NUREG-1118

Environmental Assessment
for renewal of Special Nuclear Material License No. SNM-1107

Docket No. 70-1151

Westinghouse Electric Corporation
Nuclear Fuel Fabrication Plant

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards

May 1985

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ABBREVIATIONS AND ACRONYMS

ADU	ammonium diuranate
AQCR	air quality control region
BOD	biological oxygen demand
CaF_2	calcium fluoride
CEQ	Council on Environmental Quality
cfs	cubic feet per second (ft^3/s)
DCFB	Dry Conversion Fluidized Bed
DOT	U.S. Department of Transportation
EA	environmental assessment
EIA	environmental impact appraisal
EIS	environmental impact statement
F^-	fluoride
G.M.	geometric mean
HAPP	high air pollution potential
HEPA	high-efficiency particulate air
HF	hydrogen fluoride
IDR	integrated dry route
JTU	Jackson turbidity unit
LWR	light-water-moderated nuclear reactor
MBAS	methylene blue active substance
MMI	modified Mercalli intensity
MPC	maximum permissible concentration
MPN	most probable number
MSL	mean sea level
NEPA	National Environmental Policy Act
NFCS	Nuclear Fuel Columbia Site
NH_3	ammonia
NH_4F	ammonium fluoride
NRC	U.S. Nuclear Regulatory Commission
NPDES	National Pollutant Discharge Elimination System
SC-DHEC	South Carolina Department of Health and Environmental Control
SCWRC	South Carolina Water Resources Commission
SNM	special nuclear material
TDS	total dissolved solids
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_2F_2	uranyl fluoride
USGS	U.S. Geological Survey
χ/Q	atmospheric dispersion factor

LIST OF FACTORS FOR CONVERSION OF ENGLISH TO INTERNATIONAL SYSTEM OF UNITS (SI)

The following table gives the factors used in this document for the conversion of conventional English units to the equivalent International System of Units (SI) now being adopted worldwide or conventional metric units. The conversion factors have been obtained from the ASTM publication *Standard for Metric Practice*[a] and are used to four-digit accuracy, since most of the values in this document are not known to any more exactness. After conversion, the SI values have been rounded to reflect an accuracy sufficient for the requirements of this document. Most of the values will be presented in SI units with the equivalent English unit following within parentheses.

Conversion of English to SI Units

To Convert From	To	Multiply By
acre	hectare (ha)	0.4047
feet (ft)	meters (m)	0.3048
cubic feet (ft^3)	cubic meters (m^3)	0.02832
gallon (gal)	cubic meters (m^3)	0.003785
gallon (gal)	liters (L)	3.79
gal/min	liters/s (L/s)	0.06309
inch (in.)	centimeters (cm)	2.54
inch (in.)	meter (m)	0.0254
mile (statute)	kilometer (km)	1.609
square mile ($mile^2$)	square kilometer (km^2)	2.590
pound (lb)	kilograms (kg)	0.4536

[a]American Society for Testing and Materials, Standard E-380, *Standard for Metric Practice,* February 1980.

1. PURPOSE OF AND NEED FOR ACTION

1.1 INTRODUCTION

The Westinghouse Electric Corporation, Nuclear Fuel Division, Fuel Fabrication Plant near Columbia, South Carolina [Nuclear Fuel Columbia Site (NFCS)], manufactures low-enriched uranium oxide fuel assemblies ($\leq$5% ^{235}U) for use in light-water commercial nuclear reactors. In response to an application by Westinghouse for renewal of Special Nuclear Material (SNM) License No. SNM-1107, which covers operations of the Columbia plant, the U.S. Nuclear Regulatory Commission (NRC), with technical assistance from Oak Ridge National Laboratory, prepared this environmental assessment. The document was prepared pursuant to NRC regulations (10 CFR Pt. 51) which implement requirements of the National Environmental Policy Act (NEPA) of 1969 (P.L. 91-190). Part 51 also considers the Council on Environmental Quality (CEQ) regulations (40 CFR Pts. 1500-1508) for implementing NEPA. Sections 51.14 and 51.30 of the NRC regulations define "environmental assessment" as follows:

1. An environmental assessment is a concise public document, for which the NRC is responsible, that serves to
   - briefly provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or a finding of no significant impact,
   - aid the NRC's compliance with NEPA when no EIS is necessary, and
   - facilitate preparation of an EIS when one is necessary.
2. An environmental assessment shall include brief discussions of the need for the proposal, of alternatives as required by Sect. 102(2)(E) of NEPA, and of the environmental impacts of the proposed action and alternatives. It shall also include a listing of agencies and persons consulted.

The Westinghouse NFCS has been operating since September 1969. An Environmental Impact Appraisal (EIA) of the Westinghouse facility, issued by the NRC in 1977 (NR-FM-013), considered environmental impacts of operations at 400 metric tons (t) of uranium per year and projected impacts of future expansion of up to 1600 t/year of uranium. The 1977 EIA was based on an analysis of the effects of the ammonium diuranate (ADU) production process and an experimental Dry Conversion Fluidized Bed (DCFB) system for converting uranium hexafluoride (UF_6) to uranium dioxide (UO_2).

Subsequent to the 1977 license renewal, several environmentally related changes were made to the Westinghouse plant and its operations, including the following:

1. Uranium-contaminated calcium fluoride sludge generated from liquid waste treatment prior to 1981 was fixed with a cement-like binder and buried offsite at a radioactive waste burial facility.
2. An advanced waste treatment system was installed to increase uranium recovery from liquid process wastes. Calcium fluoride sludge generated after the installation of this system was allowed to be disposed of offsite without continuing license controls.
3. An incinerator system was installed for the recovery of uranium from combustible waste materials.

4. The production capacity of the ADU conversion process and the plant throughput were expanded from 400 to over 700 t/year of uranium.

5. A new dry conversion process called the Integrated Dry Route (IDR) was installed to replace the DCFB experimental dry process line. The IDR lines are presently undergoing preoperational testing using uranium possessed under an Agreement State License.

This environmental assessment considers the impacts of the use of both the ADU and IDR conversion processes, individually or in a worst-case combination of the two, up to a maximum production capacity of 1600 t/year of uranium.

1.2 SUMMARY OF THE PROPOSED ACTION

The proposed action is the renewal of the SNM license (SNM-1107), which is necessary for Westinghouse to continue an existing fuel fabrication operation at its Columbia facility. Principal operations at Columbia include (1) conversion of UF_6 to UO_2 powder, (2) pressing the powder into fuel pellets, (3) encapsulation of the pellets into 3.6-m (12-ft) fuel rods, and (4) stacking of the fuel rods into fuel assemblies for subsequent shipment to customers' nuclear reactor sites. The current application for renewal of the SNM license covers operations authorized previously and includes a request for an amendment to the existing license to upgrade the facility by the incorporation of the IDR conversion process. Although Westinghouse was previously authorized to receive and possess mixed oxide plutonium fuel, no operations using such fuel were ever conducted at the NFCS, nor are any planned. Therefore, this authorization will not be continued under the renewed license, and the possession of mixed oxide plutonium fuel is not part of the proposed action.

1.3 NEED FOR ACTION

The Westinghouse NFCS is one of several industrial facilities dedicated to the fabrication of fuel elements for light-water-moderated nuclear reactors (LWRs). As long as the current demand for nuclear energy continues, the fuel production rate must keep pace. Because Westinghouse is a major supplier of fuel for LWRs, denial of the license renewal for the Columbia plant would necessitate expansion of similar activities at another existing fuel fabrication facility or the construction and operation of a new plant. Although denying the renewal of the SNM license for Westinghouse's NFCS is an alternative available to the NRC, it would be considered only if issues of public health and safety cannot be resolved to the satisfaction of the regulatory agencies involved.

1.4 THE SCOPING PROCESS

The environmental impacts of operation of the Westinghouse NFCS have been previously assessed by the NRC in an EIA dated April 1977 (NRC 1977, NR-FM-013). In the EIA, the effects of plant operation up to a production capacity of 1600 t/year of uranium were predicted, based on the use of the ADU process for conversion of UF_6 to UO_2.

Along with its current application to the NRC for license renewal, Westinghouse submitted an environmental report (Westinghouse 1983) that includes (1) an updated description of the Columbia plant and the affected environment, (2) a description of environmental monitoring programs and a summary of data from recent years, (3) current information on operations, processes, and

effluents/emissions, and (4) plans for future modifications and expansion. In addition, the applicant provided the NRC with responses to staff questions on information contained in the environmental report (Westinghouse 1984).

In conducting its current environmental assessment for license renewal, the staff toured the plant site and surrounding area (December 2, 1983, and September 19, 1984) and met with the applicant to discuss data and information provided earlier and to obtain supplemental information. In addition, the staff met with the South Carolina Department of Health and Environmental Control (SC-DHEC) on December 2, 1983, and obtained information from other sources to assist in its evaluation. Because of the previous documentation (NRC 1977) and the low level of impacts predicted for continued operation of the Westinghouse NFCS (Sect. 4), the staff determined that a formal scoping process was unnecessary.

To assess impacts of the Westinghouse NFCS operation at a production capacity of 1600 t/year of uranium, the staff concluded that this environmental assessment should address effluent controls, environmental monitoring, and the environmental impacts of normal operation and of accidents. The affected environment at the site and plant operations are described to the extent necessary for this assessment.

REFERENCES FOR SECTION 1

NRC (U.S. Nuclear Regulatory Commission). 1977. *Environmental Impact Appraisal of the Westinghouse Nuclear Fuel Columbia Site (NFCS) Commercial Nuclear Fuel Fabrication Plant, April 1977,* NRC, Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle and Material Safety, Washington, D.C. (NR-FM-013).

Westinghouse. 1983. *Update for Environmental Impact Appraisal, Westinghouse Electric Corporation, NFD Plant, Columbia, South Carolina,* SNM-1107, Docket No. 70-1151, April.

Westinghouse. 1984. Letter from R. E. Fischer, Westinghouse Electric Corporation, to Mark J. Rhodes, U.S. Nuclear Regulatory Commission, in response to NRC questions concerning the applicant's *Update for Environmental Impact Appraisal* (Docket No. 70-1151), Feb. 20.

2. ALTERNATIVES INCLUDING THE PROPOSED ACTION

2.1 THE ALTERNATIVE OF NO LICENSE RENEWAL

Not granting a license renewal for the Westinghouse NFCS would result in the cessation of commercial fuel fabrication at the site. This alternative would be considered only if issues of public health and safety could not be resolved. If license renewal is denied, the minor environmental impacts described in Sect. 4 would not occur.

2.2 THE ALTERNATIVE OF LICENSE RENEWAL

This alternative, which is the proposed action, would result in the continued operation of the Westinghouse NFCS for a specified number of years. License renewal would allow the use of the IDR production process in addition to the ADU process, which has been the primary chemical conversion process used under the current license. The following sections describe present operations, waste confinement, and effluent control for the ADU and IDR processes and point out the differences between them.

2.2.1 Description of Current Operations

The following information regarding current operations at the Westinghouse NFCS was excerpted from Westinghouse (1983). Supplemental data and information were provided during the staff's site visits; see also Westinghouse (1984).

2.2.1.1 Introduction

The Westinghouse NFCS was constructed in 1969 to operate at a production capacity of 400 t/year of uranium. Plans were subsequently made to expand capacity up to 1600 t/year of uranium. Initially, Westinghouse had planned to accomplish this expansion by installing additional ADU process lines. As an alternative, Westinghouse installed and experimented with the DCFB dry process, which was expected to provide an environmental advantage over the ADU process. Although the DCFB did provide some of the desired advantages, the IDR process was found to offer an even greater environmental benefit while yielding a more superior fuel product (Westinghouse 1981). Therefore, in 1981 plans for plant expansion were changed in favor of the IDR conversion process. The IDR lines have been constructed and are undergoing preoperational testing.

The Westinghouse NFCS fabricates nuclear fuel assemblies containing low-enriched ($\leq$5% ^{235}U) UO_2 fuel for use in commercial reactors. The role that the NFCS plays in the nuclear fuel cycle is illustrated in Fig. 2.1.

As mentioned in Sect. 1.2, Westinghouse was previously authorized to possess mixed oxide plutonium fuel; however, no onsite operations were conducted using the fuel, and none are planned. Under the license renewal, no plutonium fuel may be possessed at the NFCS.

2.2.1.2 Plant facilities

Major site facilities consist of the main plant building; the chemical storage area; the waste treatment area, which has four chemical settling ponds; one reserve settling pond; and one sanitary

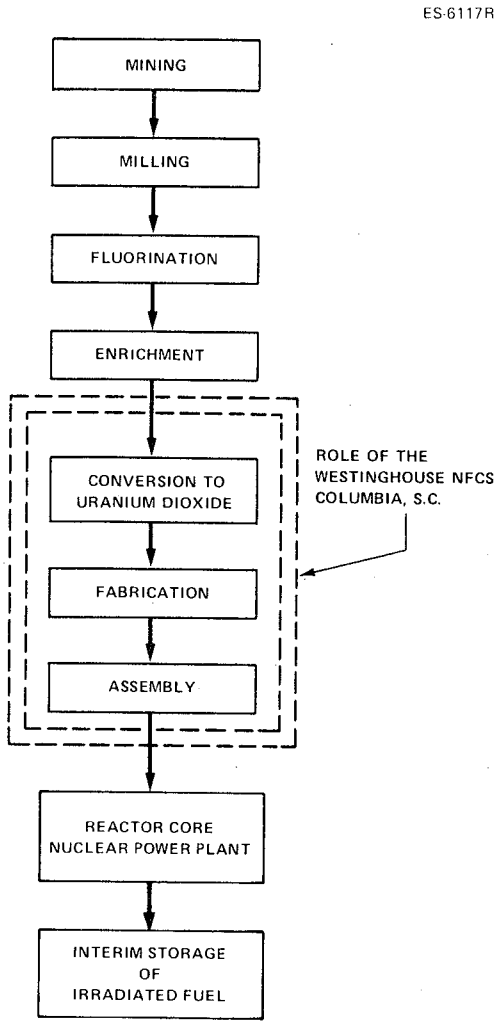


Fig. 2.1. An illustration of the nuclear fuel cycle, indicating the role of the Westinghouse NFCS.

stabilization pond. A detailed site plan for the NFCS is shown in Fig. 2.2, and the interior layout of the main building is illustrated in Fig. 2.3. The building, which covers 32,515 m^2 (350,000 ft^2), is divided into two functional areas: a chemical manufacturing area and a mechanical manufacturing area.

In the chemical manufacturing area, UF_6 is converted to UO_2 using the ADU process. This is followed by milling, pressing, sintering, and machining of the UO_2 to form fuel pellets about 0.6 cm (0.25 in.) in diameter and 1.2 cm (0.5 in.) in length. These pellets are loaded and encapsulated into fuel rods approximately 3.7 m (12 ft) long. The rods are then stacked into a fuel assembly hardware fixture frame for eventual use in nuclear reactors.

Also carried out in the chemical manufacturing area are various recovery operations that support the conversion process in the recycle of material. These recovery operations include

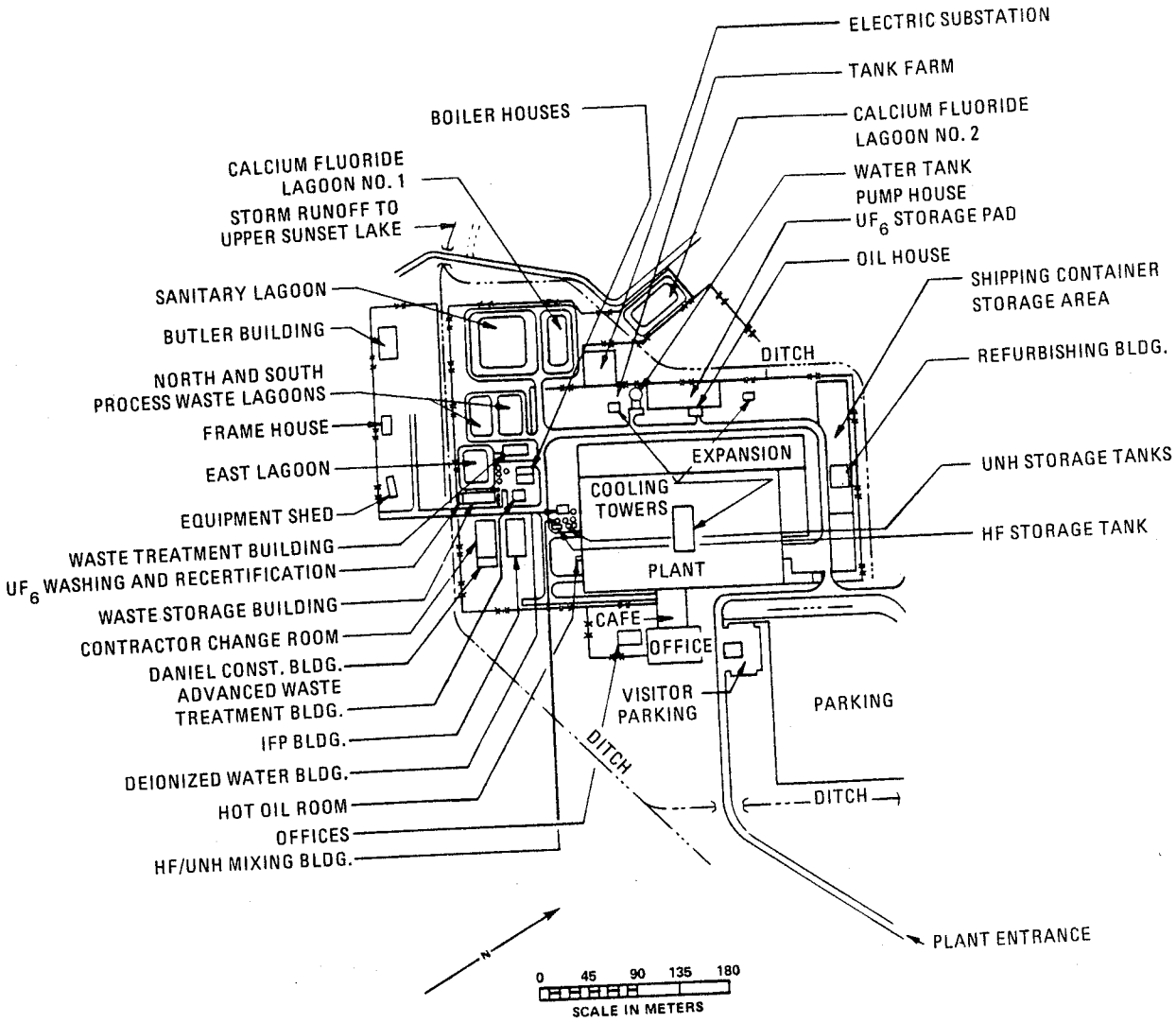


Fig. 2.2. Detailed site plan of the Westinghouse NFCS. *Source:* A. J. Nardi, Westinghouse, letter with enclosure to R. G. Page, NRC, April 16, 1985.

thermal oxidation, dissolution of scrap powders with nitric acid, chemical precipitation, wet mechanical separation, washing, and solvent extraction. Incineration is also conducted to decrease the volume of low-level wastes and to economically recover uranium contained in combustible wastes.

In the mechanical manufacturing area of the plant, additional machining, welding, electroplating, quality control testing, and other miscellaneous operations involved in the production of the assembly's hardware are performed.

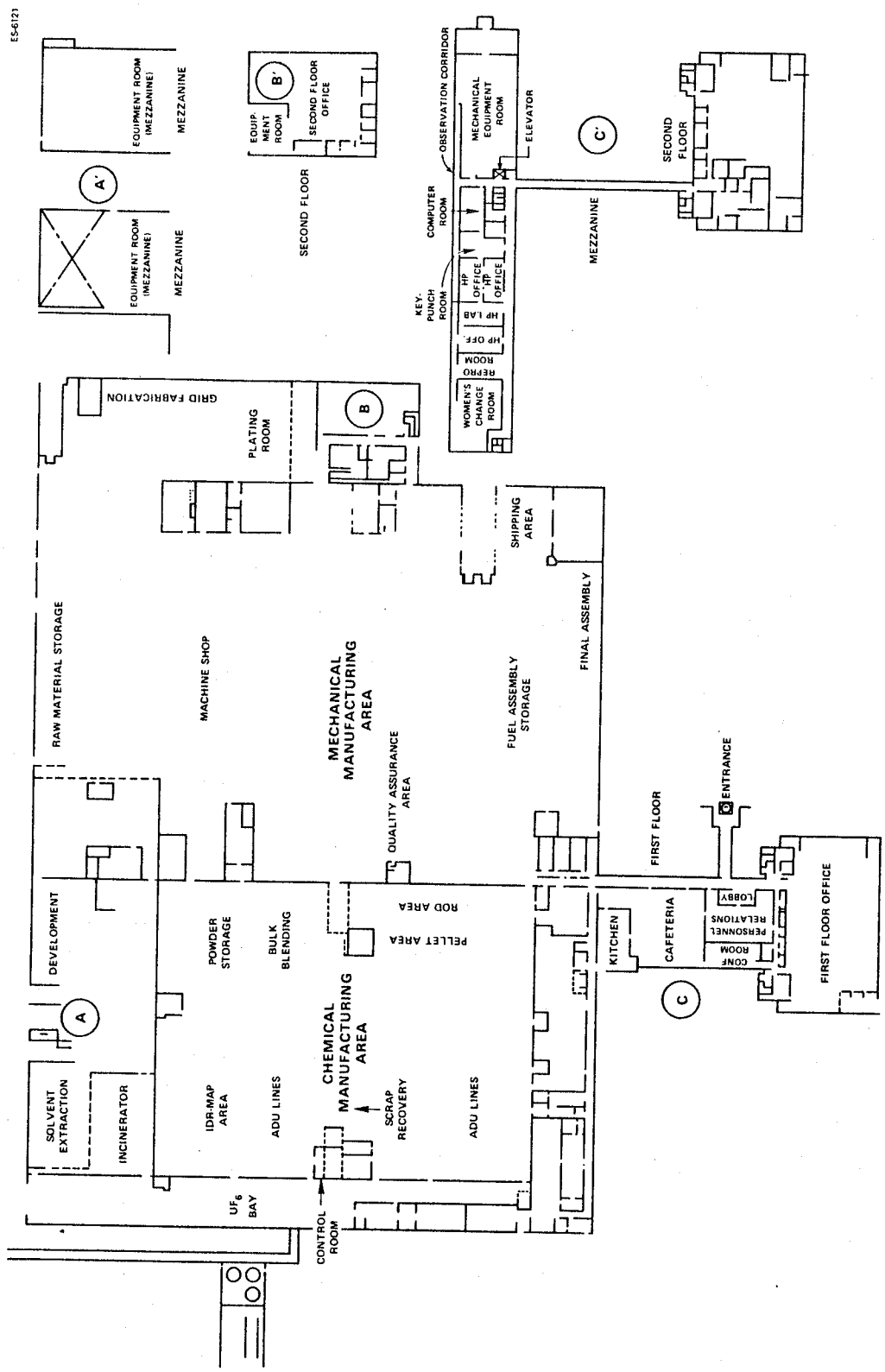


Fig. 2.3. The interior layout of the Westinghouse NFCS. *Source:* Westinghouse 1983, Fig. 2.5.

Sanitary and industrial waste treatment processes are conducted external to the main facility. These processes are described in Sect. 2.2.2.

2.2.1.3 Chemical processes

Five ADU conversion lines are currently available to process five different isotopic enrichments simultaneously. For the ADU (or future IDR process), UF_6 will be received at a maximum enrichment of 5% ^{235}U in standard 2.5-ton cylinders and shipping packages. As needed, a UF_6 cylinder is removed from the UF_6 cylinder storage area and connected to one of the conversion lines. The UF_6 is vaporized by heating the cylinder in one of the steam chambers located in the UF_6 vaporization area adjacent to the conversion lines.

