuse, or recovery are impractical.

radioactivity: The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of *radiation*. Eventually the unstable nuclei reach a stable state.

radionuclide: An atom that exhibits radioactive properties. Standard practice for naming a radionuclide is to use the name or atomic symbol of the element, followed by its atomic weight. (For example, cobalt-60 [Co-60], a radionuclide of cobalt with an atomic weight of 60.) Radionuclides can be man-made or naturally occurring, and can have a long life, and can have potentially mutagenic or carcinogenic effects on the human body.

RADTRAN 4: A computer code that calculates population risks associated with the transport of radioactive materials by truck, rail, air, ship, or barge.

raffinate: The decontaminated salt solution produced by removal of radionuclides from a high-level waste solution.

raptors: Birds of prey (for example, hawks, owls, eagles)

reference dose: The chemical intake level below which noncancer adverse effects are very unlikely. It is measured in units of milligrams per kilogram of body weight per day (mg/kg/d).

regional economic area (REA): A geographic area consisting of an economic node and the surrounding, economically related counties, including the places of work and residences of the labor force. The REA for this DEIS is made up of the 15 counties surrounding the Savannah River Site.

region-of-influence (ROI): The physical area that bounds the environmental, sociological, economic, or cultural features of interest for the purpose of analysis. A site-specific geographic area that includes the counties where approximately 90% of the site's current employees reside. The ROI for this DEIS consists of Columbia and Richmond Counties in Georgia and Aiken and Barnwell Counties in South Carolina.

release fraction: The portion, or fraction, of a material that could be released or spilled to the environment during an accident.

rem (roentgen equivalent man): A unit used to derive a quantity called absorbed dose. The dosage of an ionizing radiation that will cause the same biological effect as one *roentgen* of X-ray or gamma-ray exposure; 100 rem is equivalent to one *sievert*.

remediation: Action taken to permanently remedy a release, or threatened release, of a hazardous or radioactive substance to the environment, instead of or in addition to removal.

Resource Conservation and Recovery Act (RCRA): A federal law that provides for a "cradle-to-grave" regulatory program for hazardous waste, including a system for managing hazardous waste from its generation to its ultimate disposal.

Resource Management Class: Four classifications of use to describe different degrees of modification of the landscape. Class I are areas where the natural landscape is preserved, including national wilderness area and wild sections of national wild and scenic rivers; Class II – areas with very limited land development activity, resulting in visual contrasts that are seen but do not attract attention; Class III – areas in which development may attract attention, but the natural landscape still dominates; Class IV – areas in which development activities lead to major modification of the existing character of the landscape.

respirable: Able to be inhaled into the lungs.

Richter Scale: A logarithmic scale used to express the total amount of energy released by an earthquake. The scale has 10 divisions, from 1 (not felt by humans) to 10 (nearly total destruction).

risk: The likelihood of suffering a detrimental effect as a result of exposure to a hazard. In accident analysis, a quantitative or qualitative expression of possible loss that takes into account both the probability that an event will cause harm and the consequences of that event.

ROD - Record of Decision: A document separate from but associated with an environmental impact statement that publicly and officially discloses the responsible agency's decision on the EIS alternative to be implemented.

roentgen: A unit of exposure to ionizing X- or gamma radiation equal to or producing one electrostatic unit of charge per cubic centimeter of air. It is approximately equal to one rad.

runoff: The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and eventually enters streams.

Safe Drinking Water Act: A federal law protecting the quality of public water supplies, water supply and distribution systems, and all sources of drinking water.

Safety Evaluation Report (SER): The SER is an NRC document, associated with a proposed action, that focuses on health and safety issues and compliance with NRC regulations. There are two SERs associated with the MOX facility: one for the construction authorization and another for the operating license application.

sanitary waste: Nonhazardous, nonradioactive liquid and solid waste generated by normal housekeeping activities.

saltstone: A cement-like solid waste form that is a blend of cement, *fly-ash*, and *slag* used to immobilize low-radioactivity salt solutions.

savanna: A grassland with widely scattered trees and shrubs.

scoping: The process of inviting public comment on what should be considered prior to preparation of an environmental impact statement. Scoping assists the preparers of an EIS in defining the proposed action, identifying alternatives, and developing preliminary issues to be addressed in an EIS.

scrub-shrub: Woody vegetation that is less than 20 feet tall, including true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.

secondary contact recreations: Activities having some direct contact with water, but where swallowing of the water is not likely to occur. An example is fishing.

sedges: Perennial nonwoody plants common to most fresh water *wetlands*. They resemble grasses.

sediment: Eroded soil particles that are deposited downhill or downstream by surface runoff.

seismic: Pertaining to any earth vibration, especially that of an earthquake.

seismic zone: An area defined by the Uniform Building Code (1991) on the basis of its susceptibility to damage as the result of earthquakes. The United States is divided into six zones: Zone 0, no damage; Zone 1, minor damage; Zone 2A (Eastern United States), moderate damage; Zone 2B (Western United States), slightly more damage that 2A; Zone 3, major damage; and Zone 4, areas within Zone 3 nearer certain major fault systems.

seismology: The study of earthquakes.

shielding: Any material that is placed between a source of radiation and people, equipment, or other objects in order to absorb the radiation and reduce radiation exposure.

sievert (Sv): A unit of radiation dose used to express a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation taking into account the kind of radiation received, the total amount absorbed by the body, and the tissues involved. Not all radiation has the same biological effect, even for the same amount of absorbed dose. One sievert is equivalent to 100 rem.

silt: A sedimentary material consisting of fine mineral particles intermediate in size between sand and clay.

siltation: The process by which a river, lake, or other water body becomes clogged with sediment. The process of covering or obstructing with silt.

sinter: To form a homogenous mass by heating without melting.

slag: A glass-like material left as a residue by the smelting of metallic ore.

slope factor: An upper bound estimate of a chemical's probability of causing cancer, based on extent of intake and given in units of inverse intake (1/mg/Kg-d).

source term: The estimated quantities of radionuclides or chemical pollutants released to the environment from a source or group of sources.

special nuclear material: As defined in Section 11 of the *Atomic Energy Act*, " (1) plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the NRC determines to be special nuclear material, or (2) any material artificially enriched by any of the foregoing."

species of concern: A native species that is not listed as endangered or threatened but that has experienced a long-term decline in population or is vulnerable to a significant decline due to low numbers, restricted distribution, dependence on limited habitat resources, or sensitivity to environmental disturbance.

specific activity: The radioactivity of the radionuclide per unit mass of the nuclide. The specific activity of a material in which the radionuclide is essentially uniformly distributed is the radioactivity per unit mass of the material.

specific conductance: Specific conductance is the electrical conductivity of water normalized to a temperature of 25EC. It is a good measure of the concentration of total dissolved solids and salinity in water.

spent (nuclear) fuel: Fuel that has been withdrawn from a nuclear reactor following irradiation and whose constituents have not been separated. Spent fuel has been burned (irradiated) in a reactor to the extent that it no longer makes an efficient contribution to a nuclear chain reaction. This fuel is more radioactive than it was before *irradiation*.

SRS employees: Persons working at the Savannah River Site but not directly involved with the handling of radioactive or hazardous materials at the MOX facility.

stability class - Stability class describes the potential of atmospheric conditions to disperse pollutants. A relatively stable atmosphere contains very little turbulence so that pollutant concentrations remain high. Unstable atmospheric conditions promote vertical mixing and, thus, lower pollutant concentrations. The original Pasquill Stability Classifications consisted of six classes; A, the most unstable, through F, the most stable.

State Historic Preservation Officer (SHPO): The state officer charged with the identification and protection of prehistoric and historic resources in accordance with the *National Historic Preservation Act*.

subsidence: The process of sinking or settling of a land surface due to natural or artificial causes.

sulfur dioxide (SO_2): A compound of sulfur produced by the burning of sulfur-containing compounds and considered to be a major air pollutant. Sulfur dioxide is a *criteria pollutant.*

surface water: Water on the Earth's surface that is directly exposed to the atmosphere, as distinguished from water in the ground (*groundwater*).

temporary emergency exposure limits (TEELs): The TEEL-1 concentration for a chemical is the maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor. The TEEL-2 value is the maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action. The TEEL-3 value is the maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

terrestrial: Pertaining to plants or animals living on land rather than in the water.

threatened species: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Requirements for declaring a species threatened are contained in the *Endangered Species Act*.

threshold non-linear relationship: In a threshold non-linear relationship, some low level of exposure to a harmful substance can be tolerated without causing a health effect. (See also linear/no threshold hypothesis.)

throughput: A general term that refers to the amount of material handled or processed by a facility in a specified time period.

topography: The shape of the earth's surface. The relative position and elevations of natural and man-made features of an area.

total effective dose equivalent (TEDE): The sum of the effective dose equivalent (EDE) from exposure to external radiation and the 50-year committed effective dose equivalent (CEDE) from exposure to internal radiation.

total suspended particulate (TSP): Particles of solid or liquid matter - such as soot, dust, aerosols, fumes, and mist - up to approximately 30 :m in size, that can be suspended in the air. National, South Carolina, and Georgia, Ambient Air Quality Standards all set the annual primary (health based) TSP level at 75 :g/m^3.

toxicity: The ability of a substance to cause damage to cells or tissues of living organisms when the substance is inhaled, ingested, or absorbed by the skin.

Toxic Substances Control Act (TSCA): A federal law authorizing the U.S. Environmental Protection Agency to secure information on all new and existing chemical substances and to control any of these substances determined to cause unreasonable risk to public health or the environment. This law requires that the health and environmental effects of all new chemicals be reviewed by the EPA before such chemicals are manufactured for commercial purposes.

traditional cultural properties: Places and resources important to traditional American cultures, which include, but are not restricted to, Native American cultures.

TRAGIS (Transportation Routing Analysis Geographic Information System): A GIS-based transportation and analysis computer model for rail, highway, and waterway transportation modes.

transport index: The radiation dose rate at 1 meter (approximately 3 feet) from the lateral sides of a vehicle transporting radioactive material.

transuranic: Of, relating to, or being any element whose atomic number is higher than that of uranium (that is, 92). All transuranic elements are radioactive.

transuranic (TRU) waste: Radioactive waste that contains more than 100 nanocuries per gram of alpha-emitting isotopes with atomic numbers greater than 92 and half-lives greater than 20 years. Such wastes result primarily from fuel reprocessing and from the fabrication of plutonium weapons and plutonium-bearing reactor fuel.

Triassic: The first period of the Mesozoic era, dating from approximately 246 to 213 million years ago.

trichloroethylene (TCE): An organic solvent and degreaser.

tritium: A radioactive isotope of the element hydrogen, having two neutrons and one proton. It can be taken into the body easily because it is chemically identical to natural hydrogen. Tritium decays by beta emission with a half-life of about 12.5 years.

Type A package: A type of packaging for radioactive materials. The package must withstand the conditions of normal transportation without loss or dispersal of the radioactive contents. It does not usually require special handling or transportation equipment.

Type B package: A more durable type of packaging for radioactive materials than Type A. In addition to meeting all the Type A standards, Type B packaging must also provide a high degree of assurance that the package integrity will be maintained, even during severe accidents, with essentially no loss of the radioactive contents.

unscarified seed - Seed that has not had the hard outer coat scuffed or otherwise treated to improve germination.

Upper Cretaceous: A geologic time period from about 90 to 66 million years ago. The entire Cretaceous period dates from approximately 144 million to 66 million years ago; it is known as the age of dinosaurs.

uranium: A heavy, silvery-white metallic element (atomic number 92) with many radioactive isotopes. One isotope, uranium-235, is most commonly used as a fuel for nuclear fission. Another, uranium-238, is transformed into fissionable plutonium-239 following its capture of a neutron in a nuclear reactor.

uranium dioxide (UO_2): A black crystalline powder that is widely used in the manufacture of fuel pellets for nuclear reactors.

valence: The number of electrons with which a given atom generally bonds, or the number of bonds an atom forms.

vehicle-related impacts: Transportation risks (physical trauma or emissions) that are related to the transportation vehicle itself, not the cargo it is carrying.

viewshed: The extent of the area that may be viewed from a particular location. Viewsheds are generally bounded by topographic features such as hills or mountains.

Visual Resource Management (VRM): A process devised by the Bureau of Land Management to assess the aesthetic quality of a landscape and to design proposed activities in a way that would minimize their visual impact on that landscape. The process consists of a rating of site visual quality followed by a measurement of the degree of contrast between the proposed development activities and the existing landscape.

vitrification: A process by which glass is used to encapsulate or immobilize radioactive wastes.

volatile organic compounds (VOCs): A broad range of *organic compounds*, that readily evaporate and vaporize at normal temperatures and pressures. Examples include certain solvents, paint thinners, degreasers (benzene), chloroform, and methyl alcohol. VOCs can react with other substances, principally nitrogen oxides, to form ozone. The reactions are energized by sunlight.

Waste Isolation Pilot Plant (WIPP): A national disposal site for transuranic and mixed transuranic waste, located in southeastern New Mexico.

waste management: The planning, coordination, and direction of functions related to generation, handling, treatment, storage, transportation, and disposal of waste. It also includes associated pollution prevention and surveillance and maintenance activities.

waste minimization: An action that economically avoids or reduces the generation of waste by source reduction and recycling; or reduces the toxicity of hazardous waste, improving energy usage.

waste stream: A waste or group of wastes with similar physical form, radiological properties, EPA waste codes, or associated *Land Disposal Restriction* treatment standards. A waste stream may result from one or more processes or operations. Also, a waste or group of wastes from a process or a facility with similar physical, chemical, or radiological properties.

wastewater: Water originating from human sanitary water use (domestic wastewater) and from a variety of industrial processes (industrial wastewater).

watershed area: All land and water within the confines of a *drainage basin*.

weapons-grade: Plutonium or *highly enriched uranium*, in metallic form, that was manufactured for weapons application. Weapons-grade plutonium contains less that 7% plutonium 240.

wetland: Land areas exhibiting hydric (moist) soil conditions, saturated or inundated soil during some portion of the year, and plant species tolerant of such conditions. Wetlands include swamps, marshes, and bogs.

Wild and Scenic Rivers Act: The federal law that established the National Wild and Scenic Rivers System. It was designed to preserve and protect the free-flowing condition of selected rivers having outstanding natural, cultural, or recreational features. For federally owned land within the boundaries of rivers in the system, certain activities that would have a direct and adverse effect on the river values may be controlled.

wind rose: A circular diagram showing, for a specific location, the percentage of time the wind blows from each compass direction over a specified period of record. A wind rose for use in assessing consequences of airborne releases also shows the frequency of different wind speeds for each compass direction.

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APPENDIX A:

PROTECTED SPECIES

Appendix A:

Protected Species

Sixty-one threatened, endangered, and other special status species listed by the federal government or the State of South Carolina may be found in the vicinity of the Savannah River Site (SRS). Protected species listed by the state for Aiken and Barnwell Counties (within which most of the SRS is located) and by Georgia for the reach of the Savannah River bordering the SRS and for Burke County across the river from the SRS are listed in Table A.1. Table A.1 also lists the status and habitat preferences for the protected species. Species from Allendale County, South Carolina, and Screven County, Georgia, are not considered because of the distance of these counties from the F-Area. No designated critical habitat for threatened or endangered species exists on the SRS (DOE 1996).

The SRS has established a proactive threatened and endangered species program that includes habitat restoration. In particular, special efforts have been enacted since 1986 to reestablish and expand the population of the federally and state-endangered red-cockaded woodpecker (*Picoides borealis*) at the SRS. The SRS has been divided into three natural resource habitat management areas: (1) a 34,858-ha (86,069-acre) red-cockaded woodpecker habitat management area, (2) a 19,508-ha (48,167-acre) supplemental red-cockaded woodpecker habitat management area, and (3) other-use areas totaling 25,965 ha (64,111 acres) (DOE 2000). Within the red-cockaded woodpecker habitat management area, harvest rotation for loblolly and longleaf pine is set at 100 and 200 years, respectively. These long rotation periods are designed to increase the number of potential cavity nesting trees. Rotation for pines within the supplemental red-cockaded woodpecker habitat management and other-use areas is set at 50 years to encourage woodpecker recovery within the designated red-cockaded woodpecker habitat management area. The bottomland hardwood, upland hardwood, and mixed pine/hardwood timber management areas that do not provide red-cockaded woodpecker habitat are managed on 100-year rotations (DOE 2000). No red-cockaded woodpecker management is practiced within the other-use area (Edwards et al. 1999).

A combination of methods has been used to improve the red-cockaded woodpecker population at the SRS. These methods have included removing southern flying squirrels from red-cockaded woodpecker nesting cavities, excavating new nesting cavities, thinning hardwood midstory trees, and augmenting the number of female red-cockaded woodpeckers at the SRS. The excavation of cavities has allowed nesting use in younger tree stands several decades before the birds would be able to do this on their own (Allen 1990a,b). The annual conversion of slash and loblolly pine areas to longleaf pine also provides a long-term benefit to red-cockaded woodpeckers and other wildlife species associated with the longleaf pine savanna ecosystem (DOE 2000).

The endangered status of the red-cockaded woodpecker is primarily related to the loss of mature pine forests in the southeastern states from logging and fire suppression; only about 1%

of the species' historical habitat remains (WSRC 1994; FWS 2001a). They prefer longleaf and loblolly pines that are more than 70 years old, often selecting those trees with red-heart disease, which softens the core of the tree. They forage in pine trees over 30 years old (WSRC 1994; USAF 1996). The woodpeckers also prefer areas with minimal midstory trees, so as to lessen potential competition (e.g., from other woodpecker species) and predation (e.g., black rat snakes) (FWS 2001a). Other species either compete for or use abandoned red-cockaded woodpecker cavity holes, including southern flying squirrels, chickadees, bluebirds, titmice, herpetofauna (amphibians and reptiles) and insects (particularly bees and wasps) (FWS 2001b).

The red-cockaded woodpecker is a social species, living in a family group that inhabits a collection of cavity trees called a cluster. Each bird in the group maintains its own cavity tree, but only one pair in the group actually nests. A cluster may include from 1 up to 20 or more cavity trees on 1.2 to 24.3 ha (3 to 60 acres), averaging about 4.0 ha (10 acres). Territory size is related to both habitat suitability and population density. The typical territory for a family group ranges from about 50.6 to 81.0 ha (125 to 200 acres), but reported extremes are as low as 24.3 ha (60 acres) and as high as 243 ha (600 acres) (FWS 2001a,b).

The SRS contains two subpopulations of the red-cockaded woodpecker. Currently 26 active clusters with almost 150 individual birds occur on the SRS. In 1985, only four birds were reported from the SRS (DOE 2000). The closest nesting area to the proposed facility site is about 5 km (3.1 mi) away (DOE 1999). The proposed area for the facility does not occur within either the red-cockaded woodpecker habitat management area or the supplemental management area. However, all areas containing pines, including those at the proposed site, provide suitable forage areas for this species.

Table A.1 Rare, threatened, and endangered species from Aiken and Barnwell Counties, South Carolina, and Burke County, Georgia

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Plants			
Aethusa-like trepocarpus (*Trepocarpus aethusae*)	–/SC	A	Bottomland hardwoods
American eelgrass (*Vallisneria americana*)	–/SC	Ba	Ponds and streams, mostly in the sandhills
American nailwort (*Paronychia americana*)	–/SC	A, Ba	Sandhills, dry pinelands
Awnpetal meadowbeauty (*Rhexia aristosa*)	–/SC	Ba	Wet depressions, Carolina bays, savannas, pinelands
Bearded milkvetch (*Astragalus villosus*)	–/SC	A, Ba	Pinelands, disturbed sites

Table A.1 Continued

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Biennial beeblossum (*Gaura biennis*)	–/SC	A, Ba	Streambanks, meadows, roadsides
Bog spicebush (*Lindera subcoriacea*)	–/RC	A, Ba	Evergreen-shrub bogs, acidic swamp forests, and seepage bogs
Boykin's lobelia (*Lobelia boykinii*)	–/SC	Ba	Cypress ponds, wet pinelands, Carolina bays
Canada moonseed (*Menispermum canadense*)	–/SC	Ba	Moist woods and thickets
Candby's cowbane (*Oxypolis canbyi*)	E/E, E	Ba, Bu	Peaty muck of shallow cypress ponds, wet pine savannas, and adjacent sloughs and drainage ditches
Candy's bulrush (*Scirpus etuberculatus*)	–/SC	A	Swamps and quiet or flowing shallow water
Carolina birds-in-a-nest (*Macbridea caroliniana*)	–/SC	A, Ba	Freshwater margins
Carolina bugbane (*Trautvetteria caroliniensis*)	–/SC	Ba	Woods, especially in damp or wet soils
Carolina larkspur (*Delphinium carolinianum*)	–/SC	A	Dry woods, prairies, and sandhills
Carolina wild petunia (*Ruellia caroliniensis* spp. *ciliosa*)	–/SC	A	Moist or dry woods
Collins' sedge (*Carex collinsii*)	–/SC	A	Bogs, especially white cedar swamps
Creeping St. johnswort (*Hypericum adpressum*)	–/RC	Ba	Marshes, shores, and wet meadows
Cypressknee sedge (*Carex decomposita*)	–/SC	Ba	Wooded swamps
Drowned hornedrush (*Rhynchospora inundata*)	–/SC	A, Ba	Inundated pond margins and wet peat
Durand's white oak (*Quercus sinuata*)	–/SC	Ba	Wooded slopes, edges of streams
Dwarf burhead (*Echinodorus parvulus*)	–/SC	A, Ba	Carolina bays
Eared goldenrod (*Solidago auriculata*)	–/SC	A	Fields, roadsides, open woods

Table A.1 Continued

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Eastern leatherwood (*Dirca palustris*)	–/SC	A	Rich, moist woods
Eastern wahoo (*Euonymus atropurpurea*)	–/SC	A	Woodlands and thickets, usually on moist, rich soils
Elliott's croton (*Croton elliottii*)	–/SC	A, Ba	Carolina bays
Faded trillium (*Trillium discolor*)	–/SC	A	Moist woods
False rue anemone (*Enemion biternatum*)	–/RC	A	Moist woods
Flax leaf false-foxglove (*Agalinis linifolia*)	–/RC	A	Wet, sandy soils
Florida bladderwort (*Utricularia floridana*)	–/SC	Ba	Shallow ponds, often within Carolina bays
Georgia beargrass (*Nolina georgiana*)	–/SC	A, Ba	Sandhills
Georgia plume (*Elliottia racemosa*)	–/T	Bu	Sand ridges, dry oak ridges, evergreen hammocks, sandstone outcrops
Green fringed orchid (*Platanthera lacera*)	–/SC	A, Ba	Carolina bays, bottomland hardwoods
Ground juniper (*Juniperus communis*)	–/SC	A	Dry, rocky, or otherwise poor soils
Hooded pitcher plant (*Sarracenia minor*)	–/U	Bu	Acidic soils of open bog, wet savannas, pond margins, low areas in pine flatwoods, sphagnum seeps of bottomland forests, sloughs and ditches
Lance-leaf wild-indigo (*Baptisia lanceolata*)	–/SC	Ba	Pine forests, open woods
Least trillium (*Trillium pusillum* var *pusillum*)	–/NC	A	Alluvial or low woods, savannas
Leechbrush (*Nestronia umbellula*)	–/SC, T	A, Ba, Bu	Dry, open, upland forests of mixed hardwood and pines
Long sedge (*Carex folliculata*)	–/SC	A	Wet or swampy woods

Table A.1 Continued

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Loose watermilfoil (*Myriophyllum laxum*)	–/RC	A, Ba	Sinkhole ponds and other shallow, freshwater ponds; and sandy, clear streams draining spring-fed swamps
Lowland brittle fern (*Cystopteris protrusa*)	–/SC	A	Moist woods
Muhlenberg maidencane (*Amphicarpum muehlenbergianum*)	–/SC	Ba	Pastures, pinelands, moist margins of woods, disturbed sites
Narrow-leaved trillium (*Trillium lancifolium*)	–/NC	A	Moist woods
Nutmeg hickory (*Carya myristiciformis*)	–/RC	Ba	Bottomland hardwoods
Pickering's morning-glory (*Stylisma pickeringii* var *pickeringii*)	–/SC	A	Scrub habitats with scant litter accumulation, sparse ground cover, and little canopy cover (scrubby oaks and pines)
Piedmont azalea (*Rhododendron flammeum*)	–/SC	A, Ba	Upland hardwood bluffs
Piedmont bladderwort (*Utricularia olivacea*)	–/SC	Ba	Shallow, acidic ponds
Piedmont cucumber tree (*Magnolia cordata*)	–/SC	A	Rich woods
Piedmont mock bishopweed (*Ptilimnium nodosum*)	E/E	A, Ba	Wet savannas and peaty fringes of pineland pools and cypress ponds
Piedmont three-awned grass (*Aristida condensata*)	–/SC	A	Sand pine scrub, sandhills, disturbed sites
Pine-leaved golden aster (*Pityopsis pinifolia*)	–/SC	A	Barrens, sandy soils
Pink ladyslipper (*Cypripedium acaule*)	–/U	Bu	Acid soils of pine woodlands, upland hardwoods with pines
Pyramid magnolia (*Magnolia pyramidata*)	–/RC	A	Low, moist situations
Red standing-cypress (*Ipomopsis rubra*)	–/SC	A, Ba	Pastures, roadsides
Relict trillium (*Trillium reliquum*)	E/E	A	Rich moist woods on bluffs and ravine slopes

Table A.1 Continued

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Reticulated nutrush (*Scleria reticularis*)	–/SC	Ba	Damp, sandy soils and pine barrens
Robbins' spikerush (*Eleocharis robbinsii*)	–/SC	A, Ba	Mud or shallow water
Rose coreopsis (*Coreopsis rosea*)	–/RC	A	Wet, often sandy or acid soils, or in shallow water
Sandhill rosemary (*Ceratiola ericoides*)	–/T	Bu	Very dry, openly vegetated, scrub-oak sandhills
Sandhills milkvetch (*Astragalus michauxii*)	–/SC	Ba	Sandhills, open sandy woods
Sarvis holly (*Ilex amelanchier*)	–/SC	A	Woody streambanks in sandhills, wet depressions, Carolina bays
Scarlet beebalm (*Monarda didyma*)	–/SC	Ba	Moist woods and thickets
Shoals spiderlily (*Hymenocallis coronaria*)	–/NC	A	Major streams and rivers in rocky shoals and in cracks of exposed bedrock
Shortleaf sneezeweed (*Helenium brevifolium*)	–/RC	Ba	Swampy or boggy places and moist pine woods
Shortleaf yelloweyed grass (*Xyris brevifolia*)	–/SC	A	Pine flatwoods, pond margins
Silky camellia (*Stewartia malacodendron*)	–/R	Bu	Rich, wooded bluffs and ravine slopes, transitional areas between sandhills and creek swamps
Slender arrowhead (*Sagittaria isoetiformis*)	–/SC	A, Ba	Carolina bays
Small-flowered buckeye (*Aesculus parviflora*)	–/RC	A	Upland hardwood bluffs
Small-flowered silverbell-tree (*Halesia parviflora*)	–/SC	A, Ba	Dry, sandy, upland sites
Smooth coneflower (*Echinacea laevigata*)	E/E	A, Ba	Meadows and open woodlands on basic or near neutral soils
Southeastern sneezeweed (*Helenium pinnatifidium*)	–/SC	Ba	Wet pinelands
Spatulate seedbox (*Ludwigia spathulata*)	–/SC	A, Ba	Wet depressions, pond margins, Carolina bays
Stalkless yellowcress (*Rorippa sessiliflora*)	–/SC	A	Bottomland hardwoods

Table A.1 Continued

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Striped garlic (*Allium cuthbertii*)	–/SC	A, Ba	Sandhills, marshes
Sweet pitcher plant (*Sarracenia rubra*)	–/SC, E	A, Bu	Acidic soils in open bogs, sandhill seeps, wet savannas, low areas in pine flatwoods, along sloughs and ditches
Three-angle spikerush (*Eleocharis tricostata*)	–/SC	Ba	Pine barren ponds
Tracy beakrush (*Rhynchospora tracyi*)	–/SC	Ba	Carolina bays
Upland swamp-privet (*Forestiera ligustrina*)	–/SC	A	Sandy or rocky soils
Water toothleaf (*Stillingia aquatica*)	–/SC	Ba	Grass-sedge wet depressions, bogs
White wicky (*Kalmia cuneata*)	–/NC	A	Borders of Carolina bays and bogs; between sandhills and upland swamps
Winter grape fern (*Botrychium lunarioides*)	–/SC	A	Open fields, meadows, sandy or gravelly streambanks
Yellow pipewort (*Syngonanthus flavidulus*)	–/RC	A	Wet pinelands, pond margins
Invertebrates			
Arogos skipper (*Atrytone arogos*)	–/SC	A	Open fields, meadows, prairies
Barrel floater (*Anodonta couperiana*)	–/SC	Ba	Streams, rivers
Carolina slabshell (*Elliptio congaraea*)	T/E	Ba	Streams, rivers
Eastern creekshell (*Villosa delumbis*)	–/SC	Ba	Streams, rivers
Eastern floater (*Pyganodon cataracta*)	–/SC	Ba	Streams, rivers
Paper pondshell (*Utterbackia imbecillis*)	–/SC	Ba	Streams, rivers
Rayed pink fatmucket (*Lampsilis splendida*)	–/SC	Ba	Streams, rivers

Table A.1 Continued

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Southern rainbow (*Villosa vibex*)	–/SC	Ba	Streams, rivers
Yellow lampmussel (*Lampsilis cariosa*)	–/SC	Ba	Streams, rivers
Fish			
Robust redhorse (*Moxostoma robustum*)	–/E	Bu	Mainstream river habitats (e.g., Augusta Shoals of Savannah River)
Shortnose sturgeon (*Acipenser brevirostrum*)	E/E, E	A, Bu	Spawns in large coastal rivers; remainder of year spent in lower reaches or river estuary
Amphibians and Reptiles			
American alligator (*Alligator mississippiensis*)	T(S/A)/–	A, Ba	Savannah River Swamp, Par Pond, Beaver Dam Creek, and other streams
Bird-voiced treefrog (*Hyla avivoca*)	–/SC	A, Ba	Wooded swamps along creeks and larger waterways
Black swamp snake (*Seminatrix pygaea*)	–/SC	A	Cypress ponds
Eastern coral snake (*Micrurus fulvius*)	–/SC	A	Well-drained pine woods; open, dry, or sandy areas; pond and lake borders; and hammocks
Eastern tiger salamander (*Ambystoma tigrinum tigrinum*)	–/SC	A	Savannah River Swamp and Carolina bays
Florida green water snake (*Nerodia floridana*)	–/SC	A	Swamps, marshes, and quiet bodies of water
Gopher frog (*Rana capito*)	–/SC	A, Ba	Gopher tortoise burrows during daylight hours
Gopher tortoise (*Gopherus polyphemus*)	–/E, T	A, Bu	Sandy soil and abundant herbaceous vegetation (e.g., longleaf pine savannas); often forced to inhabit roadsides and old fields
Pine (or gopher) snake (*Pituophis melanoleucus*)	–/SC	A	Flat, sandy pine barrens, sandhills, and dry mountain ridges, usually in or near pine woods

Table A.1 Continued

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Southern hognose snake (*Heterodon simus*)	–/SC	A	Sandy woods, fields, and groves, dry river floodplains, and hardwood hammocks
Spotted turtle (*Clemmys guttata*)	–/SC, U	A, Ba, Bu	Heavily vegetated, shallow wetlands with standing or slowly flowing water
Birds			
Bachman's sparrow (*Aimophila aestivalis*)	–/R	Bu	Mature open pine woods, regenerating clearcuts, old pastures with dense ground cover of grasses and forbs, palmetto scrub
Bald eagle (*Haliaeetus leucocephalus*)	T/E	A	Active nests in Pen Branch area and area south of Par Pond
Little blue heron (*Egretta caerulea*)	–/SC	A	Freshwater ponds, lakes, and marshes; coastal saltwater wetlands
Red-cockaded woodpecker (*Picoides borealis*)	E/E, E	A, Ba, Bu	Nests in mature pine forests (particularly longleaf); forages in pine forests
Wood stork (*Mycteria americana*)	E/E, E	Ba, Bu	Variety of freshwater and estuarine wetlands for breeding, feeding, and nesting; nests in trees in standing water or on islands
Mammals			
Black bear (*Ursus americanus*)	–/SC	A	Forests and swamps
Eastern fox squirrel (*Sciurus niger*)	–/SC	A, Ba	Pine forests with interspersed clearings
Eastern woodrat (*Neotoma floridana*)	–/SC	A, Ba	Hummocks, swamps, and cabbage palmetto
Hoary bat (*Lasiurus cinereus*)	–/SC	A	Wooded areas
Rafinesque's big-eared bat (*Corynorhinus rafinesquii*)	–/E	A	Roosts in or near mature forests with water nearby; forage among canopies of large trees

Table A.1 Continued

Species common name (scientific name)	Status, federal/state[a,b]	County locations[c]	Habitat
Spotted skunk (*Spilogale putorius*)	–/SC	A	Brushy or sparsely wooded areas, along streams, among boulders, prairies
Star-nosed mole (*Condylura cristata*)	–/SC	A, Ba	Low, wet ground near lakes and streams

[a]E = endangered; T = threatened; T(S/A) = threatened (similarity of appearance); NC = of concern, national (unofficial, plants only); R = rare; RC = of concern, regional (unofficial, plants only); SC = species of concern; U = unusual; –- = not listed.

[b]For species listed from both South Carolina and Georgia counties, the status for South Carolina is provided first.

[c]A = Aiken County, South Carolina; Ba = Barnwell County, South Carolina; Bu = Burke County, Georgia.

Sources: Burt and Grossenheider (1976); Conant (1958); DCS (2002); DOE (1991); Fernald (1989); Flora of North America Editorial Committee (1997); Gleason and Cronquist (1991); Harrar and Harrar (1962); Knox and Sharitz (1990); National Geographic Society (1999); Ozier et al. (1999); Patrick et al. (1995); Petrides (1988); SCDNR (2001a,b); USDA (2001); Workman and McLeod (1990); Wunderlin (1982).

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APPENDIX B:

LETTERS OF CONSULTATION[1]

[1] The following letters have been reproduced from the best available copies.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 24, 2001

Mr. John Ross, Chief
United Keetowah Band
of Cherokee Indians
PO Box 746
Tahlequah, OK 74465-0746

Dear Mr. Ross:

The U.S. Nuclear Regulatory Commission (NRC) is evaluating the potential impacts associated with the construction, operation, and deactivation of a proposed Mixed Oxide (MOX) Fuel Fabrication Facility (Facility) to be constructed at the Department of Energy's (DOE) Savannah River Site (SRS) in South Carolina. The NRC has regulatory responsibility for approving and licensing the construction and operation of the proposed MOX facility.

On March 7, 2001, pursuant to the National Environmental Policy Act, the NRC issued a Notice of Intent to prepare an Environmental Impact Statement (EIS) for its action (66 FR 13794). The EIS will address the potential environmental effects of manufacturing MOX fuel from surplus weapons plutonium. Public scoping meetings for the MOX Facility EIS were held on April 17 and 18, 2001, in North Augusta, SC and Savannah, GA, respectively, and on May 8, 2001, in Charlotte, NC.

Two maps are enclosed. The first map shows the general location of the proposed MOX Facility and the locations of two potential recipients of the MOX fuel assemblies, the Catawba Nuclear Station and the William B. McGuire Nuclear Station. Transportation corridors between SRS and the two reactor stations have not yet been identified. The second map shows the proposed location of the MOX Facility at SRS.

Argonne National Laboratory (ANL) is assisting the NRC in preparing the MOX Facility EIS and will be evaluating potential impacts to cultural resources as part of their analysis. An archaeologist from ANL is in the process of researching available documents from SRS on archaeological surveys, historic building inventories, and resources of interest to Native Americans.

The proposed project area has been surveyed for archaeological sites. These surveys have identified five archaeological sites (38AK155, 38AK330, 38AK548, 38AK546/547, and 38AK757) in the project vicinity. Only Site 38AK546/547 will likely be affected by the construction of the MOX Facility. This site has been determined to be eligible for listing on the National Register of Historic Places (NRHP), and a data recovery plan is being implemented to mitigate impacts to this site. The possibility of indirect effects to other nearby sites from activities associated with the construction or operation of the facility will be analyzed during preparation of the EIS. Sites 38AK155 and 38AK757 have also been determined eligible for the NRHP and can be avoided during construction and operation of the MOX Facility to mitigate the potential for adverse impacts to these sites. The remaining two sites were determined not

J. Ross 2

eligible. No traditional cultural properties have been identified in the project area to date. Through previous consultations with Native Americans, some interest has been expressed in traditional plant resources that could exist at SRS. However, none of these plant resources is currently known to exist at the MOX Facility construction site.

The NRC is also initiating consultations regarding the proposed project with points of contact (Tribal Historic Preservation Officers or designated representatives) from the following Native American Tribes, Bands, and Nations, as well as with the South Carolina Department of Archives and History.

Catawba Indian Nation
Ma Chis Lower Alabama Creek Indian Tribe
Pee Dee Indian Association
Muscogee Creek Nation
National Council of the Muscogee Creek
Yuchi Tribal Organization, Inc.

We would appreciate receiving information on concerns or issues you may have regarding the proposed project. We are especially interested in your assistance in identifying properties of known religious or cultural significance that may be affected by the construction and operation of the proposed facility. Sensitive information will remain confidential as stipulated under 36 CFR Part 800.11. Please submit comments to me within 30 days. Your time and consideration are greatly appreciated.

In the meantime, if you have any questions or require further clarification regarding the project please call me at (301) 415-7293, or Jennifer Davis at (301) 415-5874.

Sincerely,

Phyllis Sobel for Charlotte Abrams

Charlotte E. Abrams, Section Chief
Environmental and LLW Section
Environmental and Performance
Assessment Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Docket: 70-3098
Enclosures: Location maps

cc: See attached list

Letter dated September 24, 2001 to:

Gilbert Blue, Chairperson,
Catawba Indian Nation
PO Box 188
Catawba, SC 29704

Virginia Montoya
Pee Dee Indian Association
101 E. Tatum Avenue
McColl, SC 29570-057

Nancy Carnley
Ma-Chis Lower Alabama Creek Indian Tribe
Route 1, 708 S. John Street
New Brockton, AL 36351

John Ross, Chief
United Keetowah Band of Cherokee Indians
PO Box 746
Tahlequah, OK 74465-0746

Tom Berryhill
Council Member
National Council of the Muscogee Creek
PO Box 158
Okmulgee, OK 74447

Andrew Skeeter, Chairman
Yuchi Tribal Organization, Inc.
PO Box 1990
Sapulpa, OK 74067

Julie Moss
United Keetowah Band
Tahlequah, OK 74464

R. Perry Beaver, Principal Chief
Muscogee Creek Nation
PO Box 580
Okmulgee, OK 74447

3

Letter dated September 24, 2001

Distribution:

cc: Arthur B. Gould, Jr.
DOE Savannah River Indian Relations Officer
PO Box A
Aiken, SC 29802

Mary Birch, P.E., C.H.P.
Environment, Safety and Health Manager
Duke COGEMA Stone & Webster
PO Box 31847
Charlotte, NC 28231-1847

Edwin D. Pentecost
Argonne National Laboratory
9700 South Cass Avenue
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James Johnson
U.S. Department of Energy
MD-12
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Henry Potter
Division of Waste Management
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File Center
EPAB r/f
NMSS r/f
JPiccone
MWeber
ELeeds
APersinko
TJohnson
JHull
AFernandez
R Martin
TEssig
DAyres/RII
THarris
DBrown
EMcAlpine/RII

Dennis Ryan
DOE Savannah River Site
PO Box A
Aiken, SC 29802

Don Moniak
Blue Ridge Defense League
PO Box 3487
Aiken, SC 29802

Glenn Carroll
Georgians Against Nuclear Energy
PO Box 8574

Ruth Thomas
Environmentalists, Inc.
1339 Sinkler Road
Columbia, SC 29206

John T. Conway, Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, Suite 700
Washington, DC 20004

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 24, 2001

Mr. Roger Banks, Field Supervisor
U.S. Fish and Wildlife Service
Charleston Ecological Services Field Office
176 Croghan Spur Road, Suite 200
Charleston, SC 29404

SUBJECT: INFORMAL CONSULTATION UNDER SECTION 7 OF THE ENDANGERED SPECIES ACT FOR THE MIXED OXIDE FUEL FABRICATION FACILITY

Dear Mr. Banks:

The U.S. Nuclear Regulatory Commission (NRC) published its Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for construction, operation and deactivation of a Mixed Oxide Fuel Fabrication Facility (MOX FFF) in the Federal Register (66 FR 13794) on March 7, 2001 (copy of NOI enclosed). The MOX FFF would be used to manufacture mixed oxide fuel from surplus weapons plutonium.