Ammonium diuranate process

In the ADU process, the vaporized UF_6 is hydrolyzed to uranyl fluoride (UO_2F_2) by mixing with water. The UO_2F_2 is subsequently converted to an ADU slurry [$(NH_4)_2U_2O_7 + 4NH_4F + 3H_2O$] by adding ammonium hydroxide solution. The ADU slurry is dewatered by centrifugation and the ADU is converted to the solid UO_2 product by heat and the introduction of hydrogen. The ammonia, fluorides, and steam in the calciner off-gases are scrubbed by a water scrubber and the gases are then passed through a high-efficiency particulate air (HEPA) filter assembly before discharge to the atmosphere. The dry UO_2 powder is conveyed from the calciner through a milling operation and into storage containers which are sampled, closed, and identified.

Integrated dry route process

The IDR process will utilize dry methods to convert solid UF_6 to UO_2. The UF_6 feed material, which is vaporized by heating the cylinders with hot spray, is reacted with superheated steam to form UO_2F_2 powder and hydrogen fluoride (HF) gas. The UO_2F_2 is further contacted with a countercurrent flow of hydrogen, nitrogen, and superheated steam to strip residual fluoride and to reduce the uranium powder to UO_2. The UO_2 is discharged into check hoppers and is then pneumatically conveyed (or otherwise transported) to the powder processing area. Process off-gases [H_2, HF, nitrogen (N_2), and steam (H_2O)] are removed continuously through off-gas filters that are periodically reverse-purged to remove uranium-bearing solids prior to the recovery of hydrofluoric acid. Hydrofluoric acid is recovered by condensation of the HF and steam before the remaining gases are released. The location of the proposed IDR system is shown in Fig. 2.3.

Scrap recovery

Scrap recovery is accomplished by batch operations involving a variety of input materials. The preliminary operations concentrate the material and convert it to forms readily processed as U_3O_8 powder and uranyl nitrate. Not all materials require processing through the entire sequence of operations. The basic processing sequence includes dissolution of solid forms in nitric acid, conversion to slurry form by precipitating ADU from the solution, dewatering the slurry form by wet mechanical separation, calcining the resulting sludge in regular or controlled-atmosphere furnaces, and packaging and storing the resulting product.

Before being released through the HEPA-filtered exhaust system to the atmosphere, off-gases from the uranyl nitrate dissolvers are routed through a reflux condenser and a scrubber to remove entrained particles and condensible vapors. The reflux condenser is mounted vertically and is directly above the dissolution tank so that any condensation formed can drain back into the tank. An incineration process is conducted to minimize the burial of low-level combustible contaminated waste and to economically recycle product-grade material. A solvent extraction process recovers and purifies various contaminated uranium materials.

Pellet and rod manufacturing processes

The product UO_2 powder from the chemical conversion area is brought to a feed preparation hood in the pellet area where it is mixed with U_3O_8 and UO_2 add-back material. The material is transferred by a bucket elevator system to a roll compactor and is precompacted. The material is then granulated and mixed with zinc stearate binder-lubricant. The granules of uranium are next fed into high-speed pellet presses where the fuel is compacted into a green pellet. The green pellets are loaded into molybdenum boats and are sintered in an electrically heated furnace in a hydrogen atmosphere. This process produces a denser, more compact pellet. To obtain precise dimensions, all pellets are processed through a grinding operation and are dimensionally checked.

Pending quality control release, the pellets are loaded onto trays for interim storage. Upon quality control approval, the pellets are loaded into empty fuel rods, a spring is inserted into the plenum section, and end plugs are inserted and girth welded to the rod. Next the rod is pressurized with helium and seal welded. Finished fuel rods are transferred to quality assurance operations.

2.2.1.4 Mechanical operations

All uranium material that is transferred to the mechanical manufacturing area has been encapsulated and sealed. A small additional room is proposed for the south end of the facility for manufacturing poison rods for nuclear fuel assemblies (Fig. 2.2).

Various quality control and quality assurance operations are performed in the manufacturing area on sealed rods, including X-ray testing, helium leak testing, gamma scanning, visual checks, and dimensional checks. Machining operations are performed to fabricate various internal parts of the nuclear fuel assembly "skeleton" structure, including grid straps, bottom nozzle, top nozzle, and guide tubes. Individual rods are loaded into the skeleton assembly. Final weighing and testing operations are performed on completed assemblies. Other machining operations are performed in fabricating the boron carbide burnable poison assemblies and silver cadmium control rod "spyder" assemblies. A nickel plating shop is maintained to assist with brazing the inconel grid straps. Zirconium grid strap fabrication using laser welding techniques has been introduced for certain fuel assemblies.

As a final step, the assembly is given a complete wash in soap and water and a deionized water rinse. The assemblies can either be stored for shipment or shipped immediately in approved containers. A substantial quantity of assemblies are stored in the fuel assembly storage area prior to shipment to the utility.

2.2.1.5 Shipping

All shipments of nuclear materials and wastes from the Columbia plant are carried out in conformance with NRC, DOT, and state of South Carolina requirements. Completed fuel assemblies

are shipped to utility customers in approved containers licensed by the NRC. Low-level waste shipments are appropriately packaged and analyzed for uranium content prior to shipment to the low-level waste burial grounds.

2.2.2 Waste Confinement and Effluent Control

The ADU and IDR processes generate gaseous and particulate emissions and liquid and solid wastes. All waste streams are controlled and treated prior to their release to the environment. The following sections (excerpted from Westinghouse 1983 and NRC 1977) discuss the types of effluents from the Westinghouse NFCS and describe methods for their control. The applicant's monitoring of effluent streams and the environment is addressed in Sect. 4.1.

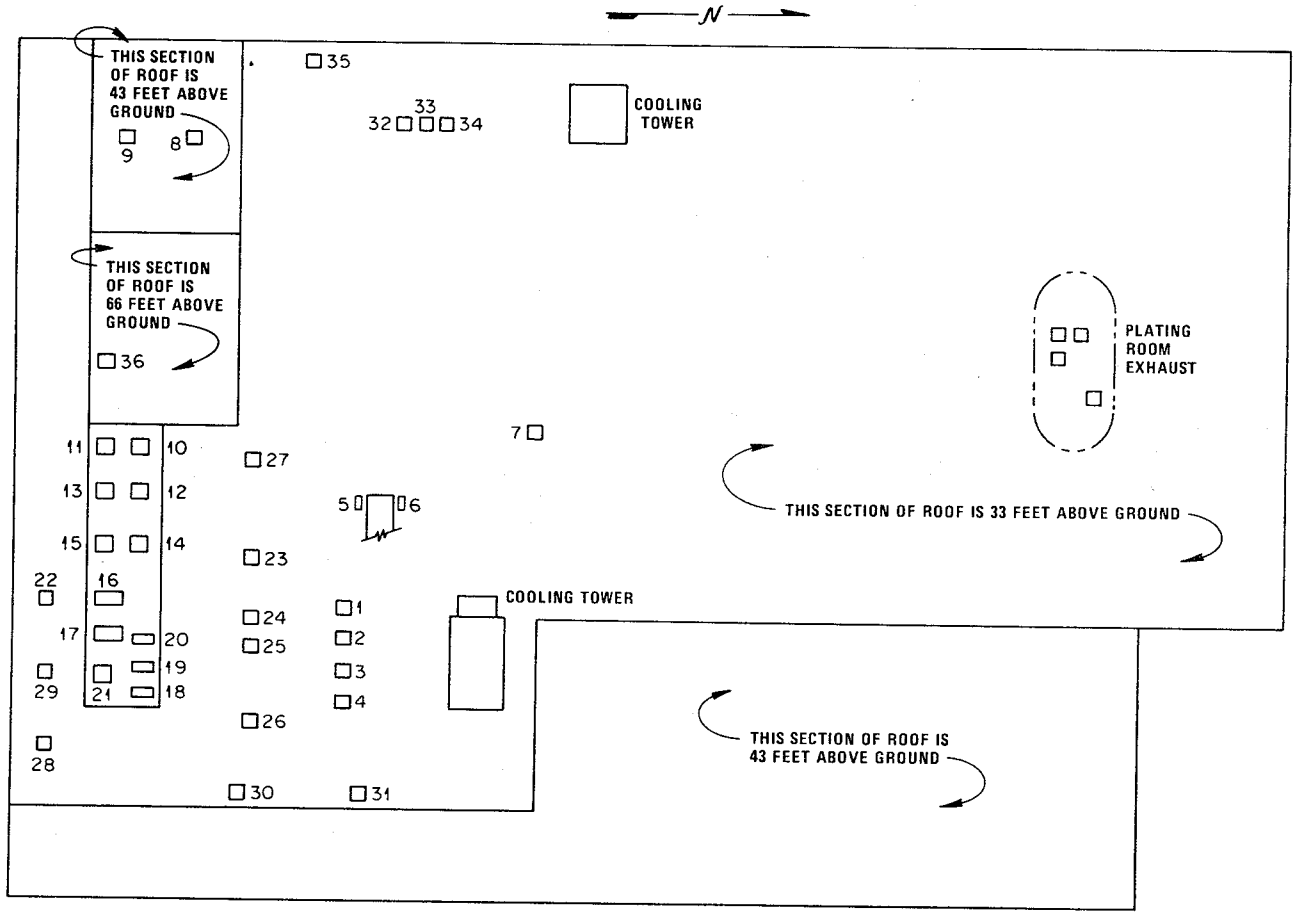
2.2.2.1 Gaseous/particulate emissions

Thirty-seven exhaust stacks currently discharge airborne emissions from the main plant facility. An additional release point will vent emissions from the IDR process when it becomes fully operational. The emissions consist primarily of uranium, ammonia (NH_3), and fluorides (NH_4F and HF). The composition of the uranium mixture will vary depending upon the enrichment of the material being processed; however, in all cases, the bulk of the material will be ^{238}U (95 wt %), whereas the predominant activity will be ^{234}U (up to 86% of the total activity). Stack locations and sources of exhaust are shown in Fig. 2.4. All release points are either short stacks or roof vents, rather than elevated stacks.

Operations involving the use of radioactive materials in unsealed physical forms are limited to low-enrichment ($\leq$5 wt % ^{235}U) uranium in the fuel manufacturing facilities or the associated analytical laboratory. The ventilation systems installed in these facilities are designed so that all of the air from zones used to handle or process uranium is treated to remove essentially all the uranium prior to release to the atmosphere. Filtration is the predominant method for removing particulate uranium from discharge air streams. HEPA filters with an efficiency of 99.97% for $\geq$0.3μ-diameter particles are used to accomplish this. Semiannual gross alpha releases from the NFCS, measured from July 1979 through June 1984, are reported in Table 2.1. During this period, operations at a nominal 700 t/year of uranium used only ADU production lines. The average emissions were 27 μCi/week.

Process gases from the ADU production lines, which contain ammonia and fluorides, are scrubbed prior to their release to the atmosphere. The scrubbers and their efficiencies are identified in Table 2.2. After scrubbing, the gases are passed through HEPA filters to remove residual particulate uranium. The average and maximum release rates for ammonia measured during normal operation at about 700 t/year of uranium are 1.8 and 2.3 g/s, respectively (Westinghouse 1983). The fluoride emissions measured at a nominal 700 t/year of uranium production capacity for the years 1981-1983 are summarized in Table 2.3. The three-year average emission rate was 81.6 μg/s (Westinghouse 1984). These emissions rates are much lower than previous estimates (Westinghouse 1975) because of efficient fluoride removal by the scrubbers and HEPA filters (Westinghouse 1981).

In its application to NRC for approval to operate the IDR dry conversion system, Westinghouse (1981) estimated the fluoride emissions to be 2125 μg/s. Uranium emissions were estimated to be 3.5 μg/s. Assuming uranium enrichment to 5% ^{235}U (or 2.4 μCi/g), the uranium emissions rate is equivalent to $\approx$5.1 μCi/week or 265 μCi/year. No ammonia emissions will result from the IDR process because ammonia is not used in the UF_6-UO_2 conversion reaction.



KEY:

NO.	STATION DESCRIPTION
1	FURNACE EX. LINE 1
2	FURNACE EX. LINE 2
3	FURNACE EX. LINE 3
4	FURNACE EX. LINE 4
5	FURNACE EX. LINE 5-S
6	FURNACE EX. LINE 5-N
7	MET. LAB EXHAUST
8	INCINERATOR EX.
9	SUPPLEMENTAL INC. EX.
10	CONVERSION I-A SYSTEM EX.
11	CONVERSION I-B SYSTEM EX.
12	SCRAP RECOVERY 2-A SYSTEM EX.
13	SCRAP RECOVERY 2-B SYSTEM EX.
14	ADU LINE SCRUBBER 3A
15	ADU LINE SCRUBBER 3B
16	MAINT VENT SYSTEM 4-A
17	MAINT VENT SYSTEM 4-B
18	CONVERSION ENCLOSURE EX. NO. 4
19	CONVERSION ENCLOSURE EX. NO. 3
20	CONVERSION ENCLOSURE EX. NO. 2
21	CHEM. LAB FILTERED EX.
22	DECON ROOM EX.
23	CALCINER COMBUST GAS LINE 1
24	CALCINER COMBUST GAS LINE 2
25	CALCINER COMBUST GAS LINE 3
26	CALCINER COMBUST GAS LINE 4
27	CALCINER COMBUST GAS LINE 5
28	AIR COMPRESSOR ROOM EX.
29	BOILER ROOM EX.
30	CHEM. LAB EX. NO. 2
31	H.P. LAB EX.
32	DEVELOPMENT LAB EX. 1
33	DEVELOPMENT LAB EX. 2
34	DEVELOPMENT LAB EX. 3
35	SOLVENT EXTRACTION AREA EX.
36	PROPOSED IDR EX.
37	CHEMICAL LAB EX. NO. 3
38	SCRAP RECOVERY DRY EXHAUST

NOTE: TWO STACKS NOT SHOWN ARE NO. 37, CHEMICAL LAB EXHAUST NO. 3, AND NO. 38, SCRAP RECOVERY DRY EXHAUST.

Fig. 2.4. Process stack discharge locations from the top view of the roof of the Westinghouse NFCS. *Source:* Westinghouse 1983, Fig. 4.1.

Table 2.1. Measured semiannual airborne releases of gross alpha activity from the Westinghouse NFCS

Period ending	Discharged (μCi)
12-31-79	1008
06-30-80	537
12-31-80	659
06-30-81	462
12-31-81	485
06-30-82	502
12-31-82	574
06-30-83	701
12-31-83	756
06-30-84	804

Source: Westinghouse 1983, Table 4.1; and S. D. Wyngarden, NRC, personal communication to A. W. Reed, ORNL, Dec. 6, 1984.

Table 2.2. Identification of process gas scrubbers at the Westinghouse NFCS, including their efficiencies

Scrubber	Location	Type and number	Efficiency	
			Chemical (%)	Particulate (wt %)
S-2A,S-2B	Plant air effluent	High-energy venturi cyclone, 2	70-85 (NH_3, HF)	90
S-3	Vessel vent header	Packed tower, 1	90 (NH_3, HF)	
S-1	Scrap recovery	Venturi, 2	90 (NH_4F)	
Calciner reaction gas effluent	Calciners	Venturi, 10	75-80 (NH_3) 75-90 (HF)	90
Incinerator effluent	Incinerator	Packed tower, 1	90 (Acids)	95
Scrap recovery (S-1056)	Scrap recovery	Spray tower, 1	95	90

Source: Westinghouse 1983, Table 4.4.

Table 2.3. Fluoride emission rates (μg/s) from the Westinghouse NFCS at a nominal 700 t/year of uranium production capacity during the period 1981–1983

Daily average	1981	1982	1983
Maximum	309	879	766
Annual	69.8	77.7	97.3
Minimum	6.5	4.1	6.5

Source: Westinghouse 1984.

2.2.2.2 Liquid wastes

Liquid waste streams at the Westinghouse NFCS include sanitary wastes and process wastewaters. Process wastewaters are primarily contaminated by ammonia and fluorides. Both waste streams are treated onsite prior to their combined discharge into the Congaree River. A 10-cm (4-in.) pipeline releases the plant effluent to the river at a point about 5.6 km (3.5 miles) south of the facility (Fig. 3.3). The pipe submerges into the river, discharging directly into the current near the bottom approximately 6 m (20 ft) from shore.

The flow rates from the process and sanitary waste streams are about equal and, at the present level of operation (approximately 700 t/year of uranium), the combined liquid effluent stream flows at about 475 m^3/d (125,00 gal/d). At the expanded 1,600 t/year of uranium capacity, it is estimated that the total waste stream flow rate will be approximately 720 m^3/d (190,000 gal/d) (Westinghouse 1983).

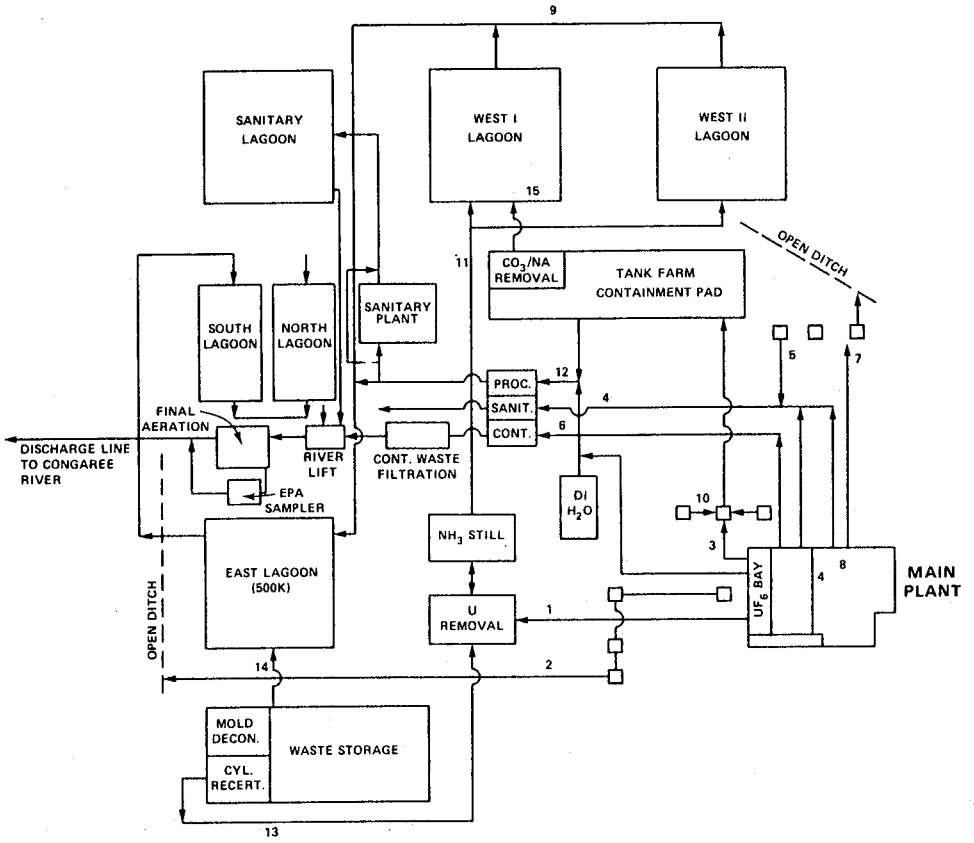
Waste treatment

Figure 2.5 indicates the treatment and flow of liquid wastes at the Westinghouse NFCS. Six onsite lagoon storage basins are illustrated in the figure; the locations of these lagoons are shown in Fig. 2.2. The north, south, and west (I and II) lagoons are used for settling solids from treated process wastewaters prior to discharge. The sanitary lagoon is used for polishing sanitary wastes after onsite treatment. The east lagoon provides extra capacity for overflow from other lagoons or for containment in the event of a spill or emergency. All process waste storage lagoons were relined with 36-mil Hypalon liners during 1981-1982. Each lagoon is also equipped with French Drain systems beneath the liners to detect lagoon leakage. Westinghouse states that no additional lagoons are planned during the next five-year period; however, three additional 110-m^3 (30,000-gal) aboveground liquid waste storage tanks are planned.

Radiological control. Compliance with 10 CFR Pt. 20 activity limits regarding the discharge of radioactive liquid wastes to an unrestricted area is assured by a continuous on-line gamma ray spectroscopy system within the main plant's controlled access area. Quarantine tanks and diversion tanks are available to increase settling times and allow sufficient filtration if the liquid activity is above release limits (30 pCi/mL, which is the 10 CFR Pt. 20 limit for release of ^{234}U to unrestricted waters). When the liquid has been successfully scanned and approved for discharge, it is sent to the advanced wastewater treatment facility for uranium removal external to the main plant. This polishing operation assures that all recoverable uranium is removed from the liquid stream and recycled through scrap recovery. The liquid stream is then discharged to the chemical waste treatment system. Typical discharge concentrations and total annual release of radioactivity at the NFCS are given in Table 2.4 (Westinghouse 1983).

Nonradiological control. The aqueous process waste solution, primarily filtrate from the ADU process lines, is circulated through filters before being pumped to tanks in the waste treatment facility. The main constituents of the process liquid wastes are ammonium fluoride (NH_4F) and uranium. Through the addition of lime and caustic, the fluoride is converted to insoluble calcium fluoride (CaF_2), which is removed by centrifugation or by settling in a series of holding lagoons (Sect. 2.2.2.3). Most of the ammonia is recovered by distillation and returned (as ammonium hydroxide) to the ADU process following pH adjustment with caustic.

After addition of lime and removal of the ammonia in the stripping still, the CaF_2 slurry is discharged to the west lagoon to permit settling of the solids. The liquid is decanted from the top



LEGEND

LINE NO.

1 PROCESS WASTE
WATER — UO_2
NH_4 — NH_4OH

2 GROUNDWATER

3 ROOF DRAIN TO STORM SEWER

4 SANITARY DRAIN

5 CLOSED COOLING-TOWER LOOP OVERFLOW AND BLOWDOWN OF SYSTEM TO STORM SEWER (NOTE: LINE NO. 5 STREAM DELETED BECAUSE OF EPA REQUIREMENTS AND NOW FLOWS TO LINE NO. 4)
WATER — NALCO 39
NALPAC 8241 — NALCO 918
NALPAC 8240 — NALCO 7373

6 CONTAMINATED WASTE
WATER — UO_2 POWDER

7 ROOF DRAIN TO STORM SEWER

8 SANITARY DRAIN
HAS BOILER BLOWDOWN
NALCO 19 — NALCO 711
NALCO 356 — NALCO 752
HAS DEIONIZER FLUSH AND BACKWASH
SULFURIC ACID (H_2SO_4) — CAUSTIC NaOH
SERVES AS WASTE DRAIN FOR X-RAY FILM DEVELOPMENT CHEMICALS
GAVAERT FIXER AND DEVELOPER IS USED IN AUTOMATIC DEVELOPING EQUIPMENT
CONTAINS WASTES FROM CAFETERIA AND KITCHEN

9 PROCESS WASTE (TREATED)
WATER — NH_4F, NH_4NO_3
NH_4OH, CaF_2, CaOH

10 STORM SEWER GROUNDWATER

11 TREATED UNCLASSIFIED WASTE

12 DEIONIZED WATER REGENERATION
H_2SO_4, NaOH — LAB WASTES

13 TEST WATER, CYLINDER RECERTIFICATION

14 WASTE STORAGE PAD DRAIN

15 FLOW FROM CARBONATE REMOVAL SYSTEM

Fig. 2.5. Building and liquid waste treatment flow sheet for the Westinghouse NFCS. *Source:* Westinghouse 1983, Fig. 4.2 and Table 4.5.

of the west lagoon on a batch basis to the north and south lagoons where additional settling takes place. After a 1- to 3-d settling time, the supernate is pumped to the Congaree River, usually together with overflow from the sanitary stabilization pond. Westinghouse discharges the combined liquid effluent in accordance with the requirements set forth by SC-DHEC in a National Pollutant Discharge Elimination System (NPDES) permit. The permit, which was modified in September 1984, is presented in Appendix B.

Table 2.4. Discharge concentrations and total annual release of radioactivity in Westinghouse NFCS liquid wastes

Radiation component	At 700 t/year of uranium			Estimated at 1600 t/year of uranium		
	Concentration (pCi/mL)	% MPC[a]	Total release rate (mCi/year)	Concentration (pCi/mL)	% MPC[a]	Total release rate (mCi/year)
Alpha	0.64	2.2[b]	97	1.77	5.9[b]	262
Beta	0.305	0.9[c]	45.2	0.823	2.4[c]	122

[a]MPC = Maximum permissible concentration.
[b]Based on ^{234}U, 10 CFR Pt. 20.
[c]Based on calculated 10 CFR Pt. 20 limits for combined daughter products:

$$\left.\begin{matrix}^{234}Th \\ ^{231}Th \\ ^{234}Pa\end{matrix}\right\} = 33 \text{ pCi/mL.}$$

Source: Westinghouse 1983, Table 4.6.

All domestic-type wastes, shower water, cafeteria water, and several miscellaneous streams are routed to the sanitary system. Contaminated laundry cleaning is performed outside the NFCS by an approved vendor.

Site sanitary sewage is treated in an extended aeration package plant and discharged into a biological oxidation/settling-polishing lagoon. The lagoon effluent is then chlorinated and mixed with treated liquid process waste at the facility lift station. The average annual nonradiological quality of the NFCS combined (process plus sanitary) liquid effluent is presented in Table 2.5. Westinghouse's compliance with its NPDES permit is discussed in Sect. 4.

IDR process

The IDR process produces a lesser volume of liquid wastes than the ADU process because no liquids are involved in the chemical conversion reactions. Hydrofluoric acid is a usable byproduct (liquid waste) that will be generated by the use of this process. The applicant presently has no definite plan for the use/disposal of the acid (Westinghouse 1981).

2.2.2.3 Solid wastes

Manufacturing

Materials such as used packaging, worn-out clothing, paper, wood-floor sweepings, discarded tools, etc., are collected and stored prior to disposal, which is made according to two primary classifications: uranium contaminated or contamination free. The contaminated material is further segregated into combustible and noncombustible classifications. Noncombustible waste is examined to determine the feasibility of recovery and is then either processed chemically or collected in boxes for ultimate disposal at a government-licensed waste disposal site. Combustible items are reduced to ash in a specially designed incinerator, and the ash is dissolved in a mixer-settler dissolver system. Solvent extraction will recover and purify the uranium for recycle back to the product

Table 2.5. Annual average nonradiological water quality of Westinghouse NFCS liquid effluent discharge at 700 t/year of uranium

Parameter[a]	Concentration (mg/L)[b]	Quantity (lb/d)[b]
pH, units	8.6	
BOD_5	18.9	16.2
Fecal coliform, MPN/100 mL	50	
Total suspended solids	23.3	20.0
Chemical oxygen demand	89	76.4
Oil and grease	3.5	3.0
Phenol, μg/L	<1	<0.001
Surfactants	0.17	0.15
Nitrate	160	137
Sulfate	140	120
Sulfide	<0.05	0.04
Ammonia (N)	17.5	15.0
Phosphorus	2.3	2.0
Cyanide	<0.02	<0.02
Fluoride	17.4	14.9
Barium	0.10	0.09
Iron	5.0	4.3
Manganese	0.04	0.03
Magnesium	6.1	5.2
Zinc	2.2	1.9
Aluminum	0.41	0.35
Cobalt	<0.01	<0.01
Molybdenum	0.04	0.03
Sodium	194	166
Boron	0.267	0.23
Bromide	<0.1	<0.09

[a]BOD = Biological oxygen demand.
MPN = Most probable number.
[b]Unless otherwise specified.
Source: Westinghouse 1983, Table 4.7.

material stream. A flow sheet for projected solid contaminated wastes at 1600 t/year of uranium production capacity is given in Fig. 2.6.

Wastewater treatment solids

In previous years, after fixation with a cement-like binder, the calcium fluoride contaminated with uranium was buried at the low-level radioactive waste burial site in Barnwell, South Carolina. All calcium fluoride generated prior to 1981, approximately 1.6×10^4 m^3 (575,000 ft^3) of material, was handled in this manner. In 1980, an advanced wastewater treatment system was installed at NFCS to remove additional quantities of uranium. Future calcium fluoride should contain <30 pCi/g of uranium activity, which is the existing NRC (1981) guideline for material that may be disposed without restriction on burial method. As such, calcium fluoride containing <30 pCi/g will be approved for disposal in a chemical or sanitary landfill.

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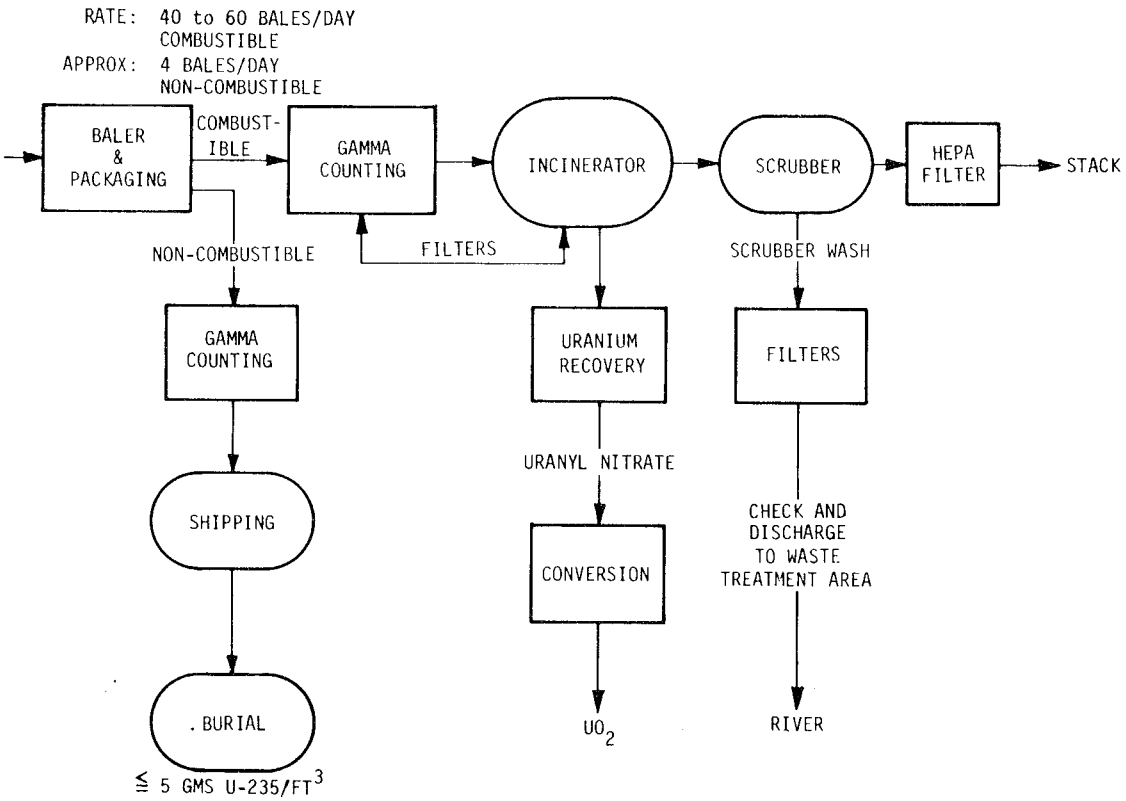

Fig. 2.6. Projected solid contaminated waste flow sheet for 1600 t/year of uranium production capacity at the Westinghouse NFCS. *Source:* Westinghouse 1975, Fig. 3.3-3.

2.3 DECOMMISSIONING

All major material licensees are required to submit a general decommissioning plan to be effected at the end of plant life. This plan describes how the facilities and grounds will be decontaminated so that they can be released for unrestricted use. The plan identifies and discusses the major factors that influence the cost of decontaminating the facilities and grounds and provides a cost estimate for these activities. The decommissioning plan and a corporate commitment to provide funds for this effort are incorporated as conditions of the license. On May 24, 1978, such conditions were incorporated into Westinghouse's License No. SNM-1107.

2.4 NUCLEAR MATERIAL SAFEGUARDS

Current safeguards are set forth in 10 CFR Pts. 70 and 73. The regulations in Pt. 70 provide for material accounting and control requirements with respect to facility organization, material control arrangements, accountability measurements, statistical controls, inventory methods, shipping and receiving procedures, material storage practices, records and reports, and management control.

The current regulations in 10 CFR Pt. 73 provide requirements for the physical security and protection of fixed sites and for nuclear material in transit. Physical protection requirements for

SNM of low strategic significance (including low-enriched uranium) include provision for the establishment of controlled access areas, monitoring of these areas to detect unauthorized penetration, provision of a response capability for unauthorized penetrations and activities, and establishment of procedures for threats of theft and for actual thefts.

The regulations in 10 CFR Pts. 70 and 73, described briefly above, are applied in the reviews of individual license applications. License conditions then are developed and imposed to translate the regulations into specific requirements and limitations that are tailored to fit the particular type of plant or facility involved.

The licensee has an approved material control and accounting plan and an approved physical security plan that meet the current requirements for the low-enriched uranium that would be possessed at the site. It is concluded, therefore, that the safeguards-related environmental impact of the proposed action is insignificant.

2.5 STAFF EVALUATION OF THE PROPOSED ACTION AND ALTERNATIVES

The staff believes that the fuel manufacturing operations at the Westinghouse NFCS are performed in a manner that protects both the public and the environment from unusual or adverse impacts. However, as discussed in the indicated sections, the staff recommends addition of the following requirements.

1. The applicant will be required to take onsite grass samples for fluoride analysis at least twice a year when the grass is being cut for hay. Onsite soybean crops, when harvested, will also be monitored for fluoride. In addition, the applicant will be required to analyze appropriate background samples of vegetation for fluoride (Sects. 4.2.2.1 and 4.2.6).

2. The applicant will be required to expand its onsite groundwater monitoring program to study changes in the contaminant plume. Appropriate existing wells (both in the shallow and deeper aquifers) will be sampled at least quarterly and analyzed for gross alpha, gross beta, and ammonia concentrations (Sects. 4.2.3.2 and 4.2.6).

3. The applicant will be required to redrill certain groundwater monitoring wells so that the wells can be completed with state-of-the-art designs. This requirement includes Monitor Well W-3, which is completed in the Black Mingo Formation underneath the shallow groundwater contamination (Sect. 4.2.6).

The environmental impact of continued operation is expected to be insignificant providing that these requirements are added to the license.

REFERENCES FOR SECTION 2

NRC (U.S. Nuclear Regulatory Commission). 1977. *Environmental Impact Appraisal of the Westinghouse Nuclear Fuel Columbia Site (NFCS) Commercial Nuclear Fuel Fabrication Plant, April 1977,* NRC, Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle and Material Safety, Washington, D.C. (NR-FM-013).

NRC (U.S. Nuclear Regulatory Commission). 1981. "Uranium Fuel Licensing Branch Technical Position, Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations," *Fed. Regist.* **146**, p. 52061, October 23.

Westinghouse. 1975. *Westinghouse Nuclear Fuel Columbia Site Evaluation Report,* submitted to the U.S. Nuclear Regulatory Commission for renewal of SNM-1107, March 1 (Docket No. 70-1151).

Westinghouse. 1981. *License Amendment Application to Upgrade Facility* (letter from A. T. Sabo, Westinghouse, to R. G. Page, NRC, dated Jan. 9, 1981). Docket No. 70-1151.

Westinghouse. 1983. *Update for Environmental Impact Appraisal, Westinghouse Electric Corporation, NFD Plant, Columbia, South Carolina,* SNM-1107, Docket No. 70-1151, April.

Westinghouse. 1984. Letter from R. E. Fischer, Westinghouse Electric Corporation, to Mark J. Rhodes, U.S. Nuclear Regulatory Commission, in response to NRC questions concerning the applicant's *Update for Environmental Impact Appraisal* (Docket No. 70-1151), February 20.

3. THE AFFECTED ENVIRONMENT

3.1 SITE DESCRIPTION

The 469-ha (1158-acre) Westinghouse NFCS is located in Richland County in central South Carolina, approximately 13 km (8 miles) southeast of the Columbia city limits. Coordinates of the site are latitude 33°50'60" and longitude 80°56'45". An exterior view of the Westinghouse plant is shown in Fig. 3.1, and a regional setting of the site is indicated in Fig. 3.2. Nearby towns, public facilities, the Congaree River, and transportation links are shown in Fig. 3.3. The site is bounded by South Carolina Route 48 (Bluff Road) to the north, the Vestal Lumber Manufacturing Company property to the east, the Liberty Life Insurance Company property to the south, and the Burrel Manning property to the west (Fig. 3.4).

The manufacturing plant and associated facilities are centrally located on the site. The developments, including the fuel fabrication facilities, holding ponds, parking lot, and landscaped grounds, occupy approximately 24 ha (60 acres) or 5% of the total site area. Figure 3.4 shows the plant boundary, adjacent properties, drainages, and elevations of the site. The plant floor is 142 ft above mean sea level (MSL). Plant site drainage flow follows original drainage patterns to Sunset Lake, Mill Creek, and the Congaree River.

The plant site and vicinity are generally flat to the north and east and flat and swampy in other directions. Westinghouse intends to keep most of the unused portion of the site (approximately 444 ha or 1098 acres) in its natural state.

3.2 CLIMATOLOGY AND METEOROLOGY

3.2.1 Climatology

A summary of local climatological features measured at the U.S. Weather Bureau Station at Columbia Metropolitan Airport (DOC 1973), located about 19 km (12 miles) west-northwest of the

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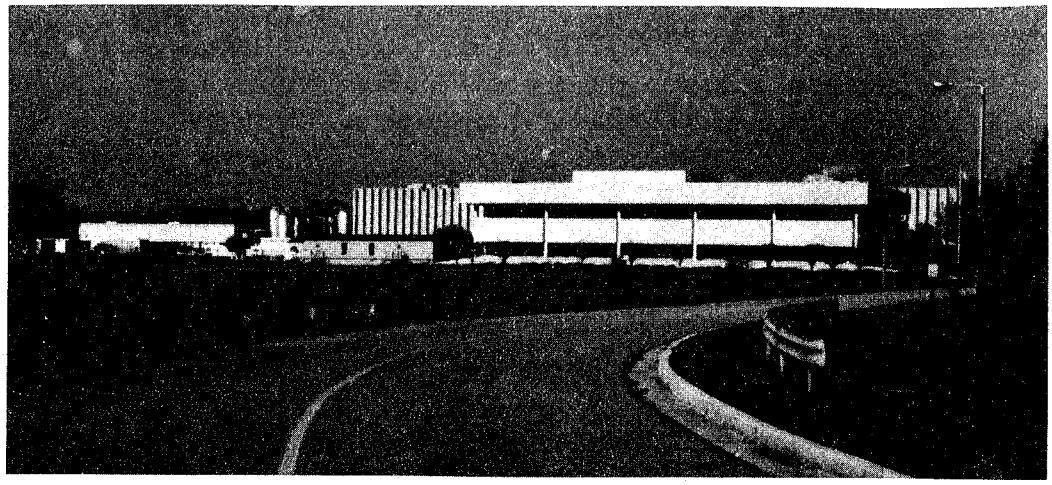

Fig. 3.1. An exterior view of the Westinghouse NFCS near Columbia, South Carolina, looking west from Bluff Road (Route 48).

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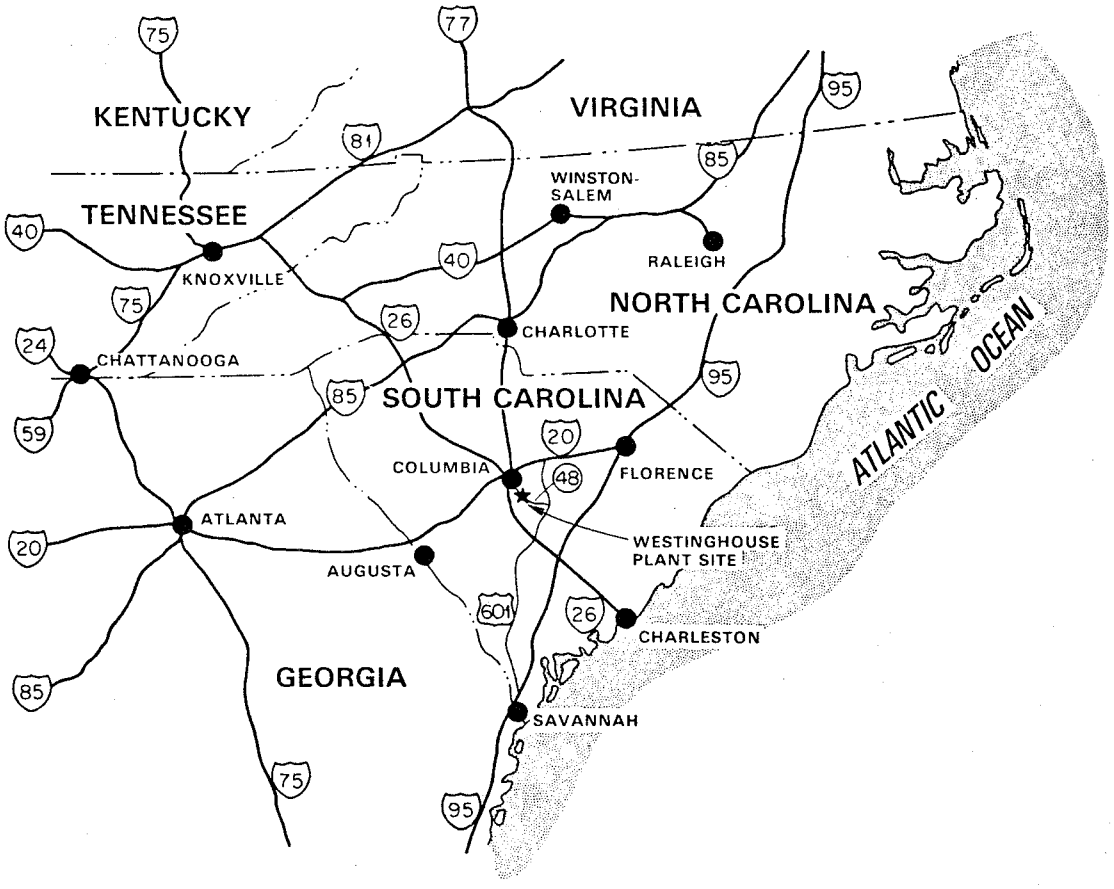

Fig. 3.2. Regional location of the Westinghouse NFCS near Columbia, South Carolina.

site, is given in Table 3.1. Temperature, relative humidity, wind, and the frequency of certain climatological events are reported.

The weather in the region of the NFCS provides a temperate climate, with high relative humidity, moderate rainfall, moderate winds, and normal diurnal temperature changes. Winters are mild, with cold waves rarely accompanied by temperatures of −18°C (0°F) or below. Freezing temperatures [0°C (32°F)] or less occur on an average of 77 d per year, generally during the months of November through March (NOAA 1978).

3.2.2 Winds, Tornadoes, and Storms

In South Carolina severe tornadoes occur almost every year, most often in the spring. During the interval of 1956 through 1973, 172 tornadoes were reported in the state. Data from Richland County show that nine tornadoes were reported from 1950 to 1973 and six tornadoes were reported from 1974 to 1982 (Jane Parvin, National Severe Storms Data Center, Kansas City, Missouri, personal communication with Andrea Reed, Oak Ridge National Laboratory, October 18, 1984). Thom (1973) developed an empirical formula to compute the mean recurrence interval for a

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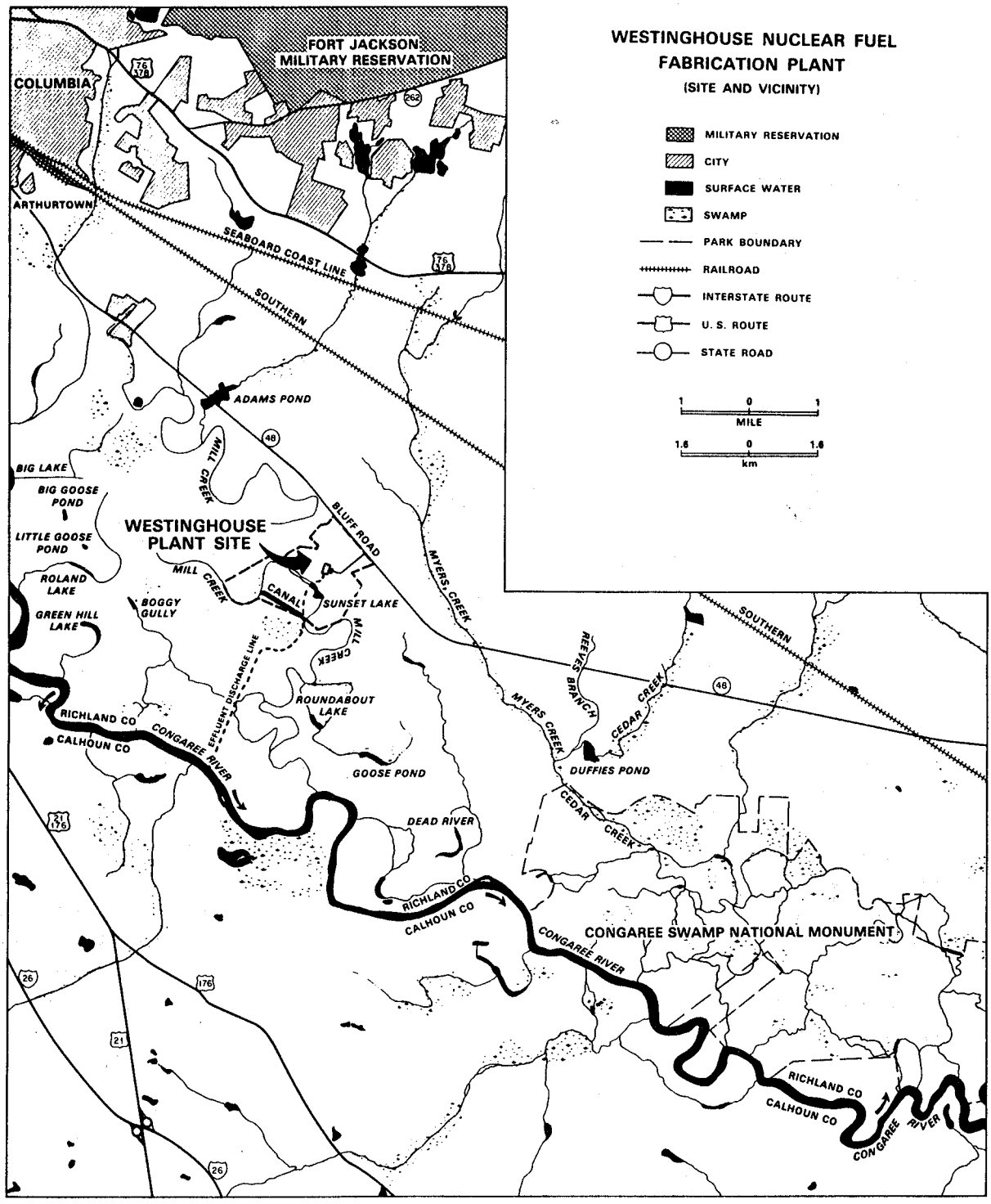

Fig. 3.3. Specific location of the Westinghouse NFCS near Columbia, South Carolina.