The proposed MOX FFF would be constructed in F Area at the Department of Energy's (DOE) Savannah River Site (SRS) in Aiken County, South Carolina (see three enclosed figures). The F Area of SRS is within the Savannah River watershed. NRC requests that the U.S. Fish and Wildlife Service provide information regarding federally listed threatened and endangered species (including candidate and proposed species) that may occur on or in the vicinity of F Area at SRS that should be considered in preparing the EIS.

The MOX FFF and associated infrastructure would occupy approximately 6.9 ha of the 16.6 ha project site. The remainder of the site will be landscaped. The F area is an upland plateau that is designated for industrial use. A portion of the MOX FFF project site was previously used to store excavation material from another facility constructed in the F Area. About 68 percent of the MOX FFF site is composed of planted longleaf and slash pine forest. No wetlands occur within the area proposed for the MOX FFF (see enclosed land cover figure), but wetlands associated with Upper Three Runs Creek are adjacent to and downslope of the project site. Operational impacts would be minimized as airborne and aqueous releases would comply with applicable standards and permit requirements. Preliminary analyses presented in the environmental report for the MOX FFF prepared by the applicant DCS (a consortium formed by Duke Engineering & Services, COGEMA, Inc., and Stone and Webster) indicate that the impacts to ecological resources from facility construction and operation would be limited to the immediate project site vicinity.

R. Banks 2

I wish to thank you in advance for the information on the threatened, endangered, candidate, and proposed species that you believe should be addressed in the EIS. Please mail your response to me within 30 days of the date of this letter.

If you have any questions, please contact me at (301) 415-7293, or Jennifer Davis at (301) 415-5874.

Sincerely,

Phyllis Sobel for Charlotte Abrams

Charlotte E. Abrams, Section Chief
Environmental and LLW Section
Environmental and Performance
Assessment Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Docket: 70-3098

Enclosures: Notice of Intent
F Area Figures
Land Cover Figure

cc: See attached list

R. Banks 3

Letter to Roger Banks, U.S. Fish and Wildlife Service, SC
dated September 24, 2001

cc: Mary Birch, P.E., C.H.P.
Environment, Safety and Health Manager
Duke COGEMA Stone & Webster
PO Box 31847
Charlotte, NC 28231-1847

Edwin D. Pentecost
Argonne National Laboratory
9700 South Cass Avenue
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James Johnson
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Henry Potter
Division of Waste Management
Bureau of Land and Waste Management
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Don Moniak
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Glenn Caroll
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PO Box 8574
Atlanta, GA 30306

Ruth Thomas
Environmentalists, Inc.
1339 Sinkler Road
Columbia, SC 29206

Edna Foster
120 Balsam Lane
Highlands, NC 28741

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 24, 2001

Mr. Jon Ambrose, Program Manager
Georgia Department of Natural Resources
Wildlife Resources Division
Nongame Wildlife & Natural Heritage Section
Georgia Natural Heritage Program
2117 US Hwy 278 SE
Social Circle, GA 30025

SUBJECT: STATE LISTED THREATENED, ENDANGERED AND RARE SPECIES IN THE VICINITY OF THE MIXED OXIDE FUEL FABRICATION FACILITY

Dear Mr. Ambrose:

The U.S. Nuclear Regulatory Commission (NRC) published its Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for construction, operation and deactivation of a Mixed Oxide Fuel Fabrication Facility (MOX FFF) in the Federal Register (66 FR 13794) on March 7, 2001 (copy of NOI enclosed). The MOX FFF would be used to manufacture mixed oxide fuel from surplus weapons plutonium.

The proposed MOX FFF would be constructed in F Area at the Department of Energy's (DOE) Savannah River Site (SRS) in Aiken County, South Carolina, (see three enclosed figures). The SRS borders several counties of Georgia (i.e., Burke and Screven Counties) and the F Area is within the Savannah River watershed. NRC requests that the Georgia Department of Natural Resources provide information regarding state listed threatened, endangered, and rare species that may occur on or in these areas that should be considered in preparing the EIS.

The MOX FFF and associated infrastructure would occupy approximately 6.9 ha of the 16.6 ha project site. The remainder of the site will be landscaped. The F area is an upland plateau that is designated for industrial use. A portion of the MOX FFF project site was previously used to store excavation material from another facility constructed in the F Area. About 68 percent of the MOX FFF site is composed of planted longleaf and slash pine forest. No wetlands occur within the area proposed for the MOX FFF (see enclosed land cover figure), but wetlands associated with the Upper Three Runs Creek are adjacent to and downslope of the project site. Operational impacts would be minimized as airborne and aqueous releases would comply with applicable standards and permit requirements. Preliminary analyses presented in the environmental report for the MOX FFF prepared by the applicant DCS (a consortium formed by Duke Engineering & Services, COGEMA, Inc., and Stone and Webster) indicate that the impacts to ecological resources from facility construction and operation would be limited to the immediate project site vicinity.

J. Ambrose 2

I wish to thank you in advance for the information on the threatened, endangered and rare species in Georgia that you believe should be addressed in the EIS. Please mail your response to me within 30 days of the date of this letter.

If you have any questions, please contact me at (301) 415-7293, or Jennifer Davis at (301) 415-5874.

Sincerely,

Phyllis Sobel for Charlotte Abrams

Charlotte E. Abrams, Section Chief
Environmental and LLW Section
Environmental and Performance
Assessment Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Docket: 70-3098

Enclosures: Notice of Intent
F Area Figures
Land Cover Figure

cc: See attached list

J. Ambrose 3

Letter to Jon Ambrose, Georgia Department of Natural Resources, dated September 24, 2001

cc: Mary Birch, P.E., C.H.P.
Environment, Safety and Health Manager
Duke COGEMA Stone & Webster
PO Box 31847
Charlotte, NC 28231-1847

Edwin D. Pentecost
Argonne National Laboratory
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Ruth Thomas
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Columbia, SC 29206

Edna Foster
120 Balsam Lane
Highlands, NC 28741

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 24, 2001

Ms. Julie Holling
South Carolina Department of Natural Resources
Wildlife and Freshwater Fisheries Division
P.O. Box 167
Columbia, SC 29202

SUBJECT: STATE LISTED THREATENED, ENDANGERED AND RARE SPECIES IN THE VICINITY OF THE MIXED OXIDE FUEL FABRICATION FACILITY

Dear Ms Holling:

The U.S. Nuclear Regulatory Commission (NRC) published its Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for construction, operation and deactivation of a Mixed Oxide Fuel Fabrication Facility (MOX FFF) in the Federal Register (66 FR 13794) on March 7, 2001 (copy of NOI enclosed). The MOX FFF would be used to manufacture mixed oxide fuel from surplus weapons plutonium.

The proposed MOX FFF would be constructed in F Area at the Department of Energy's (DOE) Savannah River Site (SRS) in Aiken County, South Carolina, (see three enclosed figures). NRC requests that the South Carolina Department of Natural Resources provide information regarding state listed threatened, endangered, and rare species that may occur on or in the vicinity of F Area at SRS that should be considered in preparing the EIS.

The MOX FFF and associated infrastructure would occupy approximately 6.9 ha of the 16.6 ha project site. The remainder of the site will be landscaped. The F area is an upland plateau that is designated for industrial use. A portion of the MOX FFF project site was previously used to store excavation material from another project site facility constructed in the F Area. About 68 percent of the MOX FFF site is composed of planted longleaf and slash pine forest. No wetlands occur within the area proposed for the MOX FFF (see enclosed land cover figure), but wetlands associated with Upper Three Runs Creek are adjacent to and downslope of the project site. Operational impacts would be minimized as airborne and aqueous releases would comply with applicable standards and permit requirements. Preliminary analyses presented in the environmental report for the MOX FFF prepared by the applicant DCS (a consortium formed by Duke Engineering & Services, COGEMA, Inc., and Stone and Webster) indicate that the impacts to ecological resources from facility construction and operation would be limited to the immediate project site vicinity.

J. Holling 2

I wish to thank you in advance for the information on the threatened, endangered, and rare species in South Carolina that you believe should be addressed in the EIS. Please mail your response to me within 30 days of the date of this letter.

If you have any questions, please contact me at (301) 415-7293, or Jennifer Davis at (301) 415-5874.

Sincerely,

Phyllis Sobel for Charlotte Abrams

Charlotte E. Abrams, Section Chief
Environmental and LLW Section
Environmental and Performance
Assessment Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Docket: 70-3098

Enclosures: Notice of Intent
F Area Figures
Land Cover Figure

cc: See attached list

J. Holling 3

Letter to Julie Holling, South Carolina Department of Natural Resources, dated September 24, 2001

cc: Mary Birch, P.E., C.H.P.
Environment, Safety and Health Manager
Duke COGEMA Stone & Webster
PO Box 31847
Charlotte, NC 28231-1847

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Ruth Thomas
Environmentalists, Inc.
1339 Sinkler Road
Columbia, SC 29206

Edna Foster
120 Balsam Lane
Highlands, NC 28741

Enclosures to letter from Abrams not included.

Department of Energy
National Nuclear Security Administration
Washington, DC 20585

September 25, 2001

Dr. Roger Stroup
South Carolina State Historic Preservation Officer
South Carolina Department of Archives and History
8301 Parklane Road
Columbia, South Carolina 29223

Subject: Designation of Department of Energy as Lead Agency for Mitigation at Proposed Location of the Mixed Oxide Fuel Fabrication Facility

Dear Dr. Stroup:

This letter is to notify you that the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC) are designating DOE as the lead federal agency, pursuant to 36 C.F.R. 800.2 (a)(2), for mitigation of potential effects to Register-eligible site 38AK546. That site is located at the proposed location of the Mixed Oxide Fuel Fabrication Facility (MOX FFF) at DOE's Savannah River Site in South Carolina.

In May 2000, your office concurred with DOE's recommendation that archaeological site 38AK546/547 was eligible under Criterion (d), 36 C.F.R. 60.4, for inclusion in the National Register of Historic Places. Following consultation, your office also concurred with the Mitigation Plan for the site. The mitigation field work is expected to begin in October, 2001.

The MOX FFF, which could affect site 38AK546, is being funded by DOE and is part of DOE's program for the disposition of surplus plutonium. The MOX FFF is also subject to NRC licensing. Thus, the MOX FFF constitutes an undertaking by both DOE and NRC pursuant to 36 C.F.R. 800.16 (y) and sections 106 and 301 of the National Historic Preservation Act, 16 U.S.C. 470f and 470w(7).

Because the potential MOX FFF and affected archaeologic site are located at DOE's Savannah River Site, they are also within the purview of DOE's 1990 "Programmatic Memorandum of Agreement Among the Savannah River Operations Office, United States Department of Energy, the South Carolina State Historic Preservation Officer and the Advisory Council on Historic Preservation Concerning the Management of Archaeological Sites on the Savannah River Site; Aiken, Allendale and Barnwell Counties, South Carolina." Under these circumstances, DOE and NRC have determined that it is appropriate to identify DOE as the lead federal agency for

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mitigation of site SBAKzde.

Please be advised that the NRC will analyze archaeologic impacts and related mitigation in its Environmental Impact Statement, pursuant to the National Environmental Policy Act (NEPA), for the proposed licensing of the MOX FFF. As part of the NEPA process, archaeological information has also been submitted to NRC in the Environmental Report prepared by Duke, Cogema, Stone and Webster (DCS), the MOX FFF license applicant, under contract with DOE.

The lead agency approach outlined above has been discussed previously with your office by staff from DOE's Savannah River Site. Both agencies agree that any written correspondence from the SHPO to DOE should be sent to NRC as well. If you should have any additional questions regarding the MOX program or the identification of DOE as lead agency, please feel free to contact Mr. James Johnson at (202) 586-2960 for appropriate coordination.

Sincerely,

Charlotte E. Abrams, Section Chief
Environmental and Low Level Waste Section
Division of Waste Management
U.S. Nuclear Regulatory Commission

L. David Nulton, Director
Reactors Group
Office of Fissile Materials Disposition

cc:
Peter Hastings, DCS
Andrew Persinko, NRC
Allison Blackman, SRS, ODNM
James V. Johnson, DOE, MM-91

Mr. Chad Lowe
South Carolina State Historic Preservation Office
South Carolina Department of Archives and History
8301 Parklane Road
Columbia, SC 29223

Dear Mr. Lowe:

SUBJECT: Data Recovery Projects 38AK249 and 38AK121 at the Savannah River Site

I am writing to inform you that the Savannah River Archaeological Research Program (SRARP) has completed the data recovery projects conducted at 38AK249 and 38AK121. The excavations were conducted to mitigate impacts caused by construction of the Mixed Oxide Fuel Facility and the Pit Disassembly and Conversion Facility on the Department of Energy's Savannah River Site.

Investigations at 38AK249 were completed on 19 April 2002 and the excavations at 38AK121 ended on 12 September 2002. Exceeding the recommendations in the data recovery plans for each site, a total of 155 square meters was excavated at 38AK249 and 300 square meters were investigated at 38AK121. Except for monitoring ground disturbing activities associated with several construction of these facilities, all fieldwork outlined in the data recovery plans has been completed. Staff members from the SRARP will monitor the removal of fill on the site where mixed construction begins late next year.

Pursuant environmental documentation regarding that DOE-SR have written concurrence from the SC SHPO that our field applications have been met. If your concurrence please send a written concurrence or if you have questions or need additional information before sending that concurrence, then call Dennis Keyes at (803) 952-8182. Thank you for your assistance in this matter.

Sincerely,

Signature illegible

A. B. Comer, Director
Environmental Quality
Management Division

EQMD:DK:ore

OE-03-003

pc: EQMD Read File
Dennis Keyes, EQMD
A. King, SRARP
MNEST Read File
A. M. Blackmon, ODNN

S. C. Department of Archives & History • 1430 Pendleton Road • Columbia • South Carolina • 29205-2825 • (803) 896-6100 • www.scdah.sc.gov

Mr. A.R. Gould, Director
Environmental Quality
Department of Energy, Savannah River Operations Office
P.O. Box A
Aiken, SC 29802

RECEIVED
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MAIL CONTROL

November 21, 2005

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ORIGINAL

RE: Data Recovery Projects 38AK248 and 38AK257 at the Savannah River Site

Dear Mr. Gould:

I am writing to inform you that our office concurs with the Department of Energy's determination that field applications have been met for data recovery investigations at 38AK248 and 38AK257. The excavations exceeded the requirements of the approved data recovery plans. We look forward to receiving the results.

This letter was written to assist you with your obligations under Section 106 of the National Historic Preservation Act, as amended, and the regulations codified at 36 CFR Part 800. Please contact me at 803-896-6181 if you have any questions or concerns regarding this matter.

Sincerely,

Chad C. Long
State Archaeologist
State Historic Preservation Officer

cc: Mark Brooks

APPENDIX C:

TRANSPORTATION RISK ANALYSIS

Appendix C:

Transportation Risk Analysis

This appendix provides the detailed methodology, input parameters and assumptions, and results for the transportation risk analysis performed in support of this Mixed Oxide Fuel Fabrication Facility Environmental Impact Statement (MOX EIS). The analysis evaluates transportation of depleted uranium hexafluoride (UF_6) from the Portsmouth Gaseous Diffusion Plant in Portsmouth, Ohio, to the General Electric (GE) Fuel Fabrication Facility in Wilmington, North Carolina; transportation of the uranium dioxide (UO_2) conversion product from Wilmington to the proposed MOX facility; transportation of plutonium metal from U.S. Department of Energy (DOE) storage sites; and transportation of the fresh MOX fuel from the proposed MOX facility to a surrogate nuclear power plant site.

C.1 Methodology

C.1.1 Overview

The transportation risk assessment considers human health risks from routine transport (normal, incident-free conditions) of hazardous materials and from potential accidents. In both cases, risks associated with the nature of the cargo itself, or “cargo-related” impacts, and those related to the transportation vehicle (regardless of type of cargo), or “vehicle-related” impacts, are considered.

C.1.1.1 Routine Transportation Risk

The radiological risk associated with routine transportation is cargo-related and results from the potential exposure of people to low levels of external radiation near a loaded shipment. It is assumed that there are no cargo-related risks posed by incident-free transport of hazardous chemicals. No direct chemical exposure to radioactive material will occur during routine transport because, as discussed in Section C.2.2, these materials will be in Type A or B packages, which are designed and maintained to ensure that they will contain and shield their contents during normal transport. Any leakage or unintended release would be considered under accident risks.

Vehicle-related risks during routine transportation are caused by potential exposure to increased vehicular emissions. These emissions include diesel exhaust, tire and brake particulate emissions, and fugitive dust raised from the roadbed by passing vehicles.

C.1.1.2 Accident Transportation Risk

The cargo-related radiological risk from transportation-related accidents lies in the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people through multiple exposure pathways, such as exposure to contaminated soil, inhalation, or the ingestion of contaminated food. Cargo-related hazardous chemical accident impacts to human health during transportation come from immediate inhalation exposure resulting from container failure and chemical release during an accident.

Vehicle-related accident risks refer to the potential for transportation-related accidents that result in fatalities caused by physical trauma unrelated to the cargo.

C.1.2 Routine Risk Assessment Methodology

The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used in the routine and accident cargo-related risk assessments to estimate the radiological impacts to collective populations. RADTRAN 4 was developed by Sandia National Laboratories to calculate population risks associated with the transportation of radioactive materials by truck, rail, air, ship, or barge. The code has been used extensively for transportation risk assessments since it was originally issued in the late 1970s as RADTRAN (RADTRAN 1) and has been reviewed and updated periodically. RADTRAN 1 was originally developed to facilitate the calculations presented in NUREG-0170 (NRC 1977b).

C.1.2.1 Collective Population Risk

The radiological risk associated with routine transportation results from the potential exposure of people to low-level external radiation in the vicinity of loaded shipments. Even under routine transportation, some radiological exposure could occur. Because the radiological consequences (dose) would occur as a direct result of normal operations, the probability of routine consequences is taken to be 1 in the RADTRAN 4 code. Therefore, the dose risk is equivalent to the estimated dose.

For routine transportation, the RADTRAN 4 computer code considers major groups of potentially exposed persons. The RADTRAN 4 calculations of risk for routine highway and rail transportation include exposures of the following population groups:

- *Persons along the Route (Off-Link Population)*. Collective doses were calculated for all persons living or working within 0.8 km (0.5 mi) of each side of a transportation route. The total number of persons within the 1.6-km (1-mi) corridor was calculated separately for each route considered in the assessment.

- *Persons Sharing the Route (On-Link Population)*. Collective doses were calculated for persons in all vehicles sharing the transportation route. This group includes

persons traveling in the same or opposite directions as the shipment, as well as persons in vehicles passing the shipment.

- *Persons at Stops*. Collective doses were calculated for people who might be exposed while a shipment was stopped en route. For truck transportation, these stops include those for refueling, food, and rest.

- *Crew Members*. Collective doses were calculated for truck transportation crew members involved in the actual shipment of material. Workers involved in loading or unloading were not considered. The doses calculated for the first three population groups were added together to yield the collective dose to the public; the dose calculated for the fourth group represents the collective dose to workers.

The RADTRAN 4 calculations for routine dose generically compute the dose rate as a function of distance from a point source (Neuhauser and Kanipe 1995). Associated with the calculation of routine doses for each exposed population group are parameters such as the radiation field strength, the source-receptor distance, the duration of exposure, vehicular speed, stopping time, traffic density, and route characteristics (such as population density). The RADTRAN manual contains derivations of the equations used and descriptions of these parameters (Neuhauser and Kanipe 1995).

C.1.2.2 Maximally Exposed Individual Risk

In addition to the assessment of the routine collective population risk, the risk to a maximally exposed individual (MEI) was estimated. In RADTRAN 4, the MEI is assumed to be located 30 m (100 ft) from the transport route as the radioactive shipment passes by at a speed of 24 km/h (15 mph).

C.1.2.3 Vehicle-Related Risk

Vehicle-related health risks resulting from routine transportation are associated with the generation of air pollutants by transport vehicles during shipment and would be independent of the radioactive or chemical nature of the shipment. The health endpoint assessed under routine transportation conditions was the excess latent mortality from inhalation of vehicular emissions. These emissions consist of particulate matter in the form of diesel engine exhaust, tire and brake particulates, and fugitive dust raised from the roadway by the transport vehicle. Risk factors for pollutant inhalation in terms of latent mortality have been used in this analysis. Vehicle-related risks from routine transportation were calculated for each shipment by multiplying the total distance traveled by the appropriate risk factor.

C.1.3 Accident Assessment Methodology

As stated above, the radiological transportation accident risk assessment also uses the RADTRAN 4 code for estimating collective population risks. The hazardous chemical transportation accident risk assessment relies on the HGSYSTEM model (Post 1994a,b; Hanna et al. 1994). The model is a widely applied code recognized by the U.S. Environmental Agency (EPA) for use in chemical accident consequence predictions. The FIREPLUME model (Brown et al. 1997) was used to supplement the HGSYSTEM model in the analysis of fire scenarios involving depleted uranium releases. The HGSYSTEM and FIREPLUME models were used previously in assessing the hazardous chemical transportation impacts from transportation of depleted uranium materials (Biwer et al. 1997).

The risk analysis for potential accidents differs fundamentally from the risk analysis for routine transportation because occurrences of accidents are statistical in nature. The accident risk assessment is treated probabilistically in RADTRAN 4 for radiological risk and in the HGSYSTEM approach used to estimate the hazardous chemical component of risk. Accident risk is defined as the product of the accident consequence (dose or exposure) and the probability of the accident's occurring. In this respect, RADTRAN 4 and the HGSYSTEM approach both estimate the collective accident risk to populations by considering a spectrum of transportation-related accidents. The spectrum of accidents was designed to encompass a range of possible accidents, including low-probability accidents that have high consequences, and high-probability accidents that have low consequences (such as "fender benders"). For radiological risk, the results for collective accident risk can be directly compared with the results for routine collective risk because the latter results implicitly incorporate a probability of occurrence of 1 if the shipment takes place. Such is not the case for chemical materials, because routine transport would pose no exposure risk.

C.1.3.1 Radiological Accident Risk Assessment

The RADTRAN 4 calculation of collective accident risk uses models that quantify the range of potential accident severities and the responses of transported packages to accidents. The spectrum of accident severity is divided into several categories, each of which is assigned a conditional probability of occurrence — that is, the probability that if an accident does occur, it will be of a particular severity. Release fractions, defined as the fraction of the material in a package that could be released in an accident, are assigned to each accident severity category on the basis of the physical and chemical form of the material. The model takes into account the mode of transportation and the type of packaging. The accident rates, the definition of accident severity categories, and the release fractions used in this analysis are discussed further in Sections C.2 and C.3.

For accidents involving the release of radioactive material, RADTRAN 4 assumes that the material is dispersed in the environment according to standard Gaussian diffusion models. For the risk assessment, default data for atmospheric dispersion were used, representing an instantaneous ground-level release and a small-diameter source cloud (Neuhauser and Kanipe

1995). The calculation of the collective population dose following the release and dispersal of radioactive material includes the following exposure pathways:

- External exposure to the passing radioactive cloud,
- External exposure to contaminated ground,
- Internal exposure from inhalation of airborne contaminants, and
- Internal exposure from the ingestion of contaminated food.

For the ingestion pathway, state-average food transfer factors, which relate the amount of radioactive material ingested to the amount deposited on the ground, were calculated in accordance with the methods described by U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 (NRC 1977a) and were used as input to the RADTRAN code. Doses of radiation from the ingestion or inhalation of radionuclides were calculated by applying standard dose conversion factors (DOE 1988a,b).

C.1.3.2 Chemical Accident Risk Assessment

The risks from exposure to hazardous chemicals during transportation-related accidents can be either acute (resulting in immediate injury or fatality) or latent (resulting in cancer that would present itself after a latency period of several years). The acute health endpoint, potential irreversible adverse effects, was evaluated for the assessment of cargo-related population impacts from transportation accidents. Accidental releases during transport of the uranium compounds (UF_6 and UO_2) were evaluated quantitatively.

The acute effects evaluated were assumed to exhibit a threshold nonlinear relationship with exposure; that is, some low level of exposure can be tolerated without inducing a health effect. To estimate risks, chemical-specific concentrations were developed for potential irreversible adverse effects. All individuals exposed at these levels or higher following an accident were included in the transportation risk estimates. In addition to acute health effects, the cargo-related risk of excess cases of latent cancer from accidental chemical exposures could be evaluated. However, none of the chemicals that might be released in any of the accidents would be carcinogenic. As a result, no predictions for excess latent cancers from accidental chemical releases are presented in this report.

The primary exposure route of concern with respect to accidental release of hazardous chemicals would be inhalation. Although direct exposure to hazardous chemicals via other pathways, such as ingestion or absorption through the skin (dermal absorption), would also be possible, these routes would be expected to result in much lower exposure than the inhalation pathway doses for the uranium compounds. The likelihood of acute effects would be much less for the ingestion and dermal pathways than for inhalation.

The HGSYSTEM model (Version 3.0) (Hanna et al. 1994) has a built-in source-term algorithm that is used to compute the rate, quantity, and type of atmospheric release of a hazardous air pollutant, including pool evaporation from a spill of a volatile organic liquid. The model can be used to evaluate frequently encountered accidental releases from ruptured tanks, drums, and pipes. The model incorporates a chemical data library of physical and chemical properties (such as vapor pressure, boiling point, and molecular weight) for 30 compounds. Physical properties of the chemical released, along with container content input, such as the container geometry and rupture characteristics (e.g., hole size), are used by HGSYSTEM to compute chemical release rate and duration. The risk assessment for hazardous chemicals assumed that particulate releases would be of short duration as liquid and solid (as respirable fraction) aerosols.

The approach for hazardous chemicals incorporates the same accident severity categories and release fractions used by RADTRAN 4 for radiological accidents. The risks associated with the consequences estimated with the HGSYSTEM code were computed separately with a risk quantification spreadsheet program.

C.1.3.3 Vehicle-Related Accident Risk Assessment

The vehicle-related accident risk refers to the potential for transportation accidents that could result directly in fatalities not related to the nature of the cargo in the shipment. This risk represents fatalities from physical trauma. State-average rates for transportation fatalities are used in the assessment. Vehicle-related accident risks are calculated by multiplying the total distance traveled by the rates for transportation fatalities. In all cases, the vehicle-related accident risks are calculated on the basis of distances for round-trip shipment since the presence or absence of cargo would not be a factor in accident frequency.

C.2 Input Parameters and Assumptions

The principal input parameters and assumptions used in the transportation risk assessment are discussed in this section. Where appropriate, applicable government regulations are referenced. Transportation of hazardous chemical and radioactive materials is governed by U.S. Department of Transportation (DOT), NRC, and EPA regulations, and by the Hazardous Materials Transportation Act. These regulations may be found in the *Code of Federal Regulations* (CFR) at 49 CFR Parts 171-178, 49 CFR Parts 383-397, 10 CFR Part 71, and 40 CFR Parts 262 and 265, respectively. State organizations are also involved in regulating such transport within their borders. All transportation-related activities must be in accordance with applicable regulations of these agencies. However, the DOT and NRC have primary regulatory responsibility for shipment of radioactive materials. Those regulations most pertinent to this risk assessment can be found in 49 CFR 173 (*Shippers—General Requirements for Shipments and Packagings*), 49 CFR 397 (*Transportation of Hazardous Materials; Driving and Parking Rules*), and 10 CFR 71 (*Packaging and Transportation of Radioactive Material*).

C.2.1 Route Characteristics

The transportation route selected for a shipment determines the total potentially exposed population and the expected frequency of transportation-related accidents. For truck transportation, the route characteristics most important to the risk assessment include the total shipping distance between each origin-and-destination pair of sites and the population density along the route.

C.2.1.1 Route Selection

The DOT routing regulations concerning radioactive materials on public highways are prescribed in 49 CFR 397.101(*Requirements for Motor Carriers and Drivers*). The objectives of the regulations are to reduce the impacts of transporting radioactive materials, to establish consistent and uniform requirements for route selection, and to identify the role of state and local governments in routing radioactive materials. The regulations attempt to reduce potential hazards by prescribing that populous areas be avoided and that travel times be minimized. In addition, the regulations require that the carrier of radioactive materials ensure that the vehicle is operated on routes that minimize radiological risks, and that accident rates, transit times, population density and activity, time of day, and day of week are considered in determining risk. However, the final determination of the route is left to the discretion of the carrier, such as for shipments of depleted UF_6 and UO_2, unless the shipment contains a "highway route controlled quantity" (HRCQ) of radioactive material as defined in 49 CFR 173.403 (*Definitions*), such as the plutonium metal or the MOX fuel.

A vehicle transporting an HRCQ of radioactive materials is required to use the interstate highway system except when moving from origin to interstate or from interstate to destination, when making necessary repair or rest stops, or when emergency conditions make continued use of the interstate unsafe or impossible. Carriers are required to use interstate circumferential or bypass routes, if available, to avoid populous areas. Any state or Native American tribe may designate other "preferred highways" to replace or supplement the interstate system. Under its authority to regulate interstate transportation safety, the DOT can prohibit state and local bans and restrictions as "undue restraint of interstate commerce." State or local bans can be preempted if inconsistent with the HRCQ regulations.

For this analysis, representative shipment routes were identified using the WebTRAGIS (Version 1.10) routing model (Johnson and Michelhaugh 2000) for the truck shipments. The routes were selected to be reasonable and consistent with routing regulations and general practice, but they are considered only representative because the actual routes used would be chosen in the future and are often determined by the shipper. At the time of shipment, route selection would reflect current road conditions, including road repairs and traffic congestion.

The HIGHWAY data network in WebTRAGIS is a computerized road atlas that includes a complete description of the interstate highway system and of all U.S. highways. In addition, most principal state highways and many local and community highways are identified. The

code is periodically updated to reflect current road conditions and has been compared with reported mileages and observations of commercial trucking firms.

Routes are calculated within the model by minimizing the total impedance between origin and destination. The impedance is basically defined as a function of distance and driving time along a particular segment of highway. The population densities along a route are derived from 2000 census data from the U.S. Bureau of the Census.

The WebTRAGIS database version used was Highway Data Network 2.1. Summary route information on the truck routes used in the analysis is provided in Table C.1.

C.2.1.2 Population Density

Three population density zones — rural, suburban, and urban — were used for the population risk assessment. The fractions of travel and average population density in each zone were determined with the WebTRAGIS routing model. Rural, suburban, and urban areas are characterized according to the following breakdown: rural population densities range from 0 to 54 persons/km^2 (0 to 39 persons/mi^2); suburban densities range from 55 to 1,284 persons/km^2 (140 to 3,326 persons/mi^2); and urban covers all population densities greater than 1,284 persons/km^2 (3,326 persons/mi^2). Use of these three population density zones is based on an aggregation of the 11 population density zones provided in the WebTRAGIS model output. For calculation purposes, information about population density was generated at the state level and used as RADTRAN input for all routes. Route average population densities and other route characteristics are given in Table C.1.

C.2.1.3 Accident and Fatality Rates

For calculating accident risks, vehicle accident involvement and fatality rates are taken from data provided in Saricks and Tompkins (1999). For each transport mode, accident rates are generically defined as the number of accident involvements (or fatalities) in a given year per unit of travel by that mode in the same year. Therefore, the rate is a fractional value — the accident-involvement count is the numerator, and vehicular activity (total traveled distance) is the denominator. Accident rates are derived from multiple-year averages that automatically account for such factors as heavy traffic and adverse weather conditions. For assessment purposes, the total number of expected accidents or fatalities is calculated by multiplying the total shipping distance for a specific case by the appropriate accident or fatality rate.

For truck transportation, the rates presented in Saricks and Tompkins (1999) are specifically for heavy combination trucks involved in interstate commerce. Heavy combination trucks are rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other and the tractor. Heavy combination trucks are typically used for shipping radioactive wastes. Truck accident rates are computed for each state on the basis of

Table C.1. Summary route data

Route		Total distance		Fraction of travel			Average population density [persons/km² (persons/mi²)]					
Origin	Destination	[km	(mi)]	Rural	Suburban	Urban	Rural		Suburban		Urban	
Portsmouth, Ohio	Wilmington, N.C.	936	(581)	55.5	40.7	3.9	18.5	(47.8)	366.7	(949.8)	2155	(5582)
Wilmington, N.C.	PDCF	443	(275)	60.1	37.5	2.4	15.7	(40.7)	353.1	(914.6)	2140	(5543)
Pantex	PDCF	2,179	(1,354)	67.8	28.5	3.7	13.4	(34.6)	332.4	(861.0)	2271	(5882)
Hanford Site	PDCF	4,434	(2,755)	76.7	20.9	2.3	11.3	(29.2)	320.5	(830.1)	2244	(5811)
Proposed MOX facility	WIPP	2,442	(1,518)	70.7	26.7	2.6	13.2	(34.2)	315.6	(817.4)	2173	(5627)
Proposed MOX facility	Surrogate Nuclear Power Plant	2,147	(1,334)	57.1	37.4	5.5	18.5	(47.8)	342.1	(886.1)	2,366	(6,128)

statistics compiled by the DOT Office of Motor Carriers for 1994 to 1996. Saricks and Tompkins (1999) present accident involvement and fatality counts, estimated kilometers of travel by state, and the corresponding average accident involvement and fatality rates for the 3 years investigated. Fatalities (including of crew members) are deaths that are attributable to the accident and that occurred within 30 days of the accident.

The truck accident assessment presented in this EIS uses accident (fatality) rates for travel on interstate highways. The total accident risk for a case depends on the total distance traveled in various states and does not rely on national average accident statistics. However, for comparative purposes, the national average truck accident rate on interstate highways presented in Saricks and Tompkins (1999) is 3.15×10^{-7} accidents/truck-km (5.07×10^{-7} accidents/mi).

Note that the accident rates used in this assessment were computed using all interstate shipments, regardless of the cargo. Saricks and Kvitek (1994) point out that shippers and carriers of radioactive material generally have a higher-than-average awareness of transportation risk and prepare cargoes and drivers for such shipments accordingly. This preparation should have the twofold effect of reducing component and equipment failure and mitigating the contribution of human error to accident causation. However, these mitigating effects were not considered in the accident assessment.

C.2.2 Packaging

Shipment packaging for radioactive materials must be designed, constructed, and maintained to ensure that it will contain and shield the contents during normal transportation. For more highly radioactive material, the packaging must contain and shield the contents in severe accidents. The type of packaging used is determined by the radioactive hazard associated with the packaged material. The basic types of packaging required by the applicable regulations are designated as Type A, Type B, or industrial packaging (generally for low-specific-activity [LSA] material).

C.2.2.1 Depleted UF_6 and UO_2 Packaging

Depleted UF_6 and UO_2 shipments would use Type A packaging. This type of packaging must withstand the conditions of normal transportation without the loss or dispersal of the radioactive contents, as specified in 49 CFR 173.413 (*Additional Design Requirements for Type A Packages*). "Normal" transportation refers to all transportation conditions except those resulting from accidents or sabotage. Approval of Type A packaging is obtained by demonstrating that the packaging can withstand specified testing conditions intended to simulate normal transportation. Type A packaging usually does not require special handling, packaging, or transportation equipment. The depleted UF_6 would be shipped in Model 30B cylinders (USEC 1999) with overpacks, and the depleted UO_2 would be shipped in 30-gal drums.

C.2.2.2 Plutonium Metal, MOX Fuel, and TRU Waste

The plutonium metal, MOX fuel, and TRU waste would be shipped in Type B packaging. In addition to meeting all the Type A standards, Type B packaging must also provide a high degree of assurance that the package integrity will be maintained even during severe accidents, with essentially no loss of the radioactive contents or serious impairment of the shielding capability. Type B packaging is required for shipping large quantities of radioactive material and must satisfy stringent testing criteria (as specified in 10 CFR 71). The testing criteria were developed to simulate conditions of severe hypothetical accidents, including impact, puncture, fire, and immersion in water. The most widely recognized Type B packagings are the massive casks used to transport highly radioactive spent nuclear fuel from nuclear power stations. Large-capacity cranes and mechanical lifting equipment are usually necessary for handling Type B packagings. Many Type B packagings are transported on trailers specifically designed for that purpose.

Plutonium metal as pits is expected to be shipped in DOE-approved FL containers, while piece parts might be shipped in DOE-approved USA/9975 containers (DOE 1999b). TRU waste would be transported to the WIPP in Type B containers referred to as the Transuranic Package Transporter-II (TRUPACT-II).

The MOX fresh fuel package is a Type B cylindrical container designed to carry three MOX fuel assemblies. MOX fuel does not require specific shielding material, and the containment shell provides a single containment boundary in accordance with 10 CFR 71.63(b)(1). The current design (DCS 2001b) specifies 4.46 m (175 in.) as the overall package length without the impact limiters. The impact limiters themselves are of a conventional polyurethane filled design and have an outer diameter of 1.5 m (60 in.). The outer diameter of the package containment shell is 0.74 m (29 in.). The package is designed to accommodate 3,200 kg (7,100 lb) of payload, including internal supports and the fuel assemblies. The package gross weight is 6,580 kg (14,500 lb).

C.2.3 Shipment Configurations and Number of Shipments

The anticipated shipment information for the proposed action is summarized in Table C.2. Table C.3 lists the radionuclide inventory for each shipment type. Depleted UF_6 shipments would consist of five overpacked 30B cylinders per truck, as depicted in Figure C.1. Each cylinder would contain about 2,277 kg (5,020 lb) of depleted UF_6. Depleted UO_2 shipments would consist of 24 30-gal drums in a commercial covered tractor trailer. Each drum would contain approximately 667 kg (1,470 lb) of depleted UO_2. For this analysis, sufficient quantities of UF_6 and UO_2 were assumed to be shipped so that a total of 34 MT(37.5 tons) of plutonium could be fabricated into MOX fuel assemblies for irradiation as reactor fuel (DCS 2002a). Thus, a total of 110 shipments of depleted UF_6 and 60 shipments of depleted UO_2 would be required.

As discussed in Section 4.4.1.1, it was assumed that 26.7 MT (29.4 tons) of plutonium would require transportation to the PDCF from Pantex and Hanford. On the basis of the information

Table C.2. Shipment information

Origin	Destination	Material	Package type	Amount per package [kg (lb)]	Packages per shipment	Number of shipments
Portsmouth, Ohio	Wilmington, N.C.	UF_6	30B cylinder	2,277 (5,020)	5	110
Wilmington, N.C.	MOX facility	UO_2	30-gal drum	667 (1,470)	24	60
Pantex	PDCF	Pu metal	Type B	124 (273)	NA[a]	343
Hanford	PDCF	Pu metal	Type B	124 (273)	NA	87
MOX facility	Surrogate nuclear power plant	MOX fuel	Type B	3 assemblies	1	598
WSB	WIPP	TRU waste	TRUPACT-II	2,590 (5,700)	3	350

[a]Not available, dependent on actual container used.

presented in Didlake (1998), approximately 124 kg (273 lb) of plutonium would be in each shipment. The plutonium would be packaged in a suitable Type B container and shipped via the SafeGuards Transporter (SGT) discussed later in this section.

Approximately 1,748 MOX fuel assemblies would be shipped to commercial reactor sites. Transport of the MOX fuel would be by SGT, one MOX fuel package per shipment. Figure C.2 shows a representative shipment configuration. With three assemblies per shipping cask, 598 shipments would be expected between the years 2007 and 2021 (DCS 2002a).

The SGT is a specially designed component of a tractor-trailer vehicle and is used by the Transportation Safeguards Division (TSD) of the DOE Albuquerque Operations Office for the transport of special nuclear materials, such as plutonium. Since its establishment in 1975, the Office of Transportation Safeguards has accumulated more than 151 million km (94 million mi) of travel transporting DOE-owned cargo without an accident involving a fatality or a release of radioactive material. Although details of vehicle enhancements and some operational aspects are classified, key characteristics are as follows (DOE 1999b):

- Enhanced structural characteristics and a highly reliable tie-down system to protect the cargo from impact,
- Heightened thermal resistance to protect the cargo in case of fire,
- Established operational and emergency plans and procedures governing the shipment of nuclear materials,
- Couriers who are armed federal officers and who have received vigorous specialized training,
- An armored tractor component that provides courier protection against attack and contains advanced communications equipment,

Table C.3. Single-shipment radionuclide inventories (Ci)[a]

Isotopes	UF_6	UO_2	Pu metal	MOX fuel[b]	TRU waste[c]
U-234	0.474	0.868	NA[d]	NA	0.0214
U-235	0.0445	0.0752	NA	0.00706	0.000492
U-238	2.57	4.74	NA	0.438	5.04×10^{-6}
Th-234	2.57	4.74	NA	NA	NA
Pa-234m	2.57	4.74	NA	NA	NA
Pu-236	NA	NA	NA	2.22	NA
Pu-238	NA	NA	836	429	0.0763
Pu-239	NA	NA	7,070	4,860	0.526
Pu-240	NA	NA	1,730	1,080	0.102
Pu-241	NA	NA	129,000	43,000	9.17
Pu-242	NA	NA	0.494	0.0956	3.49×10^{-5}
Am-241	NA	NA	3,820	NA	3,390

[a]To convert from Ci to Bq, multiply by 3.7×10^{10}.

[b]Source: DCS (2001b).

[c]Source: DCS (2002b).

[d]NA = not applicable.

Figure C.1. Trailer carrying five UF_6 cylinders in overpacks (Photo courtesy of United States Enrichment Corporation [USEC 1999])

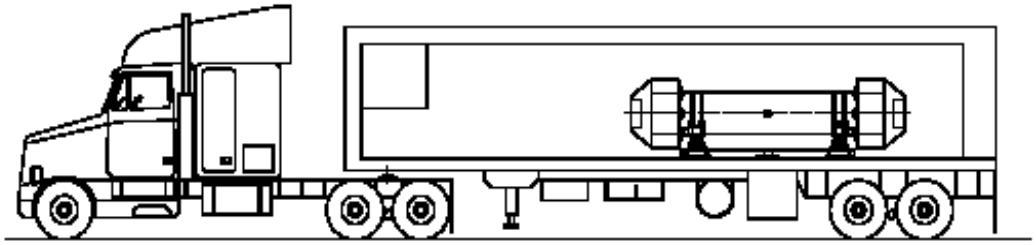

Figure C.2. MOX fresh fuel package loaded in SGT

- Specially designed escort vehicles containing advanced communications and additional couriers,
- 24-hour-a-day, real-time communications to monitor the location and status of all SGT shipments, and
- Significantly more stringent maintenance standards than those for commercial transport equipment.

TRU waste was assumed to be fixed in cement, placed in standard waste boxes (SWBs), and shipped in TRUPACT-II containers from the WSB to the WIPP for disposal (DCS 2002b). Each SWB was assumed to contain 1,290 kg (2,850 lb) of cement. Each TRUPACT-II contained 2 SWBs, and each truck shipment consisted of 3 TRUPACT-II containers. Approximately 35 shipments of TRU waste per year were estimated (DCS 2002a), resulting in about 350 shipments over a 10-year operational period.

C.2.4 Accident Characteristics

Assessment of transportation accident risk takes into account the fraction of material in a package that would be released or spilled to the environment during an accident, commonly referred to as the release fraction. The release fraction is a function of the severity of the accident and the material packaging. For instance, a low-impact accident, such as a "fender-bender," would not be expected to cause any release of material. Conversely, a very severe accident would be expected to release nearly all of the material in a shipment into the environment. The method used to characterize accident severities and the corresponding release fractions for estimating both radioactive and chemical risks are described below.

C.2.4.1 Accident Severity Categories

A method to characterize the potential severity of transportation-related accidents has been described in the NRC NUREG-0170 report, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977b). The NRC method divides the spectrum of transportation accident severities into eight categories. Other studies have divided the same accident spectrum into six categories (Wilmot 1981), 20 categories (Fischer et al. 1987), or more (Sprung et al. 2000); however, these latter studies focused primarily on accidents involving shipments of spent nuclear fuel (SNF). In this analysis, the NUREG-0170 scheme was used for all shipments.

The NUREG-0170 scheme for accident classification is shown in Figure C.3 for truck transportation. Severity is described as a function of the magnitudes of the mechanical forces (impact) and thermal forces (fire) to which a package may be subjected during an accident. Because all accidents can be described in these terms, severity is independent of the specific accident sequence. In other words, any sequence of events that results in an accident in which a package is subjected to forces within a certain range of values is assigned to the accident

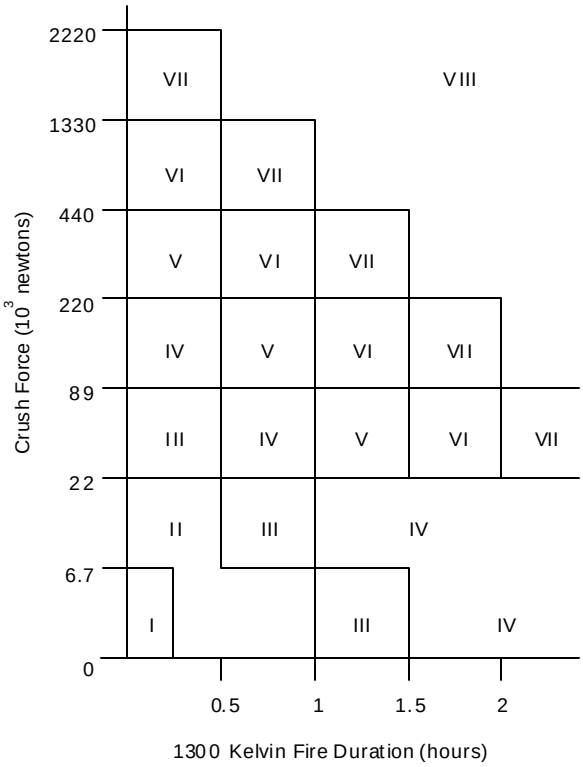

Figure C.3. Scheme for NUREG-0170 classification by accident severity category for truck accidents (*Source*: NRC 1977b)

severity category associated with that range. The scheme for accident severity is designed to take into account all credible transportation-related accidents, including those accidents with low probability but high consequences and those with high probability but low consequences.

Each severity category represents a set of accident scenarios defined by a combination of mechanical and thermal forces. A conditional probability of occurrence — that is, the probability that if an accident occurs, it is of a particular severity — is assigned to each category. The fractional occurrences for accidents by accident severity category and population density zone are shown in Table C.4 and are used for estimating both radioactive and chemical risks.

Category I accidents are the least severe but the most frequent; Category VIII accidents are very severe but very infrequent. To determine the expected frequency of an accident of a given severity, the conditional probability in the category is multiplied by the baseline accident rate. Each population density zone has a distinct distribution of accident severities related to differences in average vehicular velocity, traffic density, location (rural, suburban, or urban), and other factors.

Table C.4. Fractional occurrences for truck accidents by severity category and population density zone

Severity category	Fractional occurrence	Fractional occurrence by population density zone		
		Rural	Suburban	Urban
Truck				
I	0.55	0.1	0.1	0.8
II	0.36	0.1	0.1	0.8
III	0.07	0.3	0.4	0.3
IV	0.016	0.3	0.4	0.3
V	0.0028	0.5	0.3	0.2
VI	0.0011	0.7	0.2	0.1
VII	8.5×10^{-5}	0.8	0.1	0.1
VIII	1.5×10^{-5}	0.9	0.05	0.05

Source: NRC (1977b).

C.2.4.2 Package Release Fractions

In NUREG-0170, radiological and chemical consequences are calculated by assigning package release fractions to each accident severity category. The release fraction is defined as the fraction of the material in a package that could be released from the package as the result of an accident of a given severity. Release fractions take into account all mechanisms necessary to create release of material from a damaged package to the environment. Release fractions vary according to the type of package and the physical form of the material.

Representative release fractions for accidents involving depleted UF_6 and UO_2 shipments were taken from NUREG-0170 (NRC 1977b). The recommendations in NUREG-0170 are based on best engineering judgments and have been shown to provide conservative estimates of material releases following accidents. The release fractions used are those reported in NUREG-0170 for both low-specific-activity (LSA) drums and NRC Type A packages. Release fractions for accidents of each severity category are given in Table C.5. As shown in that table, the amount of material released from the package ranges from zero for minor accidents to 100% for the most severe accidents. As shown in Table C.5, representative release fractions for accidents involving fresh MOX fuel were assumed to be the same as those developed for SNF in the NRC's study (Fischer et al. 1987), commonly referred to as the Modal Study, on the behavior of SNF in Type B containers under accident conditions. These values were derived on the basis of best engineering judgments. These values are expected to be conservative when applied to fresh MOX fuel because the fuel has not yet become embrittled through use.

Also important for the purposes of risk assessment are the fraction of the released material that can be entrained in an aerosol (part of an airborne contaminant plume) and the fraction of the aerosolized material that is also respirable (of a size that can be inhaled into the lungs). These

Table C.5. Estimated release fractions for Type A and Type B packages under various accident severity categories

Severity category	Release fraction[a]			
	NUREG-0170			
	Type A[b]	Type B[b]	Type B[c]	TRUPACT-II[d]
I	0	0	0	0
II	0.01	0	6×10^{-8}	0
III	0.1	0.01	2×10^{-7}	8×10^{-9}
IV	1	0.1	2×10^{-6}	2×10^{-7}
V	1	1	2×10^{-6}	8×10^{-5}
VI	1	1	2×10^{-5}	2×10^{-4}
VII	1	1	2×10^{-5}	2×10^{-4}
VIII	1	1	2×10^{-5}	2×10^{-4}

[a]Values are for total material release fraction (the fraction of material in a package released to the environment during an accident).

[b]*Source:* NRC (1977b), used for Pu metal shipments.

[c]*Source:* Fischer et al. (1987), used for fresh MOX fuel shipments.

[d]*Source:* DOE (1997). Aerosolized and respirable fractions are both assumed to equal 1.0.

fractions depend on the physical form of the material. Most solid materials are difficult to release in particulate form and are, therefore, relatively nondispersible. Conversely, liquid or gaseous materials are relatively easy to release if the container is breached in an accident.

The aerosolized fraction for the UF_6 was taken to be 0.01 except in the case of higher severity accidents (Categories VI through VIII) involving fire, for which it was taken to be 0.33 (Policastro et al. 1997). The respirable fraction was taken to be 1 for all accidents. For UO_2, which was assumed to behave as a loose powder, the aerosolized fraction was set to 0.1, with a respirable fraction of 0.05 (Biwer et al. 1997). The aerosolized fraction and the respirable fraction were taken to be 1×10^{-6} and 0.05, respectively, for the Pu metal expected to behave as immobile material (Neuhauser and Kanipe 1992). For the MOX fuel, the aerosolized fraction was taken to be 1, and the respirable fraction taken to be 0.05 in accordance with spent fuel particulates as derived from NUREG-0170 in Neuhauser and Kanipe (1992). Release fractions used for the TRU waste shipments are given separately in Table C.5.

C.2.4.3 Atmospheric Conditions during Accidents

Hazardous material released to the atmosphere is transported by the wind. The amount of dispersion, or dilution, of the contaminant material in the air depends on the meteorologic

conditions at the time of the accident. Because predicting the specific location of an off-site transportation-related accident and the exact meteorologic conditions at the time of the accident is impossible, generic atmospheric conditions were selected for the accident risk assessment. Neutral weather conditions were assumed. These conditions were represented by Pasquill atmospheric stability Class D with a wind speed of 4 m/s (9 mph). Because neutral meteorological conditions are the most frequently occurring atmospheric stability condition in the United States, these conditions are most likely to be present in the event of an accident involving a hazardous material shipment. Observations at National Weather Service surface meteorological stations at more than 300 U.S. locations indicate that on a yearly average, neutral conditions (represented by Pasquill Classes C and D) occur about half (50%) the time; stable conditions (Pasquill Classes E and F) occur about one-third (33%) of the time; and unstable conditions (Pasquill Classes A and B) occur about one-sixth (17%) of the time (Doty et al. 1976). The neutral category predominates in all seasons, but it is most prevalent (nearly 60% of the observations) during winter.

C.2.5 Radiological Risk Assessment Input Parameters and Assumptions

The dose (and, correspondingly, the risk) to populations during routine transportation of radioactive materials is directly proportional to the assumed external dose rate from the shipment. The actual dose rate from the shipment is a complex function of the composition and configuration of shielding and containment materials used in the packaging, the geometry of the loaded shipment, and the characteristics of the radioactive material itself.

Shipments of depleted UF_6 and UO_2 have been studied previously (Biwer et al. 1997) for the Depleted UF_6 Programmatic EIS (PEIS) (DOE 1999a). Representative shipment dose rates were developed using the MicroShield™ shielding code (Negin and Worku 1992). The input to MicroShield™ consisted of the activity of a material, the geometry and composition of the shipping package, and the amount of material in the package. Where multiple packages per shipment were assumed, a dose rate for the shipment was derived from the summation of the individual package dose rates, taking into consideration the configuration of the packages on the transport vehicle and the relative distances to a receptor.

Table C.6 lists the external dose rates developed for the Depleted UF_6 PEIS and used in this transportation analysis. The dose rates are presented in terms of the transport index (TI), which is the dose rate at 1 m (3 ft) from the lateral sides of the transport vehicle. The regulatory limit established in 49 CFR Part 173.441 (*Radiation Level Limitations*) and 10 CFR Part 71.47 (*External Radiation Standards for All Packages*) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. The estimated dose rate at a distance of 1 m (3 ft) from a truck shipment of depleted UO_2 identical to that considered for this analysis was 0.0076 mSv/h (0.76 mrem/h). Depleted UF_6 in larger, 14-ton cylinders in overcontainers was estimated to have external dose rates of 0.0023 mSv/h (0.23 mrem/h) and 0.0024 mSv/h (0.24 mrem/h) for truck (1 cylinder/tractor-trailer) and rail (4 cylinders/railcar) shipments, respectively. For this analysis, depleted UF_6 shipments, each involving five 30B cylinders, were assumed to have an external dose rate of 0.0024 mSv/h (0.24 mrem/h), which is more consistent with the line source geometry of the railcar shipments

Table C.6. External dose rates and package sizes used in RADTRAN

Shipment	Dose rate at 1 m [mSv/h (mrem/h)]	Package size (m)
UF_6	0.0024 (0.24)	12[a]
UO_2	0.0076 (0.76)	6.0[a]
Pu metal	0.14 (14)	9
TRU waste	0.040 (4.0)	7.4
MOX fuel	0.0484 (4.84)	3.66[b]

[a]*Source:* Biwer et al. (1997).

[b]Active length of fuel assembly (DCS 2001a).

in the Depleted UF_6 PEIS (DOE 1999a). These estimated dose rates for the depleted uranium shipments are less than 5% of the allowed maximum value. A value of 0.040 mSv/h (4.0 mrem/h) was used for the WSB TRU waste shipments. This value represents the highest estimated dose rate for TRUPACT-II truck shipments estimated for any TRU waste generator site considered in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997). For MOX fuel shipments, preliminary analysis has estimated a conservative value of 0.0484 mSv/h (4.84 mrem/h) for the external dose rate at 1 m (DCS 2001a). The regulatory maximum of 0.10 mSv/h (10 mrem/h) at 2 m was assumed for the plutonium metal. This dose rate corresponds approximately to 0.14 mSv/h (14 mrem/h) at 1 m.

In addition to the specific parameters discussed previously, values for a number of general parameters must be specified within the RADTRAN code to calculate radiological risks. These general parameters define basic characteristics of the shipment and traffic and are specific to the mode of transportation. The user's manual for the RADTRAN code (Neuhauser and Kanipe 1992) contains derivations and descriptions of these parameters. The general RADTRAN input parameters used in the radiological transportation risk assessment are summarized in Table C.7.

C.2.6 Hazardous Chemical Risk Assessment Input Parameters and Assumptions

To estimate the consequences of chemical accidents, two potential health effects end points were evaluated: (1) adverse effects and (2) irreversible adverse effects. Potential adverse effects range from mild and transient effects — such as respiratory irritation, redness of the eyes, and skin rash — to more serious and potentially irreversible effects. Potential irreversible adverse effects are defined as effects that generally occur at higher concentrations and are permanent in nature — including death, impaired organ function (such as damaged central nervous system or lungs), and other effects that may impair everyday functions.

For uranium compounds, an intake of 10 mg or more was assumed to cause potential adverse effects (McGuire 1991), and an intake of 30 mg or more was assumed to cause potential

Table C.7. General RADTRAN input parameters[a]

Parameter	Truck[b]
Number of crew members	2
Distance from source to crew (m)	3.1
Average vehicular speed (km/h)[c]	
Rural	88.49
Suburban	40.25
Urban	24.16
Stop time (h/km)	0.011
Number of people exposed while stopped	50
Distance for exposure while stopped (m)	20
Number of people per vehicle sharing route	2
Population densities (persons/km^2)[d]	Route specific
One-way traffic count (vehicles/h)	
Rural	470
Suburban	780
Urban	2,800

[a]Accident conditional probabilities are listed by severity category in Table C.4; accident release fractions are given in Table C.5.

[b]*Source:* Biwer et al. (1997).

[c]Fraction of rural and suburban travel on freeways was set to 1 in RADTRAN. Thus, the rural speed was used for both urban and suburban zones.

[d]Route-specific population densities are listed in Table C.1.

irreversible adverse effects. These intake levels are based on NRC guidance (NRC 1994). For hydrogen fluoride (HF), which is a by-product of UF_6 reacting with moisture in the air following an accidental release, potential adverse effects levels were assumed to occur at levels that correspond to Emergency Response Planning Guideline No. 1 (ERPG-1) or equivalent levels, and potential irreversible adverse effects levels were assumed to occur at levels that correspond to ERPG-2 or equivalent levels. The ERPG values have been generated by teams of toxicologists who review all published (as well as some unpublished) data for a given chemical (AIHA 1996). In addition to potential irreversible adverse effects, the number of fatalities from accidental chemical exposures was estimated to facilitate comparisons with radiological impacts. For exposures to uranium and HF, it was estimated that the number of fatalities occurring would be about 1% of the number of irreversible adverse effects (EPA 1993a; Policastro et al. 1997).

Application of the FIREPLUME code involves the choice of a number of parameters that affect the results. Input values were selected to represent reasonable conditions at a generic location without being too conservative. More details about the models and input parameters are presented in Post et al. (1994a,b) and Brown et al. (1997).

C.2.7 Routine Nonradiological Vehicle Emission Risks

Vehicle-related risks during incident-free transportation include incremental risks caused by potential exposure to airborne particulate matter from fugitive dust and vehicular exhaust emissions. The health end point assessed under routine transport conditions is the excess (additional) latent mortality caused by inhalation of vehicular emissions. These emissions are primarily in the form of diesel exhaust and fugitive dust (resuspended particulates from the roadway). Strong epidemiological evidence exists suggesting that increases in ambient air concentrations of PM_{10} (particulate matter with a mean aerodynamic diameter less than or equal to 10 μm) lead to increases in mortality (EPA 1996a,b). Currently, it is assumed that no threshold exists and that the dose-response functions for most health effects associated with PM_{10} exposure, including premature mortality, are linear over the concentration ranges investigated (EPA 1996a). Over both the short and long terms, fatalities (mortality) may result from life-shortening respiratory or cardiovascular diseases (EPA 1996a; Ostro and Chestnut 1998). The long-term fatalities also are assumed to include those from cancer.

The increased ambient air particulate concentrations caused by the transport vehicle, due to fugitive dust and diesel exhaust emissions, were related to such premature latent fatalities in the form of risk factors by Biwer and Butler (1999) for transportation risk assessments. Thus, in this assessment, a value of 8.36×10^{-10} latent fatalities/km for truck transport was used. This value is for heavy combination trucks (truck class VIIIB). The risk factor is for areas with an assumed population density of 1 person/km^2. One-way shipment risks are obtained by multiplying the appropriate risk factor by the average population density along the route and the route distance. The risks reported for routine vehicle risks in this analysis are for round-trip travel of the transport vehicle.

The vehicle risks reported here are estimates based on the best available data. However, as is true for the radiological risks, there is a large, not readily quantifiable, degree of uncertainty in the vehicle emission risk factors. For example, large uncertainties exist as to the extent of increased mortality with an incremental rise in particulate air concentrations and as to whether there are threshold air concentrations that are applicable. Also, estimates of the particulate air concentrations caused by transport vehicles are dependent on location, road conditions, vehicle conditions, and weather.

As discussed by Biwer and Butler (1999), there are large uncertainties in the human health risk factors used to develop the emission risks. In addition, because of the conservatism of the assumptions made to reconcile results with those presented in an EPA study (EPA 1993b), latent fatality risks estimated with the above risk factor may be considered to be near an upper bound. Use of this risk factor for truck class VIIIB will give estimated fatalities comparable to those from accident fatalities in some cases. In addition, the question as to what exactly constitutes a fatality as a direct consequence of increased PM_{10} levels from vehicle emissions is still an open question, but long-term fatalities have been associated with increased levels of PM_{10} (Biwer and Butler 1999).

C.3 Transportation Impacts

Single shipment transportation impacts are presented in Table C.8. Total collective population transportation impacts are presented in Section 4.4.1.3.

Table C.8. Single-shipment collective population transportation risks

Impact category	Depleted UF_6	Depleted UO_2	Pu metal		MOX	TRU Waste
	From Portsmouth, Ohio to Wilmington, N.C.	From Wilmington, N.C. to MOX facility	From Pantex to PDCF	From Hanford to PDCF	From MOX facility to surrogate commercial reactor	From WSB to WIPP
Population impacts						
Cargo-related[a]						
Radiological Impacts						
Dose risk[b] (person-rem)						
Routine crew	0.0055	0.0075	0.14	0.27	0.16	0.16
Routine public						
Off-link	4×10^{-4}	2.2×10^{-4}	0.026	0.035	0.0064	0.0062
On-link	9.8×10^{-4}	5.8×10^{-4}	0.072	0.12	0.016	0.020
Stops	0.0041	0.0029	0.33	0.67	0.057	0.10
Total	0.0054	0.0037	0.43	0.82	0.079	0.13
Accident[c]	0.0023	8.2×10^{-4}	8.8×10^{-5}	3.8×10^{-4}	0.027	0.019
Latent cancer fatalities[d]						
Crew fatalities	3×10^{-6}	5×10^{-6}	9×10^{-5}	2×10^{-4}	9×10^{-5}	9×10^{-5}
Public fatalities	5×10^{-6}	3×10^{-6}	3×10^{-4}	5×10^{-4}	6×10^{-5}	9×10^{-5}
Chemical Impacts						
Irreversible adverse effects[e]	1.2×10^{-9}	0	NA	NA	NA	NA
Vehicle-related[f]						
Emission fatalities	4×10^{-4}	1×10^{-4}	7×10^{-4}	9×10^{-4}	0.001	6×10^{-4}
Accident fatalities	2.7×10^{-5}	2×10^{-5}	5.4×10^{-5}	1.1×10^{-4}	4.8×10^{-5}	5.8×10^{-5}

[a]Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the waste material.

[b]To convert from person-rem to person-Sv, multiply by 0.01.

[c]Dose risk is a societal risk and is the product of accident probability and accident consequence.

[d]Latent cancer fatalities are calculated by multiplying dose by the FGR 13 health risk conversion factor of 0.06 fatal cancer per person-Sv (6×10^{-4} fatal cancer per person-rem) (Eckerman et al. 1999).

[e]Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds is estimated to result in fatality of approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

[f]Vehicle-related impacts are impacts independent of the cargo in the shipment.

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APPENDIX D:

SOCIOECONOMICS

Appendix D:

Socioeconomics

This appendix (1) discusses the methods and briefly describes the data sources that were used to perform the socioeconomic analyses for this environmental impact statement (EIS) (Section D.1) and (2) presents fiscal data collected from each of the counties, cities, and school districts in the region of influence (as defined below) (Section D.2).

D.1 Impact Assessment Methods

The socioeconomic analysis for a Mixed Oxide Fuel Fabrication Facility (the proposed MOX facility), including its supporting facilities, the Pit Disassembly and Conversion Facility (PDCF) and the Waste Solidification Building (WSB), at the Savannah River Site (SRS) assessed impacts at two geographic scales. A regional economic area (REA) was used to assess impacts on employment and income for the various alternatives. An REA is a broad market area defined by the economic linkages among the regional industrial and service sectors and the communities within a region. In this case, the REA consists of 15 counties in South Carolina and Georgia (see Table D.1). A region of influence (ROI) that consists of the four counties in which the majority (90%) of the SRS employees live was used to assess impacts on population, housing, community services, and traffic (see Table D.1).

D.1.1 Impacts on Regional Employment and Income

The assessment of projected impacts of the proposed facilities on regional employment and income was based on the use of regional economic multipliers. These multipliers capture the indirect (off-site) effects of on-site activities associated with construction and operation.

To estimate employment impacts of the proposed MOX facility, the PDCF, and the WSB at the SRS, direct and indirect employment impacts associated with construction and operation were taken from data provided in the Surplus Plutonium Disposition (SPD) EIS (DOE 1999, Appendix F, Section 9.2). The indirect (off-site) employment impacts were estimated from these data by using the relationship between direct and indirect employment of the facilities in the REA at the SRS as estimated in the SPD EIS. By using direct (on-site) facility employment data taken from the project Environmental Report (ER)(DCS 2002) as the basis for calculation, the indirect employment impacts were estimated for the peak year of construction and for the first year of operations.

The impact of facility construction and operation on regional incomes was estimated by using facility employment impact estimates together with average regional income multipliers for the REA taken from Intelligent Multi-Resource Planning (IMPLAN) regional economic data (MIG, Inc., 2001). IMPLAN input-output economic accounts show the flow of commodities to

Table D.1. Jurisdictions included in the regional economic area and region of influence at the SRS

Regional Economic Area

Georgia	**South Carolina**
Counties	Counties
Burke	Aiken
Columbia	Allendale
Glascock	Bamberg
Jefferson	Barnwell
Jenkins	Edgefield
Lincoln	
McDuffie	
Richmond	
Warren	
Wikes	

Region of Influence

Georgia	**South Carolina**
Counties	Counties
Columbia	Aiken
Richmond	Barnwell
Cities	Cities
Augusta	Aiken
Blythe	Jackson
Grovetown	New Ellenton
Harlem	North Augusta
Hephzibah	Wagener
School Districts	School Districts
Columbia County	Aiken County
Richmond County	Barnwell #19
	Barnwell #29
	Barnwell #45

industries from producers and institutional consumers. The accounts also show consumption activities by workers, owners of capital, and imports from outside the region. The IMPLAN model contains 528 sectors representing industries in agriculture, mining, construction, manufacturing, wholesale and retail trade, utilities, finance, insurance and real estate, and consumer and business services. The model also includes information for each sector on employee compensation; proprietary and property income; personal consumption expenditures; federal, state, and local expenditures; inventory and capital formation; imports; and exports.

Impacts on employment are described in terms of the total number of jobs created in the region in the peak year of construction and in the first year of operation. The relative impact of the increase in employment in the REA was calculated by comparing total facility construction employment over the period in which construction would occur with baseline REA employment forecasts over the same period. Impacts are expressed in terms of the percentage point difference in the average annual employment growth rate with and without facility construction. The forecasts were based on data from the U.S. Department of Commerce.

D.1.2 Impacts on Population

An important consideration in assessing potential impacts of the proposed facilities was the number of workers, families, and children who might move into the ROI (in-migrate), either temporarily or permanently, with construction and operation of the proposed facilities. The capacity of regional labor markets to provide sufficient workers in the appropriate occupations required for facility construction and operation is closely related to the occupational profile of the REA and to occupational unemployment rates. To estimate the in-migration that would occur to satisfy direct labor requirements, the analysis developed estimates of available labor in each direct labor category on the basis of REA unemployment rates applied to each occupational category. In-migration associated with indirect labor requirements was derived from estimates of available labor in the REA economy as a whole able to satisfy the demand for labor by industry sectors in which facility spending would initially occur. The national average household size was used to calculate the number of additional family members who would accompany direct and indirect in-migrating workers.

Impacts on population are described in terms of the total number of in-migrants arriving in the region in the peak year of construction and in the first year of operation. The relative impact of the increase in population in the REA was calculated by comparing total facility construction in-migration over the period in which construction would occur with baseline REA population forecasts over the same period. Impacts are expressed in terms of the percentage point difference in the average annual population growth rate with and without project construction. The forecasts were based on data from the U.S. Census Bureau.

D.1.3 Impacts on Local Housing Markets

The in-migration of workers that would occur during construction and operation would have the potential to substantially affect the housing market in the ROI. The analysis considered these impacts by estimating the increase in demand for rental housing units in the peak year of construction and for owner occupied housing in the first year of operation that would result from the in-migration of both direct and indirect workers into the ROI. The impacts on housing are described in terms of the number of rental units required in the peak year of construction and the number of owner occupied units required in the first year of operations. The relative impact on the existing housing in the ROI was estimated by comparing the calculated facility-related housing demand with the forecasted number of vacant rental housing units in the peak year of construction and the forecasted number of vacant owner occupied units in the first year of operations. The forecasts were based on data from the U.S. Census Bureau.

D.1.4 Impacts on Community Services

In-migration associated with construction and operation of the facilities could increase demand for educational services and for other public services (e.g., police and fire protection, health services) in the ROI. Estimates of the total number of in-migrating workers and their families for facility construction and operation were used as a basis for calculating the potential increase in public service demands in the core ROI counties in which the majority of new workers would be expected to locate. Impacts of the facilities on county, city, and school district revenues and expenditures were also calculated on the basis of baseline data provided in the jurisdictions' annual comprehensive financial reports. Impacts were forecasted for the peak year of construction and in the first year of operations on the basis of per capita revenues and expenditures for each jurisdiction. The population forecasts were based on data from the U.S. Census Bureau.

Impacts of facility-induced in-migration on community service employment were also calculated for the core ROI counties. The estimated numbers of in-migrating workers and families were used to calculate the numbers of new sworn police officers, firefighters, and general government employees required to maintain the existing levels of service for each community service. Calculations were based on the existing number of employees per 1,000 population for each community service. The analysis of the impact on educational employment estimated the number of teachers in each school district required to maintain existing teacher-student ratios across all student age groups. Impacts on health care employment were estimated by calculating the number of physicians in each county required to maintain the existing level of service. The estimated impacts are given in terms of the number of additional physicians and the number of additional staffed hospital beds required to maintain the existing levels of service (expressed in terms of number of doctors and number of staffed hospital beds per 1,000 population). Information on existing employment and levels of service was collected from the individual jurisdictions providing each service.

D.1.5 Impacts on Traffic

Impacts on traffic in the ROI are described in terms of the effects of the increase in traffic from the facilities on the "levels of service" of major road segments used to commute to and from the site by existing site employees. The analysis allocated trips made by construction workers to individual road segments on the basis of the residential distribution of existing site workers. The impact on the existing annual average number of daily trips was then calculated, and the impact on the level of service provided by each individual segment was estimated. Traffic information used in the analysis was collected from state and county transportation departments.

D.2. Region of Influence Fiscal Data

Financial data for local governmental bodies and school districts in the ROI for the facilities are presented in Tables D.2 and D.3.

D.3 References for Appendix D

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Table D.2. ROI local government financial data ($ millions)

Category	Columbia County, Georgia		
	Columbia County	Town of Grovetown	Town of Harlem
Revenues			
Taxes	23.4	0.7	0.9
Licenses and permits	0.3	0.0	0.0
Intergovernmental	1.6	1.0	0.0
Charges for services	1.1	0.4	0.2
Fines and forfeits	1.6	0.2	0.1
Miscellaneous	0.9	0.1	0.0
Total	28.9	2.5	1.3
Expenditures			
General government	8.1	0.7	0.2
Public safety	11.8	0.7	0.4
Highways and streets	3.3	0.3	0.2
Health, welfare and sanitation	0.9	0.4	0.1

Category	Columbia County, Georgia		
	Columbia County	Town of Grovetown	Town of Harlem
Culture and recreation	2.5	0.0	0.0
Debt service	0.0	0.0	0.0
Intergovernmental	0.0	0.0	0.0
Other	0.9	0.0	0.0
Total	27.5	2.1	1.0
Revenues less expenditures	+1.4	+0.3	+0.3

Table D.2. Continued

	Richmond County, Georgia		
	City of Augusta/ Richmond County	City of Blythe	City of Hephzibah
Revenues			
Taxes	55.9	0.1	0.8
Licenses and permits	2.3	0.0	0.0
Intergovernmental	3.0	0.0	0.0
Charges for services	12.8	0.0	0.0
Fines and forfeits	9.0	0.0	0.0
Miscellaneous	3.0	0.1	0.1
Total	86.0	0.2	0.9
Expenditures			
General government	26.3	0.1	0.1
Public safety	34.2	0.1	0.4
Highways and streets	6.1	0.0	0.0
Health, welfare and sanitation	5.2	0.0	0.0
Culture and recreation	9.3	0.0	0.0
Debt service	2.0	0.0	0.0
Intergovernmental	2.4	0.0	0.0
Other			
Total	85.5	0.2	0.5
Revenues less expenditures	+0.5	0.0	+0.4

	Aiken County, South Carolina		
Category	**Aiken County**	**City of Aiken**	**Town of Jackson**
Revenues			
Taxes	16.0	6.4	0.2
Licenses and permits	0.6	4.6	0.1
Intergovernmental	7.7	1.5	0.0
Charges for services	2.0	3.7	0.2
Fines and forfeits	3.2	0.6	0.2
Miscellaneous	1.0	11.0	0.0
Total	30.5	27.8	0.7

Table D.2. Continued

Category	Aiken County, South Carolina		
	Aiken County	City of Aiken	Town of Jackson
Expenditures			
General government	12.1	1.6	0.5
Public safety	10.6	5.4	0.1
Highways and streets	3.7	1.9	0.0
Health, welfare and sanitation	1.7	2.4	0.1
Culture and recreation	2.4	2.3	0.0
Debt service	0.0	0.3	0.0
Intergovernmental	0.0	0.0	0.0
Other	0.0	11.8	0.3
Total	30.5	25.7	0.9
Revenues less expenditures	0.0	+2.1	-0.2

	Aiken County, South Carolina		
	Town of New Ellenton	City of North Augusta	Town of Wagener
Revenues			
Taxes	0.3	3.7	0.1
Licenses and permits	0.1	2.0	0.1
Intergovernmental	0.1	0.6	0.0
Charges for services	0.2	0.8	0.1
Fines and forfeits	0.1	0.5	0.0
Miscellaneous	0.0	0.3	0.1
Total	0.8	7.9	0.4
Expenditures			
General government	0.2	1.5	0.2
Public safety	0.4	3.4	0.1
Highways and streets	0.1	0.8	0.0
Health, welfare and sanitation	0.1	0.0	0.1
Culture and recreation	0.1	1.7	0.0
Debt service	0.0	0.0	0.0
Intergovernmental	0.0	0.0	0.0
Other	0.0	0.3	0.0
Total	0.9	7.7	0.4
Revenues less expenditures	-0.1	+0.2	0.0

Table D.2. Continued

	Barnwell County, South Carolina			
	Barnwell County	City of Barnwell	Town of Blackville	Town of Williston
Revenues				
Taxes	3.0	1.2	0.4	1.1
Licenses and permits	0.0	0.4	0.1	0.0
Intergovernmental	1.6	0.2	0.1	0.2
Charges for services	0.0	0.2	0.2	0.0
Fines and forfeits	0.0	0.1	0.2	0.0
Miscellaneous	4.3	0.0	0.0	0.0
Total	8.9	2.1	1.0	1.3
Expenditures				
General government	2.5	0.4	0.1	0.2
Public safety	2.0	0.9	0.5	0.6
Highways and streets	0.6	0.2	0.0	0.2
Health, welfare and sanitation	1.1	0.2	0.1	0.2
Culture and recreation	0.2	0.0	0.1	0.0
Debt service	0.2	0.0	0.0	0.0
Intergovernmental	0.0	0.0	0.0	0.0
Other	2.0	0.0	0.1	0.1
Total	8.6	1.7	0.9	1.3
Revenues less expenditures	+0.3	+0.4	+0.1	0.0

Sources: Columbia County, annual financial report, June 30, 2000; City of Grovetown Financial Report, December 31, 2000; City of Harlem Annual Financial Report, December 31, 2000; City of Augusta/Richmond County, Annual Financial Statements, December 31, 1999; City of Blythe, Annual Financial Report, December 31, 2000; City of Hephzibah, Financial Statements and Independent Auditors Report, June 30, 2000; Aiken County, Annual Financial Report, June 30, 2000; City of Aiken, Annual Report, June 30, 2000; Town of Jackson, Financial Statements, June 30, 2000; Town of New Ellenton, Financial Statements, June 30, 1999; City of North Augusta, Annual Financial Statements, December 31, 2000; Town of Wagener, Financial Statements, June 30, 1999; Barnwell County, Audited Financial Statements, June 30, 2000; City of Barnwell, Financial Statements, September 30, 2000; Town of Blackville, Audited General Purpose Financial Statements, June 30, 2000; Town of Williston, Financial Statements, June 30, 2000.

Table D.3. ROI school district financial data ($ millions)

Category	Georgia		South Carolina	
	Columbia County	Richmond County	Aiken County	Barnwell County[a,b]
Revenues				
Local sources	32.8	81.2	31.5	8.9
State sources	64.4	134.6	66.5	20.0
Federal sources	0.1	16.1	0.1	0.1
Other	2.2	0.0	0.0	0.0
Total	99.5	231.9	98.1	29.0
Expenditures				
Administration and instruction	65.5	161.1	65.0	17.7
Services	27.9	48.0	34.6	8.3
Debt service	0.0	0.0	0.0	1.0
Other	0.0	0.0	0.0	1.2
Total	93.4	209.1	99.8	28.2
Revenues less expenditures	+6.1	+22.8	-1.6	+0.8

[a] Includes Williston School District #19, #29, and #45.

[b] Revenue data estimated based on South Carolina Department of Education (2001) and Williston School District #29 (2000).

Sources: Columbia County Board of Education, General Purpose Financial Statements, June 30, 2000; Georgia Department of Education, Local, State and Federal Revenue Report Fiscal Year 2001, available at http://dbl.doe.k12go.us:8001/ows-bin/owo/fin_pack_revenue.display.proc; Consolidated School District of Aiken County Financial Statements, June 30, 2000; South Carolina Department of Education, 2001 School and District Report Cards, available at http://www.unyscschools.com/reportcard/2001/; DCS 2002; Willston School District #29, Financial Statements, June 30, 2000.