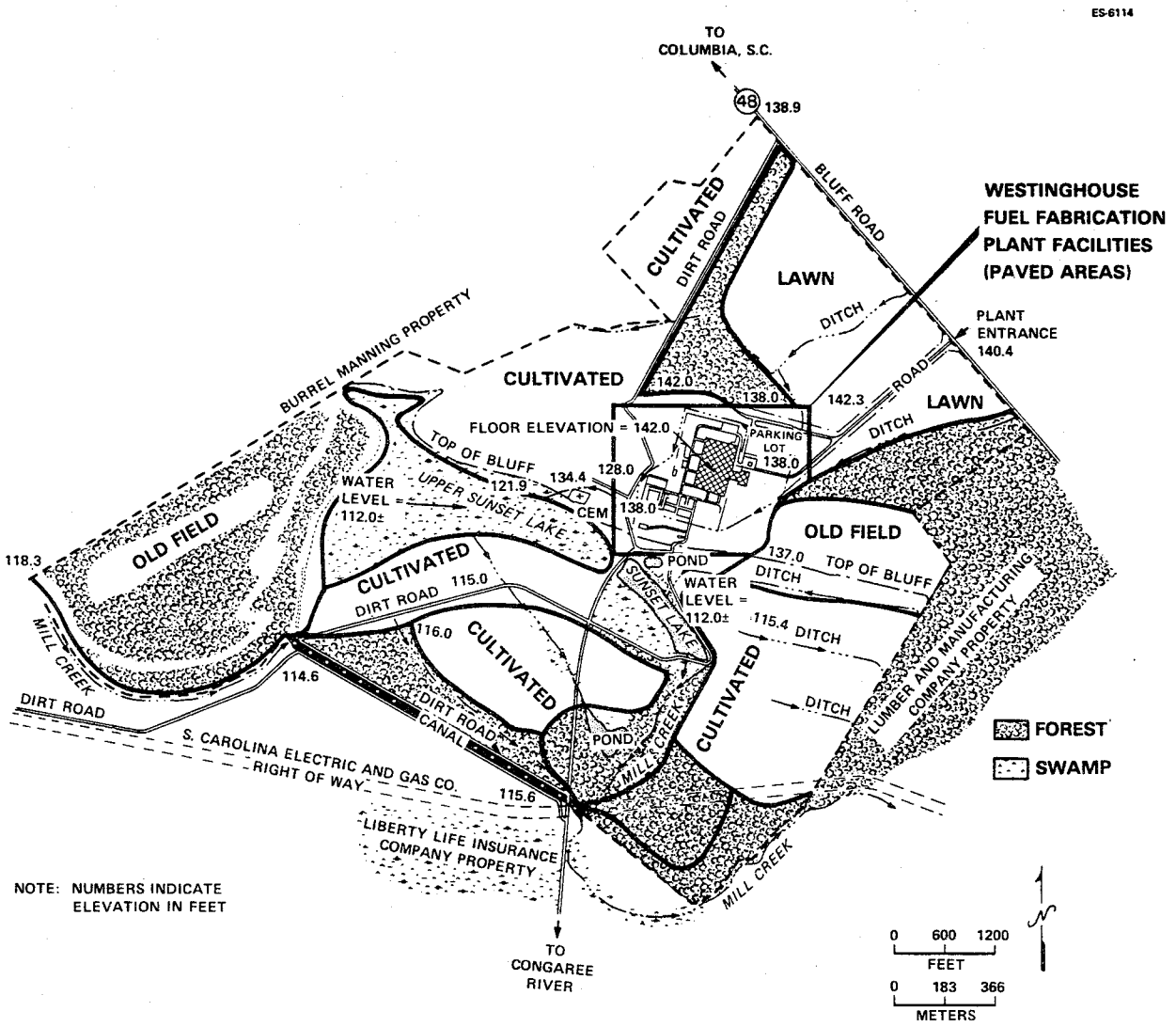

Fig. 3.4. Site layout of the Westinghouse NFCS near Columbia, South Carolina, showing the plant boundary, adjacent properties, drainage, elevations, and current land use. *Source:* Modified from Westinghouse 1983, Fig. 6-1.

Table 3.1. Climatological data from Columbia Metropolitan Airport[a]

Temperature (°C)	
Annual average	17.5
Mean daily high	24.1
Mean daily low	10.8
Record high	41.7
Record low	−18.9
Degree days	2598
Relative humidity (%)	
Annual average	73
Wind	
Annual average speed (mph)	7.0
Prevailing direction	SW
Fastest mile	
Speed (mph)	60
Direction	W
Precipitation (in.)	
Annual average	46.36
Monthly maximum	16.72
Monthly minimum	Trace
24-hr maximum	7.66
Snowfall (in.)	
Annual average	1.9
Monthly maximum	16.0
24-hr maximum	15.7
Mean annual (no. of days)	
Precipitation of 0.1 in.	110
Snow, sleet, hail of 1.0 in.	1
Thunderstorms	53
Heavy fog	27
Temperature of 32°C (90°F) or higher	65

[a]Data based on 7 to 30 years of record.
Source: Westinghouse 1975, Table 2.6-1.

tornado striking any location by approximating the location with a geometrical point. Based on the mean path area of a tornado, the number of tornadoes per year, and the area over which tornadoes may occur (Richland County), the probability of a tornado striking any location within Richland County, which includes the site, is less than 1 in 700 years.

During the 30-year period of 1941-1970, four or five North Atlantic hurricanes out of a total of 31 penetrated into the central part of South Carolina. There was no severe damage from winds, although flash floods caused damage to farmlands and public utilities in the Columbia region (Purvis

1964; DOC 1971). The strongest wind recorded in the Columbia region was 97 km/h (60 mph); the speed of the strongest wind expected in a 100-year period is estimated to be 160 km/h (100 mph) (Thom 1968).

3.2.3 Meteorology

Atmospheric dispersion

High air pollution potential is caused by low mixing heights and light winds (Holzworth 1971). Holzworth's data on the frequency of high air pollution potential (HAPP) indicate that, from 1960 to 1965, the Columbia region experienced no HAPP cases of low mixing heights and light winds.

Diffusion climatology

The annual and seasonal summaries of the joint wind stability frequency were obtained from onsite meteorological data (August 1, 1972, through July 31, 1973) by use of the STAR program (Westinghouse 1972). The data indicate that stable conditions exist 47% of the time, neutral conditions occur about 43% of the time, and unstable atmospheric conditions prevail about 10% of the time. The seasonal distribution of the various stability classes indicates that the greatest number of hours of unstable conditions (310 h) and slightly stable conditions (412 h) occurs in the spring; in winter, the most hours (1047) of neutral conditions occur; and, in summer, the most hours (984) of stable conditions occur.

The annual wind rose for NFCS (August 1, 1972, to July 31, 1973) is shown in Fig. 3.5, and the wind rose for the Columbia Metropolitan Airport is shown in Fig. 3.6.

Estimates of atmospheric dispersion factors (χ/Q) on an annual basis at downwind distances up to 80 km (50 miles) in 16 compass directions at the 15-m (50-ft) level are provided in Table 3.2. These factors were calculated using the Gaussian plume model and diffusion coefficients for Pasquill-type turbulence. Because the NFCS effluent release points are generally lower than 2.5 times the height of adjacent solid structures, the release was conservatively assumed to occur at ground level, with credit for building wake effects. Using these assumptions, the annual average χ/Q at the nearest residence (1000 m or 3300 ft northeast) is 7.67×10^{-6} s/m^3 and, at the nearest site boundary (550 m or 1800 ft north-northwest), is 1.54×10^{-5} s/m^3.

3.2.4 Air Quality

Richland County lies in the Columbia Intrastate Air Quality Control Region (AQCR). Air quality in this AQCR is generally good and does not violate the National Ambient Air Quality Standards (Table 3.3) for total suspended particulates, sulfur dioxide, carbon monoxide, and nitrogen oxides (40 CFR Pt. 81, revised July 1, 1983). However, concentrations of ozone in the Columbia area, including Richland and Lexington counties, do not meet the national primary standard (40 CFR Pt. 81, revised July 1, 1983).

3.3 DEMOGRAPHY AND SOCIOECONOMIC PROFILE

The plant site is located in a predominantly forested area of low population density southeast of the city of Columbia in Richland County, South Carolina. Richland County, which lies close to the geographical center of South Carolina (Fig. 3.2), covers 2×10^6 m^2 (762 miles^2) and has a

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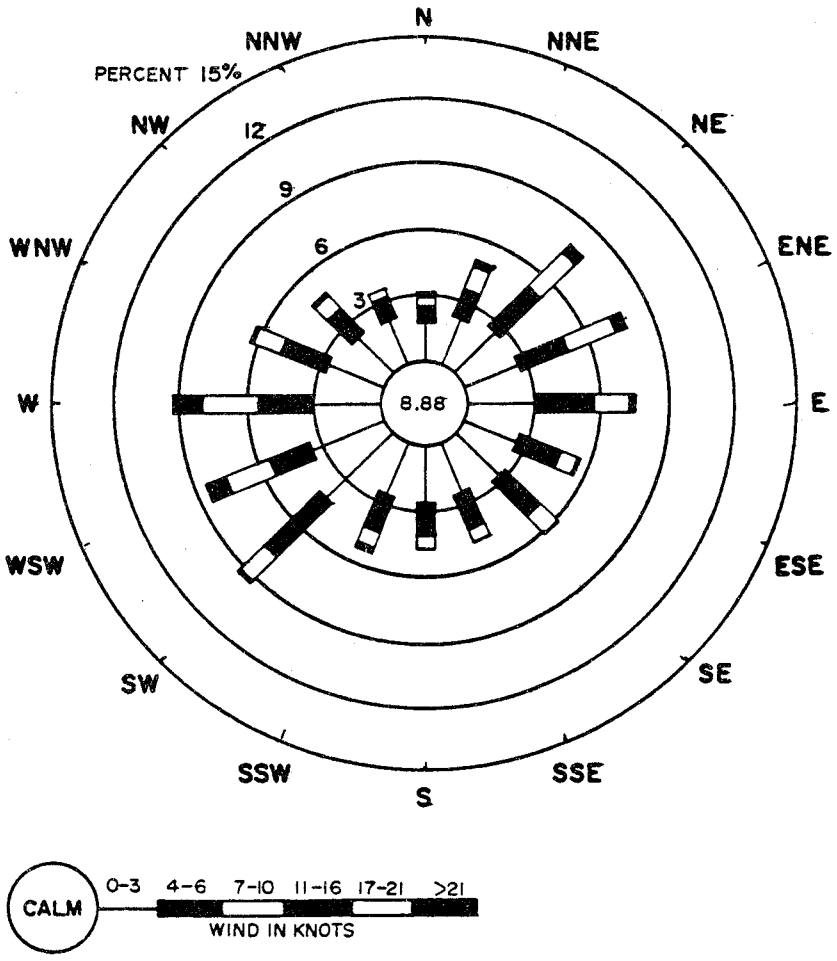

Fig. 3.5. Annual wind rose for the Westinghouse NFCS based on site-specific data collected Aug. 1, 1972, through July 31, 1973. *Source:* Westinghouse 1983, Fig. 3-6.

population of 269,735 (DOC 1983). Approximately 87.1% of the county's population resides in urban areas. An estimate of the 1980 population within 80 km (50 miles) of the plant is given in Table 3.4 for each of the 160 segments defined by 16 radial (compass) directions and 10 radial distances. The 1980 population in each circular zone (annulus) is represented as totals in Table 3.4. The total population within 80 km (50 miles) of the site is 783,181. During work and school hours (daytime) approximately 2,200 individuals are transient within an 8-km (5-mile) radius of the plant site (Westinghouse 1983). The nearest resident to the plant is located about 1 km (0.6 mile) northeast of the center of the manufacturing building.

Total Westinghouse NFCS employment ranges between 800 to 1000 employees (R. E. Fischer, Westinghouse, personal communication with A. W. Reed, Oak Ridge National Laboratory, September 19, 1984) working over three shifts. Plant employment represents 0.9% of 1980 Richland County total employment (116,637) (DOC 1983), which is not a significant fraction of the employment in Richland County. County employment is roughly distributed as follows: 13.1%

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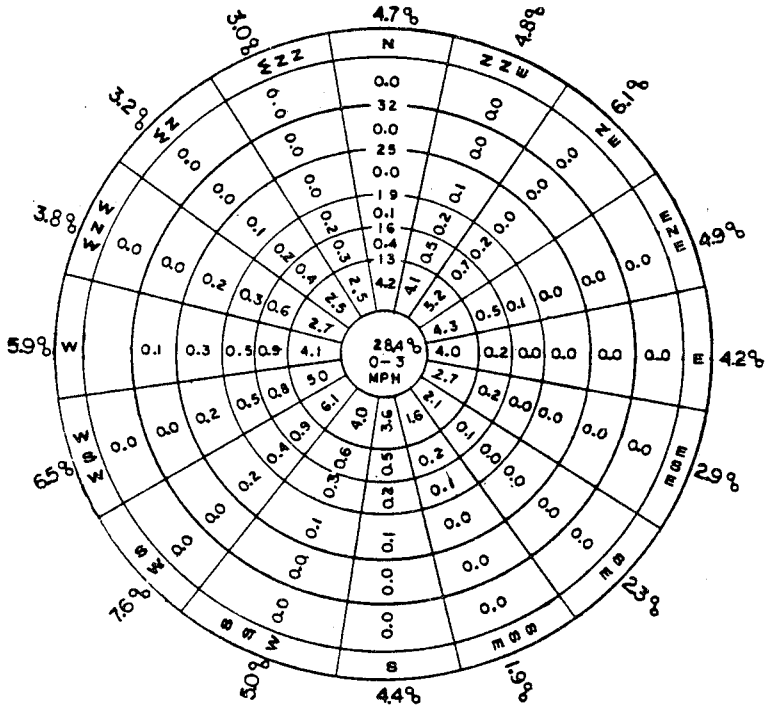

Fig. 3.6. Average annual wind rose for the Columbia Metropolitan Airport based on National Oceanic and Atmospheric Administration data, 1948–1981. Units are mph. Convert to km/h by multiplying by 1.61. *Source:* Westinghouse 1983, Fig. 3.7.

manufacturing; 19.5% wholesale and retail trade; 28.0% professional and related services; 31.5% government (Columbia is the state capital); and 4.5% self-employed (DOC 1983).

3.4 LAND

The following sections describe characteristics of local land use that are important in the environmental assessment of the NFCS operation and/or expansion. Here, the staff describes the distribution and nature of agriculture, the important historic and prehistoric landmarks, and the distribution of undeveloped nonagricultural land in a study area within 8 km (5 miles) of NFCS.

3.4.1 Site Area

The location of the Westinghouse facilities and various land uses on the 469-ha (1158-acre) site are shown in Fig. 3.4. The facilities are centrally located on the site and lie about 550 m (1800 ft) from Bluff Road (South Carolina Route 48). The developed area (buildings, parking lots, and associated facilities) occupies about 24 ha (60 acres) or 5% of the site property. Undeveloped areas are occupied primarily by roughly equal areas of cultivated fields and forest. A large grassy field, which lies between the facilities and Bluff Road, and Sunset Lake occupy the remainder of the site. Approximately 20 ha (50 acres) of the grassy field are cut for hay, which is fed to a herd of about 150 dairy cows belonging to the McGregor's Dairy, Hopkins, South Carolina (Westinghouse

Table 3.2. Annual average atmospheric dispersion factors (χ/Q) by distance and direction from the Westinghouse NFCS (s/m^3)

Direction from NFCS	Distance (miles)					
	0.5	1.0	2.0	3.0	4.0	5.0
N	0.693×10^{-5}	0.212×10^{-5}	0.704×10^{-6}	0.380×10^{-6}	0.247×10^{-6}	0.178×10^{-6}
NNE	0.749×10^{-5}	0.228×10^{-5}	0.759×10^{-6}	0.410×10^{-6}	0.267×10^{-6}	0.193×10^{-6}
NE	0.113×10^{-4}	0.345×10^{-5}	0.115×10^{-5}	0.626×10^{-6}	0.409×10^{-6}	0.296×10^{-6}
ENE	0.881×10^{-5}	0.270×10^{-5}	0.901×10^{-6}	0.489×10^{-6}	0.319×10^{-6}	0.231×10^{-6}
E	0.123×10^{-4}	0.379×10^{-5}	0.127×10^{-5}	0.692×10^{-6}	0.452×10^{-6}	0.327×10^{-6}
ESE	0.962×10^{-5}	0.295×10^{-5}	0.988×10^{-6}	0.536×10^{-6}	0.350×10^{-6}	0.253×10^{-6}
SE	0.725×10^{-5}	0.223×10^{-5}	0.745×10^{-6}	0.404×10^{-6}	0.263×10^{-6}	0.190×10^{-6}
SSE	0.641×10^{-5}	0.197×10^{-5}	0.661×10^{-6}	0.359×10^{-6}	0.234×10^{-6}	0.169×10^{-6}
S	0.584×10^{-5}	0.179×10^{-5}	0.602×10^{-6}	0.327×10^{-6}	0.214×10^{-6}	0.155×10^{-6}
SSW	0.750×10^{-5}	0.230×10^{-5}	0.771×10^{-6}	0.418×10^{-6}	0.273×10^{-6}	0.197×10^{-6}
SW	0.104×10^{-4}	0.320×10^{-5}	0.107×10^{-5}	0.583×10^{-6}	0.381×10^{-6}	0.275×10^{-6}
WSW	0.110×10^{-4}	0.337×10^{-5}	0.114×10^{-5}	0.419×10^{-6}	0.406×10^{-6}	0.294×10^{-6}
W	0.126×10^{-4}	0.387×10^{-5}	0.130×10^{-5}	0.711×10^{-6}	0.466×10^{-6}	0.339×10^{-6}
WNW	0.102×10^{-4}	0.313×10^{-5}	0.105×10^{-5}	0.575×10^{-6}	0.377×10^{-6}	0.274×10^{-6}
NW	0.959×10^{-5}	0.295×10^{-5}	0.989×10^{-6}	0.537×10^{-6}	0.350×10^{-6}	0.253×10^{-6}
NNW	0.785×10^{-5}	0.241×10^{-5}	0.808×10^{-6}	0.437×10^{-6}	0.285×10^{-6}	0.205×10^{-6}

Table 3.2. (continued)

Direction from NFCS	Distance (miles)				
	10.0	20.0	30.0	40.0	50.0
N	0.671×10^{-7}	0.271×10^{-7}	0.161×10^{-7}	0.112×10^{-7}	0.845×10^{-8}
NNE	0.729×10^{-7}	0.296×10^{-7}	0.177×10^{-7}	0.123×10^{-7}	0.932×10^{-8}
NE	0.113×10^{-6}	0.460×10^{-7}	0.276×10^{-7}	0.192×10^{-7}	0.145×10^{-7}
ENE	0.876×10^{-7}	0.353×10^{-7}	0.209×10^{-7}	0.145×10^{-7}	0.109×10^{-7}
E	0.125×10^{-6}	0.515×10^{-7}	0.311×10^{-7}	0.217×10^{-7}	0.165×10^{-7}
ESE	0.965×10^{-7}	0.393×10^{-7}	0.236×10^{-7}	0.164×10^{-7}	0.124×10^{-7}
SE	0.722×10^{-7}	0.292×10^{-7}	0.175×10^{-7}	0.121×10^{-7}	0.915×10^{-8}
SSE	0.643×10^{-7}	0.262×10^{-7}	0.157×10^{-7}	0.109×10^{-7}	0.826×10^{-8}
S	0.590×10^{-7}	0.241×10^{-7}	0.145×10^{-7}	0.101×10^{-7}	0.766×10^{-8}
SSW	0.750×10^{-7}	0.306×10^{-7}	0.183×10^{-7}	0.128×10^{-7}	0.965×10^{-8}
SW	0.105×10^{-6}	0.429×10^{-7}	0.258×10^{-7}	0.180×10^{-7}	0.136×10^{-7}
WSW	0.113×10^{-6}	0.469×10^{-7}	0.284×10^{-7}	0.199×10^{-7}	0.151×10^{-7}
W	0.130×10^{-6}	0.540×10^{-7}	0.327×10^{-7}	0.229×10^{-7}	0.174×10^{-7}
WNW	0.106×10^{-6}	0.436×10^{-7}	0.263×10^{-7}	0.184×10^{-7}	0.139×10^{-7}
NW	0.963×10^{-7}	0.392×10^{-7}	0.235×10^{-7}	0.164×10^{-7}	0.124×10^{-7}
NNW	0.774×10^{-7}	0.313×10^{-7}	0.187×10^{-7}	0.130×10^{-7}	0.977×10^{-8}

Source: NRC 1980.

Table 3.3. Ambient air quality standards for South Carolina

Pollutant	Measuring interval	Standard[a,b] ($\mu g/m^3$)
Sulfur dioxide	3 h	1,300[c]
	24 h	365[c]
	Annual	80
Suspended particulates	24 h	250
	Annual G.M.[d]	60
Carbon monoxide	1 h	40,000
	8 h	10,000
Ozone	1 h	235[e]
Non-methane hydrocarbons	3 h	160
Gaseous fluorides (as HF)	12-h av.	3.7
	24-h av.	2.9
	1-week av.	1.6
	1-month av.	0.8
Nitrogen dioxide	Annual	100
Lead	Calendar quarterly mean	1.5

[a]Arithmetic average except in the case of suspended particulates.
[b]At 25°C and 760 mm Hg.
[c]Not to be exceeded more than once a year.
[d]Geometric mean.
[e]Not to be exceeded more than one day per year.
Source: "State Air Laws," *Environ. Rep.* **506**, 1004, June 29, 1984.

1984). At the time of the staff site visit (September 19, 1984), the cultivated lands consisted of soybeans and recently plowed fields. Soybeans, the principal crop, are grown on about 182 ha (450 acres) on the site and are transported to Cameron, South Carolina, where they are processed into soya oil and feed meal (Westinghouse 1984).

3.4.2 Adjacent Area

The nature, extent, and distribution of local land uses are important in the environmental assessment of NFCS operations and/or expansion. The primary interaction to evaluate is that of NFCS radiological and chemical atmospheric effluents with local human and biological populations, and with farming and manufacturing activities. Interactions involving water supplies to these populations and activities are of equal importance and are treated elsewhere (Sects. 3.5 and 3.7) in this assessment.

Approximately 5% of the land within 8 km (5 miles) of NFCS is residential, less than 1% (exclusive of NFCS) is industrial, and about 20% is agricultural. Seventy percent of the land is uninhabited forest or swamp forest (Westinghouse 1983).

Table 3.4. Incremental 1980 population estimates by sectors within 80 km (50 miles) of the Westinghouse NFCS

Sector	Miles[a,b]									
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
N	11	87	19	22	255	11,738	68,207	5,442	4,371	6,300
NNE	0	0	114	53	56	3,340	6,962	5,062	9,882	5,413
NE	0	0	122	448	128	1,062	1,065	1,577	11,977	8,093
ENE	0	0	160	266	213	2,090	1,549	16,363	9,846	12,856
E	8	46	110	156	224	924	1,719	3,577	44,962	8,387
ESE	0	30	91	141	160	530	913	1,783	5,273	9,886
SE	0	0	27	34	53	426	1,572	3,355	5,022	13,905
SSE	0	0	0	0	4	281	1,648	22,571	4,587	13,621
S	0	0	4	0	8	315	1,153	17,759	4,511	5,893
SSW	0	0	0	0	0	674	1,159	4,158	7,410	15,291
SW	0	0	0	0	0	680	2,722	3,727	3,631	8,259
WSW	0	0	0	0	0	1,550	1,794	3,383	1,955	39,096
W	0	0	0	0	0	2,788	2,918	3,565	13,445	11,580
WNW	0	0	0	8	4	2,464	6,488	9,862	5,228	8,230
NW	0	0	8	11	2,386	6,268	65,703	7,194	5,239	20,759
WNW	0	76	57	8	47	17,673	111,972	4,010	5,396	3,543
Total	19	239	712	1,147	3,538	5,2803	277,544	113,388	142,646	191,141
Total, 0-50 miles = 783,181										

[a]Estimates for 0-5 miles based on data given in Westinghouse (1983); estimates for 5-50 miles based on 1980 U.S. Bureau of Census data.

[b]Kilometers = miles × 1.6.

3.4.2.1 Manufacturing

Except for the Carolina Eastman plant, which lies 7.6 km (4.75 miles) directly west of NFCS, all firms with five or more employees are within the 180° sector north of the plant site. Those facilities with potentially significant atmospheric or aquatic effluent loads with which the NFCS effluents could interact include the Carolina Eastman plant (man-made production fibers), Wallace Concrete Products (manhole production), and Square D Company (industrial motor control production).

3.4.2.2 Agriculture

Agricultural land occupies about 20% of the land area within an 8-km (5-mile) radius of NFCS, primarily in the northern and eastern portions of the study area. Crops include soybeans, corn, hay, cotton, wheat, and oats. Pecan groves are present to the east.

Only one dairy farm is operating within the study area: McGregor's Dairy, 7.7 km (4.8 miles) north-northeast of NFCS. According to Westinghouse (1983), this dairy has about 150 milk cows. No other important crop or livestock production appears to occur in the study area. Subsequent to the previous NRC review for license renewal (NRC 1977), the Power's Dairy ceased operations. It was located 3.5 km (2.2 miles) northwest of NFCS. The light agricultural production in the area is an advantage of the Columbia site.