APPENDIX E:

HUMAN HEALTH RISK

Appendix E:

Human Health Risk

This appendix provides detailed information concerning the input data and assumptions used in the chemical and radiological human health risk assessments performed for this Mixed Oxide (MOX) Fuel Fabrication Facility Environmental Impact Statement.

E.1 Chemical

Impacts from chemical materials were assessed for Savannah River Site (SRS) workers outside the restricted area of the facility ("SRS employees") and members of the public. Impacts to facility workers would be sensitive to the specific circumstances of each accident and are not estimated in this assessment.

A total of more than 40 MOX process chemicals were identified for use in the proposed MOX facility. A chemical was eliminated from the analysis if it had a very low volatility (i.e., vapor pressure <1 Pa (7.5×10^{-3} mmHg), had a low toxicity (i.e., a temporary emergency exposure limit 1 [TEEL 1] $\geq$15 mg/m^3, was stored in small quantities (maximum container quantity <38 L [10 gal]), or was stored and used as a solid. Impacts of a chemical release with these characteristics would be expected to be minimal. Chemicals eliminated from evaporative spill analysis because of very low vapor pressures at ambient temperatures were (1) manganese nitrate, (2) oxalic acid, (3) silver nitrate, (4) uranyl nitrate, (5) sodium hydroxide, (6) aluminum nitrate, and (7) phosphoric acid. Chemicals eliminated because of low toxicity were (1) aluminum sulfate, (2) isopropanol, (3) sodium carbonate, and (4) zirconium nitrate. Chemicals eliminated because they are solids were azodicarbonamide and zinc stearate. All other material inventories were analyzed in detail. A sulfuric acid spill at the PDCF was also eliminated from further analysis based on the assumption that it would contain a concentration of less than 30% sulfur trioxide (i.e., not fuming) and would therefore not pose a toxic inhalation hazard if spilled in water or under moist atmospheric conditions.

The quantity of material released to the atmosphere was determined on the basis of the available physical properties of the spilled chemical (e.g., vapor pressure, mass transfer coefficient), meteorological conditions (e.g., wind speed), and the chemical storage conditions (e.g., temperature, pressure). This quantity defines the source term, which is determined either by estimating chemical evaporation rates or pressurized release rates and the associated release durations. The evaporative source term is used as input to the National Oceanic and Atmospheric Administration (NOAA) Areal Locations of Hazardous Atmospheres (ALOHA) dispersion model (Reynolds 1992). Impacts from pressurized releases are simulated with the HGSYSTEM model.

For modeling potential impacts to the general public at the SRS site boundary (approximately 8.2 km [5.1 mi] from the proposed MOX facility), the estimated source term was used as input to the ALOHA dispersion model. For modeling potential impacts to SRS workers (assumed to

be located a minimum of 100 m [330 ft] from the proposed MOX facility), the ARCON96 model (Ramsdell and Simonen 1997) was used because this model is more accurate for estimating near-field concentrations affected by low wind speeds, plume meander, and building wake effects. This model is also used to be consistent with U.S. Nuclear Regulatory Commission (NRC) licensing requirements involving the use of hazardous chemicals (NRC Regulatory Guide 1.78 (NRC 2001), as it pertains to releases in and around buildings. ARCON96 was used for modeling impacts for all receptors (SRS workers and general public) for uranium dioxide powder releases, similar to the modeling done for accidental releases of other radionuclides.

Two of the MOX process chemicals, nitrogen tetroxide and chlorine, are stored as pressurized liquids. Impacts from accidental releases of these two compounds were estimated with the HGSYSTEM model (Post 1994a,b).

Evaporative releases can be considered as either the “puddle” or “direct” source release mode in ALOHA. To use the puddle option, physical properties of the spilled chemical must be known. These properties, such as vapor pressure and molecular weight, are required in estimating evaporation rates. Physical properties are included for approximately 800 pure chemicals in ALOHA’s chemical library. Because only two of the 13 MOX chemicals are included in the library and because the effect of dilute solution adjustments to vapor pressure are not allowed in ALOHA, the direct source release option was used to assess impacts for 11 evaporative spill scenarios. A simple evaporation algorithm, similar to ALOHA and other source evaporation codes, such as ADAM (Raj and Morris 1987; Kawamura and MacKay 1987), was incorporated into a spreadsheet along with the necessary physical properties for each of the eight chemicals. A brief description of the spreadsheet algorithm and its limitations and assumptions are given below:

$$Q_{evap} = \frac{A_p * k_m * MW_m * P_{sat}}{R * T_p}, \qquad \text{(E-1)}$$

where

A_p = pool area (m^2),

k_m = mass transfer coefficient (m/s),

MW_m = molecular weight of chemical (g/mole),

P_{sat} = saturation vapor pressure of chemical (Pa),

R = Universal Gas Constant (= 8314.472), and

T_p = pool temperature (K).

The evaporation rate from spilled chemical pools is conservatively assumed to be constant, along with the pool temperature and saturation vapor pressure, for the entire release duration.

The saturation vapor pressure is set equal to the partial pressure over the pool. The saturation vapor pressure or the partial pressures of the vapors emanating from the pool are a function of the pool temperature through use of chemical-specific Antoine or Harlacher coefficients for inorganic compounds, and through the use of the Clausius-Clapeyron equation for organic compounds (e.g., tributyl phosphate [TBP]). In addition to the assumption that the saturation vapor pressure is equal to the vapor pressure of the chemical at ambient release conditions, the pool temperature is assumed equal to the ambient temperature for the entire release duration. Two ambient cases were assessed, one representing the 95th percentile temperature during the day and the other the 95th percentile during the night (see discussion of the full set of assumed weather conditions below). In cases where temperature-specific data (e.g., Antione coefficients and equations) were not available, temperature-dependent P_{vap} adjustments from a reference level (e.g., STP) were made using the ratio of vapor pressures (reference level to compound value at specified temperature) for compounds with similar physical properties for which these pressures were known at two representative temperature levels.

Two of the chemical compounds in the inventory are binary mixtures. The vapor pressure of mixtures was estimated using the following equation (CCPS 1996):

$$P_{mixvap} = \frac{\sum_{i=1}^{n} MF_i * P_{vapi} * MW_i * e^{-kP_{vap}t}}{\sum_{i=1}^{n} MF_i * MW_i} \qquad \text{(E-2)}$$

where

MF_i = mole fraction of component i,

P_{vapi} = vapor pressure of component i,

k = $k_m A_p / n_T RT$,

n_T = total number of moles of mixture,

MW_i = molecular weight of component i, and

t = 1.

Raoult's Law was used to make additional adjustments to spill vapor pressures to account for dilute solutions(such a solution lowers the vapor pressure of the solvent below that of the solute in proportion to the mole fraction of the solute). Table E.1 gives the computed mole fractions used in the analysis, along with the assumed spill volumes and the given chemical inventories and concentrations.

The mass transfer coefficient (k_m), used in most evaporative release models, is computed by one of two main methods used in source emission models, as shown in Equations E-3 and E-4 below. Both values were calculated for each chemical in the analysis and the expression giving

Table E.1. Chemical inventory, spill quantity, concentrations, and mole fraction (MF) calculations[a]

Facility and Chemical name	Formula	MW_{solute} (g/mole)	MW_{sol} (g/mole)	Density: Pure Compound (kg/m^3)	Density: Solution (kg/L)	Concentrations: M_{pure} [100%] (moles/L)	Concentrations: M (moles/L)	Concentrations: %	Concentrations: N (moles/L x #_H atoms)
MOX (BAP and BRP)									
Nitrogen tetroxide	N_2O_4	92.01	92	1,450	1.45	15.76	15.76	***100***	15.76
Hydrazine hydrate	H_6N_2O	32.05	50.1	1,030	1.01	32.14	11.25	***35***	67.5
Hydrazine-NaOH mixture	N_2H_4-NaOH	32.05	94	1,030	2.13	32.14	0.03	0.10	***0.16***
Hydrazine/hydroxylamine nitrate mixture	$H_4N_2O_4 – N_2H_4$	32.05	128.1	1,030	1.54	32.14	***0.15***	0.47	0.6
Hydroxylamine nitrate (HAN)	$H_4N_2O_4$	96.05	114.1	1,540	1.29	16.03	***1.90***	11.8	7.6
Hydrogen peroxide	H_2O_2	34.02	52	1,440	1.27	42.33	14.82	***35***	29.6
Tributyl phosphate (TBP)	$C_{12}H_{27}O_4P$	266.36	266.4	980	0.98	3.68	3.68	***100***	99.3
Nitric acid (13.6 M)	HNO_3	63.01	81	1,380	1.28	21.90	13.6	62.1	***13.6***
Nitric acid (2.1 M)	HNO_3	63.01	81	1,380	1.20	21.90	2.1	9.6	***2.1***
WSB									
Nitric Acid	HNO_3	63.01	81	1,276	1.18	15.74	7.87	**50**	7.87
PDCF[b]									
Chlorine (gas)	Cl_2	70.91	70.9	1,491	1.49	21.03	21.03	***100***	21.03

TABLE E-1. (Cont.)

Facility and Chemical name	Inventory: Process tank fill quantity kg	Inventory: Process tank fill quantity gal	Spill volume: Solution gal	Spill volume: Solution L	Spill moles: n_{solute} (moles)	Spill moles: $n_{solvent}$ (water) (moles)	Spill moles: $n_{solution}$ (moles)	Spill moles: MF	Spill mass: m_{solute} (kg)	Spill mass: $m_{solvent}$ (x or H_2O) (kg)	Spill mass: $m_{sol.}$ (kg)
MOX (BAP and BRP)											
Nitrogen tetroxide	907	165	165	626	9,871.3	0	9,871.3	1	908.3	0.00	908.3
Hydrazine hydrate	491	126	126	478	5,371.4	3,491	8,862.8	0.6061	268.9	62.90	331.8
Hydrazine-NaOH mixture	1,497	384	384	1,455	46.6	46,725	46,771.3	0.0010	4.4	841.75	846.1
Hydrazine/hydroxylamine nitrate mixture	2,445	627	627	2,376	356.4	76,012	76,368.8	0.0047	45.7	1,369.36	1,415.0
Hydroxylamine nitrate (HAN)	1,166	200	200	758	1,440.2	1,270	2,709.7	0.5315	138.3	22.87	161.2
Hydrogen peroxide	300	55	55	208	3,088.6	2,008	5,096.2	0.6061	105.1	36.17	141.2
Tributyl phosphate (TBP)	467	126	126	478	1,757.0	0	1,757.0	1	468.0	0.00	468.0
Nitric acid (13.6 M)	841	161	161	610	8,298.6	3,145	11,443.8	0.7252	522.9	56.66	579.6
Nitric acid (2.1 M)	6,901	1,321	1,321	5,007	10,514	9,506	20,020	0.5252	662.5	171.24	833.8
WSB											
Nitric Acid	2,414	500	500	1,895	14,916	7,458	22,374	0.6667	939.9	134.35	1,074.2
PDCF[b]											
Chlorine (gas)	430	240	240	911	19,158	0	19,158	1	430	0.00	430

[a]Chemicals used, concentrations, and process tank fill quantities for the proposed MOX facility obtained from DCS (2002b, Table 8-2a); values for the WSB obtained from DCS (2002a, Appendix G); values for the PDCF obtained from DOE (1999, Appendix E). Concentrations obtained from these sources are in bold italics; others are calculated values.

[b]Sulfuric acid was also listed for this facility with an annual usage of 470 kg. The concentration was not given, so quantitative spill modeling was not performed. If dilute, the solution would have low volatility and would present minimal hazards from accidental spills. However, if it was a concentration of 30% or more sulfur trioxide, sulfuric acid is highly water reactive and could present inhalation risks to facility workers or SRS employees if spilled.

Abbreviations: MOX: proposed MOX Fuel Fabrication Facility; BAP: Aqueous Polishing Area; BRP: Reagent Processing Building; WSB: Waste Solidification Building; PDCF: Pit Disassembly and Conversion Facility.

the largest mass transfer rate between the liquid and the vapor was used in estimating the chemical-specific evaporative rate:

$$k_m = \frac{N_{Sh} D_{ma}}{d_p} \quad \text{(E-3)}$$

$$k_{m_2} = 0.0048 u_{10}^{7/9} d_p^{-1/9} N_{Sc}^{-2/3} \quad \text{(E-4)}$$

where

D_{ma} = molecular diffusivity,

d_p = pool depth,

u_{10} = wind speed at 10-m level,

u_m = kinematic viscosity of the chemical,

N_{Re} = Reynolds number,

$$N_{Re} = \frac{u_{10} d_p}{v_m}$$

N_{Sc} = Schmidt number,

$$N_{Sc} = \frac{v_m}{D_{ma}}$$

and,

N_{Sh} = Sherwood Number,

$$N_{Sh} = 0.664 N_{Sc}^{1/3} N_{\mathrm{Re}}^{1/2} \quad for \quad N_{\mathrm{Re}} < 320{,}000$$

$$N_{sh} = 0.037 N_{Sc}^{1/3} [N_{\mathrm{Re}}^{0.8} - 15{,}200] \, for \; N_{\mathrm{Re}} \geq 320{,}000$$

Chemical-specific molecular diffusivities (i.e., of chemical in air) and kinematic viscosities were used in all cases where data were available. In the absence of data (about one-third of the cases), the molecular diffusivity of water or the kinematic viscosity of air were used as substitutes. This estimate was made to be conservative (i.e., use of Graham's Law to estimate molecular diffusivity would produce a value smaller than that of water).

Pressurized releases (i.e., nitrogen tetroxide and chlorine) were modeled with HGSYSTEM's SPILL, AEROPLUME, and HEGADAS modules. To estimate the effects of building

aerodynamic influence, the WAKE module was also run, assuming winds perpendicular to the largest building width. The source term was generated from the SPILL module, which simulates the transient liquid release from a pressurized vessel. AEROPLUME is a multicomponent, two-phase thermodynamic aerosol jet model that simulates steady-state release rates from a rupture or a leaking pressurized vessel and the near-field vapor cloud development of the flashed vapor and aerosol components in expelled jet release. Upon formation of the flow field from the release point and establishment of a heavy aerosol laden cloud, the release is linked to the HEGADAS module to simulate dense vapor cloud dispersion and entrainment of ambient air as the cloud moves and disperses downwind. For the building-influenced case, the WAKE module uses the source term from the SPILL module and simulates the aerodynamics in the wake of structures and neutrally buoyant vapor cloud dispersion beyond the wake. In the near-field, WAKE also simulates the concentration field of a release that may get trapped with the cavity recirculation region close to the building. It can also account for air entrainment and escape of vapors initially captured in the cavity region in back of the building, and the transport and dispersion of contaminants in the far wake and beyond.

Site-specific data used are from a 60-m meteorogical tower in the H-Area, relatively close to the proposed MOX location. Hourly wind speed and direction and related fluctuating parameters at the 60-m level were available for a 5-year period from 1992 through 1996. The data were preprocessed at the SRS Plant and sent to Argonne for use in the MOX environmental evaluation. The data were reported in Greenwich Mean Time (GMT) and were adjusted in the analysis for local time. Winds at the 60-m level were adjusted to 10 m with a power-law equation.

As mentioned previously, two sets of meteorological conditions, representative of daytime and nighttime conditions and producing conservative emissions and dispersion, were simulated for each evaporative release scenario. Although daytime releases would have more favorable dispersion conditions than nighttime releases, a larger release rate would occur because of higher ambient temperatures and higher near ground-level wind speeds. Both cases needed to be examined in order to determine the controlling, or “worst-case,” site-specific weather conditions.

To be consistent with the ARCON model, the 95th percentile daytime and nighttime winds were computed from the 5 years of tower data. Wind speeds were adjusted from the measured 60-m level to the 10-m level by using the standard power-law wind profiles employed in most EPA models (e.g., ISC). The 95th percentile day and night winds are representative of winds that occurred over the measurement period. By definition, 95% of all measured day and night wind speeds at the site would cause more plume dispersion. Similar computations were performed to derive the 95th percentile temperatures, defined as ambient temperatures producing reasonable upper-bound evaporative emission rates. Because higher wind speeds also tend to increase pool evaporation, the 5th percentile wind speeds (i.e., the 5th percentile here is defined as representing the largest wind speeds measured in the 5-year period studies) were also computed. Each of the meteorological cases, including the 95th percentile concentration ARCON case used for estimating 100-m downwind involved worker exposures, are summarized in Table E.2. In addition to wind speed and temperature, the complete set of

Table E.2. Scenario meteorology[a,b]

Parameter	Day (95% temp/ 95% winds)	ARCON (95% conc., ARCON)	Night (95% temp/ 95% winds)	Sunrise/ Sunset (95% temp/ 5% winds)
T_a (K)	304.0	299.2	299.2	299.2
T_a (°F)	87.5	78.5	78.5	78.5
U_{10} (m/s)	1.3	2.2	1.3	4.7
Stability	D	F	F	D
Frequency	27%	n/a	11%	100%
z_i (m)	416	n/a	Unlimited	Unlimited
Cloud Cover	7/10	Clear to 4/10	Clear to 4/10	Clear to 4/10
RH (%)	85%	65%	65%	65%
Insolation	Slight	Night	Night	Slight

[a]T_a – ambient temperature, u_{10} – wind speed at 10 m, z_i = mixing height, RH – relative humidity.
[b]z_o – surface roughness = 50 cm; season = summer.

meteorological parameters used in the ALOHA simulations and the temperatures and wind speeds used in the evaporative spreadsheet calculation tool are summarized in the table. A fourth set of conditions, typical during sunrise or sunset (given in the table), was also run to see if the larger wind speed and neutral conditions would result in more conservative impacts. These conditions resulted in lower impacts and are not further discussed.

Surface roughness was assumed to be 50 cm, which is representative of a good portion of the SRS (Weber 2002). This roughness is large enough to switch the ALOHA computed dispersion coefficients to that representative of urban environments, which will enhance the horizontal and vertical spread of released contaminant as it is advected downwind.

The spill scenario assumed that a forklift punctured a liquid storage tank containing the chemical. Estimates are needed for three key parameters used in determining the evaporation rates (Equation E-1). These parameters are the ambient temperature (T_a), pool area, and vapor pressure. Varying stability conditions, temperatures, and wind speeds were modeled to determine worst-case emission and dispersion conditions. Unlimited mixing was assumed to be consistent with U.S. Environmental Protection Agency (EPA) models (e.g., TSCREEN, ISC) for these conservative nighttime dispersion conditions. The maximum mixing height value, set as a default in ALOHA, is 1,524 m (5,000 ft).

All of the tanks were assumed to be cylindrical in shape with the puncture hole assumed to be located near the tank bottom. Tank dimensions varied depending on the specific chemical inventories. The calculated spill quantities were conservatively assumed to be the full contents of each liquid storage container. The spilled liquid was assumed to spread out on a concrete surface, with a surface roughness of around 3 cm (1.2 in.), to a pool depth of 2.54 cm (1 in.). The final pool area and diameter were computed by assuming a circular pool with a uniform

Table E.3. Evaporative release modeling results

Chemical	MET	Maximum evaporation rate Q (kg/h)	Release duration[a] t_d (h)	SRS worker exposure @100 m (mg/m^3)	Hazard distances TEEL1 Passive (km)	TEEL1 Dense (km)	TEEL2 Passive (km)	TEEL2 Dense (km)	TEEL3 Passive (km)	TEEL3 Dense (km)
Hydrazine hydrate	Day	**11.5**	**28.8**		1.9	3.7	1.9	3.7	1.9	3.7
	ARCON	**17.4**	**19.1**	**2.3**	-[b]	-	-	-	-	-
	Night	**8.8**	**37.5**		5.6	6	5.6	6	5.6	6
Hydrazine/NaOH	Day	**0.065**	**34,000**		0.032	NA[c]	0.01	NA	< 0.010	NA
	ARCON	**0.098**	**23,000**	**0.01**	-	-	-	-	-	-
	Night	**0.056**	**15,000**		0.064	NA	0.020	NA	< 0.010	NA
Hydrazine/HAN	Day	**8.5**	**246.0**		0.381	NA	0.117	NA	0.045	NA
	ARCON	**12.8**	**163.4**	**1.7**	-	-	-	-	-	-
	Night	**6.6**	**116.5**		0.855	NA	0.233	NA	0.086	NA
Hydroxyl-amine nitrate (HAN)	Day	**7.7**	**20.9**		0.07	0.135	0.053	0.101	0.024	0.044
	ARCON	**11.6**	**13.9**	**1.5**	-	-	-	-	-	-
	Night	**5.9**	**10.0**		0.135	0.206	0.102	0.151	0.045	0.063
Hydrogen peroxide	Day	**0.70**	**202.6**		0.023	0.044	< 0.010	0.02	< 0.010	0.011
	ARCON	**1.44**	**155.7**	**0.2**	-	-	-	-	-	-
	Night	**0.7**	**108.4**		0.050	0.075	0.022	0.033	0.016	0.022
Tributyl phosphate (TBP)	Day	**6.51**	**71.8**		0.103	NA	0.079	0.014	NA	6
	ARCON	**9.81**	**47.7**	**1.7**	-	-	-	-	-	-
	Night	**6.6**	**26.1**		0.233	NA	0.178	0.031	NA	
Nitric acid 13.6 M	Day	**9.9**	**58.3**		0.197	0.388	0.08	0.146	0.022	0.032
	ARCON	**12.9**	**44.8**	**1.7**	-	-	-	-	-	-
	Night	**7.9**	**38.5**		0.417	0.616	0.158	0.042	0.041	
Nitric acid 2.1 M	Day	**34.9**	**23.9**		0.378	0.752	0.151	0.282	0.041	0.06
	ARCON	**49.5**	**16.8**	**6.7**	-	-	-	-	-	-
	Night	**27.8**	**11.7**		0.86	1.2	0.310	0.079	0.072	
Nitric acid 7.9 M	Day	**116.4**	**56.3**		0.710	1.4	0.279	0.536	0.075	0.107
	ARCON	**25.1**	**37.4**	**20**	-	-	-	-	-	-
	Night	**13.3**	**70.8**		1.6	2.0	0.547	0.666	0.134	0.119

Table E.3. Continued

Chemical		Health index concentration TEEL 1 (mg/m³)	TEEL 2 (mg/m³)	TEEL 3 (mg/m³)	Downwind concentration at SRS boundary (8.2 km) mg/m³
Hydrazine hydrate	Day	0.04	0.04	0.04	0.003
	ARCON				-
	Night				0.03[d]
Hydrazine/NaOH	Day	0.6	6	40	1.9×10^{-5}
	ARCON				-
	Night				0.001
Hydrazine/ HAN	Day	0.6	6	40	0.002
	ARCON				
	Night				0.076
Hydroxyl-amine nitrate (HAN)	Day	15	26	125	0.002
	ARCON				-
	Night				0.068
Hydrogen peroxide	Day	12.5	60	125	2.0×10^{-4}
	ARCON				-
	Night				0.008
Tributyl phosphate (TBP)	Day	6	10	300	0.002
	ARCON				-
	Night				0.075
Nitric acid 13.6 M	Day	2.5	15	200	0.003
	ARCON				-
	Night				0.090
Nitric acid 2.1 M	Day	2.5	15	200	0.010
	ARCON				-
	Night				0.319
Nitric acid 7.9 M	Day	2.5	15	200	0.024
	ARCON				-
	Night				0.883

[a]"Reported duration is based on maximum spill volume and evaporation rate. However, the ALOHA model restricts the maximum release duration to one hour. At constant wind speed, the highest concentration would occur in this first hour.

[b]"-" = not applicable.

[c]NA = not available.

[d]Estimated value.

depth along with the spill volume. The pool size for each of the spill scenarios ranged from 8 m^2 (hydrogen peroxide spill outside the MOX BRP building) to 435 m^2 (nitric acid spill at the WSB).

As previously mentioned, the vapor pressures, as well as other the physical properties required in estimating the evaporation rate from Equation E-1, were computed by using chemical-specific coefficients in Antione or equivalent equations, or (in the absence of temperature dependent data) obtained directly from published literature (e.g., Linde 1999; Perry and Green 1984; NIST 2001; DIPPR 1989). Adjustments for dilute solutions were accounted for by multiplying by the computed mole fraction, the ratio of the number of moles of a substance to the total amount of that substance in a mixture. The physical properties, including the mole fraction adjusted vapor pressures, and the computed chemical specific nondimensional numbers used in computing evaporation rates (e.g., Reynolds Number), are summarized in Table E.4.

Accident consequences for evaporative releases, expressed as the ambient concentration at specified downwind distances, are reported in Table E.3. These concentrations are compared with TEEL values (see text box in Section 4.3.5.3). To assess impacts for SRS employees, concentrations greater than TEEL-3 levels at 100 m for any chemical were defined as high consequence, and levels less than TEEL-3 but greater than TEEL-2 were defined as moderate consequence. To assess impacts for the general public, SRS boundary concentrations greater than TEEL-2 levels for any chemical were defined as high consequence, and levels less than TEEL-2 but greater than TEEL-1 were defined as moderate consequence. In addition, the hazard distances (i.e., maximum distances from the release point to which chemical TEEL-1, TEEL-2, and TEEL-3 air concentrations could extend) were estimated with the ALOHA model and are listed in Table E.3.

The impacts to SRS workers, located 100 m (330 ft) from the spill, were estimated by multiplying the ARCON 95th percentile chi/Q value (0.00061 s/m^3) by the estimated evaporation rate, assuming the same wind speed that produces the ARCON 95th percentile chi/Q (2.2 m/s) and the 95th percentile site-specific temperature (78.5 ^{o}F) derived from 5 years of data from the meteorological tower in the H-area. For evaporative releases, worker exposures above the TEEL-2 level could occur for spills involving hydrazine hydrate and 7.9 M nitric acid. In addition, two spills (hydrazine/HAN mixture and 2.1 M concentrations of nitric acid) have the potential to expose SRS employees above the TEEL-1 levels. The 100-m (330 ft) concentration reference level for SRS employees is consistent with the SRS Emergency Response Plan (SRS 2001), which defines the facility boundary as follows:

> "Generally, the facility boundary is the fence line for a property, protected area or a limited area, depending upon the facility. When a physical boundary is unavailable, the distance of 100 meters from the point of release or edge of the spill is used. Area/facility-specific Emergency Preparedness Hazard Assessment Documents identify facility boundaries and should be referenced."

Since the wind speed and atmospheric stability generating the upper-bound impacts for nighttime conditions were 1.3 m/s with stable conditions (i.e., PG Class F), the plume transport

Table E.4. Physical property data

Chemical/ property[a]	Nitrogen tetroxide (N_2O_4)	Nitric acid (HNO_3)	Hydrazine hydrate (H_6N_2O)	HAN ($H_4N_2O_4$)	Hydrazine-HAN ($H_4N_2O_4$ -N_2H_4)	Hydrazine-NaOH (N_2H_4-NaOH)	Tributyl phosphate ($C_{12}H_{27}O_4P$)	Hydrogen peroxide (H_2O_2)	Chlorine (Cl)
MW	92.0	63.1	50.06	96.04	128.09	93.99	266.36	34.02	70.91
?$_l$ (kg/L)	1.443	1.383	1.03	1.54	1.54[c]	2.13	0.979	1.44	1.49
?$_v$ (kg/m^3)	3.2-998.9[f]	2.012	0.95	0.981	–[g]	–[g]	–[g]	2.72	4.72-432.5[f]
k_m (m/s)	NA[e]	2.67×10^{-4}–5.76×10^{-4}	5.26×10^{-3}	6.17×10^{-3}	3.82×10^{-4}	5.26×10^{-3}	8.86×10^{-4}	5.07×10^{-3}	NA[e]
D_m (m^2/s)	NA[e]	1.19×10^{-5}	1.65×10^{-5}	1.63×10^{-5}	–[g]	–[g]	–[g]	1.62×10^{-5}	NA[e]
<$_k$ (m^2/s)	NA[e]	5.84×10^{-4}	1.28×10^{-5}	6.65×10^{-6}	–[g]	–[g]	–[g]	7.92×10^{-4}	NA[e]
P_{Vap} (Pa) (78.9 ºF)	2,038.5	4,540.8–6,269.9[d]	1,235.5	281.5	289.7	2.2	134.8	1,912.2	8.02×10^5
P_{Vap} (Pa) (87.5 ºF)	2,701.9	5,800.2–8,008.9[d]	1,637.5	373.1	379.0	2.6	135.3	1,978.0	9.37×10^5
N_{Sc}	NA[e]	49.7	0.909	0.923	0.625	0.625	0.625	48.9	NA[e]
N_{sh}	NA[e]	271–458	593	829	1,439	1,090	524	177	NA[e]
N_{Re}	NA[e]	12,307–35,254	423,749	534,226	945,897	1,251,896	424,029	5,307	NA[e]

[a]?1 = liquid density, ?$_v$ = vapor density, k_m = mass transfer coefficient, D_m = molecular diffusivity, P_{vap} = vapor pressure, <$_k$ = kinematic viscosity, N_{Sc} = Schmidt number, N_{Sh} = Sherwood number, N_{Re} = Reynolds number.

[b]Hydroxylamine nitrate.

[c]No published value available, set equal to the HAN published density at STP.

[d]Nitric acid (1.21 N) [4,540.8 (78.9EF), 5,800.2 (89.5EF)]; Nitric acid (7.9 N) [5,764.2 (78.9EF), 7,362.9 (89.5EF)]; Nitric acid (13.6 N) [6,269.9 (78.9EF), 8,008.9 (89.5EF)].

[e]NA = not applicable, modeled as a pressurized release.

[f]Aerosol vapor mixture density from jet release is initially very high; it is diluted over time to its vapor density at ambient conditions.

[g]– = not available.

time or the time it would take the release to reach the nearest SRS boundary (8.2 km downwind) would be almost 2 hours. Because ALOHA restricts the maximum release duration and plume transport time to one hour or less, ALOHA impact estimates at the SRS boundary could not be made for the low wind speed assumed in the simulations. Therefore, maximum impact estimates at the SRS boundary were made by using a formula for a ground-level release producing maximum ground-level concentrations (i.e., on the plume centerline at the surface), similar to that used in ALOHA. Ground-level centerline passive plume concentrations were estimated using the following formula, derived from the standard Gaussian equation: $C(x,0,0) = Q/p\,u s_y s_z$. Dense gas estimates at the fence line were estimated by increasing the wind speed from 1.3 to 2 m/s to shorten the transport time to the fence line to less than one hour. The ALOHA-estimated concentration was then multiplied by 1.3 [chi/u(2) x u(1.3)] to arrive at the estimated SRS boundary concentration. The highest concentrations at this distance occurred subsequent to transition to a purely passive plume (i.e., no negative buoyancy influences from density effects). Estimates at 100 m using the above expression compared well (no more than a 1 to 2% difference) with the ALOHA estimate at the same location.

The ALOHA estimated hazard distances are also given in Table E.3 for evaporative plumes exhibiting dense vapor cloud dispersion. These plumes disperse downwind to a transition point at which ambient air entrainment into the cloud sufficiently dilutes concentrations so that the plume continues to disperse from that point downwind as a neutrally buoyant plume. Almost all of the releases considered that initially behave as dense clouds produced the largest hazard distance. The largest potential health hazard was shown to extend 6 km (3.7 mi) downwind for an accidental spill of 477 L (126 gal) of 35% hydrazine hydrate. With the exception of two nitric acid spills, all other potential chemical spills would produce hazard distances less than 1 km (0.6 mi).

Releases of two materials, nitrogen tetroxide and chlorine, were modeled as pressurized releases. The analysis showed that these pressurized releases would potentially produce very large exposures to SRS workers at a distance of 100 m (330 ft) because the concentrated dense gas plume could extend to this distance for a short time. The concentrations within the jet plume would approach 10,000 and 1,500 mg/m^3 at 100 m (330 ft) for nitrogen tetroxide and chlorine, respectively. The TEEL-2 hazard distance for accidental releases of both substances could extend to 4 km (2.5 mi) from the release location. The high concentrations close to the source are primarily due to the release of a pressurized, two-phased vapor-aerosol, which forms a dense vapor cloud. It should be noted that building influences on the heavy vapor cloud are not accounted for in the AEROPLUME and HEGADAS simulations. Such influences on passive releases are accounted for in the WAKE model, but not the combination of building aerodynamics and density effects. The estimated 100-m (330-ft) exposure calculated with the WAKE model approached 1,600 mg/m^3 and 500 mg/m^3 for nitrogen tetroxide and chlorine, respectively. The likely actual concentrations would likely fall between the two modeled results for each chemical.

E.2 Radiological

Risks from radioactive materials were assessed for workers involved in facility operations ("facility workers") at the proposed MOX facility, the PDCF, and the WSB; other SRS workers outside the restricted area of the facility site ("SRS employees"); and members of the public.

E.2.1 Normal Operations

E.2.1.1 Facility Workers

For facility workers, external radiation from the direct handling of radioactive materials and/or the close working distances to radiation sources would be the primary exposure pathway. Radiation exposures through inhalation and incidental ingestion of contaminated particulates would be possible but for the average worker would be expected to be very small compared with exposures to external radiation.

Operations that could result in potential airborne radiological emissions would be conducted under fume hoods or in gloveboxes. Even if airborne releases from the gloveboxes did occur, the use of high-efficiency particulate air (HEPA) filters and protective air circulation systems would reduce the airborne pollutants in the working place to a minimal level. Exposures from inhalation could also be prevented by implementation of as-low-as-reasonably-achievable (ALARA) practices, such as requiring workers to wear respirators while performing activities with potential for generating airborne emissions. Potential exposure from incidental ingestion of particulate matter could be reduced by workers' wearing gloves and exercising good working practices.

For the proposed MOX facility, radiation exposure was estimated on the basis of exposures received during operation of a similar facility, the MELOX plant in Marcoule, France. External dose rates at the MELOX plant were extrapolated on the basis of the plutonium composition of the MELOX MOX fuel (8.5%) and proposed facility MOX fuel (5%) (DCS 2001b). Scaling was done by using the ratios of the photon and neutron intensities for the two concentrations. An annual collective external dose of 0.10 person-Sv (10 person-rem) was estimated for the processing area. An additional annual external dose of 0.02 person-Sv (2 person-rem) was assumed for the aqueous polishing area because no data were available (DCS 2001b). Thus, an annual external exposure of 0.12 person-Sv (12 person-rem) was estimated for facility workers.

Facility workers may also receive an internal dose. At the MELOX plant, from 1996 through July 2001, 41 individuals had received an internal radiation exposure: 30 had received <10% of the annual limit on intake (ALI), 10 ranging from 10% to 33.3% ALI, and 1 ranging from 33.3% to 100% ALI. With an intake of 100% ALI, an individual receives a dose of 0.05 Sv (5 rem). Because design and management measures at the MELOX plant are similar to those planned for the proposed facility, a MOX facility worker MEI may receive a dose of 0.017 Sv (1.7 rem), corresponding to a 33% ALI, in a year. The total dose of 0.13 person-Sv (13 person-rem) over

this 5-year period results in an average internal dose of less than 0.03 person-Sv (3 person-rem) per year (assuming the full 50-year dose commitment in the year of exposure) (DCS 2001b). Thus, the annual collective facility worker exposure is estimated to be 0.15 person-Sv (15 person-rem), the sum of the estimated external and internal exposures.

For the PDCF and WSB, no historical operational experience is available to provide a reasonable estimate of the worker exposures. Because these two facilities would be owned and operated by the DOE, individual facility worker exposure would be maintained below 0.005 Sv/yr (0.5 rem/yr), the SRS site guideline, which is below the DOE administrative limit of 0.02 Sv/yr (2 rem/yr) (DOE 1994). However, using best practices under the ALARA principle, the average individual dose should be kept close to or lower than the average SRS radiological worker dose of 0.00048 Sv/yr (0.048 rem/yr) (DOE undated).

The information on radiation sources, worker activities, and number of required workers is subject to a large degree of uncertainty, as are the estimated collective and MEI worker doses. However, the radiation dose to the individual worker would be monitored and maintained below the NRC annual occupational total effective dose limit of 0.05 Sv (5 rem) (*Code of Federal Regulations*, Title 10, Part 20 [10 CFR 20]).

E.2.1.2 SRS Employees

Inhalation of contaminated particulates and external exposure to the plume of routine airborne releases from the plant and to soil contaminated by deposition of those airborne releases were considered for SRS employees. Because they would be located farther from the radiation sources handled in the three facilities than would facility workers, those SRS employees would not be exposed to direct external radiation from those sources. However, secondary external radiation would be possible from the deposited radionuclides on ground surfaces and from airborne radionuclides when the emission plume from the stack of the facilities passed the locations of the SRS employees. To obtain conservative estimates of potential exposure and doses, the SRS employees were assumed to be exposed to radiation from airborne emissions without any shielding by buildings or other structures.

The GENII computer code (Napier et al. 1988) was used to estimate radiological impacts to the SRS employees on the basis of emissions data shown in Table E.5. GENII has been used for the same application in several previous environmental impact statement projects, such as the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (WM PEIS) (DOE 1997). The GENII code uses either site-specific or representative meteorological data (joint frequency data) selected to estimate the air concentrations at downwind locations. The code implements the internal dosimetry models recommended by the International Commission on Radiological Protection (ICRP) in Publication 26 (ICRP 1977) and Publication 30 (ICRP 1979). The GENII code considers the transport of radioactive material in air, soil, water, and food sources to the human body.

Table E.5. Estimated annual radiological releases from the facilities during normal operations

	Airborne releases (:Ci/yr)[a]	
Isotope	**Proposed MOX facility and WSB[b]**	**PDCF[c]**
Plutonium-236	1.3×10^{-8}	9.3×10^{-11}
Plutonium-238	8.5	0.065
Plutonium-239	91	0.69
Plutonium-240	23	0.18
Plutonium-241	101	0.69
Plutonium-242	6.1×10^{-3}	4.8×10^{-5}
Americium-241	48	0.37
Uranium-234	5.1×10^{-3}	NA[d]
Uranium-235	2.1×10^{-4}	NA
Uranium-238	0.012	NA
Tritium	NA	1.1×10^{9}

[a]To convert from microcuries (:Ci) to becquerels (Bq), multiply by 3.7×10^{4} (or 37,000).

[b]*Source:* DCS (2002a).

[c]*Source*: DOE (1999).

[d]N/A = Not Applicable.

The SRS employee population distribution used to estimate the SRS employee dose is given in Table E.6. This distribution is centered at the proposed MOX facility and involves a total population of 12,192 site workers. A stack height of 37 m (121 ft) (as specified in Section 3.1.1 of DCS 2002a) was used as the release height for normal emissions from the proposed MOX facility. WSB emissions were included in the proposed MOX facility estimates (DCS 2002a,b). An estimated stack height of 35 m (115 ft) was used as the release height for emissions from the PDCF (LANL 1998). Five years of weather information in the form of joint frequency data (1992-1996 average [as shown in Table E.7]) was used for the air dispersion calculations. On an annual basis, the total time of external exposure to the plume and contaminated soil for all SRS employees was assumed to be 0.5 year (NRC 1977). Resuspension of contaminated soil was not considered, and the soil was assumed to be previously uncontaminated. Ingestion of contaminated foodstuffs was not considered because food is not grown on-site and consumed.

The maximally exposed individual (MEI) for the SRS employees was assumed to be within the SRS boundary (but outside the facility site) at a location that would have the maximum air concentration and would thus yield the largest radiation dose. On an annual basis, the total time of annual external exposure to the plume and contaminated soil for the MEI was assumed to be 0.7 year. For the inhalation pathway, an exposure time of 1 year was assumed (NRC 1977).