3.4.2.3 Undeveloped nonagricultural land

The applicant has reported that 70% of the land in the study area is covered by forest or swamp forest (Westinghouse 1983). Extensive forests and swamps lie along the Congaree River west and south of the plant. Water tupelo-sweet gum forests occur in swamps and on wet alluvial substrates along the Congaree River. A more mesic oak forest dominates the better-drained sites, whereas the driest sites in the area may be dominated by loblolly pine and hardwoods (oak species, red maple, yellow poplar, etc.). Presently, there are no important logging activities in the forests on the site (Westinghouse 1983, Sect. 3.3.1.3). The distribution of vegetation types is discussed in Sect. 2.8.1.

The Congaree River Swamp, an 8,500-ha (21,000-acre) forested swamp lying along the Congaree River about 6.5 km (4 miles) southeast of the site (Fig. 3.3), is listed as a natural landmark (DOI 1983). This area has been largely undisturbed for 200 years and contains several of the largest trees of certain species (Dennis 1967; Westinghouse 1983). It is a rare remnant of previously extensive southern river floodplain forests.

3.4.3 Historic Significance

Several known archaeological sites are located within 8 km (5 miles) of the NFCS, although none are located onsite (N. Brock, South Carolina Department of Archives and History, personal communication with R. L. Kroodsma, ORNL, January 17, 1985). Undiscovered, undisturbed sites probably do not exist in the expansion area at the plant facilities, because the development substrate was disturbed during original construction.

Other historical and cultural sites occur within the 8-km radius, although none are recognized by the National Register of Historic Places (DOI 1979-1983). According to correspondence from the South Carolina Department of Archives and History (Westinghouse 1983), the following historical

sites, listed in the Central Midlands Survey of 1974, are potentially eligible for the National Register but are not presently of high priority for nomination. All sites are within an 8-km (5-mile) radius of the plant.

1. Raiford's Mill Creek (Mill Creek)—18th century

   The first settlements in the county were made along Mill Creek in the 1740s. Hopewell Ferry, across the Congaree River below the creek's mouth, was used in 1756 and throughout the Revolution. The creek was named for Philip Raiford, who settled on the creek below Adams' Mill Pond. The creek was later called Hays' Creek for William Hays, who built a mill there in 1748-1750. It was known by 1800 simply as Mill Creek.

2. Cabin Branch (John Hopkins, Jr., Plantation House)—1796

   This building is off County Road 1159, 0.4 km (0.25 mile) south of intersection with County Road 223, near Congaree Community. The 18th century house had two large front rooms, a center hall, and an open loggia. About 1835, two large rooms were added at the rear, and the loggia was extended into a hall. It is still owned by the Hopkins.

3. Claytor House—1887

   Located on Highway 37 at Hopkins, this wooden cottage built by Dr. Hubert Claytor has a porch and fish-scale gable and is architecturally distinctive.

4. Chappell Cabin Branch (Hicks Plantation House and Garden)—1781

   This two-story rectangular frame house with a single-story front porch is located on a dirt road off County Road 37, 0.8 km (0.5 mile) south of Hopkins. There have been recent alterations. A garden with original plantings remains, and the house is still occupied by the Chappell family.

5. Hopkins Overseers Dwelling—19th century

   The dwelling is located in the Hopkins Community on County Road 37, 0.4 km (0.25 mile) south of the intersection of County Roads 37 and 55. The center section is a pedimented frame cottage. The Hopkins family cemetery is nearby.

3.4.4 Floodplains and Wetlands

Extensive floodplains and wetlands lie along the Congaree River in the vicinity of the site (Figs. 3.3 and 3.4). The elevation of the flood limit, according to U.S. Army Corps of Engineers maps, is 39.6 m (130 ft) above MSL. Slightly more than half of the site lies below this elevation in the bottomlands of the Congaree River, but the plant facilities lie mostly above 41.8 m (137 ft) (Fig. 3.4).

Most wetlands in the area consist of bottomland forests and forested swamps. Several ditches drain the cultivated fields in the bottomlands on the site, but these have little significance as natural wetlands. Sunset Lake is a shallow artificial impoundment on Mill Creek on the site. The upper 85% of the original lake is now a wooded swamp, whereas the lower part has some open water. A small pond and a canal also lie in the southern half of the site. No construction of facilities is planned in the site's floodplain or wetland areas.

3.5 HYDROLOGY

3.5.1 Surface Water

3.5.1.1 Congaree River hydrology

The closest offsite surface water body to the NFCS is the Congaree River (Fig. 3.7), which is formed by the confluence of the Broad and Saluda rivers 16 km (10 miles) upstream at Columbia, South Carolina. Tributaries to the river in the plant vicinity are Gills Creek at Columbia; Mill Creek, adjacent to the Westinghouse site; and Beaver and Cedar creeks near Hopkins. Mill Creek flows through an impoundment, Sunset Lake, on the NFCS property before reaching the Congaree River (Figs. 3.4 and 3.7).

In the NFCS vicinity, the Congaree River, which is a typical South Atlantic Piedmont stream, is characterized by sandy bottoms and beaches and high levels of suspended solids. The flow of the river is regulated by Lake Murray and Lake Greenwood on the Saluda River, and to some extent by power plants along the Broad River (USGS 1981). At the point of the NFCS discharge, the Congaree River is approximately 150 m (500 ft) wide and no more than 3 m (9 ft) deep (Westinghouse 1983).

The average flow of the Congaree River at the USGS gaging station at Columbia was 266 m^3/s (9388 cfs) for the period of 1939 to 1981 (USGS 1981). The 7-d, 10-year low flow that could occur would be 45 m^3/s (1590 cfs) (NRC 1977, Sect. 2.5.2.1); the minimum daily flow for the period 1939 to 1981 was 19 m^3/s (662 cfs). The lowest flows occur during the late summer months.

Since the beginning of stage and discharge measurements at Columbia in 1892, the highest stage of record was 12 m (39.8 ft) with a discharge of 1.0×10^4 m^3/s (3.6×10^5 cfs) on August 27, 1908 (USGS 1981). After impoundment of the Saluda River with Lake Greenwood and Lake Murray, the maximum stage of 10 m (33 ft) and discharge of 6500 m^3/s (2.3×10^5 cfs) occurred on April 19, 1964 (USGS 1981). The NFCS plant is located approximately 4 m (12 ft) above the maximum stage reached by the 1908 flood waters (Westinghouse 1983, Sect. 3.5.2.1). According to the U.S. Army Corps of Engineers' flood-line map, the line separating flood-prone areas from higher land areas is at 39.6 m (130 ft) above MSL in the vicinity of the NFCS; the manufacturing plant is 43 m (140 ft) above MSL (Westinghouse 1983, Sect. 3.5.2.1).

Flow from Mill Creek and its associated impoundment, Sunset Lake, which is on the NFCS property, enters the Congaree River about 5 km (3 miles) downstream of the Westinghouse plant's discharge point. Sunset Lake, an artificial impoundment about 0.4 km (0.25 mile) south of the NFCS plant, is divided by a small dam into upper and lower lakes. The upper lake covers an area of 1.9×10^5 m^2 (44 acres) and is primarily a swamp because part of the flow from Mill Creek is diverted into a canal (Westinghouse 1983, Sect. 3.5.2.2). The lower part of Sunset Lake covers approximately 3.2×10^4 m^2 (8 acres) and has an open-water area (see Sect. 3.7.2). The flow from Mill Creek is into upper Sunset Lake and the canal, from upper Sunset Lake through a causeway to lower Sunset Lake, and over a dam at the south end of the lower lake to the Congaree River.

3.5.1.2 Congaree River water quality

Water quality data for the Congaree River in the vicinity of the Westinghouse plant were compiled from SC-DHEC data for 1981 (Table 3.5). Discussions with the SC-DHEC staff confirmed

ES-6130

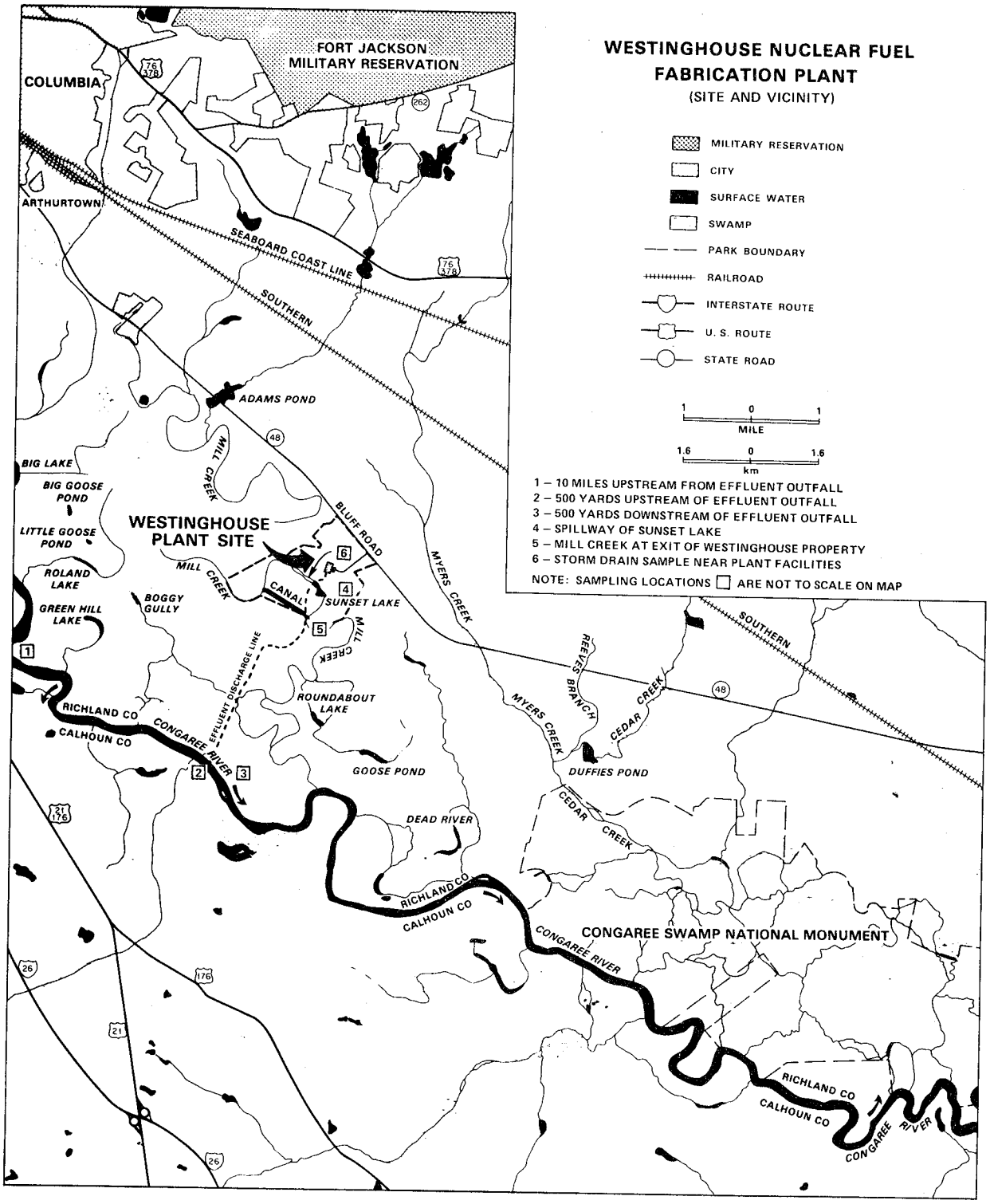

Fig. 3.7. Locations of surface water monitoring stations at the Westinghouse NFCS. *Source:* Westinghouse 1983, Fig. 6.2.

Table 3.5. Congaree River annual (1981) water quality averages upstream and downstream of the NFCS discharge (outfall)[a]

Constituent[b]	Blossom St. Bridge[c] (upstream)	U.S. 601 Bridge[d] (downstream)
Temperature, °C	16	16.8
Turbidity, JTU	14	14.1
Conductivity, μmhos	68	70
Dissolved oxygen, mg/L	10.1	8.1
BOD_5, mg/L	3.4	3.9
pH, units	7.1	6.8
Total alkalinity, mg/L	16	17
$NH_3 + NH_4$, mg/L	0.53	0.095
$NO_2 + NO_3$, mg/L	0.34	0.042
Phosphates, mg/L	0.13	0.32
Total organic carbon, mg/L	4.3	5.1
Cadmium, μg/L	<10	<10
Chromium, μg/L	50	<50
Copper, μg/L	<50	<50
Iron, μg/L	787	1300
Nickel, μg/L	<50	<50
Lead, μg/L	55	<50
Mercury, μg/L	0.2	0.3
Fecal coliform, per 100 mL	249	1490

[a]Compiled from South Carolina Department of Health and Environmental Control Data and reported in Westinghouse 1983, Tables 3.11 and 3.12.

[b]JTU = Jackson turbidity units.

BOD = biological oxygen demand.

[c]Sampling location is 16 km (10 miles) upstream of Westinghouse outfall.

[d]Sampling station is 40 km (25 miles) downstream of Westinghouse outfall.

that these values are typical of present water quality (Russell Sherer, SC-DHEC, personal communication with V. R. Tolbert, Oak Ridge National Laboratory, October 15, 1984). Comparison of the upstream and downstream stations (Table 3.5) shows that, except for concentrations of iron and fecal coliform bacteria, there are no appreciable differences in water quality parameters. Increased fecal coliform counts and phosphate and decreased dissolved oxygen at the downstream station are indicative of agricultural runoff and of sewage discharges to the river from the communities of Columbia, West Columbia, and Cayce.

The Congaree River receives discharges directly from Columbia, West Columbia, Cayce, and the Westinghouse plant. Municipal wastewater from Columbia is treated by trickle filtration and activated-sludge processing at a metropolitan area wastewater treatment plant before discharging at an average of 1.2 m^3/s (42 cfs). Peak sewage discharge from the city of Columbia is 2.6 m^3/s (93 cfs) (Westinghouse 1983, Sect. 3.5.3.2). The combined sewage discharge from Cayce and

West Columbia to the Congaree River is 0.08 m^3/s (3 cfs). The NFCS currently discharges 0.006 m^3/s (0.2 cfs) of treated process and sanitary wastes to the river (R. E. Fischer, Westinghouse, personal communication with V. R. Tolbert, Oak Ridge National Laboratory, September 19, 1984). The only other industrial discharge to the Congaree River in the NFCS vicinity is from Carolina Eastman, which discharges 1.4 m^3/s (49 cfs) of cooling tower water into the Congaree River upstream of the NFCS via Hale's Branch (Westinghouse 1983, Sect. 3.5.3.2).

3.5.1.3 Local surface water use

The city of Columbia diverts 1.5 m^3/s (54 cfs) of water from the Broad River upstream of Columbia for municipal use (USGS 1981). There are no industrial or municipal users along the Congaree River from the confluence of the Saluda and Broad rivers to the Congaree's confluence with the Wateree River to form the Santee River approximately 97 km (60 miles) downstream of the NFCS. Water used by the Westinghouse plant is obtained from the Columbia Municipal Water System. Water use by the plant during the period of January to August 1984 was 0.008 m^3/s (0.3 cfs) (R. E. Fischer, Westinghouse, personal communication with V. R. Tolbert, Oak Ridge National Laboratory, September 19, 1984).

3.5.2 Groundwater

3.5.2.1 Groundwater regime

The aquifer system in the vicinity of the NFCS has two components: (1) a shallow, unconfined aquifer that is capable of producing relatively small quantities of water from individual wells for rural, domestic use; and (2) deeper, confined aquifers that are capable of providing large quantities of water for industrial and municipal supplies (SCWRC 1983). The unconfined aquifer consists of surficial marine terrace deposits of Pliocene-Pleistocene age, whereas the upper Cretaceous Tuscaloosa formation is the principal confined aquifer at NFCS. The stratigraphy of these and other units is discussed in detail in Sect. 3.6.1.

Presently, groundwater in the shallow aquifer is contaminated by waste streams from plant discharge (Davis and Floyd 1982). However, the quality of Tuscaloosa groundwater beneath the contaminated zone is unknown. Groundwater quality is discussed in detail in Sect. 3.5.2.2.

The shallow and deep aquifers are separated by a 10-20-m-thick (30-60-ft) aquitard identified as the Black Mingo formation by Davis and Floyd (1982). This aquitard appears to be thick enough and sufficiently low in permeability ($<10^{-7}$ cm/s) to prevent more than insignificant natural hydraulic communication between the surficial and confined aquifers.

Several meters of sand are believed to be present in the lowermost (basal) part of the Black Mingo (Davis and Floyd 1982). Although this sand is described by Davis and Floyd as a separate artesian aquifer, it is unclear whether there is a hydraulic boundary between this sand and the uppermost Tuscaloosa aquifer. The two units may behave as a single combined aquifer.

It is possible to have hydraulic communication between deep confined aquifers and shallow terrace aquifers through poorly completed or abandoned wells that fully penetrate the confining strata. Davis and Floyd (1982) have identified two NFCS wells (W-1 and W-2, respectively, Fig. 3.8) adjacent to and immediately north of the main plant that penetrate into an artesian aquifer. These are older wells with uncertain completion records. Well W-1 is definitely a Tuscaloosa well. A third well [designated 30Q-6 by the South Carolina Water Resources

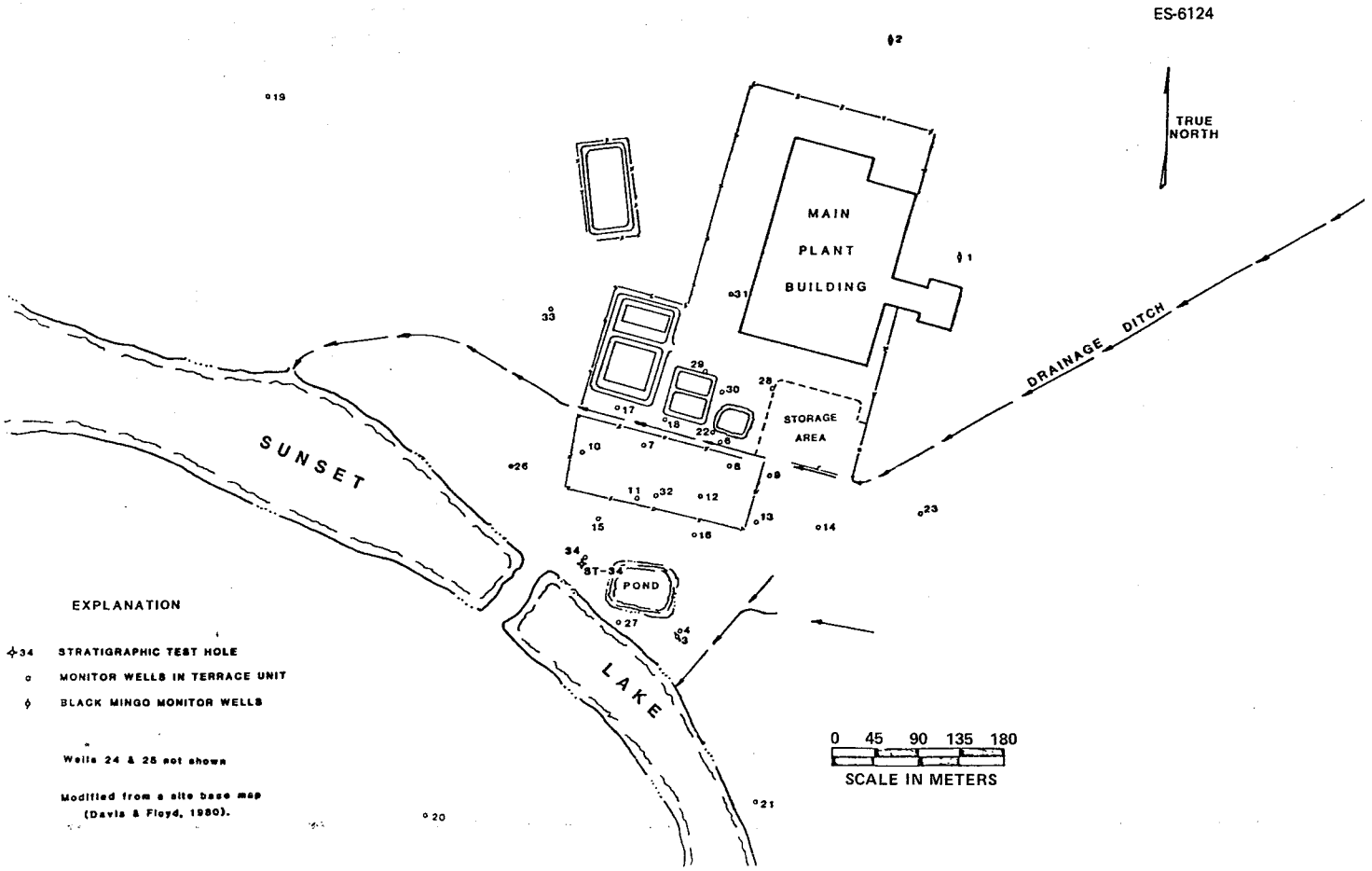

Fig. 3.8. Location of monitoring wells at the Westinghouse plant site. *Source:* Davis and Floyd 1980.

Commission (SCWRC)] was drilled in 1963 in the vicinity of NFCS. This well probably also penetrated the Tuscaloosa (Davis and Floyd 1982). If these wells were properly completed and/or plugged, there should be no hydraulic communication between shallow and deeper aquifers. The uncertain completion status of these wells, however, prevents a definitive answer to the question of existing hydraulic communication between deeper artesian and shallow terrace aquifers.

Piezometric head data for the Tuscaloosa aquifer adds another element of uncertainty in the vicinity of NFCS. Davis and Floyd (1982) state that the piezometric head in Wells W-1, W-2, and W-3 (another deep well in the overlying Black Mingo formation) rises 5 to 6 m (15 to 20 ft) above the top of the basal Black Mingo sand, and that the piezometric surface for this unit slopes to the southeast. It is likely, however, that the piezometric heads in the basal sand of the Black Mingo are strongly influenced at NFCS by the underlying Tuscaloosa aquifer. According to Davis and Floyd (1982), Tuscaloosa aquifers have higher artesian pressures than Black Mingo aquifers. Considerable upward vertical leakage probably occurs through thin confining strata (it is not certain that confining strata lie between the Black Mingo and Tuscaloosa aquifers at NFCS) and through Well W-1, which is an open-hole completion in the Tuscaloosa.

Hydraulic communication between shallow terrace and deeper confining aquifers would be immaterial if the piezometric head of the latter were greater than that of the former. A high peizometric head in the Tuscaloosa would create an upward flow toward the shallow aquifer, thus preventing the downward flow of contaminants.

The piezometric surface of the shallow aquifer is well known. Figure 3.9 is a contour map of the piezometric surface (Davis and Floyd 1982). This surface slopes southward through the main plant area toward Sunset Lake where it intersects the surface. It is evident from these data that shallow groundwater discharges into Sunset Lake.

3.5.2.2 Groundwater quality

Table 3.6 is an analysis of water quality from the surficial aquifer northeast of the plant (up the groundwater gradient at Well W-24, located near the intersection of the plant entrance and Bluff Road). As expected, there is no evidence of NFCS contaminants from the Westinghouse facility. Ammonia and fluoride were below detectable limits, total dissolved solids (TDS) was 50 mg/L, and the pH (6.0) was slightly acidic.

In mid-April 1980, a fish kill occurred in the small man-made pond located onsite south of the Westinghouse facilities (Fig. 3.8). It was determined that the kill probably resulted from elevated concentrations of fluoride and ammonia nitrogen present in the pond, and that these contaminants were being discharged to the pond from a nearby spring located downgradient from the Westinghouse wastewater treatment plant. Since the kill, several groundwater quality investigations were conducted at NFCS, and two sources of contamination were identified: the concentrated waste treatment tanks and the ammonia storage tank area. In addition, the waste treatment ponds may have been a source of groundwater contamination in previous years (Davis and Floyd 1982).