Table E.6. SRS employee population distribution centered at the proposed MOX facility on the SRS

	Population by distance (miles[a])						
Direction	**0 to 1**	**1 to 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 10**	**Total**
S	1,191	0	225	171	0	397	1,984
SSW	592	0	0	0	0	7	600
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	1,728	110	0	0	1,839
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	2,408	897	3,305
NNW	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	18	0	0	5	23
E	0	438	1,863	0	0	0	2,300
ESE	0	722	754	0	0	0	1,476
SE	70	101	26	0	0	25	221
SSE	282	0	0	1,164	0	100	1,547
Total	2,135	1,260	4,614	1,446	2,408	1,432	13,295

[a]To convert from miles to kilometers, multiply by 1.61.

E.2.1.3 Members of the Public

The GENII code was used to assess radiation exposures of members of the public outside the SRS boundaries. The exposure pathways analyzed included inhalation of contaminated particulates, external radiation from deposited radionuclides and from airborne radionuclides, and ingestion of contaminated food products (plants, meat, and dairy products). Plants grown in the area where the emission plume passed could become contaminated by deposition of radionuclides on the leaves or ground surfaces. Radionuclides deposited on leaves could subsequently translocate to the edible portions of the plants, and those deposited on ground surfaces could subsequently be absorbed by plant roots. Livestock and their products could become contaminated if the livestock ate the contaminated surface soil and plants.

The off-site population distribution out to 80 km (50 mi), centered at F-Area, for the SRS area used in the assessment is given in Table E.8. The annual time of external exposure to the plume and contaminated soil for the general public off-site was assumed to be 0.5 year (NRC 1977). No credit for shielding was given for inhalation exposure. Ingestion parameters are provided in Table E.9. Food production data for the area surrounding the SRS are provided in Table E.10.

For the public, the location of the MEI was considered to be at the SRS boundary as a conservative assumption. Table E.11 lists the distance from the proposed MOX facility to the

Table E.7. Joint frequency distribution used for calculation of receptor dose from facility air emissions

Wind speed (m/s)	Stability class	Wind direction															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
2.0	A	0.25	0.20	0.24	0.24	0.21	0.18	0.15	0.18	0.17	0.17	0.21	0.22	0.18	0.18	0.16	0.21
	B	0	0.03	0.03	0.03	0.01	0.00	0.00	0.01	0	0	0.03	0.03	0.00	0.03	0.03	0.02
	C	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.03	0.03	0	0	0	0.01	0.02	0.01	0.01
	D	0.01	0.02	0.00	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0	0.01	0.01	0.01	0.03
	E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0	0	0.00	0.00	0.00
	F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00
5.5	A	0.88	0.73	0.92	1.04	1.06	0.79	0.70	0.55	0.74	0.78	1.12	1.37	1.19	0.8	0.56	0.57
	B	0.24	0.36	0.43	0.44	0.35	0.25	0.19	0.21	0.26	0.24	0.34	0.38	0.29	0.3	0.2	0.16
	C	0.15	0.39	0.73	0.50	0.39	0.24	0.24	0.29	0.33	0.36	0.43	0.49	0.34	0.28	0.2	0.18
	D	0.09	0.25	0.59	0.34	0.31	0.27	0.34	0.37	0.42	0.39	0.38	0.33	0.30	0.22	0.26	0.21
	E	0.01	0.09	0.28	0.11	0.08	0.16	0.17	0.18	0.26	0.22	0.19	0.20	0.13	0.13	0.11	0.13
	F	0.01	0.02	0.02	0.01	0.00	0.03	0.02	0.03	0.03	0.03	0.02	0.05	0.00	0.01	0.02	0.04
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	A	1.03	0.66	0.53	0.50	0.44	0.30	0.26	0.20	0.37	0.43	0.60	0.70	0.71	0.48	0.24	0.36
	B	0.21	0.57	0.65	0.67	0.32	0.23	0.16	0.19	0.31	0.33	0.55	0.75	0.55	0.36	0.16	0.18
	C	0.16	0.69	1.49	0.86	0.67	0.44	0.42	0.42	0.52	0.58	0.74	0.78	0.78	0.57	0.27	0.14
	D	0.12	0.52	1.64	0.95	0.81	0.70	0.84	1.12	1.48	1.05	1.26	1.27	1.01	0.88	0.50	0.20
	E	0.06	0.64	1.08	0.81	0.62	0.62	0.82	0.98	1.20	1.10	1.06	1.12	0.63	0.47	0.42	0.24
	F	0.02	0.22	0.19	0.07	0.10	0.16	0.18	0.17	0.22	0.16	0.21	0.27	0.07	0.06	0.05	0.06
	G	0.00	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.00	0.00	0.00	0.00
15.5	A	0.21	0.18	0.03	0.03	0.01	0.02	0.02	0.01	0.02	0.04	0.05	0.10	0.09	0.11	0.03	0.09
	B	0.02	0.17	0.12	0.04	0.04	0.03	0.05	0.04	0.04	0.09	0.18	0.31	0.46	0.34	0.09	0.03
	C	0.00	0.18	0.46	0.21	0.08	0.09	0.16	0.22	0.20	0.29	0.41	0.46	0.73	0.62	0.13	0.01
	D	0.00	0.09	0.19	0.08	0.05	0.06	0.13	0.46	0.43	0.24	0.24	0.12	0.13	0.11	0.07	0.00
	E	0.00	0.09	0.06	0.09	0.07	0.05	0.05	0.09	0.13	0.10	0.19	0.07	0.02	0.02	0.01	0.00
	F	0.00	0.04	0.02	0.03	0.01	0.03	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	A	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.00	0.01
	B	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.08	0.06	0.01	0.00
	C	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.04	0.04	0.05	0.05	0.08	0.18	0.10	0.02	0.00
	D	0.00	0.00	0.00	0	0.00	0.00	0.00	0.03	0.02	0.02	0.01	0.00	0.02	0.00	0.00	0.00
	E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table E.7. Continued

Wind speed (m/s)	Stability class	Wind direction															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.0	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: DCS (2002a).

Table E.8. Projected off-site population distribution at the SRS for the public for the year 2030

	Population by distance (miles[a])						
Direction	**0 to 5**	**5 to 10**	**10 to 20**	**20 to 30**	**30 to 40**	**40 to 50**	**Total**
S	0	0	920	2696	11,367	6,013	20,996
SSW	0	15	1,317	3,692	8,115	4,376	17,515
SW	0	186	1,978	7,732	3,535	4,579	18,010
WSW	0	171	2,572	7,553	4,368	10,385	25,049
W	0	407	10,186	17,766	15,109	11,753	55,221
WNW	0	2,331	8,556	219,212	54,849	24,980	309,928
NW	0	1,861	25,692	137,243	15,851	5,567	186,214
NNW	0	1,978	33,320	18,925	11,627	5,648	71,498
N	0	3,500	36,210	15,530	11,294	17,670	84,204
NNE	0	397	3,010	3,515	6,925	28,857	42,704
NE	0	14	2,609	4,611	8,850	19,325	35,409
ENE	0	0	5,535	7,865	8,764	53,785	75,949
E	0	2	8,061	8,590	18,423	9,310	44,386
ESE	0	14	3,658	4,352	5,466	488	13,978
SE	0	0	951	7,673	7,409	17,619	33,652
SSE	0	0	615	1,154	1767	4,234	7,770
Total	0	10,876	145,190	468,109	193,719	224,589	1,042,483

[a]To convert from miles to kilometers, multiply by 1.61.

Source: DCS (2002a).

SRS boundary for the 16 compass directions from which the MEI was determined. Because of the close proximity of the PDCF and WSB to the proposed MOX facility, the same MEI receptor locations were used for these facilities. The annual external exposure to the plume and contaminated soil for the public off-site MEI was assumed to be 0.7 year (NRC 1977). No credit for shielding was given for inhalation exposure. Ingestion parameters are provided in Table E.9.

E.2.2 Accidents

For the proposed MOX facility, four accident events were considered for detailed analysis, as discussed in Section 4.3.5.1. In each case, the amount of material released to the atmosphere was determined by multiplying the amount of material present (material at risk [MAR]) by the fraction of material involved in the event (damage ratio), fraction of material released that is airborne and respirable, and the fraction of material transported through a confinement mechanism (leak path factor). The values used for these parameters and the initial amount of plutonium material assumed to be present for each accident considered are given in Table E.12. Table E.13 lists the activity by radionuclide estimated to be released to the environment for each hypothetical accident.

Table E.9. Ingestion parameters used in GENII for calculation of radiological exposure of the public for normal and accident air emissions

Parameter	Value: Maximally exposed individual	Value: Population
Terrestrial food		
Consumption rate (kg/yr)[a]		
Leafy vegetables	43	21
Root vegetables	276	163
Fruit	276	163
Grain	276	163
Crop yield (kg/m^2)[b]		
Leafy vegetables	1.5	1.5
Root vegetables	4	4
Fruit	2	2
Grain	0.8	0.8
Hold time between harvest and storage (days)[b]		
Leafy vegetables	1	14
Root vegetables	5	14
Fruit	5	14
Grain	180	180
Animal products		
Consumption rate (kg/yr)		
Beef[a]	81	43
Milk[a]	230	120
Poultry[b]	18	8.5
Eggs[b]	30	20
Holdup time (days)[b]		
Beef	15	34
Milk	1	3
Poultry	1	34
Eggs	1	18
Production rate (kg/yr)	NA[c]	d
Diet fraction for animal food sources[b]		
Stored feed		
Beef	0.25	0.25
Milk	0.25	0.25
Poultry	1	1
Eggs	1	1
Fresh forage		
Beef	0.75	0.75
Milk	0.75	0.75

Table E.9. Continued

Parameter	Value: Maximally exposed individual	Value: Population
Growing time for animal food sources (days)[b]		
Stored feed		
Beef	90	90
Milk	45	45
Poultry	90	90
Eggs	90	90
Fresh forage		
Beef	45	45
Milk	30	30
Yield of animal food sources (kg/m^3)[b]		
Stored feed		
Beef	0.8	0.8
Milk	2	2
Poultry	0.8	0.8
Eggs	0.8	0.8
Fresh forage		
Beef	2	2
Milk	1.5	1.5
Storage time for animal food sources (days)[b]		
Stored feed		
Beef	180	180
Milk	100	100
Poultry	180	180
Eggs	180	180
Fresh forage		
Beef	100	100
Milk	0	0

[a]*Source*: Arnett and Mamatey (2001).

[b]GENII default values.

[c]NA = not applicable.

[d]See Section E.1.3 and Table E.8.

Table E.10. Food production data used in GENII for calculation of radiological ingestion exposure of the public for normal and accident air emissions

Product/ direction	Production (kg/yr) by distance (miles[a])					
	0 to 5	5 to 10	10 to 20	20 to 30	30 to 40	40 to 50
Leafy vegetables						
S	0	0	0	0	0	1.0×10^5
SSW	0	0	0	0	0	1.0×10^5
SW	0	3.4×10^5	0	0	0	1.1×10^3
WSW	0	3.7×10^2	3.3×10^1	0	1.6×10^3	8.8×10^3
W	0	1.3×10^3	1.3×10^2	0	2.8×10^3	4.1×10^3
WNW	0	1.4×10^3	3.4×10^3	0	0	0
NW	0	1.4×10^3	6.3×10^3	4.7×10^3	0	0
NNW	0	1.3×10^3	6.9×10^3	8.7×10^3	8.6	2.4×10^3
N	0	1.1×10^3	6.9×10^3	1.2×10^4	1.1×10^4	4.8×10^4
NNE	0	5.9×10^2	6.9×10^3	1.2×10^4	3.1×10^5	9.6×10^5
NE	0	4.6×10^1	6.0×10^3	3.1×10^4	2.5×10^5	7.7×10^5
ENE	0	0	7.6	3.2×10^4	1.6×10^5	2.1×10^5
E	0	0	0	0	2.3×10^4	1.3×10^5
ESE	0	0	0	0	0	1.0×10^5
SE	0	0	0	0	0	1.0×10^5
SSE	0	0	0	0	0	1.0×10^5
Root vegetables						
S	0	0	1.8×10^6	3.1×10^6	4.1×10^6	6.3×10^6
SSW	0	3.1×10^3	2.1×10^6	3.4×10^6	4.3×10^6	6.7×10^6
SW	0	9.7×10^7	2.2×10^6	3.6×10^6	4.8×10^6	5.8×10^6
WSW	0	1.1×10^5	2.1×10^6	3.6×10^6	5.3×10^6	8.0×10^6
W	0	1.8×10^5	2.3×10^5	1.3×10^6	3.4×10^6	4.4×10^6
WNW	0	1.9×10^5	5.0×10^5	1.1×10^5	5.4×10^4	3.2×10^5
NW	0	2.0×10^5	8.8×10^5	8.2×10^5	4.0×10^5	1.4×10^5
NNW	0	1.9×10^5	9.6×10^5	1.3×10^6	7.3×10^5	1.2×10^6
N	0	1.5×10^5	9.6×10^5	1.6×10^6	1.7×10^6	2.4×10^6
NNE	0	8.1×10^4	9.6×10^5	1.6×10^6	2.5×10^6	3.8×10^6
NE	0	6.3×10^3	1.2×10^6	2.6×10^6	4.2×10^6	5.1×10^6
ENE	0	0	3.4×10^6	6.3×10^6	7.8×10^6	9.9×10^6
E	0	0	3.6×10^6	6.3×10^6	7.9×10^6	1.0×10^7
ESE	0	0	3.3×10^6	6.6×10^6	8.4×10^6	5.3×10^6
SE	0	0	6.4×10^7	6.8×10^6	8.8×10^6	9.2×10^6
SSE	0	0	3.8×10^7	3.0×10^7	6.7×10^6	7.8×10^6
Fruit						
S	0	0	3.9×10^5	1.1×10^6	1.7×10^6	2.5×10^6
SSW	0	6.9×10^2	4.5×10^5	8.7×10^5	1.4×10^6	2.3×10^6
SW	0	3.3×10^7	4.8×10^5	7.9×10^5	1.2×10^6	1.2×10^6
WSW	0	4.4×10^4	4.7×10^5	7.9×10^5	1.0×10^6	8.8×10^5
W	0	1.1×10^5	4.5×10^4	2.7×10^5	4.4×10^5	3.9×10^5
WNW	0	1.2×10^5	2.8×10^5	1.1×10^3	2.3×10^2	1.3×10^3
NW	0	1.2×10^5	5.3×10^5	2.8×10^6	6.6×10^6	2.2×10^6
NNW	0	1.1×10^5	5.8×10^5	2.8×10^6	1.2×10^7	1.4×10^7
N	0	9.0×10^4	5.8×10^5	9.7×10^5	5.1×10^6	4.8×10^6
NNE	0	4.9×10^4	5.8×10^5	9.7×10^5	1.0×10^6	7.4×10^5
NE	0	3.9×10^3	5.3×10^5	8.9×10^5	1.0×10^6	7.5×10^5
ENE	0	0	2.5×10^5	4.9×10^5	8.5×10^5	1.1×10^6

Table E.10. Continued

Product/ direction	Production (kg/yr) by distance (miles[a])					
	0 to 5	5 to 10	10 to 20	20 to 30	30 to 40	40 to 50
E	0	0	2.6×10^5	3.4×10^5	1.6×10^5	7.0×10^5
ESE	0	0	2.4×10^5	4.0×10^5	1.8×10^5	5.6×10^4
SE	0	0	4.3×10^6	3.1×10^5	3.7×10^5	3.1×10^5
SSE	0	0	2.6×10^6	2.0×10^6	1.1×10^6	1.0×10^6
Grains						
S	0	0	2.6×10^6	7.4×10^6	1.1×10^7	1.5×10^7
SSW	0	4.5×10^3	2.9×10^6	6.0×10^6	1.1×10^7	1.4×10^7
SW	0	1.1×10^8	3.1×10^6	5.1×10^6	8.2×10^6	1.0×10^7
WSW	0	1.4×10^5	3.0×10^6	5.1×10^6	8.1×10^6	1.5×10^7
W	0	2.1×10^5	6.4×10^5	2.2×10^6	6.1×10^6	7.9×10^6
WNW	0	2.2×10^5	7.6×10^5	7.2×10^5	2.6×10^5	6.5×10^5
NW	0	2.2×10^5	1.0×10^6	1.2×10^6	7.5×10^5	3.3×10^5
NNW	0	2.1×10^5	1.1×10^6	1.6×10^6	1.3×10^6	2.0×10^6
N	0	1.7×10^5	1.1×10^6	1.8×10^6	2.3×10^6	4.1×10^6
NNE	0	9.3×10^4	1.1×10^6	1.8×10^6	2.7×10^6	3.6×10^6
NE	0	7.3×10^3	1.3×10^6	3.6×10^6	6.1×10^6	6.9×10^6
ENE	0	0	4.0×10^6	8.7×10^6	1.4×10^7	1.8×10^7
E	0	0	4.2×10^6	9.0×10^6	1.6×10^7	1.9×10^7
ESE	0	0	3.9×10^6	8.9×10^6	1.6×10^7	1.2×10^7
SE	0	0	8.2×10^7	1.1×10^7	1.5×10^7	1.7×10^7
SSE	0	0	5.2×10^7	5.2×10^7	1.3×10^7	1.6×10^7
Beef						
S	0	0	1.2×10^5	4.6×10^5	7.3×10^5	9.9×10^5
SSW	0	2.2×10^2	1.5×10^5	3.4×10^5	6.9×10^5	9.3×10^5
SW	0	6.0×10^4	1.5×10^5	2.5×10^5	4.6×10^5	6.1×10^5
WSW	0	1.0×10^4	1.5×10^5	2.5×10^5	4.1×10^5	7.9×10^5
W	0	2.1×10^4	4.0×10^4	1.2×10^5	3.4×10^5	5.1×10^5
WNW	0	2.2×10^4	7.0×10^4	5.0×10^4	9.5×10^4	1.8×10^5
NW	0	2.3×10^4	1.1×10^5	1.4×10^5	1.6×10^5	2.1×10^5
NNW	0	2.2×10^4	1.1×10^5	1.8×10^5	2.3×10^5	3.5×10^5
N	0	1.7×10^4	1.1×10^5	1.9×10^5	3.1×10^5	6.5×10^5
NNE	0	9.6×10^3	1.1×10^5	1.9×10^5	2.5×10^5	2.9×10^5
NE	0	7.5×10^2	1.0×10^5	2.6×10^5	4.3×10^5	5.0×10^5
ENE	0	0	2.4×10^4	2.2×10^5	8.2×10^5	1.1×10^6
E	0	0	2.6×10^4	1.4×10^5	5.2×10^5	8.8×10^5
ESE	0	0	2.4×10^4	8.2×10^4	3.4×10^5	4.5×10^5
SE	0	0	4.8×10^5	6.4×10^4	2.0×10^5	5.2×10^5
SSE	0	0	3.6×10^5	5.8×10^5	4.3×10^5	6.7×10^5
Poultry						
S	0	0	0	0	0	5.4×10^4
SSW	0	0	0	0	0	6.7×10^4
SW	0	4.7×10^7	0	0	0	4.5×10^1
WSW	0	5.1×10^4	4.5×10^3	0	6.1×10^1	3.5×10^2
W	0	1.7×10^5	1.8×10^4	0	1.1×10^2	1.6×10^2
WNW	0	1.9×10^5	4.6×10^5	0	0	5.1×10^3
NW	0	1.9×10^5	8.6×10^5	6.4×10^5	0	3.0×10^5
NNW	0	1.8×10^5	9.4×10^5	1.2×10^6	1.2×10^3	5.4×10^5
N	0	1.5×10^5	9.4×10^5	1.6×10^6	1.7×10^6	3.6×10^6
NNE	0	8.0×10^4	9.4×10^5	1.6×10^6	1.3×10^6	5.4×10^3

Table E.10. Continued

Product/ direction	Production (kg/yr) by distance (miles[a])					
	0 to 5	5 to 10	10 to 20	20 to 30	30 to 40	40 to 50
NE	0	6.3×10^3	8.2×10^5	1.2×10^6	9.7×10^5	0
ENE	0	0	1.1×10^3	0	0	0
E	0	0	0	0	0	1.0×10^5
ESE	0	0	0	0	0	1.0×10^5
SE	0	0	0	0	0	1.0×10^5
SSE	0	0	0	0	0	1.0×10^5
Milk						
S	0	0	5.5×10^5	6.2×10^5	6.5×10^5	7.6×10^5
SSW	0	9.7×10^2	6.4×10^5	2.9×10^6	7.9×10^6	8.1×10^6
SW	0	3.2×10^6	6.7×10^5	1.1×10^6	3.8×10^6	2.9×10^6
WSW	0	2.2×10^4	6.6×10^5	1.1×10^6	2.0×10^6	4.4×10^6
W	0	1.2×10^4	4.9×10^4	3.8×10^5	1.8×10^6	3.5×10^6
WNW	0	1.3×10^4	3.1×10^4	0	4.7×10^4	1.2×10^6
NW	0	1.3×10^4	5.8×10^4	4.4×10^5	1.1×10^6	7.9×10^5
NNW	0	1.2×10^4	6.4×10^4	4.3×10^5	2.0×10^6	3.3×10^6
N	0	9.9×10^3	6.4×10^4	1.1×10^5	1.9×10^6	7.4×10^6
NNE	0	5.4×10^3	6.4×10^4	1.1×10^5	3.9×10^5	9.7×10^6
NE	0	4.2×10^2	5.5×10^4	6.9×10^5	1.7×10^6	1.8×10^6
ENE	0	0	7.0×10^1	1.1×10^6	4.6×10^6	5.6×10^6
E	0	0	0	9.6×10^5	4.2×10^6	5.7×10^6
ESE	0	0	0	3.2×10^5	2.6×10^6	1.6×10^6
SE	0	0	2.4×10^4	1.2×10^4	4.2×10^4	1.2×10^5
SSE	0	0	2.0×10^5	3.2×10^5	3.5×10^5	3.9×10^5
Eggs						
S	0	0	6.3×10^2	0	0	8.3×10^4
SSW	0	0	0	0	0	1.0×10^5
SW	0	6.2×10^5	0	0	0	9.1×10^1
WSW	0	0	0	0	1.2×10^2	7.0×10^2
W	0	0	0	0	2.2×10^2	3.3×10^2
WNW	0	0	0	0	0	1.0×10^5
NW	0	0	0	1.2×10^5	3.2×10^5	1.1×10^5
NNW	0	0	0	1.0×10^5	5.9×10^5	6.4×10^5
N	0	0	0	0	1.7×10^5	2.9×10^1
NNE	0	0	0	0	0	1.0×10^5
NE	0	0	4.1×10^3	4.0×10^3	1.6×10^2	1.2×10^2
ENE	0	0	4.3×10^4	5.5×10^4	5.0×10^2	6.3×10^2
E	0	0	4.5×10^4	5.6×10^4	7.1×10^1	4.0×10^2
ESE	0	0	4.2×10^4	5.8×10^4	1.2×10^2	0
SE	0	0	6.3×10^5	1.2×10^3	0	0
SSE	0	0	3.1×10^5	0	0	0

[a]To convert from miles to kilograms, multiply by 1.61.

Source: DCS (2002a).

Accident events considered for the PDCF and the WSB were discussed in Section 4.3.5.1. Six accident events were considered for the PDCF as taken from DOE (1999). Three accident events for the WSB were considered (DCS 2002a,b; Bowling 2002). Table E.13 lists the activity by radionuclide estimated to be released to the environment for each hypothetical accident.

Table E.11. Centerline distance to site boundary from the proposed MOX facility stack for the primary 16 compass directions

Direction	Distance (m)
S	20,480
SSW	17,700
SW	12,130
WSW	15,000
W	9,490
WNW	9,930
NW	9,070
NNW	9,720
N	10,680
NNE	13,060
NE	16,520
ENE	19,040
E	19,150
ESE	20,030
SE	21,130
SSE	20,580

E.2.2.1 SRS Employees

SRS employees downwind of an accident might be exposed to airborne radioactive contamination. Exposure would result primarily from external radiation from the radioactive contamination in the passing plume (cloudshine) released from the accident location and inhalation of the airborne contaminants. Short-term exposure to external radiation from ground-deposited radionuclides (groundshine) might also occur.

The GENII computer code (Napier et al. 1988) was also used to assess the radiological impacts to the sitewide population of SRS employees for each accident considered. The SRS employee population distribution used for the accident analysis is given in Table E.6, and the joint-frequency weather data are given in Table E.7. A ground-level release (1-m [3.3-ft] release height) was assumed for all accidents. To provide a conservative estimate for the impacts, 95% meteorology (meteorological conditions that produce impacts that are not exceeded 95% of the time) was used. Employees were assumed to be unshielded during passage of the contaminant plume

Table E.12. Source terms for detailed accident analyses

Hypothetical accident event	Quantity of plutonium at risk (kg)	Damage ratio	Respirable release fraction	Leak path factor
Internal fire	64 (polished)	1	0.0006	0.01
Load handling	254 (polished)	1	0.0006	0.0001
Explosion	75 (unpolished)	1	0.01	0.01
Criticality	41.5 (unpolished)	1	0.0005[a]	0.0001[b]

[a]For particulate matter, respirable release fraction = 1 for gases.

[b]For particulate matter, leak path factor = 1 for gases.

Sources: DCS (2002a); Brown (2001).

Table E.13. Radionuclide quantities (Ci)[a] released to the atmosphere for each accident type

	Proposed MOX facility				WSB		
Isotope	Internal fire	Load handling	Explosion	Criticality	Fire	Explosion	Loss of confinement
Pu-238	1.4×10^{-2}	1.2×10^{-4}	5.4×10^{-2}	6.0×10^{-13}	2.83×10^{-5}	1.55×10^{-5}	2.70×10^{-6}
Pu-239	1.2×10^{-1}	1.0×10^{-3}	4.5×10^{-1}	5.0×10^{-12}	1.84×10^{-4}	1.01×10^{-4}	1.76×10^{-5}
Pu-240	2.9×10^{-2}	2.5×10^{-4}	1.1×10^{-1}	1.3×10^{-12}	6.74×10^{-5}	3.69×10^{-5}	6.44×10^{-6}
Pu-241	2.1	1.9×10^{-2}	8.2	9.0×10^{-11}	3.40×10^{-3}	1.87×10^{-3}	3.25×10^{-4}
Pu-242	8.2×10^{-6}	7.1×10^{-8}	3.1×10^{-5}	3.5×10^{-16}	1.30×10^{-8}	7.12×10^{-9}	1.24×10^{-9}
Am-241	NA[b]	NA	2.4×10^{-1}	2.1×10^{-12}	0.00	1.03×10^{-1}	4.39×10^{-2}
U-232	NA	NA	NA	NA	9.89×10^{-4}	3.51×10^{-9}	4.69×10^{-10}
U-233	NA	NA	NA	NA	4.26×10^{-3}	1.51×10^{-8}	2.02×10^{-9}
U-234	NA	NA	NA	NA	5.52×10^{-2}	1.95×10^{-7}	2.62×10^{-8}
U-235	NA	NA	NA	NA	5.54×10^{-4}	1.96×10^{-9}	2.62×10^{-10}
U-236	NA	NA	NA	NA	1.14×10^{-2}	4.04×10^{-8}	5.30×10^{-9}
Kr-83m	NA	NA	NA	1.1×10^{2}	NA	NA	NA
Kr-85m	NA	NA	NA	7.1×10^{1}	NA	NA	NA
Kr-85	NA	NA	NA	8.4×10^{-4}	NA	NA	NA
Kr-87	NA	NA	NA	4.3×10^{2}	NA	NA	NA
Kr-88	NA	NA	NA	2.3×10^{2}	NA	NA	NA
Kr-89	NA	NA	NA	1.3×10^{4}	NA	NA	NA
Xe-131m	NA	NA	NA	1.0×10^{-1}	NA	NA	NA
Xe-133m	NA	NA	NA	2.2	NA	NA	NA
Xe-133	NA	NA	NA	2.7×10^{1}	NA	NA	NA
Xe-135m	NA	NA	NA	3.3×10^{3}	NA	NA	NA
Xe-135	NA	NA	NA	4.1×10^{2}	NA	NA	NA
Xe-137	NA	NA	NA	4.9×10^{4}	NA	NA	NA
Xe-138	NA	NA	NA	1.1×10^{4}	NA	NA	NA
Te-134	NA	NA	NA	NA	NA	NA	NA
I-131	NA	NA	NA	2.8	NA	NA	NA
I-132	NA	NA	NA	2.9×10^{2}	NA	NA	NA
I-133	NA	NA	NA	4.1×10^{1}	NA	NA	NA
I-134	NA	NA	NA	1.1×10^{3}	NA	NA	NA
I-135	NA	NA	NA	1.1×10^{2}	NA	NA	NA
H-3	NA	NA	NA	NA	NA	NA	NA

Table E.13. Continued

Isotope	PDCF					
	Criticality	Earthquake	Explosion	Fire	Leak/spill	Tritium release
Pu-238	NA	2.62×10^{-6}	2.15×10^{-5}	8.06×10^{-8}	2.62×10^{-8}	NA
Pu-239	3.5×10^{-8}	2.22×10^{-5}	1.82×10^{-4}	6.82×10^{-7}	2.21×10^{-7}	NA
Pu-240	3.3×10^{-8}	5.43×10^{-6}	4.45×10^{-5}	1.67×10^{-7}	5.40×10^{-8}	NA
Pu-241	8.3×10^{-7}	4.04×10^{-4}	3.31×10^{-3}	1.24×10^{-5}	4.00×10^{-6}	NA
Pu-242	6.1×10^{-11}	1.55×10^{-9}	1.27×10^{-8}	4.76×10^{-11}	1.53×10^{-11}	NA
Am-241	2.0×10^{-7}	1.20×10^{-5}	9.82×10^{-5}	3.68×10^{-7}	1.18×10^{-7}	NA
U-232	NA	NA	NA	NA	NA	NA
U-233	NA	NA	NA	NA	NA	NA
U-234	NA	NA	NA	NA	NA	NA
U-235	NA	NA	NA	NA	NA	NA
U-236	NA	NA	NA	NA	NA	NA
Kr-83m	1.3	NA	NA	NA	NA	NA
Kr-85m	3.0	NA	NA	NA	NA	NA
Kr-85	NA	NA	NA	NA	NA	NA
Kr-87	1.9×10^{1}	NA	NA	NA	NA	NA
Kr-88	5.5×10^{1}	NA	NA	NA	NA	NA
Kr-89	NA	NA	NA	NA	NA	NA
Xe-131m	NA	NA	NA	NA	NA	NA
Xe-133m	NA	NA	NA	NA	NA	NA
Xe-133	4.5×10^{-1}	NA	NA	NA	NA	NA
Xe-135m	2.8×10^{1}	NA	NA	NA	NA	NA
Xe-135	8.0	NA	NA	NA	NA	NA
Xe-137	NA	NA	NA	NA	NA	NA
Xe-138	3.5×10^{2}	NA	NA	NA	NA	NA
Te-134	2.1×10^{1}	NA	NA	NA	NA	NA
I-131	4.3×10^{-2}	NA	NA	NA	NA	NA
I-132	3.5×10^{-1}	NA	NA	NA	NA	NA
I-133	7.5×10^{-1}	NA	NA	NA	NA	NA
I-134	9.5	NA	NA	NA	NA	NA
I-135	2.5	NA	NA	NA	NA	NA
H-3	NA	NA	NA	NA	NA	1.90×10^{5}

[a]To convert from curies (Ci) to becquerels (Bq), multiply by 3.7×10^{10}.

[b]NA = not applicable.

from an accident. Both the inhalation and external exposure pathways were considered. Further external exposure to ground contamination for a period of 5.6 hours (8 hours with a shielding factor of 0.7) after the accident was also considered. Resuspension of contaminated soil was not considered, and the soil was assumed to be previously uncontaminated. Ingestion of contaminated foodstuffs was not considered because food is not grown on-site and consumed. Accident impacts to the SRS employee population are presented in Section 4.3.5.2 (see Table 4.13).

Radiological impacts to an MEI of the SRS employee population were assessed by assuming that the MEI was located outside the facility boundary, 100 m (330 ft) from the accident location. Inhalation exposure and external exposure from the passing radioactive cloud were evaluated. The ARCON96 computer code (Ramsdell and Simonen 1997) was used to estimate contaminant air concentrations at the MEI receptor location following an accidental release. ARCON96 was designed to model air dispersion in the vicinity of buildings. The code uses hourly meteorological data in order to estimate relative air concentrations of atmospheric releases. Ten years, 1987 to 1996, of hourly meteorological data and a building area of 6,580 m^2 (70,825 ft^2) (DCS 2001a) were used as input to the code. The 95th percentile relative concentration, the air concentration that is more than what might be expected 95% of the time, in any given direction for the 0- to 2-hour averaging period was conservatively used to estimate impacts. This 95th percentile relative concentration was calculated to be 6.1×10^{-4} s/m^3.

An inhalation rate of 3.47×10^{-4} m^3/s (NRC 1972) was then used in conjunction with inhalation dose conversion factors from Federal Guidance Report (FGR) 11 (Eckerman et al. 1988) to estimate inhalation exposure. The most conservative (largest) dose conversion factor among the clearance classes for each radionuclide was used. For external exposure, the external dose conversion factors from FGR 12 (Eckerman and Ryman 1993) were used. Estimated impacts to the SRS employee MEI are presented in Table 4.13 (Chapter 4) of this EIS. With the exception of the criticality accidents, inhalation exposure was the dominant impact. External exposure to cloudshine from the passing radioactive cloud after the criticality accident accounted for approximately 93% of the estimated dose to the MEI.

E.2.2.2 Members of the Public

Radiation exposures to members of the off-site public were assessed for hypothetical accidental releases. Impacts from a short-term exposure and a one-year exposure were evaluated for each accident. Exposure pathways evaluated for short-term exposures were inhalation, cloudshine, and groundshine. For 1-year exposures, ingestion was considered in addition to the short-term exposures.

The GENII computer code (Napier et al. 1988) was used to assess the radiological impacts to the collective off-site population (members of the public) for each accident considered. The off-site population distribution used for the accident analysis is given in Table E.8, and the joint-frequency weather data are given in Table E.7. A ground-level release (1-m [3.3-ft] release height) was assumed for all accidents. To provide a conservative estimate for the impacts, 95% meteorology (weather conditions that produce impacts that are not exceeded

95% of the time) was used. For the short-term exposure, no credit was given for shielding for the inhalation and external exposures to the passing airborne plume. Exposure to groundshine was evaluated for 8 hours, but a shielding factor of 0.5 (NRC 1977) was used.

For the 1-year exposure period, the length of time of external exposure to contaminated soil was 0.5 year (NRC 1977), and no credit was given for shielding for the inhalation exposure and external exposure to the passing airborne plume. Ingestion parameters are provided in Table E.9. Food production data for the area surrounding the SRS are provided in Table E.10. The estimated impacts for each accident in the short term and after 1 year of exposure are presented in Table 4.14 (Chapter 4). No mitigative actions were assumed.

Accident impacts to an MEI member of the public were determined using the GENII code for both short-term and 1-year exposures following an accidental release. Potential MEIs were assumed to live at the site boundary, one at each of the 16 compass directions, as given in Table E.11. Exposure pathways considered in the analysis included inhalation, external exposure from the passing plume and contaminated soil, and, in the case for 1-year exposure, ingestion of contaminated foodstuffs. The same release height and meteorology conditions as used for the population accident impacts were used for the MEI analysis. The amount of time of external exposure to contaminated soil was 8 hours (with a 0.7 shielding factor) and 0.7 year (NRC 1977) for the short-term and 1-year exposure periods, respectively. No credit for shielding was given for the inhalation and external exposures to the passing airborne plume. As a conservative assumption, potential MEIs were assumed to consume locally grown food for the 1-year exposure period. Ingestion parameters are provided in Table E.9. The estimated impacts for each accident are given in Table 4.15 (Chapter 4) for the short-term and 1-year exposure periods. No mitigative actions were assumed.

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APPENDIX F:

AIR QUALITY IMPACT ASSESSMENT

Appendix F:

Air Quality Impact Assessment

F.1 Introduction

Air quality impacts are generally assessed by determining the concentrations of pollutants in the air caused by the major sources associated with an action. For an action proposed for the future, the assessment is based on projected pollutant concentrations determined by computer modeling. This projection involves three steps. First, the emissions of the sources are calculated. Most frequently, this calculation requires knowing the activity level of the source and applying an appropriate set of emission factors that specify the quantity of air pollutants emitted per unit of activity.

In the second step, the pollutant concentrations in the air associated with these emissions are determined for various locations (receptors) by using an air quality model. The model uses information on the emissions along with meteorological conditions, source and receptor elevations, and source characteristics to estimate concentrations. Meteorological conditions included in these calculations are ambient temperature, wind speed and direction, mixing heights, and atmospheric stability. Source characteristics include location, temperature, diameter, exit velocity, and height for stacks; size and orientation for area sources; and initial horizontal and vertical dispersions for volume sources.

Finally, the modeled concentrations are compared with standard measures of impact, typically ambient air quality standards set by regulatory agencies, such as the National Ambient Air Quality Standards (NAAQS) or state standards and Prevention of Significant Deterioration (PSD) increments. The standards and increments depend on the averaging time, with periods of 1, 3, 8, and 24 hours, and annual being specified in the NAAQS. The air quality model uses hourly emissions and meteorological data and can be executed to produce concentrations for periods corresponding to the selected impact measures.

For the Mixed Oxide Fuel Fabrication Facility (proposed MOX facility), the Pit Disassembly and Conversion Facility (PDCF), and the Waste Solidification Building (WSB), air emissions from construction activities and operations were estimated on the basis of standard references and site-specific data or were taken from previous work on the facilities. Ambient concentrations were then computed with a model recommended by the U.S. Environmental Protection Agency (EPA). Five years of meteorological data taken at locations near the Savannah River Site (SRS) were used in the modeling. Pollutant concentrations at the SRS boundary and at off-site receptor locations were modeled. Section F.2 discusses estimating emissions associated with the facility; Section F.3 discusses the air quality model, its data input, and modeling assumptions.

F.2 Emission Estimates

This section discusses the methods used to calculate emissions projected to be associated with construction and operation of the facility.

F.2.1 Construction Emissions

Construction fugitive dust, emissions from the concrete batch plant, and exhaust emissions from construction equipment were modeled for the construction phase. Emissions from fuel storage, refueling construction equipment, and worker and delivery vehicles were not modeled. Because of the low volatility of diesel fuel, emissions from storing diesel fuel and refueling construction equipment would be negligible. Emissions from worker and delivery vehicles would be dispersed along roadways around the site and would have lesser impacts than emissions from the limited construction area.

The activity levels, associated emission factors, and other data used to calculate emissions for the construction sources are shown in Table F.1. Construction of the proposed MOX facility is expected to disturb about 39 ha (96 acres), of which 28 ha (69 acres) would be located on the proposed MOX facility site itself, be contiguous to the site, or be used for fill on the PDCF site during proposed MOX facility construction (DCS 2002a). The remaining 11 ha (27 acres) would be used for ancillary activities, such as road work and utility corridors. Construction of the concrete batch plant would disturb an additional 4.0 ha (10 acres). Only limited portions of most of these areas would be disturbed at any time, and the disturbance of a given section would last only a short time. It was assumed that 50% of the contiguous 28-ha (69-acre) area would be disturbed at any one time and that heavy earth-moving activities would occur over a 6-month period. For the ancillary areas, emissions were estimated assuming that construction would last 6 months and that only about 10% of the area would be disturbed at any time. Modeling was carried out for the entire disturbed area. It was further assumed that 30% of the construction fugitive emissions would be particulate matter with a diameter less than or equal to 10 :m (PM_{10}) (EPA 1988) and that 15% would be $PM_{2.5}$ (Kinsey and Cowherd 1992). Disturbed areas would be watered to control dust emissions, reducing emissions by 50% (EPA 2002).