Table 3.7 presents water quality data from the surficial aquifer immediately downgradient from the sludge ponds toward Sunset Lake (Well W-7). This well generally has the greatest amount of contamination of all wells monitored at the site. High levels of NFCS source contaminants, 49 and 602 mg/L of fluoride and ammonia, respectively, were reported. Furthermore, the TDS was an order of magnitude greater concentration (642 mg/L) than at the upgradient well location (Well W-24), and the pH (9.4) was strongly alkaline. Apparently, the above analyses were obtained in 1981 or 1982 (Westinghouse 1983).

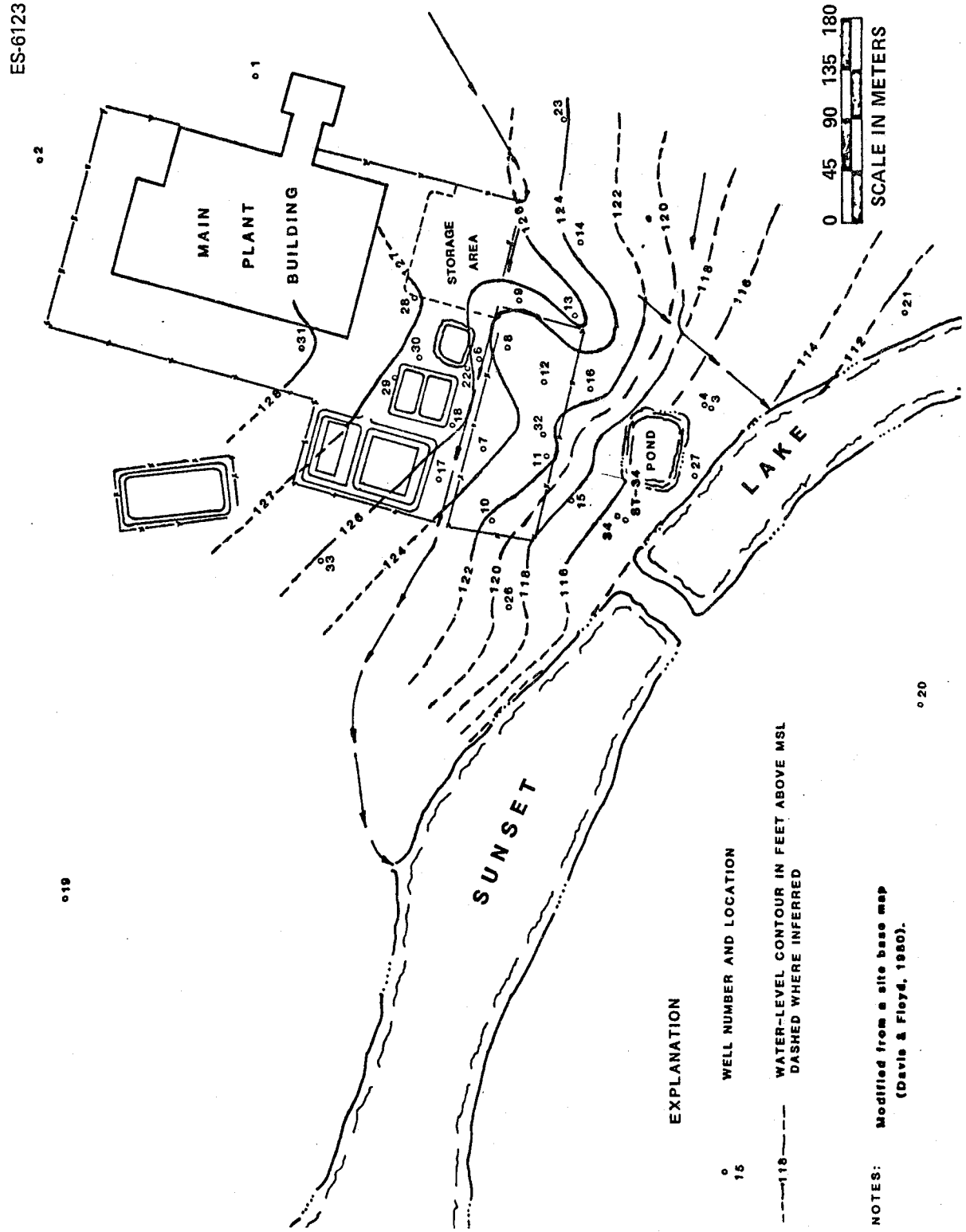

Fig. 3.9. Water table elevation, terrace unit, on Nov. 15, 1981, at the Westinghouse plant site. *Source:* Davis and Floyd 1980.

Table 3.6. Analysis of groundwater in the near-surface aquifer northeast of the Westinghouse NFCS (Well W-24)[a]

Parameter	mg/L, or as indicated
Arsenic	<0.005
Barium	<0.1
Cadmium	<0.005
Chromium	<0.01
Fluoride	<1.0
Lead	<0.05
Mercury, μg/L	<0.2
Nitrate nitrogen	0.7
Ammonia nitrogen	<1
Selenium	<0.01
Silver	<0.01
Turbidity	1.7
Chloride	2.0
Hydrogen sulfide	<0.01
Copper	<0.01
Iron	0.04
Manganese	0.018
Sulfate	18
Dissolved solids	50
Zinc	0.042
Color	5
pH, units	6.0
Surfactants (MBAS[b])	0.47
Nickel	<0.01
Conductance, mhos	180

[a]Well W-24 is located upgradient, near the intersection of the plant entrance and Bluff Road.

[b]MBAS = Methylene blue active substances (detergents).

Source: Westinghouse 1983, Table 3.9.

Because Westinghouse has not sampled most of the onsite wells on a routine basis, only sporadic results are available. Table 3.8 provides the most recent data (May 1984) for nonradiological contaminants (Westinghouse 1984). These data, which are typical of other sampling times, indicate that conditions remain much as they were in 1981-82. Furthermore, nearly all shallow wells located downgradient between the sludge ponds and Sunset Lake showed various levels of contamination, ranging from about 5 to nearly 100 mg/L fluoride and 5 to 445 mg/L ammonia. Table 3.9 shows the most currently available results (April 1983) for radiological parameters in the onsite groundwater. At the time of that sampling, the greatest radioactive contamination was found in Well W-30 (204 ρCi/L gross alpha and 320 ρCi/L gross beta) and Well W-7 (88 ρCi/L gross alpha and 914 ρCi/L gross beta). The other wells generally had much

Table 3.7. Analysis of groundwater in the near-surface aquifer southeast of the Westinghouse NFCS (Well W-7)[a]

Parameter	mg/L, or as indicated
Arsenic	<0.005
Barium	0.1
Cadmium	<0.005
Chromium	<0.01
Fluoride	49
Lead	<0.05
Mercury, μg/L	<0.2
Nitrate nitrogen	310
Ammonia nitrogen	602
Selenium	<0.01
Silver	<0.01
Turbidity	1.2
Chloride	20
Hydrogen sulfide	<0.01
Copper	<0.01
Iron	0.04
Manganese	<0.005
Sulfate	125
Dissolved solids	642
Zinc	0.021
Color	25
pH, units	9.4
Surfactants (MBAS[b])	0.54
Nickel	0.02
Conductance, mhos	2,950

[a]Well location is shown on Fig. 3.8.

[b]MBAS = Methylene blue active substances (detergents).

Source: Westinghouse 1983, Table 3.10.

lower concentrations of radioactivity. As shown in Tables 3.8 and 3.9, upgradient wells were generally free of contaminants (both radiological and nonradiological) except when immediately adjacent to the ponds. An analysis of the impacts of this groundwater contamination is presented in Sect. 4.2.3.2.

Background groundwater quality in shallow terrace aquifers is described by the SCWRC (1983) in only general terms. According to SCWRC, shallow groundwater may be high in iron, sulfate, or nitrate but is generally soft. Except for the information provided by NFCS for the onsite wells, groundwater quality of nearby privately owned shallow wells is undocumented.

Although water quality in the Tuscaloosa aquifer is generally good in Richland and surrounding counties (SCWRC 1983), data for the NFCS vicinity are sparse. Two deep wells (W-1 and W-2 on

Table 3.8. Special water quality analysis report for monitoring wells at the Westinghouse NFCS, May 27, 1984[a]

Well number	pH (units)	F^- (mg/L)	NH_3 (mg/L)	Conductivity (mhos)
3	6.6	1.8	1.8	700
4	6.2	2.2	1	100
6	6.2	2.0	1	42
7	9.2	91.0	445	2900
8	7.0	2.3	20	460
9	5.6	2.3	1	250
10	6.3	11.5	14	410
11	6.0	31.9	5.5	100
12	6.5	2.1	1.5	61
13	6.7	2.2	13	330
14	5.9	2.2	1	59
15	6.7	6.5	34	600
16	7.0	2.3	38	61
17	5.8	2.8	1	420
18	7.1	26	45	870
19	5.5	1.9	1	120
20	6.2	2.0	115	140
21	5.6	1.4	1	138
22	7.5	23	56	1300
24	5.8	2.0	1	56
25	6.4	2.4	1	121
26	6.3	2.4	29	620
27	6.3	2.1	2.5	390
28	6.0	34	4.2	350
29	8.9	23	116	1420
30	7.8	22	1.2	2100
31	6.7	2.3	5.4	190
32	8.8	38	188	1600
33	5.2	1.3	1	180
34	6.0	1.4	2.1	340

[a]Well locations are shown on Fig. 3.8 except for W-24, which is located upgradient, near the intersection of the plant entrance and Bluff Road (Route 48).

Source: Westinghouse 1984.

NFCS) were completed in the Tuscaloosa. Since these are the oldest onsite wells, they would probably require reconditioning or replacement before reliable Tuscaloosa piezometric or water quality data could be obtained. A third deep well (W-3) was completed in the overlying Black Mingo formation. No Tuscaloosa wells are known to have been drilled through the contaminated zone of the shallow aquifer.

Water quality data are available from two Tuscaloosa wells located about 8 km (5 miles) south of the NFCS on the Richland-Calhoun county line. These wells were completed in November 1975

Table 3.9. Special radiological water quality analysis report for monitoring wells at the Westinghouse NFCS, April 15, 1983[a]

Well number	Gross alpha (pCi/mL)	Gross beta (pCi/mL)
6	0.033	0.020
7	0.088	0.914
8	0.045	0.073
9	0.004	0.010
11	0.041	0.233
12	0.015	0.014
13	0.003	0.011
14	0.000	0.005
15	0.017	0.240
16	0.009	0.053
17	0.000	0.027
18	0.033	0.212
19	0.004	0.006
21	0.000	0.002
22	0.014	0.199
23	0.002	0.004
24	0.000	0.000
26	0.002	0.026
27	0.002	0.003
28	0.002	0.006
29	0.036	0.043
30	0.204	0.320
32	0.004	0.044
33	0.016	0.013

[a]Well locations are shown in Fig. 3.8, except for W-24, which is located upgradient, near the intersection of the plant entrance and Bluff Road (Route 48).

Source: Westinghouse 1984.

and in November 1976 for Tee Pac, Inc., of Sandy Run, South Carolina. These wells (29R-f1 and 29R-f2) (SCWRC 1984) were multiply screened in the Tuscaloosa formation. Several chemical analyses were obtained between November 1975 and December 1976. At that time water quality was good, fluoride was not detectable, TDS ranged between 15 and 30 mg/L, and pH ranged between 5.1 and 6.8. No tests were conducted for ammonia (SCWRC 1984).

Another Tuscaloosa well [Well 29P-v2, owned by Laurington Dairy Farm (SCWRC 1984)] was completed in Richland County about 6 km (4 miles) north of NFCS. Water samples were drawn from this well shortly after completion (November 1956). Water quality (TDS 17 mg/L, pH 5.2, fluoride not detectable) was similar to that of the Tee Pac wells.

3.5.2.3 Groundwater use

The surficial terrace aquifer is primarily used for rural, domestic water supplies (SCWRC 1983). Wells completed in the terrace aquifer generally produce small quantities of water [<1 L/s (<20 gpm)] of marginal quality. Hence, they are seldom developed for municipal or industrial use. Terrace aquifers are a primary source of water for rural inhabitants who cannot afford to drill and maintain deeper wells.

More than 700 privately owned shallow wells lie within 8 km (5 miles) of NFCS (NRC 1977). Nearly all of these wells are located upgradient to the north and northeast. The closest downgradient wells are in Congaree Swamp National Monument Park, 6 km (4 miles) away, and near Zion Pilgrim Church, 4.5 km (3 miles) southeast of NFCS. The nearest wells to the south are across the Congaree River near Sandy Run Community, about 8 km (5 miles) from NFCS. None of the downgradient wells is likely to be effected by NFCS contaminated groundwater because of distance and the large intervening groundwater discharge area encompassing Congaree Swamp. The Congaree Swamp is, itself, an unlikely locale for shallow wells because of its general unsuitability for agriculture and human habitation.

The Tuscaloosa aquifer is a widely used industrial and municipal groundwater resource (Park 1979). Figure 3.10 illustrates regional Tuscaloosa water production by county. The Tuscaloosa in central South Carolina is described by SCWRC (1983) as a major source of high-quality groundwater, with yields up to 200 L/s (3400 gpm) from individual wells in Richland and surrounding counties. Tuscaloosa wells nearest NFCS are capable of producing 14 to 25 L/s (225 to 400 gpm). Tee Pac, Inc. [8 km (5 miles) south of NFCS], uses Tuscaloosa water for industrial purposes and Laurington Dairy Farm [6 km (4 miles) north of NFCS] uses it for livestock and irrigation (SCWRC 1984).

Long-term production from the Tuscaloosa can evidently be sustained without substantial loss in piezometric head. The Laurington Dairy Farm well has been producing water since 1956 from screened intervals ranging from 64 to 90 m (210 to 294 ft). The shut-in water level at a nearby Tuscaloosa well was 12 m (39 ft) below ground level in November 1982 (SCWRC 1984). An observation well in southern Richland County was drilled in July 1980 and screened at various intervals from 127 to 165 m (425 to 542 ft). The water level in this nonproducing well ranged from 6 to 11 m (21 to 37 ft) below ground surface from October 1980 through September 1982. The piezometric head in an observation well in nearby Sumter County was affected to some degree by nearby pumping wells. This well was screened from 155 to 191 m (508 to 625 ft), and the water level ranged from 12 to 24 m (40 to 78 ft) below ground surface from October 1981 through September 1982 (SCWRC 1984).

From the foregoing discussion it appears likely that the piezometric head in the Tuscaloosa formation is high at NFCS. The nearest wells pumping from the Tuscaloosa are 6 km (4 miles) away so that the drawdown would be trivial. Thus, the piezometric head in the Tuscaloosa is probably near that of the overlying terrace aquifers at NFCS, and any transfer of fluid between the terrace and Tuscaloosa aquifers would be minimal and subject to seasonal variation. Whether the flow is up or down is indeterminant at this time.

3.6 GEOLOGY

This section describes regional and site physiography, stratigraphy, structure, soils, mineral resources, and seismicity. These characteristics relate directly to foundation stability and impact on groundwater resources.

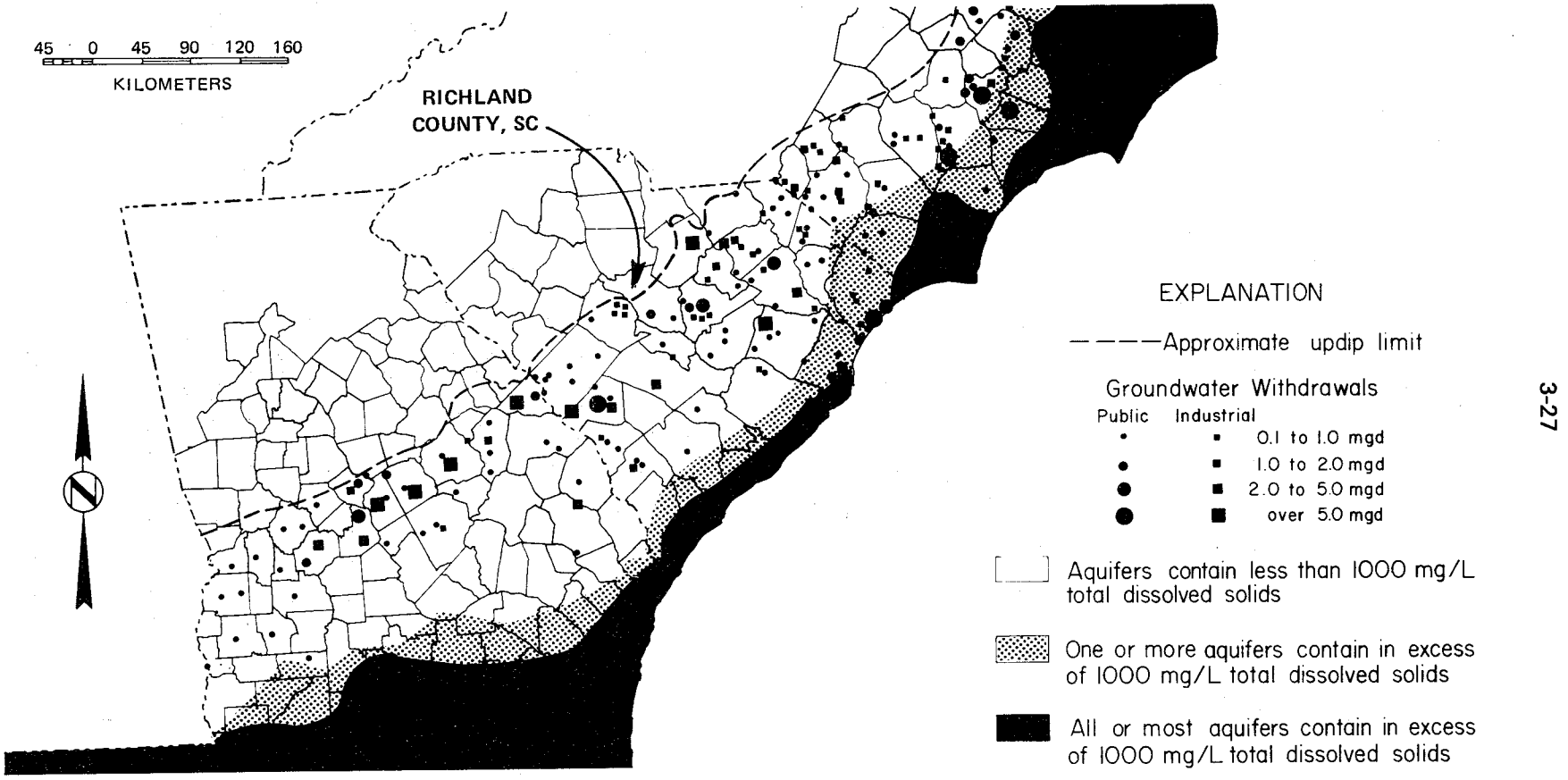

Fig. 3.10. Hydrogeologic map of the Cretaceous aquifer system in the southeastern United States, including South Carolina. Regional Tuscaloosa water production is indicated by county. *Source*: Park 1979.

3.6.1 Physiography

Southeastern Richland County lies within the upper Coastal Plain, a subprovince of the Atlantic Coastal Plain (Davis and Floyd 1982). The topography ranges from very flat and poorly drained near the Congaree River to the well-drained sand hills. The topography surrounding NFCS is generally flat with only slight local relief.

The physiography of the upper Coastal Plain is controlled by unconsolidated sands and clays that are easily weathered and eroded in comparison to the hard, consolidated Paleozoic and Precambrian rocks north of Columbia, South Carolina. Columbia is located on the Fall Line, a zone of river rapids and small waterfalls, which forms the boundary between the Piedmont and Coastal Plain physiographic provinces (Fig. 3.11).

3.6.2 Stratigraphy and Structure

The regional geology is illustrated by two figures. Figure 3.11 is a geologic map of South Carolina's Coastal Plain and Piedmont, including a structure section through Richland County along line A-A'. Figure 3.12 is a stratigraphic column of formation names which are keyed to the map symbols in Fig. 3.11.

The NFCS is located in the subcrop of the upper Cretaceous Tuscaloosa formation (Kul). Some geologists prefer the use of the local term "Middendorf" rather than Tuscaloosa. The Tuscaloosa deserves special consideration because it is perhaps the most important regional aquifer in South Carolina (Park 1979). A detailed discussion of groundwater resources is provided in Sect. 3.5.2.

The Tuscaloosa and younger strata form a thin veneer [a few tens of meters along the Fall Line near Columbia to more than 180 m (600 ft) in southeastern Richland County] overlying "basement" rock. The depth to basement is estimated to be 75 to 90 m (250 to 300 ft) at NFCS.

The following discussion describes the stratigraphy of the basement and overlying coastal plain sediments. The order of discussion is from oldest (basement) to youngest (Pliocene-Pleistocene).

Little is known about the basement rock of the area because so few holes have been drilled into it. The available data suggest, however, that the buried basement rocks are little different from those exposed in South Carolina's Piedmont province; that is, they are Paleozoic and Precambrian metomorphic rocks and intrusives.

The Tuscaloosa formation is arkosic cross-bedded sand and gravel, interbedded with lenses of mixed clay composition and kaolin. The depositional environment was mixed continental-marine, characterized by fluvial, deltaic, and littoral deposits (SCWRC 1983).

In the vicinity of NFCS, the base of the Tuscaloosa formation rests on basement rocks believed to be similar to those exposed in the South Carolina Piedmont. The top of the Tuscaloosa is eroded out at the NCFS. Uppermost Tuscaloosa strata are encountered between 15 to 30 m (50 to 100 ft) below land surface (depending on topography) in the vicinity of the NCFS.

The stratigraphic units lying directly over the Tuscaloosa are difficult to decipher at NFCS for two reasons. First, the Fall Line is only about 15 km (10 miles) to the northwest, so that most strata overlying the Tuscaloosa are thin or absent. Second, outcrops of strata older than Pliocene are rare. They are generally covered by 6 to 12 m (20 to 40 ft) of Pliocene-Pleistocene marine terrace deposits. What little is known of the stratigraphic interval between the upper Cretaceous and Pliocene is obtained from well cuttings and geophysical well logs. Interpretations based on such data are generally tentative.

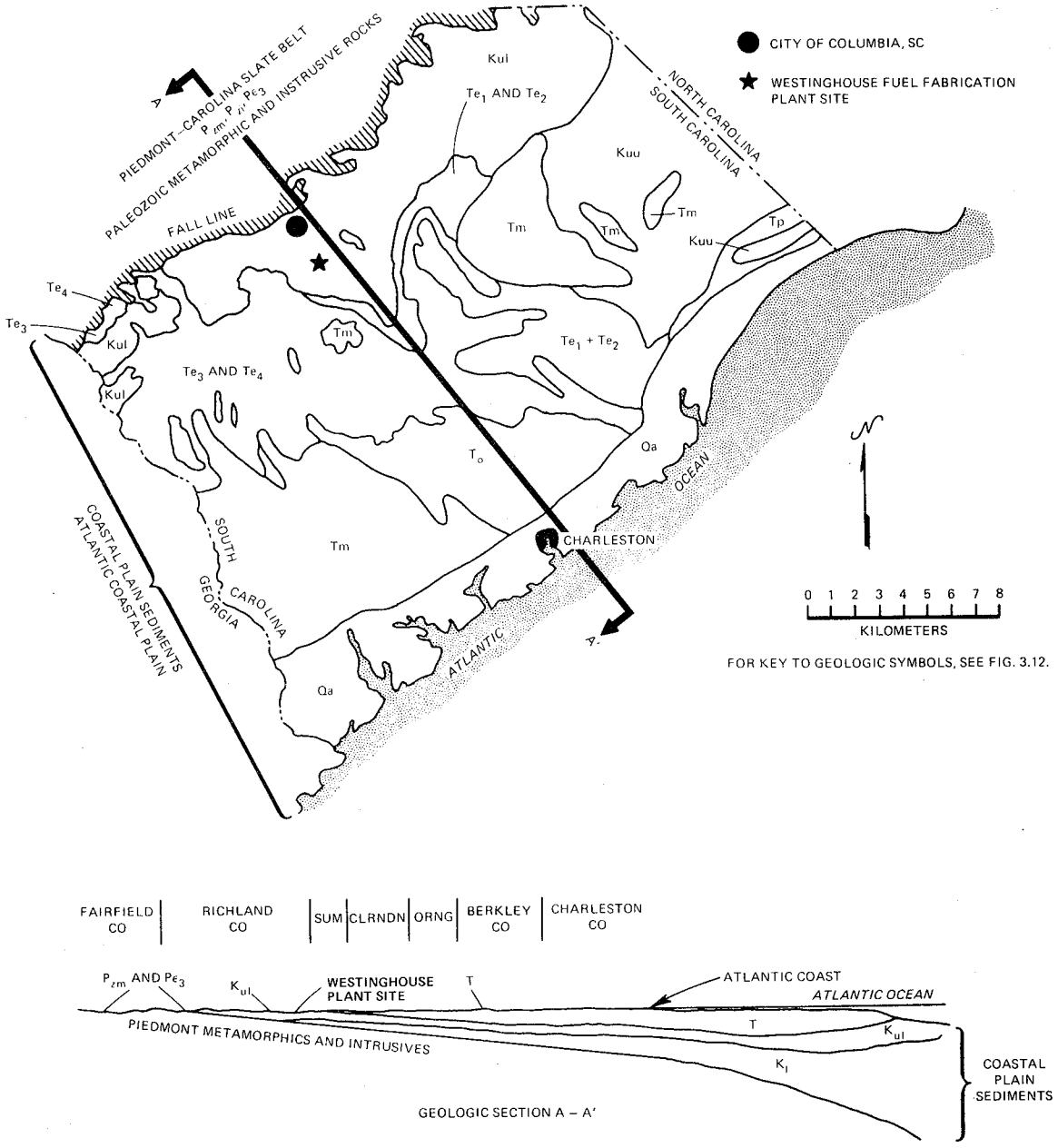

Fig. 3.11. Regional geology of the Westinghouse NFCS, indicating features of South Carolina's Piedmont and Coastal Plain. A key to geologic symbols is given in Fig. 3.12. *Source:* See Fig. 3.12.