Construction of the concrete batch plant would disturb 4.0 ha (10 acres) (DCS 2002a). The entire disturbed area was assumed to be part of the contiguous site, and emissions calculation and modeling used the same assumptions as were used for the proposed MOX facility construction fugitive emissions.

Construction of the PDCF was assumed to disturb about 14 ha (35 acres) (DCS 2002b). The contiguous site area was assumed to account for about two-thirds of the total and dispersed ancillary activities the remainder. Emissions calculation and modeling used the same assumptions as were used for modeling MOX facility construction fugitive emissions.

Table F.1. Emission factors, activity levels, and emissions for facility construction

Source	Pollutant[a]	Emission factor	Annual activity: MOX	Annual activity: PDCF	Annual activity: WSB	Annual activity: Batch plant
Construction fugitives[c]	PM	0.6 tons/acre/mo[d]	Site: 69 acres; 5 months Ancillary: 35 acres; 6 months	Site: 23 acres; 12 months Ancillary: 12 acres; 6 months	5 acres; 5 months	10 acres; 5 months
	PM_{10}	-[e]				
	$PM_{2.5}$	-				
Batch plant[f]	PM	0.2 lb/yd^3 [(g)]	NA[h]	NA	NA	62,500 yd^3/yr[i]
	PM_{10}	0.058[g]	NA	NA	NA	
	$PM_{2.5}$	NA	NA	NA	NA	
Equipment exhaust[j]	CO	14.67 kg/10^3 liters[k]	1,250,000 liters diesel fuel/yr[l]	495,000 liters diesel fuel/yr[m]	114,000 liters/diesel fuel/yr[n]	0[o]
	VOC	3.76 kg/10^3 liters[k]				
	NO_x	38.75 kg/10^3 liters[k]				
	SO_x	3.74 kg/10^3 liters[k]				
	PM	3.20 kg/10^3 liters[k]				
	PM_{10}	3.20 kg/10^3 liters				
	$PM_{2.5}$	3.20 kg/10^3 liters				

Source	Pollutant[a]	Annual emissions (kg/yr): MOX	PDCF	WSB	Batch plant	Hourly emissions (g/h)[b]: MOX	PDCF	WSB	Batch plant
Construction fugitives[c]	PM	103,000	79,900	6,800	13,600	49,400	38,400	3,270	6,540
	PM_{10}	30,800	24,000	2,040	4,080	14,800	11,500	981	1,960
	$PM_{2.5}$	15,400	12,000	1,020	2,040	7,410	5,760	491	981
Batch plant[f]	PM	NA	NA	—[m]	5,670	NA	NA	NA	2,730
	PM_{10}	NA	NA	—[m]	1,640	NA	NA	NA	790
	$PM_{2.5}$	NA	NA	—[m]	850	NA	NA	NA	409
Equipment exhaust[j]	CO	18,300	7,260	1,670	—[p]	8,810	3,490	801	—[p]
	VOC	4,690	1,960	427	—[p]	2,260	894	205	—[p]
	NO_x	48,400	19,200	4,400	—[p]	23,300	9,220	2,120	—[p]
	SO_x	4,670	1,850	424	—[p]	2,240	889	204	—[p]
	PM	4,000	1,580	363	—[p]	1,920	761	175	—[p]
	PM_{10}	4,000	1,580	363	—[p]	1,920	761	175	—[p]
	$PM_{2.5}$	4,000	1,580	363	—[p]	1,920	761	175	—[p]

[a]PM: particulate matter with a diameter less than about 30 : m; PM_{10} = particulate matter with a diameter less than 10 : m; $PM_{2.5}$ = particulate matter with a diameter less than 2.5 : m; CO = carbon monoxide; VOC = volatile organic compound; NO_x = nitrogen oxides; SO_x = sulfur oxides.

[b]Hourly emissions based on annual rates assuming construction activities occur 8 hours per day, five days per week, 52 weeks per year.

[c]PM_{10} taken as 30% of PM (EPA 1988); $PM_{2.5}$ taken as 15% of PM (Kinsey and Cowherd 1992).

Footnotes continue on next page.

Table F.1. Continued

[d]*Source:* EPA (2002, Section 13.2.3) and a 50% reduction in emissions due to watering used to control dust.

[e]- indicates emissions calculated as percentage of PM.

[f]$PM_{2.5}$ taken as 15% of PM (EPA 2002, Category 3, Table B.2-2, Appendix B-2).

[g]*Source:* EPA (2002, Section 11.12).

[h]NA = not applicable.

[i]*Source:* DCS (2002a); includes concrete for both proposed MOX facility and WSB.

[j]All emissions assumed to be $PM_{2.5}$.

[k]*Source:* EPA (1985, Table II-7.1).

[l]*Source:* DCS (2002b, Table 5.5).

[m]*Source:* DOE (1999, Table 5.5).

[n]*Source:* DCS (2002b, Table G-4).

[o]Fuel use for construction of batch plant included in fuel use for proposed MOX facility.

[p]Emissions included in emissions from proposed MOX facility.

Construction of the WSB was assumed to disturb about 2 ha (5 acres) (DCS 2002a). The entire disturbed area was assumed to be part of the contiguous site. Emissions calculations and modeling used the same assumptions as were used for proposed MOX facility construction fugitive emissions.

The concrete batch plant is expected to produce 47,800 m^3 (62,500 yd^3) of concrete annually (DCS 2002a). This amount would be sufficient for both proposed MOX facility and WSB construction. The emission factors used in the modeling represent the total particulate matter process emissions from concrete batching. $PM_{2.5}$ was taken as 15% of the particulate matter, on the basis of the cumulative weight-percent distribution for Category 3 in EPA (2002, Table B.2-2).

Information on the mix of construction equipment types that would be used at the site was not available. It was assumed that all construction equipment would be diesel powered. The factors presented in Table F.1 are averages over the different types of equipment listed in EPA (1985, Table II-7.1). Factors for off-highway trucks and the miscellaneous category were excluded from the averages. Particulate emissions from diesel engines are expected to have small diameters, so it was assumed that all particulate emissions would be in the $PM_{2.5}$ category.

Hourly emission rates for all three sources were calculated from annual rates on the basis of a construction schedule of 8 hours per day, 5 days per week, and 52 weeks per year. This assumption leads to higher hourly emissions and thus is more conservative than assuming a longer work day or a longer work week.

F.2.2 Emissions during Operation

Emissions from the facility processes and from operation of the emergency and standby generators were modeled for the operation phase of the facilities. As for the construction phase, emissions from worker and delivery vehicles were not included.

Table F.2 summarizes the activity levels and emissions from standby and emergency diesel-powered generators at the proposed MOX facility and WSB. There would be seven engines at the proposed MOX facility expected to operate a total of 636 h/yr. Each engine would use about 522 L (138 gal) of diesel fuel per hour or 331,375 L/yr (87,540 gal/yr) for all seven engines (DCS 2002a). Engine-specific emission factors were available for criteria pollutants. The calculation of air toxic emissions used standard emission factors from EPA (2002) and assumed a heating value of 137,000 Btu/gal for diesel fuel.

Detailed information on emergency generator use at the PDCF was unavailable. Total fuel use during operation is expected to be 37,998 L (10,038 gal/yr) (DOE 1999, Table E-7). Table G-59 in DOE (1999) gives the annual emissions of criteria pollutants from the PDCF. Emergency generator emissions from the proposed MOX facility were scaled by the ratio of proposed MOX facility and PDCF annual fuel uses to estimate emissions of air toxics from the PDCF. This procedure may overestimate the PDCF emissions, because the annual PDCF fuel use includes diesel, fuel oil, and gasoline, not just fuel for the emergency generators.

The WSB is expected to have one emergency generator that will operate about 250 h/yr. Engine-specific emission factors were available for criteria pollutants (DCS 2002a). Air toxic emissions from proposed MOX facility emergency generators were scaled by the ratio of proposed MOX facility and WSB annual hours of operation to estimate WSB emergency generator emissions.

Table F.3 summarizes process emissions. The aqueous polishing process at the proposed MOX facility would emit nitrogen dioxide. The chlorine would come from chloride in the plutonium feedstock (DCS 2002b). Hourly emissions were based on 8,760 h/yr of continuous operation.

The PDCF would have no process emissions (DOE 1999, Table G-59). The WSB would emit particulates when the cement silo is operated and when cement is withdrawn into the weigh hopper and mixed during the waste cementation process. Hourly emissions are based on the assumption that silo operations, including cement delivery, would occur 12 times per year and would be completed in less than one hour. The WSB would process about 25 batches of waste per year. Each batch would require operating each of two hoppers for 1 hour and each of two mixers for 12 hours (DCS 2002a). Depending on the final process design, evaporation of acidic waste in the WSB could emit up to 9,175 kg/yr (20,230 lb/yr) of nitrogen dioxide. An amount of acetone would also be emitted.

Table F.2. Emission factors, activity levels, and emissions for emergency generators[a]

Facility	Pollutant	Emission factor ($lb/10^6$ Btu)[b,c]	Activity	Emissions[d] (kg) Annual	Emissions[d] (kg) Hourly
MOX	CO	6.43	7 engines; 636 engine-hours/yr	1,860	2.04
	VOC	2.88		832	9.2
	NO_x	67.0		19,400	213
	SO_x	3.9		1,130	12.4
	PM	0.63		182	2.0
	PM_{10}	0.52[e]		150	1.7
	$PM_{2.5}$	0.49[f]		140	1.5
	Benzene	0.000776		4.22	0.013
	Toluene	0.000281		0.017	0.0047
	Xylenes	0.000193		1.05	0.012
	Propylene	0.00279		15.19	0.17
	Formaldehyde	0.0000789		0.43	0.0047
	Acetaldehyde	0.0000252		0.14	0.0015
	Acrolein	0.00000788		0.043	0.00047
	Naphthalene[g]	0.00013		0.71	0.0078
	Total PAH[h]	<0.000212		1.15	0.013
PDCF	CO		10,038 gal/yr fuel	520[i]	5.72
	VOC			58[i]	0.638
	NO_x			2,000[i]	22.0
	SO_x			34[i]	0.324
	PM			50[i]	0.550
	PM_{10}			41	0.452
	$PM_{2.5}$			39[f]	0.424
	Benzene			0.485	0.00053
	Toluene			0.175	0.0019
	Xylenes			0.121	0.0013
	Propylene			1.74	0.0192
	Formaldehyde			0.049	0.00054
	Acetaldehyde			0.016	0.0002
	Acrolein			0.005	0.00005
	Naphthalene[g]			0.081	0.00089
	Total PAH[h]			0.132	0.0015
WSB[j]	CO	24.92	1 engine; 250 engine-hours/yr	575	2.30
	VOC	5.07		50.0	0.20
	NO_x	1.62		2,830	11.3
	SO_x	0.44		184	0.735
	PM	4.24		481	1.93
	PM_{10}	4.07[e]		462	1.85
	$PM_{2.5}$	3.98[f]		451	1.81
	Benzene	0.000776		1.66	0.0066
	Toluene	0.000281		0.601	0.0024
	Xylenes	0.000193		0.413	0.0017
	Propylene	0.00279		5.97	0.024

Table F.2. Continued

Facility	Pollutant	Emission factor ($lb/10^6$ Btu)[b,c]	Activity	Emissions[d] (kg) Annual	Emissions[d] (kg) Hourly
	Formaldehyde	0.0000789		0.169	0.00068
	Acetaldehyde	0.0000252		0.054	0.00022
	Acrolein	0.00000788		0.017	0.00007
	Naphthalene[g]	0.00013		0.278	0.0011
	Total PAH[h]	<0.000212		0.454	0.0018

[a]Emissions from emergency generators at the PDCF were calculated from those at the proposed MOX facility based on the ratio fuel use. The ratio is (10,038/87,450) based on data in DOE (1999) and DCS (2002a).

[b]*Source* (unless otherwise specified): Criteria pollutants: DCS (2002a); Air toxics: EPA (2002, Section 3.4-5).

[c]Units: Criteria pollutants = lb/(engine-h). Air toxics = $lb/10^6$ Btu.

[d]Heating value of 137,000 Btu/gal used diesel fuel to calculate emissions of air toxics.

[e]Based on a ratio of PM_{10}/PM factor in Table 3.4-2, EPA (2002).

[f]$PM_{2.5}$ taken as 90/96 of PM_{10} (Category 1, Table B.2-2, Appendix B-2, EPA [2002]).

[g]Included in total PAH.

[h]PAH = polycyclic aromatic hydrocarbon.

[i]*Source*: DOE (1999, Table G-59).

[j]Annual emissions of air toxics at the WSB were calculated from those at the proposed MOX facility based on the ratio of annual operating hours (= 250/636).

Storage of diesel fuel for use in emergency and standby generators would emit volatile organic compounds (VOCs) at each facility. Emission estimates from DCS (2002b) were used to estimate emissions from the other two facilities. As was done for estimating emergency generator emissions, proposed MOX facility fuel storage emissions were scaled by the ratio of proposed MOX facility and PDCF annual fuel uses to estimate PDCF fuel storage emissions, and were scaled by the ratio of proposed MOX facility and WSB annual hours of operation to estimate WSB emissions.

F.3 Air Quality Modeling

This section presents information on the air quality model and modeling assumptions, meteorological data, source data, receptors, and terrain data used to estimate the air quality impacts of the facility.

Table F.3. Process emissions during operations

Facility	Operation	Pollutant	Emissions Annual (kg/yr)	Emissions Hourly (g/hr)
MOX[a]	Aqueous polishing	NO_2	1,300	148
	Chlorine in Pu	Chlorine	15	1.7
	Diesel fuel storage	VOC	0.90	0.10
PDCF	Diesel fuel storage	VOC	0.10	0.012
WSB[b]	Silo operations	PM	5.55	463
		PM_{10}	2.78	231
		$PM_{2.5}$	0.833	69.4
	Cementation	PM	0.450	5.14
		PM_{10}	0.225	2.57
		$PM_{2.5}$	0.068	70.2
		Acetone	2.93	9.75
	Acidic waste evaporation	NO_2	<9800	<30,600
	Diesel fuel storage	VOC	0.35	0.040

[a]*Source*: DCS (2002b, Table 5-7).

[b]*Sources:* DCS (2002a-c).

F.3.1 Air Quality Model

Version 3 of the Industrial Source Complex Short-Term (ISCST3) model (EPA 1995) was used to estimate potential impacts of facility construction and operation on ambient air quality. ISCST3 has numerous options that can be set to make the calculations conform to the actual situation being modeled. The following options were used for the facility model runs: (1) the regulatory default options, (2) building downwash, and (3) rural dispersion.

In its guideline on air quality modeling, the EPA (1999) specifies ISCST3 as the “guideline” model for a wide variety of regulatory applications. The modeling guideline also specifies a set of “regulatory options,” specific settings for some of the options included in the model. The model was always run using the regulatory options.

In addition, as specified in the guideline, effective building widths were included in the operation runs to account for building-induced downwash of pollutants released from the facility stack. These effective widths were calculated from the physical widths and heights by using EPA’s Building Profile Input Program (BPIP) (EPA 1993). The physical dimensions for the proposed MOX facility and nearby buildings were taken from DCS (2002a). No information was available in the dimensions of the PDCF. Dimensions for the WSB were taken from DCS (2002a).

The way air pollutants disperse differs between predominantly urban and predominantly rural areas. The SRS and the surrounding area are generally rural rather than urban in character, so the model was run in the rural mode.

F.3.2 Meteorological Data

The ISCST3 code uses hourly surface data (wind speed, wind direction, ambient temperature, and atmospheric stability) and twice-daily mixing-heights. Modeling for the facility used 5 years of surface data collected at Columbia, South Carolina, for the period from 1900 through 1994. Mixing height data came from Athens, Georgia, for the period from 1990 through August 1994. The Athens site was moved to Atlanta, Georgia, in September 1994.

F.3.3 Source Data

The characteristics used to model the sources are listed in Table F.4. Volume source dimensions were converted into the initial dispersion values in Table F.4 on the basis of the suggestions in EPA (1995).

F.3.3.1 Construction

Construction fugitive emissions were modeled as square area sources centered on the associated facility site and oriented with its sides parallel to the site's side. It was assumed that 50% of the area would be disturbed at any time.

Thirty-nine ha (96 acres) of the 43 ha (106 acres) disturbed during construction of the proposed MOX facility would be the site itself, contiguous areas, fill area on the PDCF site, and work on roads and utilities (DCS 2002a). This 39-ha (96-acre) area was modeled to estimate the impact of construction fugitives. One-half of this area corresponds to a square 441 m (1,450 ft) on a side. The remaining 4.0 ha (10 acres) of the disturbed area would be the site of the batch plant (whose construction fugitives were modeled as a square at the appropriate location).

The total area disturbed during PDCF construction is expected to be 36 ha (90 acres) (DOE 1996, Section 4). About two-thirds of this total, the same fraction as used for the proposed MOX facility, was modeled. One-half of this area corresponds to a square about 344 m (1,140 ft) on a side.

The modeled area for WSB construction was taken as one-half of the entire area of the site, 2.0 ha (5.0 acres), corresponding to a square about 101 m (330 ft) on a side.

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Figure F.1. Receptor locations used in air quality modeling.

Table F.4. Characteristics of modeled sources

Source	Source characteristics							
				Initial dispersion[a] (m)		Release characteristics		
	Modeled type	Release height (m)	Length (m)	Horizontal	Vertical	Temperature (K)	Velocity (m/s)	Diameter (m)
Construction fugitives-proposed MOX facility	Area	1	441	NA[b]	NA	NA	NA	NA
Construction fugitives-PDCF	Area	344	344	NA	NA	NA	NA	NA
Construction fugitives-WSB	Area	101	101	NA	NA	NA	NA	NA
Construction fugitives-batch plant	Area	142	NA	NA	NA	NA	NA	NA
Concrete batch plant	Volume	4.6	NA	7.5	2.1	NA	NA	NA
Construction equipment exhaust-proposed MOX facility	Volume	3.1	NA	87	1.4	NA	NA	NA
Construction equipment exhaust-PDCF	Volume	3.1	NA	80	1.4	NA	NA	NA
Construction equipment exhaust-WSB	Volume	3.1	NA	23	1.4	NA	NA	NA
Proposed MOX facility stack[c]	Point	36.6	NA	NA	NA	290.3	16.7	2.59
WSB silo stack	Point	15.2	NA	NA	NA	290.3	0.031	0.457
WSB mixer/hopper stack	Point	12.2	NA	NA	NA	290.3	0.031	0.203
WSB main stack	Point	24.4	NA	NA	NA	290.3	3.0	1.52
Emergency generators	Point	14.3	NA	NA	NA	1180	98.5	0.204

[a]Volume source dimensions were converted into the initial dispersion values using the suggestions in EPA (1995).

[b]NA = not applicable.

[c]*Source:* DCS (2001).

During operations, the concrete batch plant was modeled as a volume source. In ISCST3, volume sources are square in the horizontal plane. Batching activities were assumed to take place in a square about 32 m (110 ft) on a side, corresponding to an area of about 0.10 ha (0.26 acre). The plant structure was assumed to be about 9.1 m (30 ft) high. A release height of 4.6 m (15 ft) was taken as representative of all batching activities.

Emissions from construction equipment exhaust would be released over the same area as the construction fugitive emissions and were modeled as volume sources located at the center of the facility sites. An exhaust release height of 3.1 m (10 ft) was assumed for the construction equipment.

For short-term averages, all construction sources were assumed to operate 8 hours per day — from 8:00 a.m. to 12 p.m. and from 1 p.m. to 5 p.m. Emissions were assumed to be zero during other hours. Annual averages were calculated by assuming a construction schedule of 260 days per year as discussed in Section F.2.1.

F.3.3.2 Operation

Facility stacks were modeled as points (see Table F.4). There would be a single stack on the proposed MOX facility and two on the WSB. One WSB stack would exhaust the silo, another would exhaust hoppers and mixers, and the main stack would provide general building exhaust.

Emissions from the standby and emergency generators were modeled as points using representative release characteristics.

Different approaches were used to estimate short-term impacts for periods of 24 hours and less and annual impacts. The proposed MOX facility process was assumed to operate continuously, and the same rate was used for estimating both short-term and annual impacts. The WSB would operate in a batch mode, as discussed above. For short-term impacts, emissions were assumed to occur during a 12-hour period from 6 a.m. to 6 p.m. at actual rates. Annual impacts were estimated on the basis of 12 hours per day of operations at rates consistent with the expected annual emissions. The emergency and standby generators would operate intermittently for testing and for unscheduled emergencies. Short-term impacts were assessed by assuming that the generators for all three facilities would operate 24 hours per day to simulate an extended emergency. Annual impacts were assessed by assuming 8,760 hours per year of operation at rates consistent with the expected annual emissions.

F.3.4 Receptor Data

Two types of receptors were used in the analysis: boundary receptors and off-site receptors. The receptor network is shown in Figure F.1. The boundary receptors were located every 200 m (660 ft) along the SRS boundary. No boundary receptors were placed along the narrow section of the SRS extending south and southwest along Lower Three Runs Creek to the Savannah River. The off-site receptors consisted of two Cartesian grids oriented along the

north-south direction and extending 50 km (31 mi) in each direction from the facility site. From the SRS boundary out to 20 km (12 mi), the grid spacing was 1.0 km (0.62 mi). Farther out, the grid spacing was 5.0 km (3.1 mi).

F.3.5 Terrain Data

Terrain effects were included in all the modeling runs. Terrain data for sources and receptors were taken from electronic data available from the U.S. Geological Survey (2001) 1:24,000 scale (7.5-minute series) digital elevation model. The grade level for the proposed MOX facility was taken as 83 m (270 ft) above mean sea level (DCS 2002b).

F.4 References for Appendix F

DCS (Duke Cogema Stone, and Webster) 2001. *Changes to Mixed Oxide Fuel Fabrication Facility Environmental Report*. Letter with attachments submitted by P. S. Hastings (DCS, Charlotte, NC) to U.S. Nuclear Regulatory Commission, Washington, DC. Dec. 11.

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DCS 2002b. *Mixed Oxide Fuel Fabrication Facility Environmental Report Revision 1 & 2*. Docket Number 070-03098. Charlotte, NC.

DCS 2002c. *Corrections to Responses to the Request for Additional Information on the Environmental Report Revisions 1 & 2*. Letter with attachments from P. S. Hastings (DCS, Charlotte, NC) to U.S. Nuclear Regulatory Commission, Washington, DC. Nov. 15.

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APPENDIX G:

ADDITIONAL IMPACTS OF THE NO-ACTION ALTERNATIVE

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Appendix G includes impacts of the no-action alternative that are not addressed in Chapter 4. Technical areas included in the appendix are geology, seismology, and soils; noise; ecology; land use; cultural and paleontological resources; infrastructure; socioeconomics; and esthetics. Other potential impacts are addressed in Chapter 4.

G.1 Geology, Seismology, and Soils

In general, continued storage of surplus plutonium at current storage locations would have no impact on geology or seismology at the sites. If new construction was required to upgrade storage facilities at any of the sites, there could be localized, minor effects on soils, such as compaction and erosion, as a result of construction activities.

G.2 Noise

The ongoing operations at the storage sites would result in no appreciable change from current levels of traffic noise and on-site operational noise. Nontraffic noise sources are far enough from off-site areas that the noise of operations would not be expected to cause annoyance to the public. However, some noise sources could be close enough to on-site noise-sensitive areas to result in impacts, such as the disturbance of wildlife.

G.3 Ecology

No construction or demolition of buildings is planned under the continued storage option. If any modifications were required to ensure safe storage, they would not result in appreciable change to current conditions. Therefore, continued storage would have negligible impacts on ecological resources. At Pantex, any upgrading of existing storage facilities would occur in an area that is currently disturbed, so minimal impacts to biota would occur. Also, no impacts to threatened and endangered species would be expected (DOE 1996, pg. 4-207). Regardless, the impacts of new construction would be addressed under a separate environmental review conducted by the U.S. Department of Energy (DOE).

G.4 Land Use

No new land use is planned in association with continued storage of surplus plutonium, except possibly at the Pantex site. If upgrading of the storage facility at Pantex was required, it would take place on previously disturbed land and would have minimal impacts on existing land use plans.

G.5 Cultural and Paleontological Resources

No impacts on cultural or paleontological resources are expected from the continued storage of surplus plutonium.

G.6 Infrastructure

Detailed data on infrastructure for the current storage sites are presented in the Storage and Disposition Programmatic Environmental Impact Statement (S&D PEIS) (DOE 1996, Section 4.2). The infrastructure of the sites would be capable of supporting all anticipated missions and functions associated with continued storage.

G.7 Socioeconomics

As stated in the S&D PEIS (DOE 1996), under continued storage, the existing storage facilities at the sites would remain operational. No new employment or in-migration of workers would be required.

G.8 Aesthetics

Continued storage would not result in any adverse impacts to visual resources at the storage sites.

G.9 Reference for Appendix G

DOE (U.S. Department of Energy) 1996. *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement*. DOE/EIS-0229. Office of Fissile Materials Disposition, Washington, DC. Dec.

APPENDIX H:

ADDITIONAL IMPACTS OF THE PROPOSED ACTION

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Appendix H discusses impacts of constructing and operating the proposed Mixed Oxide (MOX) Fuel Fabrication facility, the Pit Disassembly and Conversion Facility (PDCF), and the Waste Solidification Building (WSB) that are not addressed in Chapter 4. Technical areas included in the appendix are geology, seismology, and soils; noise; ecology; land use; cultural and paleontological resources; infrastructure; and socioeconomics. Other impacts of construction related to human health risk, air quality, hydrology, waste management, deactivation and decommissioning, environmental justice, and cost benefit analysis are discussed in Chapter 4.

H.1 Geology, Seismology, and Soils

H.1.1 Construction

Construction activities for the proposed action would have no effects on geology or seismology at the Savannah River Site (SRS). For example, no deep well injection of wastewater would occur that could modify seismic activity.

The proposed facilities would be constructed entirely within F-Area on the SRS. F-Area occupies about 160 ha (395 acres) of land within the 80,292-ha (198,400-acre) SRS. Activities such as clearing, excavating, compacting, and grading during construction would physically disturb a total of about 41.9 ha (103.5 acres) of land (DCS 2002). Of this disturbed area, 10.6 ha (26 acres) would be permanently altered by construction of buildings, roads, and paved parking lots. Construction of the facilities would, therefore, disturb about 26% of the land in F-Area (about 0.05% of the land area available at the SRS). This impact would be small and temporary; remediation following construction would return about 60% of the disturbed land to its original condition. The 10.6 ha (26 acres) of land permanently altered by construction would represent about 7% of the land available in F-Area (0.01% of the land area at the SRS). Because the soils that would be affected by construction activities are not unique within the SRS and the disturbed and permanently altered areas would represent a small percentage of the land area available, physical impacts on soil would be insignificant.

In addition to physical disturbance, soils could be chemically impacted during construction of the facility. For example, contaminated material from the construction site could be mobilized by runoff water or transported by wind, and accidental releases of contaminated material could adversely affect soils. However, because good engineering practices would be used during construction, sediment detention basins would be constructed, and any accidental spills would be promptly cleaned up as required by the DCS's Spill Prevention Control and Counter-measures Plan, chemical impacts on soils would be insignificant.

H.1.2 Operations

Normal operation of the proposed facilities would have no impact on geology or seismology at the SRS (e.g., there are no planned deep well injections of effluents that could modify seismic activity), but normal operation could have localized, minor effects on soil.

The 10.6 ha (26 acres) of land covered by buildings, roads, and parking lots (DCS 2002) would remain physically altered. This land area would represent about 7% of the land area available in F-Area (0.01% of the land area at the SRS). Because the soils that would be altered are not unique within the SRS and the areas represent only a small percentage of the land available, overall physical impacts of normal operations on soil would be localized and insignificant.

In addition to the physical alteration of soil, soils in the vicinity of the facility could be chemically impacted during normal operations. For example, contaminated material from the site might be mobilized by runoff water or transported by wind. However, with the use of good engineering practices during normal operations, chemical impacts on soils would be insignificant.

H.2 Noise

H.2.1 Construction

Equipment and vehicle operation would be the primary sources of noise during construction. Soil movement, land clearing, and excavation activities typically generate noise levels in the 85- to 90-dBA range at a distance of 15 m (50 ft) from the source (EPA 1974). Noise levels decrease 6 dB for each doubling of the distance from a point source (MPCA 2001). The boundary closest to the proposed MOX facility site is about 8.7 km (5.4 mi) away. Thus, construction of the proposed MOX facility would cause noise levels of about 30 to 35 dBA at the closest boundary location. A second construction site for the PDCF and WSB would add at most 3 dBA.

This noise estimate is likely to be an upper bound because it does not account for additional attenuation due to noise absorption in the air and the effects of terrain and vegetation. The 33- to 38-dBA level is below the U.S. Environmental Protection Agency (EPA) guideline of 55 dBA for protection of the public and is less than the levels found along roadways around the SRS by more than 17 dBA (Section 3.4.4). If two sound levels differ by 10 dBA or more, adding the lower level contributes very little to the upper level. Thus potential noise impacts from construction activities should be negligible at all off-site locations.

H.2.2 Operations

Noise sources during operation of the three facilities would include outdoor air conditioning systems, transformers, fans, pumps, and vents for emergency and standby diesel generators. Noise levels from interior sources are expected to be damped to imperceptible levels outside

the proposed MOX facility buildings (DCS 2002). Employee vehicles, delivery trucks, and material-handling equipment would also produce noise.

No measurements of noise associated with facility systems were available. As an example, however, sound-level measurements taken during operation of a chemical weapons incinerator in Toole, Utah, were less than 73 dBA within 30 m (100 ft) of the facility's abatement equipment (Anderson 2000). Noise levels decrease 6 dB for each doubling of the distance from a point source (MPCA 2001). The closest boundary is about 8.7 km (5.4 mi) from the proposed MOX facility. On the basis of the 73-dBA value for the Utah facility, operation of the proposed MOX facility might result in noise levels of about 25 dBA at the closest boundary location. Operations at the PDCF and WSB would add at most 4 dBA, giving a maximum noise impact of about 29 dBA. This estimate is likely to be an upper bound, because it does not account for additional attenuation from absorption in the air and effects of terrain and vegetation. The 29-dBA level is below the EPA guideline of 55 dBA for protection of the public and is more than 20 dBA less than the noise levels occurring along roadways around the SRS (Section 3.4.4). As mentioned above, if two sound levels differ by 10 dBA or more, adding the lower level contributes very little to the upper level. Thus, potential noise impacts from operation of the facility should be negligible at all off-site locations.

H.3 Ecology

H.3.1 Construction

H.3.1.1 Terrestrial

H.3.1.1.1 Vegetation

Impacts of facility construction to terrestrial resources would primarily result from the clearing and grading of the land for new facilities and infrastructure. A total land area of up to 50.0 ha (123.4 acres) would be affected by construction. About 26.2 ha (64.7 acres) would be cleared and graded within the areas designated for the proposed facilities (see Figure H.1). These site preparation activities would disturb 6.8 ha (16.9 acres) of pine forest, 1.4 ha (3.5 acres) of mixed pine forest, 0.3 ha (0.8 acres) of mixed deciduous forest, 2.6 ha (6.3 acres) of upland deciduous forest, 1.6 ha (4.0 acres) of grassland habitat, 1.1 ha (2.8 acres) of old field, 2.8 ha (6.9 acres) of spoils, and 9.5 ha (23.5 acres) of "facility" lands. An additional 3.6 ha (8.9 acres) would be graded around portions of the facility boundary. This grading would disturb mostly woodland vegetation. About 11.9 ha (29.5 acres) of the area within the facility site boundaries would be developed with buildings, other facilities, and paving. The remainder of the areas would be landscaped (e.g., with grass) (DCS 2002). Thus, after construction, the proposed MOX and PDCF/WSB facility areas would be considered as part of the industrial/transportation land cover type, as described by DOE (2000b).

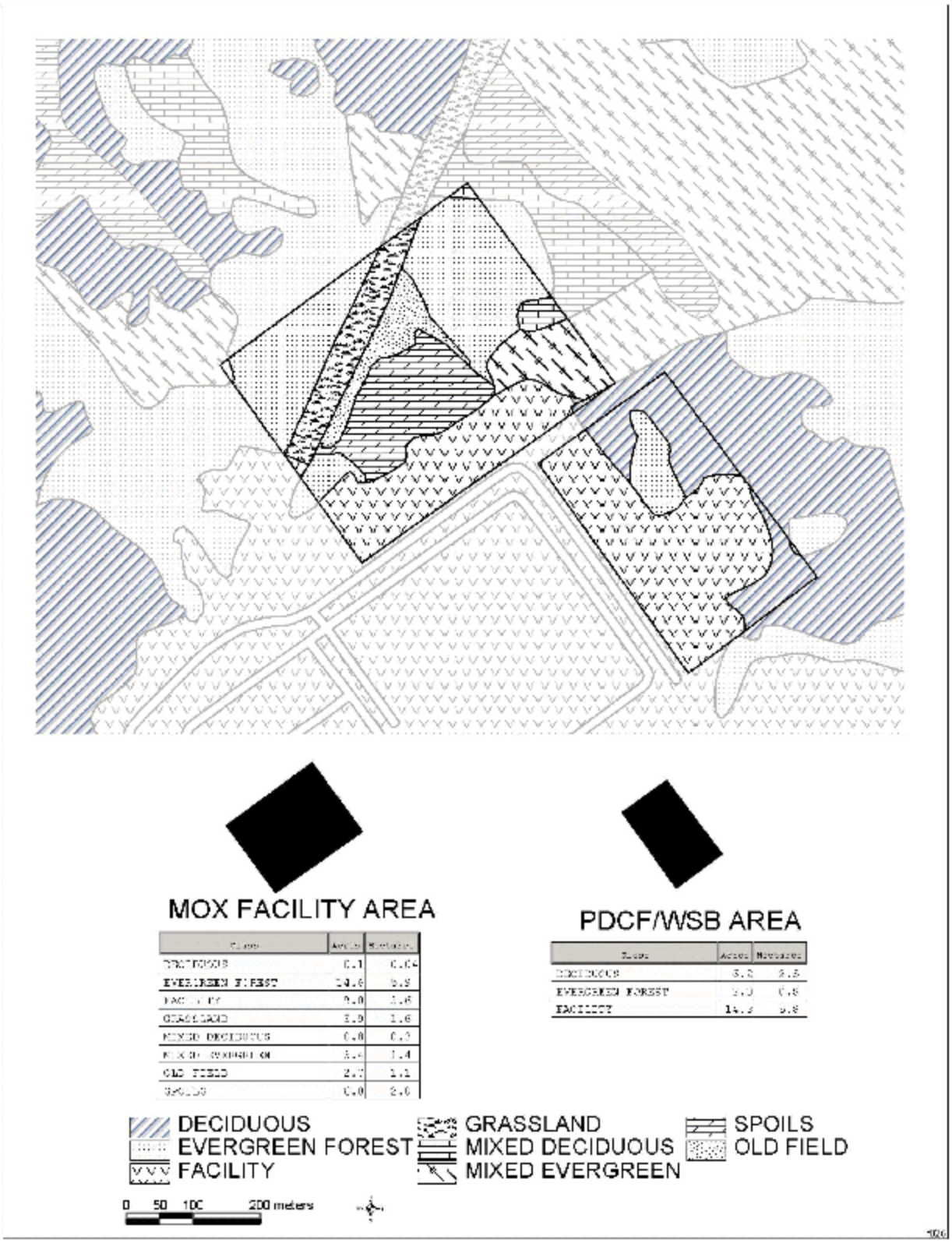

Figure H.1. Areas affected by facility construction activities.

The maximum of 14.7 ha (36.4 acres) of woodlands cleared for the proposed facilities would be a comparatively small percentage of the 1,762 ha (4,350 acres) of timber harvested each year at the SRS. Furthermore, this annual timber harvest is only about 1% of the standing volume of commercial forest land at the SRS (DOE 2000b).

New, widened, and realigned roadways would be required for the facilities. Most of the roadways would be located within previously cleared road rights-of-way. However, about 2.0 ha (5.0 acres) of new roads would be located in two areas of evergreen forest. The existing storm-water outfall and drainageways would need to be relocated. New storm-water basins would likely be constructed southeast of the proposed MOX facility. The storm-water basin would be located within the area cleared and graded for the proposed MOX and PDCF/WSB facilities. The existing 0.2-ha (0.6-acre) F-Area storm-water basin would be graded and resized to create the new 0.6-ha (1.5-acre) MOX facility storm-water basin. Drainage from this storm-water basin would flow toward an unnamed tributary of Upper Three Runs Creek (see Figure 3.3). This storm-water basin would not be located within a designated wetland area. About 0.6 ha (1.5 acres) would be disturbed for the waste pipeline to the WSB. The pipeline would be located within the industrial/transportation land cover type. A portion of the 115-kV electric transmission line would need to be relocated. This relocation may occur within the area disturbed for the proposed MOX facility. Otherwise, an additional 4.5 ha (11.0 acres) may need to be disturbed for the relocation. The area for this relocation has not been specified, but it would probably be within upland wooded areas. Similarly, 4.0 ha (10 acres) could be disturbed for the batch plant and less than 3.8 ha (9.5 acres) for miscellaneous utilities along the perimeter road.

Other possible adverse construction effects to vegetation could include the localized deposition of dust and other particulate matter from the operation of vehicles and machinery. This deposition could inhibit photosynthesis and, if chronic, could kill affected plants. In addition, soil compaction caused by heavy machinery could destroy the ground flora and indirectly damage roots of trees (by reducing soil aeration and altering soil structure). These potential impacts would be localized in the areas immediately outside the facility site boundary.

H.3.1.1.2 Wildlife

The primary construction impacts on terrestrial wildlife would result from the temporary to permanent loss and alteration of up to 50.0 ha (123.4 acres) of habitat for the facilities and associated infrastructure. Clearing and grading prior to actual construction would have localized adverse effects on animal populations on the SRS. Less mobile animals (e.g., some reptiles, amphibians, and small mammals) within the project area could be destroyed during land-clearing operations. Before construction activities (including clearing) began, the site would be surveyed for nests of migratory birds to ensure that such species would not be affected (DCS 2002). Larger and more mobile wildlife in the area would be disturbed by these activities and move to other available habitats.

Construction noise and human activity would cause additional impacts to wildlife. On the basis of noise level information provided in Section H.2, construction noise levels at about 122 m

(400 ft) could still be as high as 80 dBA. This level of noise could startle or frighten birds and small mammals (DOE 2000a). Although noise levels would be relatively low beyond this distance, the occurrence of human activity could also displace some wildlife. Some wildlife might be driven from the area permanently, while others might become accustomed to these disturbances and return to the area. Generally, these disturbances would be short-term and localized (DOE 2000a). Increased traffic could also increase the number of animals killed while crossing roads.

Following construction, all but about 11.9 ha (29.5 acres) cleared and graded for the proposed facilities would be landscaped (e.g., grass with scattered bushes and small trees). This landscaping would provide habitat for some wildlife species (Mayer and Wike 1997). Clearing of 2.0 ha (5.0 acres) of evergreen forest for roadways would eliminate a minimal amount of wildlife habitat at the SRS. Overall, the adverse impacts of construction are expected to be limited to the immediate project vicinity and should not affect the viability of any wildlife populations at the SRS.

H.3.1.2 Aquatic

Construction of the facilities would eliminate a small storm-water basin located near the southern boundary of the proposed MOX facility. This basin is shallow with little vegetation and mostly bare shoreline, thus providing minimal value to wildlife. Its loss would not jeopardize any species at the SRS. Additionally, this loss would be compensated for by construction of the new storm-water basins. The new basins would potentially be a more viable aquatic habitat than the existing storm-water basin. No direct impacts to streams (such as rerouting or channelization) would result from facility construction. Water required for construction would be drawn from existing groundwater wells in F-Area (Section 4.3.3.2.1). Indirect aquatic impacts could occur if unprotected soils eroded into the unnamed tributary of Upper Three Runs Creek that is located adjacent to the construction site. Such erosion could increase stream sedimentation and turbidity, possibly degrading water quality and adversely affecting aquatic organisms. However, use of standard erosion-control techniques as required by the South Carolina Department of Health and Environmental Control (SCDHEC) would be implemented to minimize erosion and subsequent potential increases in turbidity to the unnamed tributary of Upper Three Runs (see Section 4.3.3.1.1).