Davis and Floyd (1982) assembled an interpretation of the subsurface beneath NFCS (Fig. 3.13) based on well data. These data suggest the presence of several meters (tens of feet) of the Eocene (T_{e1}-T_{e2}) Black Mingo formation beneath the site, based on the findings of shale chips in well cuttings and on characteristic "kicks" in the geophysical logs at shale-sandstone interfaces. This

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GENERALIZED CHART OF TIME AND ROCK UNITS
PIEDMONT — COASTAL PLAIN

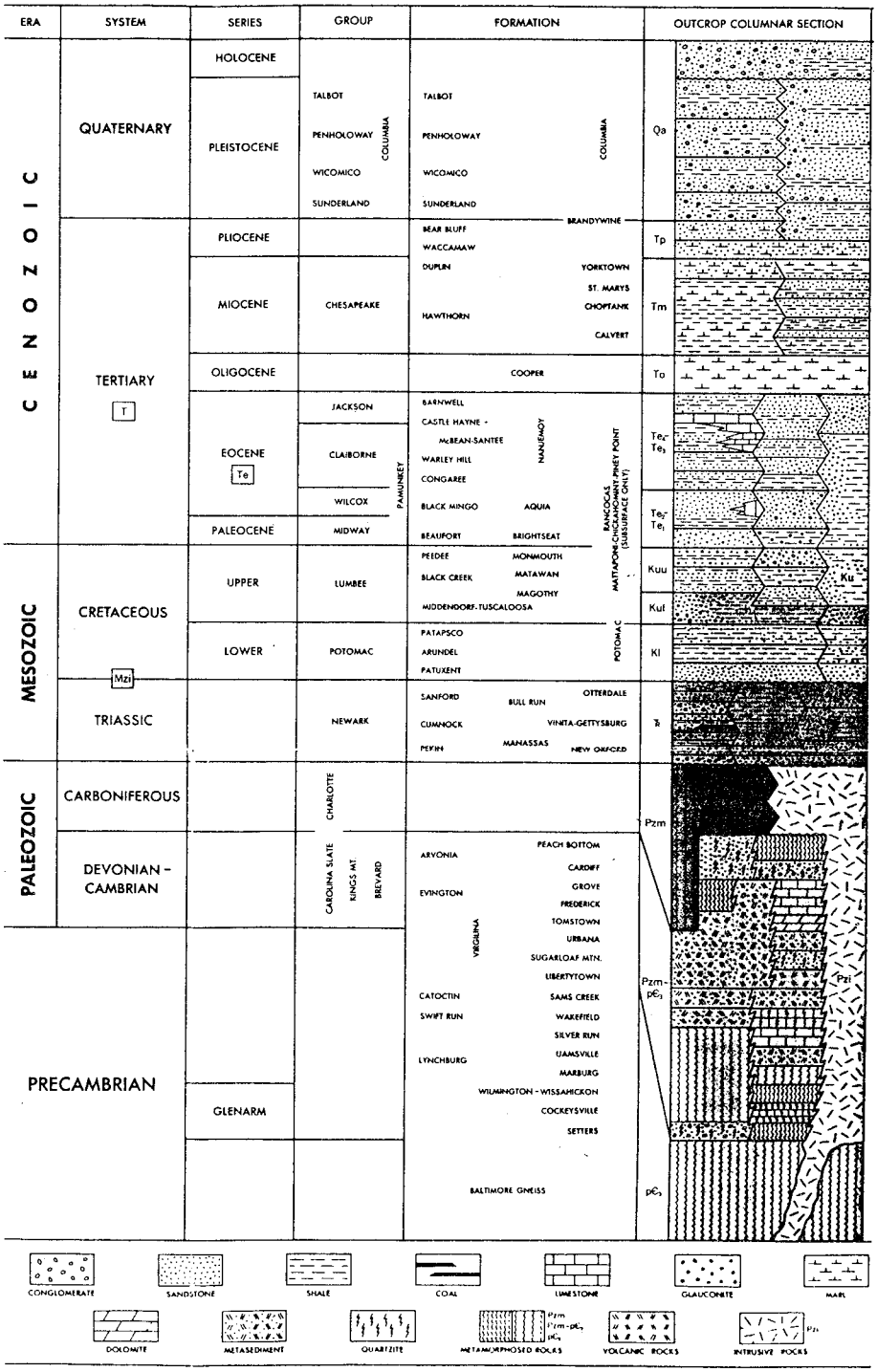

Fig. 3.12. Generalized stratigraphic chart of time and rock units for South Carolina's Piedmont and Coastal Plain. *Source:* modified after the American Association of Petroleum Geologists, Geology Highway Map of the Mid-Atlantic Region, Map 4, 1970).

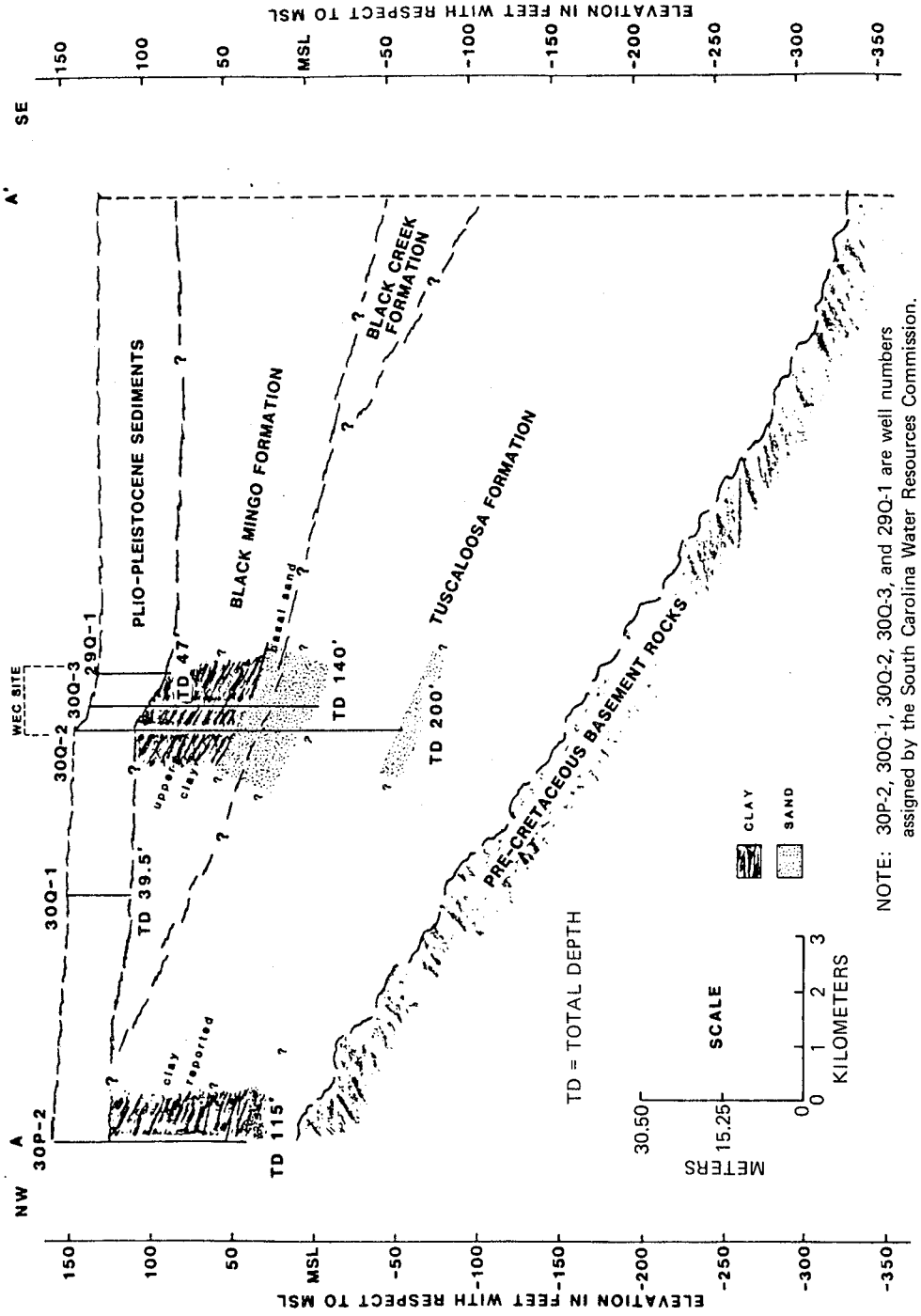

Fig. 3.13. A representation of the subsurface at the Westinghouse NFCS based on well data.
Source: Davis and Floyd 1982.

interpretation is plausible because Paleocene-Eocene outcrops have been mapped in Calhoun and Sumter counties, which are adjacent to Richland County on the south and east, respectively. Colquhoun et al. (1983) believe that remnants of the lower part of the Black Creek formation (upper Cretaceous) may also be present in the site vicinity. The identity of this stratigraphic unit is largely immaterial because Black Mingo and Black Creek lithologies are similar. Both consist of gray to black laminated shale interbedded with sand (SCWRC 1983).

The likely presence of the Black Mingo formation and/or Black Creek formation beneath NFCS is significant. About 10 m of shale between the Tuscaloosa and surficial aquifers may prevent hydraulic communication between them. Thus, contamination of one aquifer does not necessarily lead to contamination of the other.

Pliocene-Pleistocene marine terrace deposits overlie the Black Mingo formation. These terraces are exposed in scattered drainage ditches and road cuts in southern Richland County. One such terrace (the Okefenokee terrace) has been identified in the NFCS vicinity. Other nearby terraces are the Sunderland (northwest of NFCS) and Wiscomico (southeast of NFCS and along the Congaree River). The thickness of these terrace deposits ranges between 6 to 12 m (20 to 40 ft), and collectively they form the surficial aquifers of the area.

The lithology of the terrace sediments is complex. Variable mixtures of clay, silt, and sand thicken and thin appreciably over short distances, grading both laterally and vertically from one facies into another. Individual facies are difficult to recognize from one well to the next.

3.6.3 Soils

The nature of the soils in the area is important in the assessment of NFCS operations or expansion. Problems occur if soils will not support structures or holding ponds, if soil permeability allows effluents to escape into aquifers, or if the engineering limitations of soils (swelling, shrinking, corrosibility to concrete and steel, and flooding potential) cannot be overcome.

Soils groups for the NFCS region are mapped in Fig. 3.14. The plant site occurs on the Craven-Leaf-Johns association. Craven series soils are moderately well-drained, gently sloping Coastal Plain soils. The surface layer is loam, with a clay subsoil that is very firm and slowly permeable. Clayey sediments interfinger with sand lenses below. The Leaf association is poorly drained, with a silt-loam surface and silty-clay subsoil (NRC 1977).

Both soil series in the association have certain limitations. They are highly corrosive to both concrete and steel, and they have severe shrink-swell potential and severe wetness and flooding potential because of seasonal high water tables. The latter characteristic also decreases their suitability for septic tanks. The wetness of the soils also limits sewage ponds and sanitary landfills (NRC 1977).

3.6.4 Mineral Resources

Construction materials (sand and gravel) are the principal mineral resources of southeastern Richland County. These resources are not unique to NFCS. They are found in a wide variety of coastal plain sediments in South Carolina. Ceramic materials are obtained from localized pure kaolin and quartzose sand deposits in the Tuscaloosa formation.

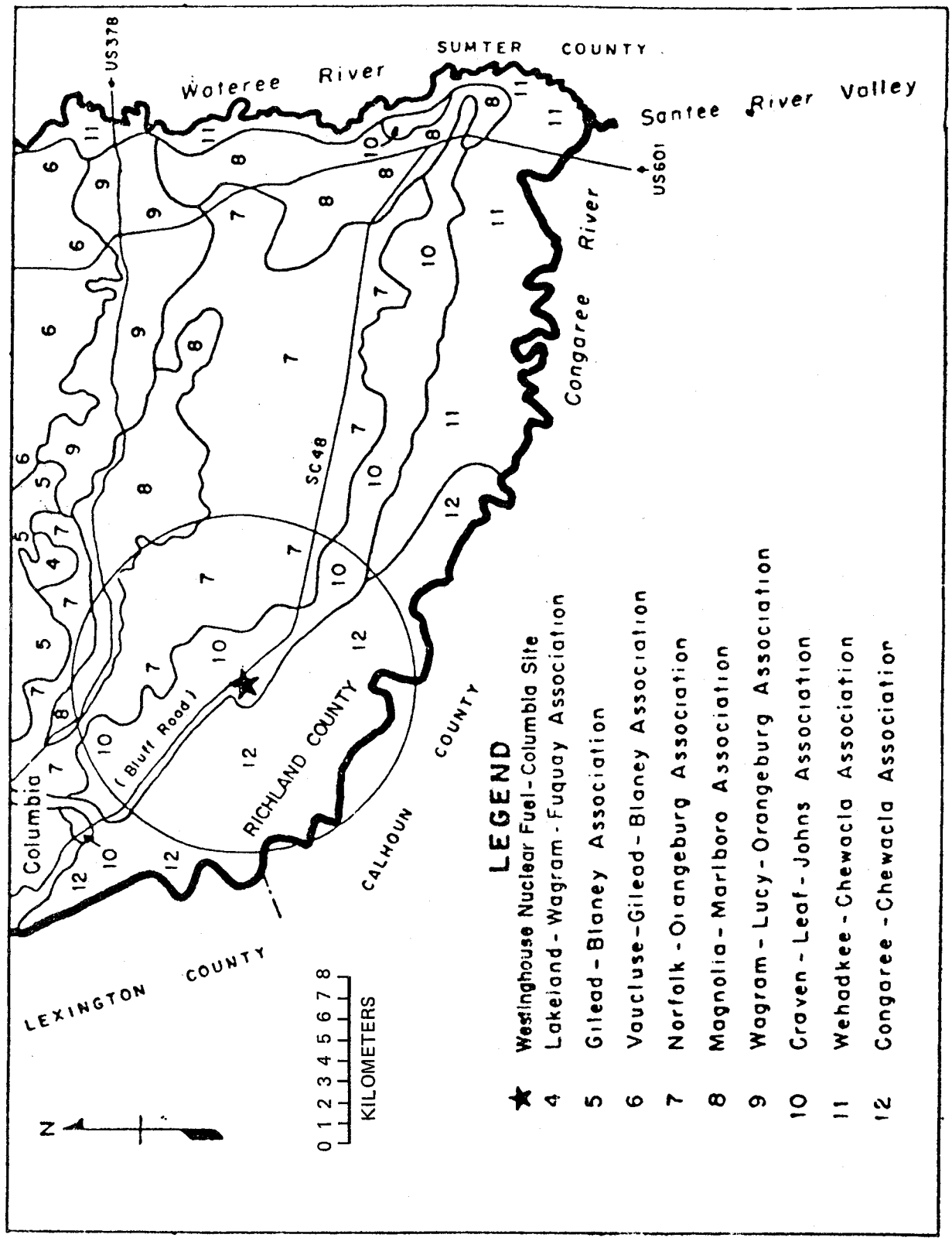

Fig. 3.14. Generalized soil associations of southern Richland County, South Carolina. *Source:* Westinghouse 1983, Fig. 3.2.

3.6.5 Seismicity

Most of this discussion is based on recent work by Bollinger (1972, 1973). Bollinger is responsible for much of the current literature on the seismology of the southeast generally and of South Carolina in particular. He suggests that, "broadly viewed, the region is a minor seismic zone, characterized by a low level of seismic energy release" (1972). He also suggests that "earthquake frequency per unit time per unit area in this region is about one-tenth that of the west coast, but the seismograph station density that exists even today is inadequate" (1973). However, he notes from other research that areas affected by shocks east of the Rocky Mountains are greater in size than those of equal magnitude events in the western United States.

The most intense shock in South Carolina cited by Bollinger (1972) was the August 1886 event at Charleston. The quake was felt as far west as Missouri and as far north as Vermont. The quake intensity in the Charleston area corresponded to a Modified Mercalli Intensity (MMI) scale X, while most of the remainder of South Carolina, including NFCS area, underwent a quake intensity of MMI VII. The expected damage at an MMI value of VII includes cracked masonry, broken chimneys, falling plaster, loose bricks and cornices, damage to concrete irrigation ditches, and caving in along sand and gravel banks. The distribution of earthquakes within 320 km (200 miles) of Columbia, South Carolina, from 1754 to 1984 is shown in Fig. 3.15.

Bollinger (1972) suggests that, "up to 1950, the seismic activity within the state is seen to be concentrated in the Charleston-Summerville area, but subsequent to that time has been primarily outside that locale...unexplained is the apparent shift, during the past two decades, of seismic activity away from the coastal Charleston-Summerville area to the interior portions of the state. This apparent shift now includes three shocks in the central part of the state that has been historically free of earthquake epicenters." Apparently, this suggested trend of Coastal Plain seismicity is quite localized, for Bollinger (1973) notes that "appreciable earthquake activity in the Coastal Plain province appears only in South Carolina." The uncertainty of the suggested trend is magnified by the sparse and often unreliable data upon which it is based. "The southeastern region has seismic monitoring inadequate to specify completely its seismicity. This in turn implies the possibility of missing any buildup or decline in that activity" (Bollinger 1973).

Using deterministic seismic risk analysis (Krinitzsky and Marcuson 1983) forces one to deal with the possibility of a local earthquake similar in intensity to the 1886 Charleston earthquake. Causes of the Charleston earthquake are speculative at best. Thus, it can be argued that such an earthquake could occur at Columbia, and ground motion under these circumstances could cause major damage to structures.

The probability of major damage from an earthquake near Columbia is slight for any reasonably assigned NFCS plant life. Algermissen et al. (1982) provide probabilistic estimates for earthquakes of various intensities. Table 3.10 lists the estimated recurrence intervals in years per 10^4 km^2 in the seismic source zone that includes both Charleston and Columbia. Estimated recurrence intervals for the New Madrid seismic zone (southeast Missouri) and the San Andreas fault zone are provided for comparison. These data show that an earthquake with an MMI of VII has a recurrence interval of about 250 years (about a 10% probability of occurring in a 25-year interval) in the 10^4 km^2 surrounding Columbia. Hence, it makes good sense to prepare, either through design or remedial action, for the possibility of minor earthquake damage. However, the probability of an MMI X earthquake in the near future is vanishingly small. By comparison, the New Madrid and San Andreas seismic zones are 3 and 50 times more active, respectively, than the Columbia-Charleston zone.

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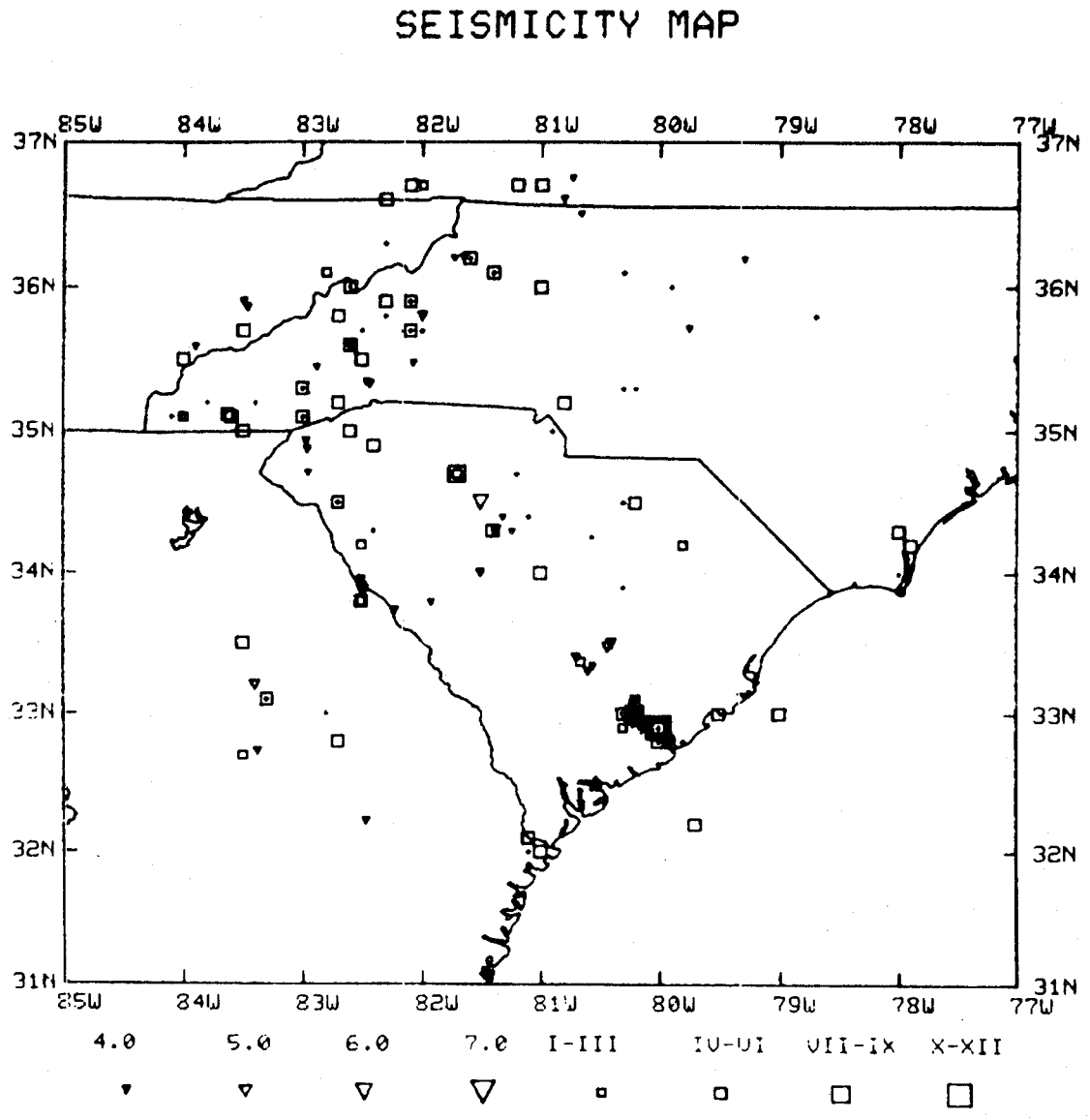

Fig. 3.15. Distribution of earthquakes within 320 km (200 miles) of Columbia, South Carolina, 1754–1983. *Source:* Computer search of data on file at the National Oceanographic and Atmospheric Administration, Boulder, Colo.