H.3.1.3 Wetlands

Negligible direct impacts (such as dredging or filling) to wetlands would occur from facility construction. Indirect impacts could occur if unprotected soils eroded into wetlands adjacent to the construction site and adversely affected hydrological and ecological conditions there. However, erosion control techniques would be implemented to prevent construction-related runoff of soils (see Section 4.3.3.1.1). Careful attention to sediment and erosion control during site preparation and construction would protect wetland resources near the facility site (Wike and Nelson 2000).

H.3.1.4 Protected Species

Construction activities are not expected to have direct impacts on any of the federally listed species on the SRS because they have not been reported to occur in the areas to be disturbed by construction. Indirect impacts could occur to listed wildlife species from disturbance (e.g., noise and human presence). Also, clearing would eliminate habitat that could provide support to some of the species. In particular, the pine trees that would be removed could provide forage habitat for the red-cockaded woodpecker. However, the pines to be removed are a negligible portion of those present throughout the SRS. Also, the facility site is not located within either the red-cockaded woodpecker management area or the supplemental management area.

The transmission line right-of-way within the facility area provides suitable habitat for the smooth coneflower. Thus, the right-of-way would need to be surveyed for this plant before clearing and grading operations start. If the smooth coneflower was discovered, the U.S. Fish and Wildlife Service would have to be consulted before any land was disturbed.

Implementation of standard erosion-control practices would prevent potential impacts (see Section 4.3.3.1.1) to protected fish species (i.e., shortnose sturgeon) or wildlife species that utilize or forage in aquatic habitats (e.g., wood stork and American alligator) in potential suitable habitat in surface waters receiving runoff from the facility sites.

H.3.2 Operations

Within the facilities' boundaries and in most associated infrastructure areas, vegetation would be limited to landscaped lawns. A more diverse vegetation community (e.g., grassland/forb/ scrub-shrub land cover) would be maintained within the transmission line right-of-way.

Noise would probably be the most notable impact of routine operation of the facilities on wildlife and would be localized to within a radius of about 61 m (200 ft) of the facility. Scrubbers and filters would be used on the facilities, so no impacts to wildlife would be expected from airborne releases of contaminants (DCS 2002). The presence of the facilities would increase the potential of bird collisions with structures (Klem 1990). However, this source of bird mortality would not cause impacts at the population level.

No liquid process effluents would be directly released by operation of the facilities. Liquid effluents would be treated at the ETF. There would be no impacts to aquatic or wetland biota from these effluents. Storm water would be collected and routed through the existing SRS NPDES-permitted outfall or new outfalls, and sanitary wastewater would be treated in the sitewide treatment system (DCS 2002). Thus, no significant adverse impacts to aquatic or wetland biota would be expected. Detention ponds and associated drainage ditches would provide habitat that could support a number of wildlife species (Mayer and Wike 1997).

No adverse impacts to protected species would be expected from facility operations because of the suitable habitats and minimal facility releases to the environment. Habitat suitable for the

smooth coneflower would develop within the rerouted segment of the transmission line right-of-way, but the potential for a population of that plant to develop in this area is remote.

H.4 Land Use

H.4.1 Construction

Up to 50 ha (123.4 acres) of F-Area would be disturbed during construction of the facilities. Land use of the entire F-Area at the SRS, including the areas of proposed construction for the facilities, is classified as developed/industrial. Thus, the proposed use of the project area is consistent with this classification and with the SRS Long Range Comprehensive Plan (DOE 2000b). No adverse effect to land use would result from construction of the facilities.

H.4.2 Operations

The proposed facilities are industrial, and their operation would be consistent with the classification of the F-Area land use as developed/industrial. Therefore, there would be no adverse effect to land use as a result of routine operation of the facilities.

H.5 Cultural and Paleontological Resources

H.5.1 Construction

H.5.1.1 Archaeological Resources

Construction of the proposed facilities would directly affect two prehistoric archaeological sites that are eligible for listing on the *National Register of Historic Places* (NRHP) (Sites 38AK546/547 and 38AK757). Data recovery plans detailing the proposed mitigation for the adverse impacts to Sites 38AK546/547 and 38AK757 have been prepared and accepted by the South Carolina State Historic Preservation Office (SCSHPO) (Gould 2001; Marcil 2001). Site 38AK546/547 was excavated according to the data recovery plan to mitigate the adverse effects to that site from construction of the proposed MOX facility. Data recovery for Site 38AK546/547 was completed April 19, 2002. Site 38AK757 was excavated according to its data recovery plan to mitigate the adverse effect to that site from construction of the PDCF. Data recovery for Site 38AK757 was completed September 15, 2002. Monitoring of the ground-disturbing activities during construction is also expected to occur as part of the planned mitigation (Gould 2002). Concurrence of the SCSHPO that these investigations have met the obligations set forth in the data recovery plans was provided in November 2002 (Long 2002).

Five additional eligible sites are located in the vicinity of the construction area (Sites 38AK106, 38AK155, 38AK563, 38AK564, and 38AK581), but no direct impacts to these sites are expected as a result of facility construction. Mitigation measures might be needed to avoid the possibility of indirect effects to these sites. Such measures could include conducting awareness training for workers so they would not inadvertently disturb the sites and possibly imposing restrictions regarding where heavy machinery is allowed. Mitigation might also include periodic monitoring to check for possible erosion caused by surface runoff during construction or evidence of other impacts resulting from an increase in F-Area activities (e.g., unauthorized pedestrian or vehicular activity at the archaeological sites). The potential exists for erosion to occur along the current drainage at the outfall east-northeast of the proposed facilities that may affect eligible sites (38AK106, 38AK563, and 38AK564). Minor erosion potential at another small drainage may affect Site 38AK581. Although direct impacts are not expected to Site 38AK155, the site is located very near an area previously identified as grading area for the proposed MOX facility. Depending on the final footprint of the grading and fill area for the proposed MOX facility, Site 38AK155 may require monitoring to ensure avoidance of the site to prevent any direct or indirect impacts from construction activities. An updated contour map of the proposed grading area was not available at the time this DEIS was being prepared. A memorandum of agreement with the SCSHPO stipulating avoidance of the site and how it is to be implemented could be required. Specific mitigation measures would be determined in consultation with the SCSHPO.

H.5.1.2 Historic Structures

No structures are located in the facility project area; therefore, no impacts to historic structures would occur during the construction of the facilities.

H.5.1.3 Traditional Cultural Properties

No traditional cultural properties have been identified near the proposed facilities. Consultation with appropriate Native American groups has been initiated to request information on any concerns regarding the potential for the MOX facility to affect traditional cultural properties. Copies of the consultation letters are presented in Appendix B.

H.5.1.4 Paleontological Resources

No fossil-bearing strata are known to exist within the F-Area; therefore, no impacts to paleontological resources are expected during construction.

H.5.2 Operations

Archaeological resources are unlikely to be affected by routine operation of the facilities. Ground disturbance and outdoor activities outside of the original construction footprint are not part of routine operations.

Traditional cultural properties and paleontological resources are not known to be present in F-Area, and, thus, none would be affected during routine facility operations.

H.6 Infrastructure

H.6.1 Construction

Construction activities are not expected to adversely impact current SRS infrastructure. The maximum water and electrical power demands during construction of the facilities were estimated by DOE in the Surplus Plutonium Disposition Environmental Impact Statement (SPD EIS) (DOE 1999) and by DCS (DCS 2002). Electrical power needed during construction of the facilities is estimated to be 17,700 MWh/yr. This power represents only about 3.7% of the current electrical power available (482,700 MWh/yr) at the SRS (DOE 1999). Maximum water requirements are not projected to exceed 139 million L/yr (37 million gal/yr), or about 3.4% of the F-Area groundwater capacity.

No new off-site roads would be constructed or improved to bring construction materials or workers to the SRS from local communities. An additional 4.8 to 6.4 km (3 to 4 mi) of roadways would be necessary to support facility construction activities within the F-Area.

The existing SRS road network plus the additional roads in F-Area needed for construction site access can readily accommodate the additional traffic expected during construction of the facilities. Some workers are expected to carpool during construction. During peak construction and assuming all three facilities are constructed simultaneously, the increase in the number of average daily one-way traffic on the roads leading to F-Area is expected to be about 30%.

The total diesel fuel required for a 5-year construction period is estimated to be about 7,624,000 L (1,960,000 gal). On-site storage of this volume of fuel is not anticipated because the majority of diesel fuel would be used in construction equipment that would likely be refueled each day by tanker trucks.

The surplus plutonium disposition program at the SRS would require a coordinated upgrading of the infrastructure to support the proposed MOX facility, the PDCF, and the WSB (DCS 2002). A storm-water retention pond and a sedimentation basin will be developed to handle runoff from all three of these facilities that are planned to be constructed in the same general vicinity within the F-Area.

H.6.2 Operations

The SRS infrastructure would not be adversely affected by operations of the proposed facilities. Infrastructure for the facilities would be modified and upgraded before and during construction to accommodate operational needs. Electrical power required during operation of the proposed facilities is estimated to be 186,000 MWh/yr, or about 36.4% of the available electrical capacity in the F-Area (DCS 2002).

Service and process water usage in the F-Area is currently about 374 million L/yr (98.8 million gal/yr) (DCS 2002). The available capacity is 4.2 billion L/yr (1.1 billion gal/yr), and the annual water demand for facility operations would be about 76 million L/yr (20.1 million gal/yr). Water needs for the proposed facilities would represent about 11% of the available F-Area capacity.

Fuel oil would be used to test the diesel generators that would provide emergency power for operations in the event of a failure of the electrical supply system. An estimated 430,100 L/yr (179,000 gal/yr) of diesel fuel would be needed for generator testing (DCS 2002; DOE 1999).

The traffic from 510 permanent workers traveling to and from the facility might cause some impacts during peak travel periods. Local roads providing access to the SRS and on-site roadways experience traffic congestion during peak commuter periods. If individuals elect to participate in carpools, the impact on traffic flow and volume would tend to be reduced.

H.7 Socioeconomics

H.7.1 Construction

This section discusses the potential socioeconomic consequences from constructing the proposed MOX facility, PDCF, and WSB at the SRS. The socioeconomic analysis includes the effects on employment, income, and regional growth in a 15-county regional economic area (REA) and on population, housing, and community resources in a 4-county region of influence (ROI). Impacts on traffic are provided for the road network in the vicinity of the SRS in Aiken County. Impacts from construction are summarized in Table H.1.

In addition to the impacts shown in the table, minor impacts would also occur to agriculture in the REA and commercial fishing downstream of the SRS as demand for the products of these industries increases with the growth in REA payroll and salary expenditures resulting from the construction of the facilities.

The potential socioeconomic impacts from constructing the facilities would be relatively small. Construction activities would create direct employment of approximately 1,000 people in the peak construction year and an additional 810 indirect jobs in the REA (see Table H.1). Construction activities would increase the annual average employment growth rate by less than 0.1 of a percentage point over the duration of construction. Facility employment and associated

Table H.1 Effects of construction on socioeconomics[a]

Impact category	Impacts
Employment (number of jobs in REA)[b]	
Direct	1,000
Indirect	810
Total	1,810
Income ($ million in REA)	
Direct	48.9
Indirect	39.3
Total	88.2
Population (number of new ROI residents)	350
Housing (number of ROI units required)	130
Public Finances (% impact on fiscal balance)	
Cities in ROI[c]	<1
Counties in ROI[d]	<1
Schools in ROI[e]	<1
Public service employment (number of new employees in ROI)	
Police officers	1
Firefighters	0
General	2
Physicians	1
Teachers	1
Number of new staffed hospital beds in the ROI	1
Traffic (impact on current levels of service in Aiken County)	None

[a]Impacts are shown for the peak year of construction (2005).

[b]Employment data based on DCS (2002) and NNSA (2002).

[c]Includes impacts that would occur in the South Carolina cities of Aiken, Jackson, New Ellenton, North Augusta, Wagener, Barnwell, Blackville, Williston and the Georgia cities of Grovetown, Harlem, Augusta, Blythe, and Hephzibah.

[d]Includes impacts that would occur in Aiken and Barnwell Counties in South Carolina and in Columbia and Richmond Counties in Georgia.

[e]Includes impacts that would occur in Aiken County, Barnwell County #19, #29, #45, Columbia County, and Richmond County school districts.

wages and salaries would also produce about $88 million of income in the peak year of construction.

In the peak year of construction, about 350 people would move to the ROI (in-migrate) (see Table H.1). However, in-migration would have only a marginal effect on population growth and would require only 2% of the vacant rental housing in the ROI during the peak year. No significant impact on public finances would occur as a result of in-migration, and four additional local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have no impact on levels of service in the local transportation network surrounding the site.

H.7.2 Operations

This section presents the potential socioeconomic consequences from operating the proposed facilities at the SRS. As for the construction evaluation, the socioeconomic analysis for operations covers the effects on employment, income, and regional growth in the 15-county REA and on population, housing, and community resources in the four-county ROI. Impacts on traffic are provided for the road network in the vicinity of the SRS in Aiken County. Impacts from operation are summarized in Table H.2.

In addition to the impacts shown in the table, insignificant impacts would also occur to agriculture in the REA and commercial fishing downstream of the SRS as demand for the products of these industries increases with the growth in REA payroll and salary expenditures resulting from the operation of the facilities.

The potential socioeconomic impacts from operating the facilities would be relatively small. Operational activities would create about 480 direct jobs annually and an additional 780 indirect jobs in the REA (see Table H.2). The facilities would produce $61 million in direct and indirect income annually during operations.

About 180 people would move to the area at the beginning of facility operation (see Table H.2). However, in-migration would have only a marginal effect on population growth and would require less than 1% of the vacant owner-occupied housing in the area during facility operations. No significant impact on public finances would occur as a result of in-migration, and two new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have no impact on levels of service in the local transportation network surrounding the site.

Any impacts that would occur with the transportation of MOX fuel, including impacts on property values, would be minimal. This conclusion is reached because it is likely that the current transportation of other hazardous materials and the risk of accidents involving those materials are already captured in housing values in the vicinity of transportation routes. An accident

Table H.2. Effects of operations on socioeconomics[a]

Impact factor	Impacts
Employment (number of jobs in REA)[b]	
Direct	480
Indirect	780
Total	1,260
Income ($ million in REA)	
Direct	23.4
Indirect	38.0
Total	61.4
Population (number of new ROI residents)	180
Housing (number of ROI units required)	70
Public finances (% impact on fiscal balance)	
Cities in ROI[c]	<1
Counties in ROI[d]	<1
Schools in ROI[e]	<1
Public service employment (number of new employees in ROI)	
Police officers	0
Firefighters	0
General	1
Physicians	0
Teachers	1
Number of new staffed hospital beds in the ROI	0
Traffic (impact on current levels of service in Aiken County)	None

[a]Impacts are shown for the first year of operations (2008).

[b]Employment data taken from DCS (2002).

[c]Includes impacts that would occur in the South Carolina cities of Aiken, Jackson, New Ellenton, North Augusta, Wagener, Barnwell, Blackville, Williston and the Georgia cities of Grovetown, Harlem, Augusta, Blythe and Hephzibah.

[d]Includes impacts that would occur in Aiken and Barnwell Counties in South Carolina, and in Columbia and Richmond Counties in Georgia.

[e]Includes impacts that would occur in Aiken County, Barnwell County #19, #29, #45, Columbia County, and Richmond County school districts.

involving MOX fuel may only create significant additional impacts on the housing market if residents were prevented from quickly returning to their homes.

H.8 Aesthetics

H.8.1 Construction

During construction of the proposed facilities, large construction cranes and fugitive dust produced by earthmoving equipment may be visible to the general public from the nearest publicly accessible viewpoint, located on State Highway 125 and SRS Road 1, both more than 6.5 km (4 mi) away. Once the proposed facilities were constructed, however, the height, size, and appearance of the new structures would be similar to existing buildings adjacent to the F-Area site and would therefore maintain the industrial nature of F-Area and be consistent with the current VRM Class IV designation of the site. The newly constructed facilities themselves would not generally be visible from off-site, with visibility restricted by the undulating terrain and the forested nature of the landscape.

H.8.2 Operations

During operations, it is unlikely that any additional visual impacts would occur beyond those resulting from the presence of the facilities. Exhaust stacks located on or near the proposed facilities would not generally be visible to members of the public because of the undulating, forested nature of the landscape. While any emissions from these stacks, as well as other evidence of operations at each facility (such as area lighting), might be visible from the nearest viewing point, these aspects of facility operation would be some distance away and therefore would not affect the current VRM Class IV designation of the site.

H.9 Accident Impacts

H.9.1 Geology, Seismology, and Soils

Accidental releases of contaminated material might adversely affect soils. However, use of good engineering practices and implementation of appropriate cleanup procedures following the accident would result in negligible chemical impacts on soils.

H.9.2 Ecology

An operational accident at the facility could potentially impact biota in natural plant communities and streams near the facility. The degree to which impacts would occur would depend on the

type of accident, kind and amount of contaminants released, and wind direction at the time of release. Natural areas likely to experience the greatest impact would be those located immediately north and northeast of the facility. Prompt action to clean up or otherwise mitigate contaminants released during an accident would reduce the likelihood of contaminant bioaccumulation and biomagnification in the food chain. No protected species are known to occur within these areas (see Section 3.5.4 and Appendix A).

H.9.3 Land Use

An operational accident at the facility would be unlikely to affect land use within the F-Area, the SRS, or the region. The entire F-Area would remain developed/industrial land use if an operational accident were to occur. Access to the area might be temporarily restricted during cleanup operations following an accident. Minor impacts to lands outside of the SRS might be anticipated in the event of a worst-case accident, but most impacts would remain within the SRS boundary. Future use of the central portion of the SRS, which includes the F-Area, is expected to be maintained by the federal government as industrial (DOE 2000b).

H.9.4 Cultural and Paleontological Resources

An operational accident at the facilities might affect significant archaeological resources in the vicinity of the project area by restricting access to sites that currently require regular monitoring. This impact would likely be temporary, depending on the duration of cleanup after the accident.

It is possible that important nuclear production facilities that have historic value related to events during the Cold War could be temporarily affected during an operational accident. It is also possible that traditional plant resources of concern to Native Americans could be affected during an operational accident. No other traditional cultural properties that could be affected have been identified to date but may be identified as a result of the ongoing consultation.

Paleontological resources are unlikely to be affected by an operational accident at the facilities.

H.9.5 Socioeconomics

An operational accident at the facilities could impact the workforce if the accident was severe enough to result in lost work time. The extent of impacts to the local economy would depend on employment income losses during closure of the facilities following an accident. An accident involving fresh MOX fuel during transport might create significant additional impacts on the housing market only if residents were evacuated and prevented from quickly returning to their homes.

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APPENDIX I:

SCOPING SUMMARY REPORT

DOCKET 70-3098

ENVIRONMENTAL IMPACT STATEMENT SCOPING PROCESS

SCOPING SUMMARY REPORT

Mixed Oxide Fuel Fabrication Facility
Savannah River Site

August 2001

U.S. Nuclear Regulatory Commission
Rockville, Maryland

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Attachment A

Preliminary Outline for the Mixed Oxide Fuel Fabrication Facility EIS 31

ABBREVIATIONS

ADAMS	Agency wide Document Access and Management System
CAR	Construction Authorization Request
DCS	Duke Cogema Stone & Webster
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
H&S	human health and safety
HEPA	high-energy particulate air
HLW	high-level (radioactive) waste
MINATOM	Ministry for Atomic Energy of the Russian Federation
MOX	mixed oxide
MOX FFF	Mixed Oxide Fuel Fabrication Facility
MT	metric tons
NEPA	National Environmental Policy Act
NAACP	National Association for the Advancement of Colored People
NMSS	Nuclear Material Safety and Safeguards (part of the Nuclear Regulatory Commission)
NRC	U.S. Nuclear Regulatory Commission
NOI	Notice of Intent
ROD	Record of Decision
SER	Safety Evaluation Report
SPD	surplus plutonium disposition
SRS	Savannah River Site
YMP	Yucca Mountain Project

1. INTRODUCTION

On March 7, 2001, the United States Nuclear Regulatory Commission (NRC) issued a notice of intent (NOI) in the *Federal Register* (66 FR 13794) to prepare an environmental impact statement (EIS). As indicated in the NOI, the proposed major federal action requiring the EIS is the construction and operation of a mixed oxide (MOX) fuel fabrication facility (MOX FFF) at the Savannah River Site (SRS) near Aiken, South Carolina. If authorized under the requirements of 10 CFR Part 70, Duke Cogema Stone & Webster (DCS), a contractor chosen by the United States Department of Energy (DOE), would build and operate the proposed MOX FFF. The EIS will examine the potential environmental impacts of manufacturing MOX fuel from surplus weapons-grade plutonium. The potential impacts associated with processing 36.4 tons (33 metric tons (MT)) of this surplus plutonium will be evaluated. The evaluation of these impacts will be based on the proposed maximum annual MOX FFF capacity of 3.5 MT.

Under the present technical review schedule, the EIS will be used to support a decision in 2002 by the NRC whether or not to authorize construction of the proposed MOX FFF. The current schedule is to publish the draft EIS in February 2002. Following a public comment period, the draft EIS would be revised, and a final EIS would be published in September 2002. No cooperating agencies have been identified during the scoping process. NRC, as the lead agency, will prepare the EIS with the assistance of Argonne National Laboratory.

In addition to the EIS for the MOX FFF, NRC will prepare two safety evaluation reports (SERs) on health and safety issues raised by the proposed action. The first SER will evaluate such issues raised by the construction authorization request submitted by DCS in February 2001. A second SER will evaluate health and safety issues raised by the DCS request for authority to operate the proposed MOX FFF, which DCS plans to submit in July of 2002. The SERs document our evaluation of the safety of DCS's applications and compliance with applicable regulations. As discussed later in Section 3, the EIS will analyze both construction and operation impacts.

In the NOI, NRC announced plans for two scoping meetings: one in North Augusta, South Carolina, on April 17, 2001, and another scoping meeting in Savannah, Georgia, on April 18, 2001. In a second *Federal Register* notice on April 11, 2001 (66 FR 18223), NRC announced that a third scoping meeting would be held in Charlotte, North Carolina, on May 8, 2001. Announcements of the meetings were also made on the World Wide Web at the NRC MOX FFF Information Home Page, (http://www.nrc.gov/NRC/NMSS/MOX), through an electronic newsletter, through radio advertisements, through press releases, and through direct mailing to individuals who had attended past meetings associated with MOX. Announcements of the meetings were also made in the following local newspapers:

- The Augusta Chronicle (Thursday, April 12, & Sunday, April 15)
- Aiken Standard (Thursday, April 12, & Sunday, April 15)
- North Augusta Star (Thursday, April 12, & Sunday, April 15)
- Savannah Morning News (Thursday, April 12, & Sunday, April 15)
- The State News, Columbia, SC (Sunday, May 6)
- The Charlotte Observer (Sunday, May 6)

The three scoping meetings were held as planned. At each meeting, the NRC staff distributed background materials on the MOX fuel program and NRC's plans for conducting licensing and environmental reviews for the MOX FFF. An open house held before each meeting provided attendees an opportunity to view informational materials and talk informally with NRC staff. During the meeting, the NRC staff presented an overview of NRC'S role in the MOX FFF licensing process and described NRC'S approach to meeting its obligations under the National Environmental Policy Act (NEPA). The presentations were followed by a question and answer period in which the NRC staff responded to questions from attendees. The majority of time at the meetings was devoted to allowing individuals to express their views on the scope of the EIS. Transcripts of the meetings can be viewed on the World Wide Web at the NRC MOX FFF Information Homepage (http://www.nrc.gov/NRC/NMSS/MOX).

A total of about 300 individuals attended the three scoping meetings, and about 80 of them asked questions or provided oral comments at the meetings. In addition, approximately 60 individuals or organizations submitted written comments to NRC by regular mail, fax transmittal, e-mail, or in person at the meetings. Some of the individuals who provided written comments also spoke at the meetings. Some individuals attended and offered comments at more than one meeting.

The public comments are discussed in Section 2 of this summary. All comments received through May 21, 2001, the date announced in the NOI for closing of the scoping period, were considered. Comments received after this date were considered to the extent possible in preparing this report. The comments have been categorized by subject under the following issue headings:

- NEPA Issues
- Policy Issues
- Alternatives
- Ecology, Air and Water
- Cultural Resources
- Cumulative Impacts
- Human Health Impacts
- MOX Fuel Processing
- Transportation Issues
- Waste Management
- Socioeconomics
- Security and Terrorism
- Environmental Justice
- Decommissioning vs. Deactivation
- SRS Infrastructure and Existing Conditions
- Reactor Use Issues
- Lead Test Assemblies

The scope of the EIS and summary of issues that will be addressed in the EIS are discussed in Section 3. Although issues raised during the scoping period will be considered in the preparation of the MOX FFF EIS, some of those issues will either be analyzed in less detail or will not be analyzed at all, depending on their relevance to the proposed action and the anticipated impacts. Issues that will be considered, but not analyzed in detail, are summarized in Section 4. The preliminary outline for the EIS is included as Attachment A.

2. SCOPING COMMENT SUMMARY

2.1 INTRODUCTION

Several commenters voiced their support for the MOX fuel option, stating that it was the best option for using excess plutonium. They cited the commercial MOX reactors in Europe along with an experimental MOX program in the United States as evidence that MOX technology is both safe and feasible. They also believed that converting the plutonium to MOX fuel would make it more difficult to recover the plutonium for future use in nuclear weapons than if it were disposed of by immobilization (i.e., conversion of surplus plutonium into plutonium oxide and then into a ceramic or glass form suitable for disposal in a geologic repository). These commenters also supported the SRS as the best location for the MOX FFF, citing experience, expertise, and existing infrastructure.

Although they were in favor of reducing quantities of weapons-grade plutonium, other commenters felt that the MOX program was not the best method for addressing non-proliferation. These commenters preferred immobilization or continued storage to the MOX alternative. These commenters believed that immobilization would offer the greatest deterrent to terrorism and felt that proceeding with the MOX project would lead to widespread reprocessing of spent nuclear fuel. Several commenters voiced their opposition to the project, but did not provide any basis or provide comments on the scope of the EIS.

Several commenters had specific questions or comments on the Environmental Report (ER) and Construction Authorization Request (CAR) prepared by DCS. These comments will be considered in NRC's review of the ER and in the preparation of the EIS and Safety Evaluation Report (SER).

The following summary groups the comments received during the scoping period, both at scoping meetings and through written submittals to the NRC, by technical area and issue.

2.2 SUMMARY of COMMENTS

2.2.1 NEPA Issues

Consideration of Reactor Use Impacts: A few people commented that NRC should limit the scope of the MOX FFF EIS to the environmental impacts of constructing, operating, and deactivating the MOX FFF. They believed that analyzing impacts of the reactors using the MOX fuel as part of the current MOX FFF EIS would create a "double jeopardy" for DCS in that the company would have to provide data twice: now for MOX FFF licensing and again during the license amendment process for the reactors in which the fuel was to be used. One commenter noted that in order to avoid being accused of segmentation (not looking at the full consequences of an action) the EIS must include reactor impacts in its analysis. Several commenters wanted a supplemental EIS to be prepared for the reactor sites if reactor impacts are not addressed in the MOX FFF EIS. Further discussion of reactor use impacts is provided in Section 2.2.16.

NEPA Coverage for Actions in a Foreign Country: A few commenters believed that the link between the U.S. and Russian programs is so strong that, under NEPA, the United States would be obligated to consider environmental impacts of MOX in Russia. One organization indicated that there was a precedent for conducting a NEPA analysis for a major federal action

having a significant impact in a foreign country. (No specific example was provided.) Another commenter stated that environmental impacts occurring outside the United States and within the borders of a sovereign nation are outside the scope of NEPA.

Supplemental EIS: Several commenters thought that DOE's Surplus Plutonium Disposition (SPD) EIS should be supplemented. They contended that the original EIS did not adequately address the need for the action and the alternatives and that DOE did not conduct an adequate life-cycle analysis of the all-MOX option and the all immobilization option. They maintained that if DOE does not prepare a supplemental EIS, NRC needs to evaluate the full range of alternatives related to the MOX program.

Proprietary Information: A few commenters wanted NRC to evaluate the harm to the public caused by withholding information labeled proprietary. They claimed that there was not enough technical information to adequately evaluate the CAR, especially with respect to health and safety. For example, a complete list of source terms was not available. They would also like to examine the types of information that can be categorized as proprietary.

Use of Existing DOE Documentation and Decisions: A few commenters wanted NRC to make full use of environmental documentation already prepared by DOE and avoid reevaluation of issues where DOE has already made a decision. This position includes adopting the DOE decision that the need for the MOX FFF has been established.

Additional Scoping Meetings: Several commenters asked for additional scoping meetings: at reactor sites, along transportation routes, and specifically at Columbia, South Carolina. In addition, several commenters asked that the scoping period be extended beyond the May 21 deadline.

Communicating Information to the Public: A number of people commented on NRC's efforts to communicate information to the public. There were complaints that ADAMS (Agency wide Document Access and Management System), the system that NRC uses for viewing documents, is not user friendly and that since it was implemented the local public reading rooms at nuclear power plants were eliminated. These commenters felt NRC should provide a computer at the NRC reading room and that the CAR and ER should be made available free of charge. One commenter asked for more informational meetings before the draft EIS is issued. Another commenter wanted NRC to indicate how it will handle distribution of MOX information to the public in the future. A request was made for NRC and DCS to define terms such as "highly unlikely" and "unlikely" and to involve the public in determining the appropriateness of these definitions.

2.2.2 Policy Issues

Price Anderson: The Price-Anderson Act limits the liability of organizations in the event of an incident involving nuclear materials. A commenter asked NRC to put a license condition on the MOX fuel project that MOX fuel cannot be covered by Price-Anderson. A commenter wanted the EIS to include a full disclosure of who is legally (and financially) responsible for MOX fuel accidents, including transportation impacts and reactor accidents.

NRC's Role as Lead Agency: A commenter stated that NRC was too closely tied to the nuclear power industry to impartially evaluate the plutonium fuel project. A commenter stated the belief that NRC receives funding from this regulated community and, at times, acts as an

advocate for nuclear power. A commenter asked that NRC support an independent review of DOE's plutonium work, as recommended by the National Research Council in March 1988.

NRC Experience and Precedent: Several commenters thought that NRC was not qualified to regulate and oversee weapons-grade plutonium. They contended that there is no precedent for NRC to analyze reactor impacts as part of a licensing action for a fuel fabrication facility.

Conflict of Interest: A few commenters expressed concern that NRC may not be sufficiently independent from DOE to review the DCS application. Another commenter asked if using Argonne National Laboratory (a DOE Laboratory) as the contractor preparing the NRC EIS represented a conflict of interest.

Agency Interactions: Some commenters thought that the interactions of NRC, DOE, SRS, and DCS should be considered, particularly in terms of their regulatory roles. One commenter thought the EIS should address the question of who owns the MOX fuel at each stage of the process. Commenters were particularly concerned because both DOE and NRC have regulatory roles related to waste disposal. A commenter wanted to know which agency would have jurisdiction over the waste at each stage of the MOX process. Another commenter stated that the commercial and military nuclear waste materials should remain separate.

Non-Proliferation: A comment was made that the United States should reevaluate its non-proliferation agreement with Russia. A commenter argued that MINATOM (Ministry for Atomic Energy of the Russian Federation) intends to take money from the United States and other western countries and build a plutonium fuel infrastructure and export plutonium fuel.

Another commenter thought that the EIS should consider the proliferation impacts of constructing a MOX FFF, which (according to the commenter) violates a long-standing U.S. policy of separating civilian use and military applications of nuclear technology. According to this commenter, MOX would encourage other countries to develop reprocessing, which would have serious non-proliferation consequences. The possible use of the .polishing. portion of the facility for missions other than purifying plutonium for MOX use was also a concern.

Savannah River Site (SRS) Cleanup Funds: Some commenters wanted the EIS to consider the impacts of recent cuts in cleanup and restoration funds to the SRS. One commenter viewed this as the transfer of funds from the SRS cleanup to plutonium production.

Changes in Project Direction: Some commenters wanted the EIS to consider the impacts that would result if the proposed pit disassembly facility was canceled in favor of using existing infrastructure at the SRS. Another commenter felt that this issue had been adequately explored in the DOE SPD EIS and that NRC should be limited to evaluating the cumulative impacts of this related action.

A commenter asked that the EIS consider the impacts of building a MOX facility and then indefinitely suspending or canceling its use if the Russian political situation changes. Another commenter wanted the EIS to determine the cost of the MOX project if the Russian program were canceled.

Some commenters wanted the EIS to assess the impacts on the MOX program caused by delaying immobilization, in particular the impacts of indefinitely storing the plutonium. Commenters were also concerned that delaying or canceling the immobilization project could lead to greater quantities of MOX fuel.

A commenter thought the EIS should consider the environmental impacts of new reprocessing missions at the SRS that could be triggered by the MOX project. A commenter noted that commercial reprocessing is proposed in legislation in Congress and that the current ban is being reviewed by the Bush administration.

International Implications/Treaties: A commenter pointed out that there were several international treaties that must be identified and analyzed for impacts of MOX commercialization in the United States, including the Nuclear Non-Proliferation Treaty of 1968, the Stockholm Declaration on the Human Environment, and the Law of the Sea Convention.

2.2.3 Alternatives

No-action - Continued Storage: Some commenters wanted NRC to fully develop and advance the No-action Alternative. They pointed out that the Bush administration has questioned the U.S. government's commitment to a dual track approach to plutonium disposition and that it is not clear that the MOX program will go forward in Russia. Furthermore, the immobilization program has been postponed. Given this situation, the MOX program could be subject to continued review, making status quo (continued storage) a likely No-action Alternative. Therefore, some commenters wanted the EIS to consider the implications of the SRS becoming a long-term storage facility for the nation's surplus plutonium if the MOX program did not proceed.

One commenter wondered if adopting the No-action Alternative would be a tacit (indirect) way of saying that the MOX process cannot be done safely. Some commenters wanted NRC to explore the effect the No-action Alternative would have on proliferation and acts of terrorism.

No-action - 100 Percent Immobilization: Several commenters wanted the EIS to consider the costs and programmatic requirements of a 100 percent immobilization alternative. They believed that this was a viable alternative if the MOX project was not licensed. A few commenters specifically thought the EIS should consider (1) cost savings from not pursuing the MOX program, (2) the short- and long-term storage and monitoring requirements of plutonium pits and oxides until immobilization is complete, and (3) decreased waste volumes as compared to the MOX process. Another commenter felt that considering a 100 percent immobilization alternative would be inappropriate since DOE has already set surplus plutonium disposition policy.

One commenter wanted the alternatives to include building an immobilization (vitrification) plant at the Nevada Test Site to minimize transportation distances and maximize distances to population centers.

Conversion of All Surplus Plutonium to MOX Fuel: A few commenters wanted the EIS to consider the impacts of an all-MOX alternative. Many commenters wanted the EIS to be very specific in the quantity of plutonium that would be converted to MOX fuel. These commenters believe that addressing the quantity generically or leaving it open ended could lead to widespread reprocessing of spent nuclear fuel. A commenter wanted the EIS to consider a range of plutonium quantities for processing, suggesting that the amount may ultimately be greater than the 50 metric tons specified by the SPD EIS.

Range of Alternatives: A few commenters wanted to restrict the scope of the NRC EIS to the Proposed Action, the No-action Alternative, siting alternatives within the F-Area, and a reasonable range of MOX FFF design alternatives. They also stated that the official statement

of proposed action and no-action should be broadened to include the issuance of a license to possess and use special nuclear material at the MOX Fuel Fabrication Facility. Other commenters wanted to make sure that the no-action alternatives were considered viable options. That is, the no-action alternatives should be defined so that the EIS could select a no-action alternative and not just do an analysis because it was required by law.

The Parallex Project: Some commenters stated that the No-action Alternative from NRC could mean 100 percent immobilization and immobilization has already been delayed. These commenters wanted the EIS to consider the possibility that DOE would export the surplus plutonium to Canada under the Parallex Project. [Note: The Parallex (parallel experiment) Project would be a joint agreement between Russia, Canada, and the United States to demonstrate the feasibility of burning MOX fuel in a heavy-water-moderated reactor, located at Chalk River, Ontario. The project would use MOX fuel made in the United States and Russia from surplus weapons-usable plutonium out of both countries' nuclear stockpiles.]

Aqueous vs. Dry Purification Process: Some commenters wanted NRC to evaluate both the wet and the dry plutonium purification processes. The analysis should include a cost/benefit analysis that weighs the effectiveness of the process against the costs, the effects the impurities have on the MOX fuel use, waste streams, quantities of waste, etc.

Contingency Issues: One commenter wanted to make sure that the impacts of unusable MOX fuel were assessed, noting that historically MOX production has exceeded use and that if the MOX fuel is stored too long, the plutonium converts to americium, which ruins the reactivity.

2.2.4 Ecology, Air, and Water

Surface Water Impacts: One commenter pointed out that the choice of F-Area for the MOX facilities would probably hasten whatever impacts there would be to Upper Three Runs Creek. The commenter wanted the impact analysis to consider the current conditions of the F-Area, pointing out that it was already contaminated.

Groundwater Quality: A number of commenters expressed concerns about potential contamination of groundwater by plutonium, especially since there are a number groundwater aquifers beneath the F-Area. The Floridian aquifer was specifically mentioned. The point was made that there is already existing groundwater contamination from radioactive releases (primarily tritium) from the SRS (communities downstream from the SRS in both South Carolina and Georgia have already been affected; tritium has been found in wells and surface water). Commenters pointed out that there is the potential that liquid radioactive waste generated by the MOX process, which would contain plutonium, would be stored in the same tanks that “caused” the tritium releases. One commenter pointed out that plutonium studies at the Nevada Test Site and at West Valley in New York have shown that plutonium has migrated much faster than predicted. A commenter wondered if the contaminated water would move between the soil and aquifers via the deep rock borings at the SRS.

Several commenters were concerned that any further contamination of the Savannah River could push the ecosystems “over the edge” and cause serious long-term consequences for human health and the economy that depends on resources from the river. They stated that existing water quality in the Savannah River, and Georgia in general, is compromised and that according to U.S. Environmental Protection Agency (EPA) data the Savannah River is already among the 10 most contaminated rivers in the country.

One commenter wanted the EIS to look at the effects of radioactive storm-water runoff on the ecology of the surrounding area. This commenter thought that storm-water runoff from retention ponds should be captured, not released to creeks.

HEPA vs. Sand Filters: Several people commented on the decision to use high-efficiency particulate air (HEPA) filters instead of sand filters for air filtration in the MOX facility. The point was made that the SRS prefers sand filters which are more efficient, safer and more reliable than HEPA filters. They wanted the EIS to consider the use of sand filters in its analysis.

Air Emissions: A commenter stated that the EIS should look at all air contaminants released by the MOX process, how contaminants will be removed and scrubbed from the air stream, and the probable path of contamination spread through the air. Other commenters noted that over the years, tritium had been released through the air pollution stacks and had fallen back to Earth as radioactive tritiated water, which contaminated the region's well water and agricultural products. One commenter questioned why the MOX FFF would be exempted from the National Emission Standards for Hazardous Air Pollutants as was suggested in the ER prepared by DCS. Another commenter stated that the EIS should consider air emissions from the emergency generators and volatile organic compounds from diesel storage tanks.

Tidal Wetlands: Some commenters were concerned about impacts to tidal wetlands along the Georgia coast, stating that they represent about one-third of the remaining tidal wetlands along the Atlantic shore of the United States. A commenter noted that in addition to ecological impacts, there is the potential for economic impacts to fisheries and other natural marine resources, as high as $1 billion annually.

General Ecological Impacts: Several commenters felt the ecological impacts were very important and that the EIS should look at the ecological impacts of the proposed facility. One commenter suggested using an ecological system upstream from the site as a benchmark; other commenters stated the impacts to endangered species and habitat should be re-evaluated given the changes to MOX design from what was presented in the DOE SPD EIS, in particular the changes in the waste streams and incremental volumes of waste.

2.2.5 Cultural Resources

One commenter thought the EIS should discuss the impacts of having deadly radioactive wastes in proximity to ancient cultural archeological sites. Another commenter questioned how cultural resources could be managed without a programmatic memorandum.

2.2.6 Cumulative Impacts

Some commenters wanted cumulative impacts to consider all existing (baseline) contamination and future actions at the SRS. Another commenter suggested that this should include all the auxiliary facilities associated with the MOX project. Chemical as well as radiological impacts should be evaluated. One commenter noted that any radioactive contamination of natural resources could have a cumulative adverse effect on businesses that rely on natural resources. Another commenter noted that cumulative build up of contaminated sediments could directly impact human health. It was noted that the Savannah River is currently among the 10 most contaminated rivers in the country and that further contamination would "push the ecosystem over the edge." A commenter thought cumulative impacts would be the appropriate place to consider the impacts on existing SRS infrastructure if construction of the pit disassembly facility was canceled.

2.2.7 Human Health Impacts

Safety Record: Several people expressed concern that DCS did not have an environmental and safety compliance record specific to DCS; there were only individual records for Duke, Cogema, and Stone & Webster. Commenters thought that it was inappropriate for DCS to use the safety data from the Westinghouse contract site. They pointed out that DCS has not established a safety culture; probability assessments and reliance on the fact that nothing bad has happened yet do not prove acceptability. Commenters wanted the EIS to evaluate Cogema's safety record in Canada and France.

Risk Determination: A commenter wanted the degree of uncertainty associated with the risk calculations used in models to be included, especially when data used to support the models were not based on weapons grade plutonium. Another commenter wanted the health-based standards to be based on EPA's 1 in 1 million accepted deaths rather than the 1 in 10,000 allowed by NRC.

Radiation Hazards: A commenter stated that in addition to looking at cancer fatalities, the EIS should address noncancer effects resulting from ionizing radiation exposures, such as immune deficiencies and genetic defects. A commenter thought that accident impacts should consider radiation exposure impacts to all individuals (including children, the unborn, the sick, and the elderly), not only the "standard man."

A commenter wanted the EIS to assess the dose to workers that would result from the MOX process. The analysis should include every worker involved: those at the MOX facility, workers at nuclear laundries, workers at reactor sites, workers at waste disposal sites, etc. A few commenters wanted to know what measures would be taken to protect MOX construction workers from the existing contamination at the MOX site.

Chemical Hazards: A commenter wanted the EIS to include the health effects of chemical exposure both during normal conditions and accident scenarios. The EIS should consider the fact that there will be a radioactive component to the chemical exposure.

Emergency Preparedness: Several commenters were concerned that DCS had not prepared an emergency management plan for the MOX facility. According to commenters, DCS claimed that a plan was not needed because its models showed that the public radiation dose during a major accident would be within regulatory limits. These commenters wanted the EIS to address the implications of running the MOX program with and without an emergency management plan.

A few commenters wanted the EIS to address the SRS Emergency Management Plan. One commenter expressed concern about impacts to the public from a rupture of a high-level waste tank containing MOX waste.

One commenter wanted to be assured that the SRS would communicate safety related information to the public in a timely manner. According to this commenter, there had been a situation where SRS had failed to warn the public about a tritium release that came downstream from the site.

Some commenters thought that the EIS should evaluate the impacts (costs) of having to upgrade the emergency response equipment and train emergency responders in the communities surrounding the SRS and the reactors and along transportation routes. One

commenter made the point that many of the emergency responders are volunteers. Some commenters wanted the EIS to identify the capabilities of local, regional, and national medical facilities to manage acute and long-term casualties resulting from an accidental release. It was noted that medical facilities along transport routes are seldom adequately equipped to treat radiation victims.

A few commenters thought that using computer models to predict possible releases was inadequate and wanted the EIS to include the costs of purchasing and maintaining monitoring equipment on-site and off-site out to 40 miles. This would include monitoring of air, ground, water, vegetation, and livestock. The instrumentation should cover all forms of radiation, including alpha. A commenter stated that it was in the public's interest to know the measured amount of radiation as opposed to a calculated amount.

One commenter stated that an iodized prophylaxis, which could be used to prevent thyroid damage (including cancer), had been approved by the NRC. This commenter wants sufficient quantities to be in place in the event of an accidental release from the MOX FFF. (Note: An iodized prophylaxis is a non-radioactive form of iodine that is administered before exposure to saturate the thyroid and prevent the later uptake of any airborne radioactive iodine that might be dispersed in a nuclear accident. Any additional iodine that is later inhaled or ingested is eliminated by the kidneys.)

Accidents Related to the MOX Process: A commenter wanted the EIS to discuss the worst-case scenario for an accident related to plutonium processing and the safety factors that would be used to protect the public. All the consequences, not just the probability-weighted risks from accidents, need to be considered. Doses to populations as well as to individuals should be provided. Another commenter thought that the EIS should analyze the impacts caused by a criticality accident due to dust accumulation in the air ducts. There was a comment that the accident analyses should include a plutonium fire, given that plutonium is highly flammable in several of its states. A few commenters wanted the EIS to consider the impacts of accidents involving ruptures or explosions of the tanks used to store liquid radioactive waste. One commenter stated that power outages to the tanks could eventually lead to conditions that could cause the tanks to explode.

Other Accident Issues: Some commenters felt that accident analyses in DOE's EIS were inadequate and that detailed accident analyses should be done for the MOX FFF EIS.

Commenters expressed concern that the design basis earthquake assumed by DCS was not as severe as the one normally assumed by DOE for the SRS; this could also be true for the high winds or tornado design basis. A commenter felt that corners were being cut by using less stringent parameters.

A commenter wanted the EIS accident analyses to include scenarios like plane crashes, insider sabotage, missile attacks, truck bombings, the facility dropping into a sinkhole (there are soft zones near the MOX FFF location), and events happening in other nearby areas that could cripple the facility. One commenter wanted the EIS to provide details on the most probable accident.

One commenter thought that human error should be considered in accident analysis, noting that hazards in nuclear power plants are a combination of human and technical errors and that human failings cannot be completely eliminated by using engineering controls.

2.2.8 MOX Fuel Processing

Concerns were raised about the safety of the proposed design for the MOX FFF, in particular the sintering (baking) process that converts the MOX fuel pellets to a ceramic form. Commenters felt that the design for furnace confinement did not adequately protect the public from a plutonium release. A commenter stated that heating the plutonium in an inert atmosphere that contains some hydrogen could result in a hydrogen burn or an explosion if certain controls were violated. Commenters pointed out that similar work at the SRS is carried out in glove boxes, which provides additional containment in case of an accidental release.

A commenter wanted NRC (and the DOE) to conduct a thorough review of all MOX fuel specifications and quality control procedures. This commenter stated that failure to do so would compromise nuclear safety. In addition, the specifications and procedures must be provided to the public.

2.2.9 Transportation Issues

General Transportation Issues: A commenter wanted to know what security measures will be taken to protect the public during MOX fuel transport. In addition, the commenter also wanted the EIS to look at the impacts of transporting the surplus plutonium and the uranium hexafluoride gas to the SRS and of transporting the spent fuel to the storage facility. One commenter asked if the current transportation casks would work for the MOX spent fuel rods.

Some commenters wanted to know how the transport of nuclear materials related to the MOX project would affect traffic and emergency vehicles and if certain highways (specifically Highway 73) would be closed during transport.

A commenter asked what corporate entity would be responsible for the transport of MOX fuel through North and South Carolina and if they would be exempt from liability insurance for transport as they are exempt from liability in operations under Price-Anderson.

A few commenters believed it was not appropriate for NRC to rely on the DOE transportation analyses.

One state agency wanted NRC to consider their comments on the DOE Surplus Plutonium Disposition Final EIS (DOE/EIS-0283) when conducting the MOX FFF EIS analysis and safety review, particularly with respect to transportation and emergency preparedness.

Risks from Transportation Accidents: Some commenters thought that the EIS should evaluate the impacts of transportation accidents on communities in the transportation corridors. Impacts from both truck and rail accidents should be included. In addition to human health impacts, the effects on homes, schools, churches, etc. need to be considered.

One commenter wanted to make sure the transportation risk analysis was put in the proper perspective; for example, the exposure to the public in the event of an accident would be equivalent to that of a dental x-ray. Transportation risks should be compared to those of an exploding gas truck (again, for perspective). DOE's transportation statistics should be compared to those from the Department of Transportation.

2.2.10 Waste Management

Wastes Associated with the MOX FFF: Several commenters expressed concerns about high activity alpha liquid radioactive wastes resulting from the aqueous process that is proposed for removing gallium and other unwanted material from the weapons-grade plutonium. Commenters wanted the EIS to look at the types of wastes produced by this process (solid, liquid, and gaseous), waste storage, treatment, and ultimate disposal; they also wanted details included on the radiological and chemical character of the waste.

There were concerns that not enough waste tanks exist at the SRS to store the large quantities (estimates were as high as 81,000 gallons annually) of liquid radioactive waste that would be generated. One commenter suggested that the existing liquid waste (35 million gallons) be vitrified. Another asked if there would be liquid waste storage tanks dedicated to the MOX FFF.

High-Level Waste: A few commenters raised concerns over waste material supposedly leaking from high-level waste (HLW) storage tanks at the SRS. One commenter noted that 95 percent of the HLW generation from 2000 to 2070 would be from the SRS and wanted the EIS to determine what percentage will be from the plutonium processing facilities.

Low-Level Waste: One commenter stated that NRC must consider the fact that North Carolina will soon be excluded from using the Barnwell site for low-level waste disposal.

Wastes Associated with Converting DUF_6 to DUO_2: A commenter requested that the EIS consider wastes associated with converting depleted uranium hexafluoride to depleted uranium dioxide.

Spent Fuel Storage: Several commenters were concerned that a final waste site for spent fuel rods has not been determined and that reactor sites currently have spent fuel rods with no place to go. The EIS should address the impacts from the storage of spent MOX fuel at the reactor sites.

Secondary Wastes: A commenter wanted the EIS to include the chemical and radiological character, quantities, treatment methods, and destination of waste produced by the treatment of the original waste (secondary waste). The details should be comparable to those used for primary waste.

2.2.11 Socioeconomics

Economic Effects of Radioactive Contamination on Natural Resources: Some commenters wanted the EIS to assess the economic damage that would result from any radioactive contamination of natural resources. They maintained that the contamination would have a lasting, possibly cumulative, adverse effect on businesses that would not be solved by “cleanup” alone. A commenter pointed out that the economy of the Savannah region was very dependent on natural resources. According to this commenter, about one out of five jobs is related directly or indirectly to natural resources: commercial and recreational fishing, tourism, and seafood processing. About $1 billion in business is associated with these industries; even a reduction of 1 percent would be $10 million.

Cost/Benefit Analysis: Some commenters thought that a full cost/benefit analysis of the MOX program should be conducted, including use of MOX as a fuel. The analysis should extend beyond the usual "region of influence" to include national and international impacts as well. The analysis should also be looked at from the perspective of the taxpayer. A national-scale study of costs of the MOX program should be prepared as a report to the General Accounting Office.

Several commenters wanted the EIS to consider the cost of using MOX fuel in a reactor. They stated that Cogema in France recently admitted that the reactor fuel made with separated plutonium was three to four times more expensive than the conventional fuel made with low-enriched uranium. They also pointed out that the cost of using blended highly enriched uranium is lower, as would be the cost for mined uranium, and even uranium processed from the sea.

Costs of the MOX Program: A commenter noted that over the past four years, the estimated cost of the MOX program has doubled. The concern was that in a risk/benefit culture the environment is often compromised to keep expenses down. This commenter did not want the environment to "take the hit" for higher costs.

Electricity Rates: A commenter wanted the EIS to assess costs associated with the MOX program. There were concerns that project cost overruns would be passed on to consumers in the form of rate increases, as has happened, according to the commenter, in the past with the Vogtle nuclear power station.

Government Subsidy of Nuclear Power: A commenter was concerned about the impacts that "yet another" subsidy (funding) of nuclear power would have on the whole energy economy. Would the utilities be paid twice for the same kilowatt hour, once by taxpayers and again by ratepayers? That is, the taxpayers would be paying to produce the MOX fuel, and ratepayers would still be charged the same for electricity from fuel paid for by them (taxpayers). This commenter thought that the plutonium fuel subsidy would give an unfair advantage to nuclear energy suppliers in contrast to the nationwide effort to create a level playing field for energy producers. Also, the subsidy would put other sustainable energy technologies (solar and fuel cells) at a disadvantage. A comment was made that the MOX program no longer had a non-proliferation mission; it was really a subsidy to build a fuel infrastructure in this country using non-proliferation funds.

Land value: Some commenters wanted the EIS to consider the economic impacts on landholders along transportation routes. This would include transportation during all phases: delivery of the surplus plutonium to the SRS; transport of the MOX fuel to the reactors; and transport of the spent fuel to the repository.

2.2.12 Security and Terrorism

Many commenters were concerned about the increased threat of terrorism that would result from the transport of weapons-grade plutonium. A comment was made that the MOX program causes unnecessary transportation of nuclear material, thereby increasing the risk of accident or interception by terrorists. Commenters suggested that both the Proposed Action and the No-action Alternatives should look at the environmental and human impacts resulting from an act of terrorism, including the detonation of a nuclear weapon. One commenter suggested that the EIS should evaluate both foreign and domestic terrorism. Another felt that NRC regulations governing security were inadequate.

Some people thought that immobilization was the best technology for making weapons-grade plutonium less attractive to terrorists. Their arguments included the following: (1) immobilized plutonium would still be highly radioactive, thus making it more theft proof; (2) MOX fuel is very vulnerable to theft since it is not highly radioactive; the plutonium can be separated chemically and is still weapons grade; and (3) plutonium processing cannot properly account for all the plutonium that passes through the fuel cycle; incremental amounts can be systematically removed and used to make terrorist weapons. Other commenters felt that converting the surplus plutonium to MOX fuel was the more effective means of making it unavailable to terrorists.

2.2.13 Environmental Justice

General Comment: One commenter indicated that the National Association for the Advancement of Colored People (NAACP) would be monitoring the environmental justice part of the MOX project carefully. Another commenter pointed out that most African American workers in the area are a captive workforce since few companies are willing to move near the SRS; the same is true for poor whites. Some commenters suggested that the environmental justice analysis in the EIS evaluate the decision making to locate the proposed MOX FFF in the South.

Communicating Information: Concern was expressed that information related to the MOX project was not reaching the African American community. It was suggested that information be conveyed directly via their churches or the NAACP rather than expecting people to search the *Federal Register* for information.

Applicable Geographic Area: One commenter stated that it was not clear how environmental justice would be used in the decision making process. Some commenters thought that the geographic area considered for environmental justice should include communities both downwind and downstream of the MOX FFF. It should also include communities along transportation routes and near reactors. One commenter questioned why NRC had changed the region of analysis from a 4-mile radius to 50-mile radius from the MOX facility. Another commenter encouraged NRC to apply the guidance of the NMSS Policy and Procedures Letter 1-50, Rev 2, “Environmental Justice in NEPA Documents,” to its MOX FFF EIS. According to this commenter, the document recommends that a 4-mile radius be used for evaluating Environmental Justice when a facility is in a rural area; evaluations beyond this distance are not warranted.

Subsistence Fishing: A few commenters stated the EIS should consider the effects of radioactive contamination on subsistence fishing. A commenter stated that people of modest income often depend on fishing local rivers for a greater proportion of their nutrition. This could lead to a situation where impacts to surface water could result in a greater than average risk to those modest income individuals.

Civil Liberties: A commenter expressed a general concern about the effects that the use of MOX fuel would have on civil liberties in local, regional, national, and international communities. Infringements on the civilian population due to the security necessary to guard the plutonium was specifically mentioned.

2.2.14 Decommissioning vs. Deactivation

Some commenters thought that the EIS should analyze the impacts of MOX FFF decommissioning (not just deactivation) and any site remediation following decommissioning. Issues such as how the closure and removal will be funded need to be addressed. The terminal facility condition should be compared to its present condition. The NRC should have regulatory responsibility for the facility through the entire project life, including decommissioning. One commenter felt that consideration of decommissioning impacts at this time would be too remote and speculative, pointing out that since the CAR called for the MOX facility to be turned over to DOE at the conclusion of the contract and prior to decommissioning, decommissioning should not be within the scope of the MOX FFF EIS.

2.2.15 SRS Infrastructure and Existing Conditions

Infrastructure: Several people wanted the EIS to address MOX FFF impacts on existing infrastructure. Some commenters wanted the EIS to consider the impacts of processing weapons-grade plutonium at a 50-year-old site with reported cracks in the concrete. There were also commenters who thought the EIS should compare the impacts of the MOX FFF being a dedicated site (including waste storage tanks) to those associated with using existing SRS infrastructure.

Existing Conditions: One commenter thought that the description of existing conditions at the SRS should include the status of all nuclear materials on site, with a discussion of criticality issues.

2.2.16 Reactor Use Issues

General: A commenter noted that in order to avoid being accused of segmentation (not looking at the full consequences of an action) the EIS must include reactor impacts in its analysis. Other commenters wanted assurance that the MOX FFF EIS would be specific to the reactors actually designated to use the MOX fuel and would not ultimately be transferable to all United States reactors. They indicated that, if reactor impacts are not specifically addressed in this EIS, that EIS's should be performed for each reactor site prior to allowing use of MOX fuel.

Another commenter stated the prospect of analyzing reactor impacts as part of the current MOX FFF EIS would create a double jeopardy for DCS in that the company would have to provide data twice: now for MOX FFF licensing and then again during the license amendment process for the reactor.

Reactor Program Licensing and Implementation: A commenter wanted to know what the impacts would be if the Duke reactor license expired before the MOX fuel was used, if the reactors could not meet licensing requirements, or if Duke decided to shut its reactors down early because they were too expensive to run. A commenter wanted the EIS to consider the impacts that would result if the reactor portion of the MOX program was never implemented. Another commenter asked if the MOX FFF EIS would consider impacts of using MOX fuel and the revisions to the existing operating licenses at the Catawba and McGuire plants.

Plutonium Purification: A commenter asked that the EIS assess the impacts on the environment from imperfect gallium removal and the potential of the fuel's "falling apart in the reactor." This commenter noted that both the dry and the aqueous process for removing impurities from the weapons-grade plutonium have their faults . the aqueous process is environmentally destructive (it creates large quantities of high-level alpha liquid waste) and the dry process does not remove gallium as effectively. The tolerance level for gallium in the fuel should be determined.

Use of MOX Fuel in Reactors: Many commenters wanted the EIS to include a thorough investigation of the impacts of using weapons-grade plutonium in commercial reactors. Several commenters wanted the analyses to be specific to the reactor designs at the Catawba and McGuire plants. Commenters contended that weapons-grade plutonium has never been fabricated into fuel before and has never been used in a commercial reactor. They felt it was inadequate to use the MOX program experience in Europe as an analog in safety and performance analyses because the plutonium for MOX fuel in the European reactors comes from spent fuel from nuclear reactors, not weapons-grade plutonium. It was pointed out that the plutonium from dismantled weapons contains a different mix of isotopes than plutonium obtained from reprocessing spent fuel. It was also stated that the experience with low-enriched uranium fuel was not directly applicable because of the different mix of plutonium in that type of fuel and because of differences in performance of the two fuels. The commenters wanted NRC to evaluate the performance of the MOX fuel made specifically with weapons-grade plutonium at the concentrations proposed by DCS.

A few commenters stated that the DOE SPD EIS had already specifically evaluated the use of MOX fuel in the McGuire Nuclear Station and Catawba Nuclear Station reactors, which are the proposed mission reactors. They stated additional evaluations would be more appropriately made at the time of reactor operating license amendment application and that including reactor impacts in the MOX FFF EIS would delay the MOX FFF licensing process, increasing government costs with no commensurate benefit to public health and safety.

Thermal Pollution: Some commenters were concerned about the impacts of thermal pollution from reactors using MOX fuel. They stated that since the temperature in MOX fuel will be hotter, more ice and water will be needed for cooling and the temperature of water at Lake Norman will increase. One commenter maintained that this hotter water is changing the ecology, even down to the microscopic level of the food chain. This commenter stated that even now Lake Norman is warm enough for at least one alligator to survive.

Evacuation Issues: Many commenters were concerned about whether the population could be evacuated in time, should an accidental release occur. Traffic on the exits to Interstate 77 around Lake Norman was mentioned as being particularly bad; exit 28 was also mentioned. Another commenter felt that evacuation plans should go beyond the 10-mile radius that the NRC mentions in its publications.

Risks from Reactor Accidents: Several commenters stated that DOE's Surplus Plutonium Disposition EIS addressed generic reactor impacts rather than those specific to the Duke Power reactors that would be using the MOX fuel. They wanted reactor design-specific impacts to be addressed, rather than addressing the accident impacts generically.

Some commenters expressed concern that reactors used at Catawba and McGuire posed a greater likelihood for an accident than did other types of reactors currently in use in this country. Of particular concern were safety issues related to the use of ice condensers for cooling and

the so-called "eggshell" containment at Catawba and McGuire. The point was made that ice condenser reactors lack steel-reinforced containment domes. In addition, a commenter pointed out that there had been violations involving Duke Power's failure to ensure that ice condenser inlet doors would be able to open if needed, and a forced outage could occur due to a blocked flow channel in portions of the ice condenser.

Comments were made that the Duke Power reactors were already suffering from embrittlement (a condition that causes materials to break without bending). There were concerns that the MOX fuel would cause a higher rate of embrittlement because it burns at such high temperatures. A more specific comment focused on analyzing accident consequences due to loss of power (including backup power) at the reactors.

One commenter pointed out that a severe accident at the Catawba reactors could result in a 25 percent increase in the latent cancer fatalities downwind of the reactor, resulting in anywhere from hundreds to thousands of additional cancer deaths. Another commenter wanted the EIS to consider the impacts of using plutonium fuel rather than uranium oxide fuel. A commenter stated that even DOE has admitted that the operation of nuclear power plants with plutonium fuel rather than uranium oxide fuel increases the deaths in certain accident scenarios. According to a commenter, one accident scenario had 8 percent more deaths from use of plutonium fuels rather than uranium fuel; another had 14 percent.

2.2.17 Lead Test Assemblies

Some commenters wanted NRC to fully provide and review all procedures for the fabrication of the lead test assemblies, including review of all the facilities involved, their records, quality control procedures, and the transport implications.

3. SCOPE OF THE EIS AND SUMMARY OF ISSUES TO BE ADDRESSED

The NEPA (Public Law 91-90, as amended), and the NRC's implementing regulations for NEPA (10 CFR Part 51), specify in general terms what should be included in an EIS prepared by the NRC. Regulations established by the Council on Environmental Quality (40 CFR Parts 1500-1508), while not binding on the NRC, provide useful guidance.

Pursuant to 10 CFR § 51.71(a), in addition to public comments received during the scoping process, the contents of the draft EIS will depend in part on the December 2000 environmental report submitted by DCS. Pursuant to 10 CFR § 51.71(b), the draft EIS will consider major points of view and objections concerning the environmental impacts of the proposed action raised by other Federal, State, and local agencies, and by any affected groups of Native Americans. Pursuant to 10 CFR § 51.71(c), the draft EIS will list all Federal permits, licenses, approvals, and other entitlements which must be obtained in implementing the proposed action, and will describe the compliance status with these requirements. Any uncertainty as to the applicability of these requirements will be reflected in the draft EIS.

Pursuant to 10 CFR § 51.71(d), the draft EIS analysis will include a consideration of the economic, technical, and other benefits and costs of the proposed action, and alternatives to the proposed action. In the draft analysis, due consideration will be given to compliance with environmental quality standards and regulations that have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection, including any applicable zoning and land-use regulations and water pollution limitations or requirements

established or imposed pursuant to the Federal Water Pollution Control Act. The environmental impact of the proposed action will be considered in the draft analysis with respect to matters covered by such standards and requirements regardless of whether a certification or license from the appropriate authority has been obtained. Compliance with the environmental quality standards and requirements of the Federal Water Pollution Control Act (imposed by the United States Environmental Protection Agency or designated permitting states) is not a subject for and does not negate the requirement for NRC to weigh all environmental effects of the proposed action, including the degradation, if any, of water quality, and to consider alternatives to the proposed action that are available for reducing adverse effects. While satisfaction of NRC standards and criteria pertaining to radiological effects will be necessary to meet the licensing requirements of the Atomic Energy Act, the draft analysis will, for the purposes of NEPA, consider the radiological effects of the proposed action and alternatives.

Pursuant to 10 CFR § 51.71(e), the draft EIS may include a preliminary recommendation by the NRC staff respecting the proposed action. Any such recommendation would be reached after considering the environmental effects of the proposed action and reasonable alternatives, and after weighing the costs and benefits of the proposed action.

The scoping process summarized in this report helped to determine the scope of the MOX FFF EIS and identified the significant issues to be analyzed in depth. For instance, in response to comments received during the scoping process, the EIS will evaluate the potential impacts of using sand filters instead of HEPA filters, and the potential impacts of using both wet and dry plutonium purification processes in manufacturing MOX fuel. Other options may be identified and analyzed. The EIS will also evaluate the degree to which impacts would vary depending on where within the SRS F-Area the proposed MOX FFF may be located. This will include consideration of surface water impacts as suggested by a commenter. Cumulative impacts of the proposed action will be addressed in detail.

The No-action Alternative, not licensing the MOX FFF, was also refined through the scoping process. In addition to the potential environmental impacts of the proposed action, the EIS will evaluate two no-action alternatives: (1) continued storage of all of the surplus weapons-grade plutonium at the present DOE sites in an unaltered form; and (2) immobilizing all of the surplus weapons-grade plutonium at the SRS site. Other alternatives may be identified and analyzed during the preparation of the draft EIS.

Issues to be analyzed in depth pertain to the construction, operation, deactivation and decommissioning of the MOX FFF, and transportation of fresh MOX fuel. Ordinarily, an NRC environmental impact statement also discusses in detail the need for the proposed action. Here, however, DOE has already addressed the need for the MOX FFF (*see* Section 2.2 of the DCS Environmental Report), and the EIS will reference the purpose and need analyses performed by DOE pursuant to NEPA. Impacts associated with transportation of materials to the SRS for the purpose of manufacturing MOX fuel, impacts of converting the depleted uranium, impacts of reactor use of MOX fuel, and the transportation and disposal of spent MOX fuel will be discussed. The EIS will recognize previous NEPA analyses performed by the DOE, including (1) the *Surplus Plutonium Disposition Final Environmental Impact Statement* (SPD EIS) (DOE/EIS-0283); *(2) Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE/EIS-0269); *(3) Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye*

County, Nevada (YMP EIS) (DOE/EIS-0250D); and (4) the Supplement to the Draft YMP EIS (DOE/EIS-0250D-S). Discussion of impacts associated with the two No-action Alternatives will be based largely on the SPD EIS.

Our goal in writing the EIS is to set forth the impact analyses in a manner which is readily understandable by the public. Decisions and the rationale for those decisions will be described in sufficient detail early in the EIS. Significant impacts will be discussed in greater detail in the body of the EIS. Topical areas whose impacts are less significant will be discussed in appendices to the EIS, with an explanation of why they were found to be less significant. This should allow readers of the body of the EIS to focus on issues that were important in reaching the conclusions of the EIS. The following topical areas and issues will be analyzed in the EIS:

- ***Geology and Seismicity.*** The EIS will describe the geologic and seismic characteristics of the proposed site. Evaluation of the potential for earthquakes, ground motion, soil stability concerns, surface rupturing, and any other major geologic or seismic considerations that would affect the suitability of the proposed site for the construction of the MOX FFF will be addressed primarily in the construction SER and summarized in the EIS. The EIS will not, however, evaluate the safety aspects associated with these site characteristics which will be addressed in the SER.

- ***Hydrology.*** The EIS will assess the potential impacts of the proposed project on surface water, storm-water runoff, and groundwater resources including the Floridian aquifer. The assessment will consider water resources, water quality, water use, flood plains, and the probable maximum flood (the largest flood that is likely to occur). The environmental mobility of the significant radionuclides, including plutonium, will be assessed. The EIS will not, however, evaluate the safety aspects associated with these site characteristics which will be addressed in the SER.

- ***Air Quality.*** Potential air quality impacts of the proposed project will be evaluated in the EIS. The evaluation will include potential impacts resulting from construction activities and operation (both with HEPA filters and sand filters) and will compare the anticipated air quality impacts, if any, with relevant standards.

- ***Ecology.*** The EIS will assess the potential environmental impacts of the proposed facility on ecological resources, including wetlands, plant and animal species, and threatened or endangered species and critical habitat that may occur in the area. As appropriate, the assessment will include potential effects on wildlife migration patterns; mitigation measures to address adverse impacts will be analyzed.

- ***Land Use.*** An analysis of impacts of accidents on existing land use along transportation corridors will be conducted. The EIS will also discuss the impacts of the MOX FFF on future land use on the SRS.

- ***Cultural Resources.*** The EIS will assess potential impacts of the proposed project on the historic and archaeological resources of the area. The EIS will also describe the programmatic framework of how cultural resources are evaluated at SRS and for the MOX FFF.

- ***Transportation.*** As discussed above, the transportation impacts of shipping MOX feedstock to SRS and shipping spent MOX fuel to a geologic repository will be discussed. The EIS will contain an analysis of potential impacts resulting from the transportation of fresh MOX fuel, and will assume (for purposes of ensuring that NEPA's objectives are met) that one or more commercial power reactors will later be authorized to use MOX fuel. Accordingly, the EIS will consider relevant aspects of both rail and truck transport of the fuel from the proposed MOX facility to the Catawba and McGuire reactors. The EIS will discuss the number, type, and frequency of shipments, as well as routing considerations and the quantities of MOX fuel being shipped. The impacts of transportation will be evaluated primarily in terms of radiological exposure risk to the population during normal transportation (including handling, transfer, and inspection) and under credible accident scenarios. The non-radiological impacts of transportation will also be identified and evaluated. The impacts on the usability or level of service of the roads, particularly near the SRS (such as Highway 73), will also be evaluated.

- ***Infrastructure.*** The EIS will address issues related to availability and adequacy of the infrastructure at the SRS such as waste treatment, and utility services to handle the needs of the proposed facility. The EIS will also consider impacts from any upgrades to these infrastructure.

- ***Waste Management.*** Waste management was identified as a significant issue by many commenters. The EIS will document the quantities, types, treatment, and disposal of the various potential waste streams. The EIS will also consider the impacts of storage of waste, such as the impacts on the existing high level waste tanks at SRS. The EIS will analyze the incremental impacts of MOX FFF wastes to existing facilities at SRS and at other DOE and non-DOE facilities. The EIS will evaluate the impacts of wastes generated at the MOX FFF either specifically or through incorporation of reference material from existing NEPA documents that analyze the overall waste management impacts at the SRS.

- ***Socioeconomics.*** The socioeconomic issues that fall within the scope of the EIS include the direct and indirect economic impacts on city, county, and school district revenues and expenditures, property values, residential and commercial development, housing, and public services in a four county region surrounding SRS. In addition, the economic effects on employment (including agricultural employment), unemployment and income in a 15-county region will be evaluated. These would include potential economic impacts to commercial fishing downstream of SRS. The EIS will include an analysis of the impacts on these resources that would result from the construction and operation of the proposed facility. National level impacts will be discussed under cost-benefit analysis.

- ***Environmental Justice.*** Potential for disproportionately high or adverse human health or environmental impacts on the minority and low-income populations will be evaluated and discussed at the census block level. Environmental justice will not be evaluated in detail along transportation routes because of the uncertainty associated with routing.

- ***Aesthetics.*** The EIS will analyze the visual impacts from the MOX facility being constructed in the F-Area at the SRS.

- ***Human Health Impacts.*** The potential human health impacts of the proposed facility on the workers and the general public will be evaluated for normal operations (including handling, transfer, and inspection activities) and under accident conditions. Potential exposures to radioactive elements and to chemicals will be considered. Both cancer and non-cancer health effects will be evaluated, as appropriate. Calculations for the general public account for sensitive populations as well as normal healthy adults. Models, assumptions, and supporting data used to develop the impacts from these potential exposures will be clearly described. The SER will assess the impacts associated with all credible accidents at the proposed facility, both from natural events and human activities. The EIS will analyze the potential environmental impacts resulting from bounding credible accidents at the proposed facility.

  Emergency preparedness and environmental monitoring were raised as significant issues by several commenters. The need and extent for emergency preparedness and environmental monitoring, in context of the EIS, would be considered as mitigation measures for potential impacts. These issues may be discussed in the EIS to the extent that they are required as mitigation measures. Emergency preparedness and environmental monitoring will be addressed in greater detail in the operation SER .

- ***Decommissioning.*** The December 2000 Environmental Report (ER) submitted by DCS considered only deactivation. Evaluating the impacts of decommissioning was identified during the scoping process as a significant issue and is required by NEPA. The EIS will evaluate the impacts of deactivating and decommissioning the proposed MOX FFF.

- ***Cumulative Impacts.*** The EIS will analyze the potential cumulative impacts of the proposed facility when added to other past, present, and reasonably foreseeable future actions. This will include impacts from auxiliary and infrastructure facilities associated with the MOX project. It will also include impacts to resources such as the Savannah River.

- ***Unavoidable Adverse Environmental Impacts.*** A discussion will be provided on the potential environmental impacts that could not be avoided if the proposed action were to be implemented.

- ***Irreversible and Irretrievable Commitment of Resources.*** The irreversible and irretrievable commitment of resources, including land use, materials, and energy will be discussed. Potential waste minimization and pollution prevention activities and mitigation measures will be discussed.

- ***Cost/Benefit Analysis.*** The EIS will include a cost/benefit analysis that summarizes the environmental and other costs and benefits of the proposed action.

- ***Compliance with Applicable Regulations.*** The EIS will present a listing of the relevant permits and regulations that are believed to apply to the proposed facility.

Pertinent proprietary information, although not available to the public, will be reviewed by the NRC in preparing the SERs and the EIS. As indicated above, all available documentation generated by DOE and other agencies that is related to dispositioning of surplus weapons-grade plutonium and MOX fuel production will be used, as appropriate.

4. ISSUES CONSIDERED PERIPHERAL, OUTSIDE THE SCOPE OF THE PROPOSED ACTION, OR COVERED BY PRIOR ENVIRONMENTAL REVIEW

Issues raised during the scoping period for the MOX FFF EIS are summarized in Section 2. Section 3 outlines the subjects and issues that will be addressed in depth in the EIS. Issues raised during the scoping period have been considered in the preparation of this scoping report and are reflected in Section 2. As discussed below, certain issues will not be addressed in depth in the EIS. Major categories of these issues and the reasons for not analyzing them in detail in the EIS are explained below. In general, these issues are not directly related to the assessment of potential impacts from the proposed major federal action now under consideration. The lack of in depth discussion in the EIS, however, does not imply that an issue or concern lacks value. Issues beyond the scope of the EIS may be appropriately discussed and decided in other venues. For example, many commenters were concerned about the lack of a safety record for DCS. This issue will be addressed in the SERs.

4.1 PREVIOUS DOE DECISIONS

A number of commenters requested that the SPD EIS prepared by DOE be supplemented and many of the decisions already made by DOE be revisited. Because the scope of the MOX FFF EIS is limited to the licensing action now under review by NRC, which is specific to the MOX FFF, issues pertaining to decisions already made by DOE will be addressed by referencing the appropriate DOE analysis.

4.2 INTERNATIONAL AGREEMENTS AND NATIONAL, STATE, OR LOCAL LAWS, STATUTES, AND REGULATIONS

Comments that seek to alter international treaties or affect national, state, or local laws, statutes, or regulations (e.g., comments that asked to alter Price-Anderson Act limits) will not be addressed, because they do not pertain to reasonably foreseeable impacts arising from the proposed construction and operation of the MOX FFF.

4.3 REACTOR USE OF MOX FUEL

Comments on the scope of assessing reactor use impacts in the EIS for the MOX FFF were varied (see Section 2.2.16). The NRC will consider the environmental impacts resulting from the use of MOX fuel, pursuant to 10 CFR Part 51, if and when nuclear power plant operators apply for a license amendment to use such fuel. Nevertheless, since a MOX FFF is expected to fabricate fuel for use in one or more nuclear power reactors, it is reasonable to consider the impacts of reactor use as an indirect impact in the EIS. At this time, NRC is aware that two plants, McGuire and Catawba, are considering using MOX fuel under the DOE program. The NRC is aware that DOE has analyzed the reactor use impacts of MOX fuel in its SPD EIS. Scoping comments related to reactor use impacts that were determined to be beyond the scope of this EIS will be forwarded to the appropriate NRC offices.

4.4 COST AND READINESS TO RESPOND TO EMERGENCIES

A number of commenters requested that the MOX FFF EIS analyze the impacts of having to upgrade the emergency response equipment and retrain emergency responders in the communities around the SRS, at the reactors, and along transportation routes. Other commenters requested that the EIS identify capabilities of local, regional, and national medical facilities to manage the casualties resulting from potential accidental releases and assess the readiness of communities to evacuate certain areas along the transportation routes in case of an accident. The human health impacts of potential accidents will be analyzed in the EIS. However, the costs associated with emergency preparedness and capabilities of local, regional, and national communities to respond to emergencies will not be analyzed, because such impacts are not specific to the proposed action. It is not anticipated that activities related to the proposed action will require any emergency response capabilities among communities beyond what they already have for similar purposes. Issues related to general emergency preparedness of communities are outside the scope of this EIS.

4.5 POTENTIAL DELAYS IN DOE PROGRAMS

Several commenters wanted to know what would happen if the DOE programs related to weapons-grade plutonium disposition and the opening of the HLW repository were delayed. Any such potential delays are either speculative or do not clearly affect the licensing review of the MOX FFF by the NRC. Unless it is reasonably foreseeable that a change in a DOE program or that of any other federal agency (e.g., a formal decision either has been announced or is expected to be announced soon) will have a substantive effect on the licensing of the MOX FFF, the EIS process will continue as scheduled, and the impacts of potential delays will not be analyzed in the EIS.

4.6 IMPACTS FROM TERRORISM

Many commenters raised a number of different issues concerning terrorism. However, the EIS will not address the impacts of terrorism, because these impacts are not considered to be reasonably foreseeable as a result of the proposed action.

4.7 IMPACTS OF ACTIONS IN THE RUSSIAN FEDERATION

All activities in the Russian Federation related to manufacture of MOX fuel from Russian-origin weapons-grade plutonium as part of an agreement between that country and the United States are being undertaken by the Russian authorities. They are not subject to NEPA and, therefore, will not be analyzed in the EIS.

4.8 PROPRIETARY INFORMATION

NRC will evaluate all pertinent proprietary information in its decision to grant authorization to construct the MOX FFF and to grant a license to DCS to possess special nuclear material. However, by law, NRC has to protect the proprietary information from public disclosure. Therefore, proprietary data will not be released to the public.

Attachment A

Preliminary Outline for the Mixed Oxide Fuel Fabrication Facility EIS

Summary

Table of contents, Glossary, and list of acronyms

1.0 Purpose of and Need for proposed action

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