Algermissen et al. (1982) also provide estimated probability of ground motion for central South Carolina. These estimates are based on mean values of ground motion as a function of earthquake intensity. Table 3.11 estimates the horizontal accelerations and velocities having 10% probabilities of exceedance for selected time intervals. Krinitzsky and Marcuson (1983) caution that ground motion as a function of earthquake intensity has a very wide error band, especially for structures sited on unconsolidated foundation materials (soft site) and for near-field earthquakes (epicenters

Table 3.10. Earthquake recurrence intervals (years/10^4 km^2) as a function of Modified Mercalli Intensity (MMI) for selected seismic source zones

MMI	Seismic source zone			
	Columbia-Charleston[a]		New Madrid	San Andreas
V	25	(5)	8	1
VI	79	(17)	23	2
VII	250	(53)	65	6
VIII	790[b]	(170)	190	17
IX	2500[b]	(530)[b]	540[b]	46
X	7900[b]	(1700)[b]	1600[b]	130

[a]Estimated recurrence intervals in parentheses are for the entire Columbia-Charleston seismic source zone (nearly 5 x 10^4 km^2).

[b]These estimated recurrence intervals represent extrapolation beyond the historical data base.

Source: Algermissen et al. 1982.

Table 3.11. Ten percent probability estimates for horizontal accelerations and horizontal velocities exceeding a given value as a function of time at Columbia, S.C.

	Time intervals (years)		
	10	50	250
Horizontal acceleration[a] (% of gravitational acceleration)	5	11[a]	23
Horizontal velocity (cm/s)	2	7	16

[a]Approximate mean horizontal acceleration for a Modified Mercalli Intensity VII earthquake for a near-field earthquake at a hard site, from Krinitzsky and Marcuson 1983.

Source: Algermissen et al. 1982.

less than 5 to 50 km away depending on magnitude). Thus, it is reasonable to design for a safety factor of 2 with respect to Algermissen's estimated ground motion.

3.7 BIOTA

3.7.1 Terrestrial

3.7.1.1 Vegetation

General types of vegetation found on the site are indicated in Fig. 3.4 and include bottomland forest, upland forest, cultivated field, and lawn. Bottomland forests are extensive along the

Congaree River to the west and south of the site, whereas upland forests are predominant to the north and east and on the other side of the Congaree River bottoms. The primary crop grown onsite is soybeans.

The vegetation of the United States has been described according to two different types of classifications: the potential vegetation that would be present if man had not interfered with natural physical and biological processes, and the vegetation types that actually occur at the present time. The potential vegetation in the region including the site is classified as southern floodplain forest along the Congaree River, oak-hickory-pine forest on the uplands, and southern mixed forest immediately west of Columbia (Table 3.12). The actual vegetation differs from this mix primarily in that the uplands of the region are dominated by loblolly pine-shortleaf pine forests and longleaf pine-slash pine forests (Eyre 1980). On relatively wet upland sites, fertile well-drained coves, or on

Table 3.12. Potential natural vegetation of the Columbia, S.C., area

	Southern floodplain forest
Physiognomy:	Dense, medium tall to tall forest of broadleaf deciduous and evergreen trees and shrubs and needleleaf deciduous trees
Dominants:	Tupelo *(Nyssa aquatica)* Oak *(Quercus* spp.) Bald cypress *(Taxodium distichum)*
	Oak–hickory–pine forest
Physiognomy:	Medium tall to tall forest of broadleaf deciduous and needleleaf evergreen trees
Dominants:	Hickory *(Carya* spp.) Shortleaf pine *(Pinus echinata)* Loblolly pine *(P. taeda)* White oak *(Quercus alba)* Post oak *(Q. stellata)*
	Southern mixed forest
Physiognomy:	Tall forest of broadleaf deciduous and evergreen and needleleaf evergreen trees
Dominants:	Beech *(Fagus grandifolia)* Sweet gum *(Liquidambar styraciflua)* Southern magnolia *(Magnolia grandiflora)* Slash pine *(Pinus elliottii)* Loblolly pine White oak Laurel oak *(Q. laurifolia)*

Source: A. W. Kuchler, *Potential Natural Vegetation of the Conterminous United States,* Special Publication 36, American Geographical Society, New York, 1964.

sites adjacent to creeks in the uplands, hardwood species such as red maple and sweet gum are more abundant. Various species of oaks and hickories are also associated with upland forests, as well as with most other forest types in the region.

3.7.1.2 Fauna

Wildlife species that occur in the region containing the site include about 125 breeding bird species (Cook 1969), 55 species of mammals (Simpson 1964), 44 species of reptiles (excluding turtles), and 38 species of amphibians (range maps in Conant 1958). Although all of these species are expected to occur somewhere in the central South Carolina region, the site itself is too small to contain all the habitats required by these species. Therefore, only a fraction of the total number of species would be expected to occur on the site. In addition to the breeding bird species, more than 100 other bird species probably occur at the site as migrants or visitors during fall, winter, and spring.

Wetlands, ponds, and forests on the site are the most important habitats because they support the greatest numbers and densities of wildlife species. As wetlands and bottomland forests are being rapidly drained and cleared for agriculture throughout the United States, the remaining forests, such as those along the Congaree River, are becoming increasingly important in supporting the remaining wildlife populations (Johnson and McCormick 1978). Cultivated fields and lawns support only low-density populations of relatively few species. Because the plant site has extensive fields and lawns in addition to the facilities, the site as a whole is expected to have relatively low wildlife populations.

Important game animals that occur at the plant site include the white-tailed deer, raccoon, eastern cottontail, bobwhite, gray squirrel, and wood duck. Furbearers include the bobcat, red fox, and gray fox.

3.7.2 Aquatic

Aquatic resources that occur in the NFCS vicinity are the Congaree River, Mill Creek, and Sunset Lake; their hydrology is discussed in Sect. 3.5.1. There is little information available on biota in the Congaree River. Table 3.13 identifies major fish species found in the Congaree River as listed by the South Carolina Fish and Wildlife Department and the SC-DHEC. Of these species, bass, crappie, bluegill, and catfish are popular game species. This should not be construed to be a comprehensive list of species present in the Congaree River, but rather as a list of species of economic importance.

The major invertebrate species in the Congaree River that occur both upstream and downstream of plant discharge, chironomid larvae (midges) and tubificid worms, are indicative of organic enrichment. The high fecal coliform count reported in Sect. 3.5.1 indicates that sewerage enrichment occurs downstream of Columbia. The sand and mud substrate typical of Piedmont streams restricts the benthic fauna to burrowing and filtering species and those species that live in association with plant material deposited in the river. Of the four phyla of benthic invertebrates collected with a ponar dredge from the river both above and below the plant discharge, 43% were mollusks, 29% were annelids, 27% were arthropods (primarily insects), and 1% were nematodes (NRC 1977). Fingernail clams, *Sphaerium* sp., were the most abundant organisms collected. Corbiculia clams occurred only downstream of the discharge at the time of sampling (Westinghouse 1983, Sect. 3.8.2.3).

Table 3.13. Major fish species that presently occur in South Carolina's Congaree River

Scientific name	Common name
Lepisoteidae	
Lepisosteus osseus	Long-nose gar
Amiidae	
Amia calva	Bowfin
Clupeidae	
Dorosoma cepedianum	Gizzard shad
Cyprinidae	
Cyprinus carpio	Carp
Ictaluridae	
Ictalurus natalis	Yellow bullhead
I. nebulosus	Brown bullhead
I. punctatus	Channel catfish
Serranidae	
Morone saxatilis	Striped bass
M. onrysops	White bass
Centrarchidae	
Lepomis macrochirus	Bluegill
Micropterus colomeiui	Smallmouth bass
M. salmoides	Largemouth bass
Pomoxis annularis	White crappie
P. nigromaculatus	Black crappie

Source: Westinghouse 1983, Table 3.15.

Phytoplankton collected in the vicinity of the plant discharge were predominately the colonial green algae, *Eudorina elegans.* Of the total number of individuals of 22 species collected, 73% were Chlorophyta (green algae), 14% were Chrysophytos (yellow-green or yellow-brown algae), and 12% were Cyanophyta (blue-green algae). The average number of cells in the river was 500 cells per milliliter. Because the samples were collected during a high flow period, some of the species collected were probably transported from the reservoirs upstream on the Saluda River into the Congaree River (NRC 1977).

Thirty-three species of zooplankton were identified from tow samples in the vicinity of the plant. The larval stage (glochidia) of bivalve mollusks comprised 21% of the total number of individuals collected. Copepods, rotifers, cladeocerans, and larval stages of oligochaete worms and nematedes were also collected in the tow samples (Westinghouse 1983, Sect. 3.8.2.3).

Samples from selected substrates (rocks, leaves, and logs) in the river yielded 112 species of periphyton. Of these, 97% were diatoms. The more abundant diatoms collected were *Achnanthes deflexa, Navicula minima, N. mutica,* and *N. crytocephala.* Green algae, mostly *Ulothrix* sp., and blue-green algae, *Microcoleius vaginatus* and *Oscillatoria* sp., were observed infrequently.

Because of its shallow nature, high temperature, low flow, and decomposing organic matter, the dissolved oxygen level of Sunset Lake is low (less than 4 ppm) and the lake fauna is limited.

Upper Sunset Lake is now a swamp that supports a mixed stand of swamp tupelo, *Nyssa aquatica,* and Carolina ash, *Fraxinus caroliniana.* The water surface is covered for the most part by a dense mat of duckweed, *Spirodela polyrihiga* and *Lemna minor.* Emergent vegetation is primarily yellow water lily, *Nuphar advena;* lizard tails, *Saururus cernus;* and St. John's wort, *Hypericum spathulatum.* The only benthic invertebrate collected was the phantom-midge, *Chaoborus punctipennis,* which is tolerant of low oxygen levels (Westinghouse 1983, Sect. 3.8.2.4).

The plankton fauna of Sunset Lake were abundant. Phytoplankton densities averaged 60,000 plankters per milliliter. Predominant phytoplankters in the lake were the colonial green algae, *Eudorina elegans.* In general, green algae constituted the majority of the phytoplankton community, although diatoms, euglenoids, bluegreens, and dinoflagellates were also represented. Zooplankton species were predominately protozoans *(Difflugia lobostoma* and *Difflugia oblonga)* and the rotifer *Asplanchna priodonta.* Both zooplankton and phytoplankton were more abundant at the inflow end of lower Sunset Lake, probably as a result of the inflow of swamp water from upper Sunset Lake.

Of the fish species collected in 1974 from Sunset Lake and Mill Creek (Westinghouse 1983, Table 3.16), bluegill and golden shiners *(Notemigonus crysoleucas)* were the most abundant. Recent samplings in 1981 and 1982 have yielded the following species: bowfin, carp, catfish, crappie, and bluegill (Westinghouse 1983, Sect. 3.8.2.4). Employee fishing is allowed on both lower Sunset Lake and on Mill Creek on the plant property.

3.7.3 Threatened and Endangered Species

The Region 4 Endangered Species Notebook (U.S. Fish and Wildlife Service, Endangered Species Office, Atlanta, Georgia, 1983, which is updated periodically) lists the threatened and endangered plant and animals species found in the southeastern United States and includes range maps and range descriptions for each species. This publication indicates that, although five endangered species may occur in the central South Carolina region, only the American alligator *(Alligator mississippiensis)* and the red-cockaded woodpecker *(Picoides borealis)* would be expected to occur regularly as breeding residents within 40 km (25 miles) of the site. The other species are the eastern cougar *(Felis concolor cougar),* Kirtland's warbler *(Dendroica kirtlandii),* and the bald eagle *(Haliaeetus leucocephalus).* The alligator may occur in the Congaree River and associated wetlands and swamps, including wetlands such as Sunset Lake on the site. Colonies of red-cockaded woodpeckers are known to have occurred in Richland and Lexington counties, which at the site are separated by the Congaree River. The basic habitat requirement is an open stand of pines that includes trees more than 60 years old. Because such habitat is lacking on the site, it is unlikely that red-cockaded woodpeckers occur near the plant facilities. Although the alligator and woodpecker have not been observed on the site, systematic surveys for these species have not been conducted. No threatened or endangered plant species is known to occur in the central South Carolina region.

The short-nosed sturgeon, *Acipenser brevirostrum,* is the only threatened and endangered aquatic species that might occur in the region of South Carolina near the Columbia Plant (John Sealey, South Carolina Division of Game and Freshwater Fisheries, personal communication with V. R. Tolbert, Oak Ridge National Laboratory, October 16, 1984) (Sect. 4.2.4.3). This species migrates upstream from the Atlantic Ocean to fresh water to spawn. Spawning occurs between February and May, depending on the latitude, in areas of fast flow with gravel or rubble bottoms

(Muska and Matthews 1983). Because of the rubble and gravel substrate upstream of the site in the vicinity of Columbia, the short-nosed sturgeon could occur and spawn in the area. Because of the mostly sand and mud substrate in the river around the site, little spawning should occur in the immediate vicinity of the site except possibly where small tributaries enter the river.

3.8 RADIOLOGICAL CHARACTERISTICS (BACKGROUND)

3.8.1 Total-body Dose Rates

Based on *Estimates of Ionizing Radiation Doses in the U.S.* (EPA 1972), the total-body dose rate from natural background radiation in the vicinity of Columbia, South Carolina, is about 135 millirem/year (70 millirem/year from external terrestrial radiation, 40 millirem/year from cosmic rays, and 25 millirem/year from internal terrestrial radiation). This value compares favorably with an average of 0.32 millirem/d (117 millirem/year) reported by the state for areas in South Carolina where there are no nuclear facilities (E. F. Williams, SC-DHEC, Division of Radiological Health, personal communication to H. C. Woodsum, Westinghouse Environmental Systems Department, Pittsburgh, October 19, 1973).

Total-body dose rates were measured by SC-DHEC at offsite locations in the vicinity of the plant during 1981 and 1982. These data indicate average dose rates of 0.21 to 0.23 millirem/d (77 to 84 millirem/year) from external radiation (Westinghouse 1983).

3.8.2 Environmental Background

Background radiological characteristics typical of the air and water in the vicinity of the Westinghouse plant are given in Table 3.14. Typical concentrations of uranium in surrounding vegetation and soil are less than 1 ρCi/g (Westinghouse 1975).

Table 3.14. Characteristics of background radiation in the vicinity of the Westinghouse NFCS (1981–1982)

	Average gross alpha (μCi/mL)
Ambient air	3.9×10^{-15}
Surface water	
Congaree River	2.2×10^{-9}
Well water	
Offsite	1.0×10^{-9}
Drinking water	1.0×10^{-9}

Source: Westinghouse 1983, Table 3.8.

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4. ENVIRONMENTAL CONSEQUENCES OF PROPOSED LICENSE RENEWAL

The following sections discuss the direct environmental effects of operations and activities at the Westinghouse NFCS and the significance of the effects. The analyses regarding air and water quality, land use, and ecological and radiological impacts were based primarily on data provided by the applicant (Westinghouse 1975, 1983, 1984) on an *actual* production capacity of 700 metric tons (t) per year of uranium and an *estimated* production capacity of 1600 t/year of uranium. For the latter capacity, the simultaneous use of ammonium diuranate (ADU) and integrated dry route (IDR) processing was assumed.

The current license renewal application requests authorization for operations covered under the existing license and for new operations involving the IDR process (Westinghouse 1981). A preliminary environmental review of the amendment to utilize the IDR process production line was conducted by the staff and reported in a memorandum (Shum 1981). This review is printed in Appendix C of this EA.

4.1 MONITORING PROGRAMS AND MITIGATORY MEASURES

A comprehensive effluent and environmental monitoring program is conducted by the applicant to demonstrate compliance with appropriate environmental protection standards and to provide, where possible, site-specific data to assist in the prediction of environmental impacts.

4.1.1 Effluent Monitoring Program

4.1.1.1 Radiological

Stack emissions are monitored in four facility areas (see Fig. 2.4). Each release stack is equipped with an isokinetic probe device that continuously draws a sample through a fiberglass filter paper. The filter paper is removed daily and analyzed for gross alpha activity as a measure of uranium content. Results are compiled semiannually and reported to the Nuclear Regulatory Commission (NRC). A summary of emissions measured at a production rate of 700 t/year of uranium is presented in Table 2.1.

A 30-d composite sample of liquid effluent discharged to the Congaree River is analyzed monthly for gross alpha, gross beta, and isotopic uranium. The applicant also analyzes a daily composite sample for gross alpha activity. Typical discharge concentrations and annual release rates of radioactivity at a production rate of 700 t/year are given in Table 2.4.

4.1.1.2 Nonradiological

Stack emissions in the four facility areas are monitored with an isokinetic probe device that continuously draws a sample of 224 m^3/d through a fiberglass filter paper. The filter paper is removed on a daily basis and analyzed for fluorides. The results of this monitoring program for 1981-1983 have been reported in μg of fluoride collected daily on the paper (Westinghouse 1984). The staff has calculated fluoride emission rates ($\mu g/s$) for a 700-t/year production rate (Table 2.3) on the basis of an average gas flow from the combined stacks of 13.3 m^3/s. The stack emissions are also analyzed at least quarterly for ammonia. As stated in Sect. 2.2.2.1, the average and maximum ammonia release rates during normal operation at about 700 t/year of uranium have been 1.8 and 2.3 g/s, respectively (Westinghouse 1983).

Plant liquid effluent is monitored in accordance with the requirements of the facility's National Pollutant Discharge Elimination System (NPDES) permit. The details of parameter monitoring, sampling methods and frequency, and effluent limitations of the permit are included in Appendix B. The average annual nonradiological quality of the NFCS combined liquid effluent is presented in Table 2.5. Westinghouse's compliance with the plant NPDES permit is discussed in Sect. 4.2.3.1.

4.1.2 Environmental Monitoring Program

4.1.2.1 Radiological

The current environmental monitoring program for radioactivity at the Westinghouse NFCS includes the monitoring of air, vegetation, groundwater, surface water, and soil (Westinghouse 1983). A summary of the program is given in Table 4.1, and onsite sampling locations are indicated in Fig. 4.1. Offsite surface water monitoring stations are shown in Fig. 3.7 and groundwater monitoring sites are identified in Fig. 3.8. The program is designed to ensure compliance with state and federal regulations and to provide data input to a statistical data base for environmental impact assessment of plant operation. In the event of an accidental release of radioactivity from the plant, more frequent sampling of physical and biotic environmental components would be conducted. A summary of the results of the monitoring program that has been reported to NRC (Westinghouse 1984) is presented below.

Onsite

Air. Air sampling stations for particulate monitoring (Fig. 4.1) are: No. 1, located at the nearest site boundary in a prevailing wind direction 914 m (3000 ft) northeast of the plant; No. 2, north of the employee parking lot where concentrations are expected to be maximum; No. 3, near the meteorological tower 594 m (1950 ft) west-northwest; No. 4, located at the nearest site

Table 4.1. A summary of environmental radiological monitoring at the Westinghouse NFCS

	Sample size	Sampling sites	Parameter measured	Frequency
Air particulates	571 m^3	4	Gross alpha	Continuous
Vegetation	100 g	4	Gross alpha and beta; isotopic uranium	Semiannually
Groundwater	1 L	15	Gross alpha and beta	Monthly and quarterly
Surface water	1 L	6	Gross alpha and beta	Monthly
Soil	100 g	4	Gross alpha and beta; isotopic uranium	Semiannually
Sediment	100 g	1	Gross alpha and beta; isotopic uranium	Annually
Fish	30 g	1	Gross alpha and beta; isotopic uranium	Annually

Source: Westinghouse 1983.

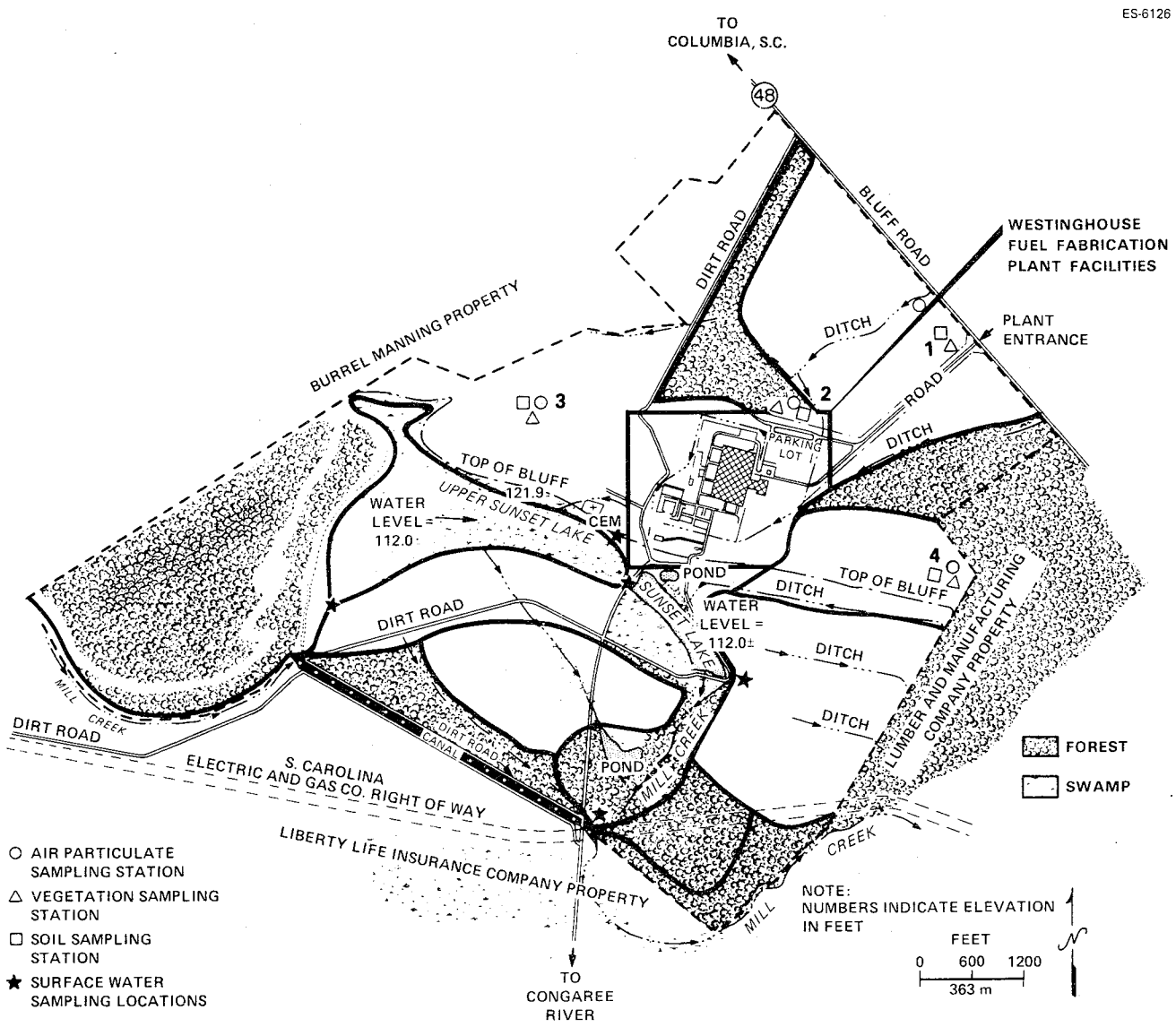

Fig. 4.1. Locations of onsite ambient air, vegetation, soil, and surface water monitoring stations at the Westinghouse NFCS. *Source:* Modified after Westinghouse 1983, Fig. 6.1.

boundary east-southeast of the plant. Air monitors continuously accumulate air particulates by pumping air through filters. The filters are changed weekly and analyzed monthly for gross alpha activity. Monitoring results for 1981-1983 are given in Table 4.2.

Table 4.2 indicates that the highest annual average for the period was 6.2×10^{-15} μCi/mL (Station 4 in 1981). Assuming that all the activity is from a single insoluble uranium isotope (i.e., ^{235}U, ^{233}U, or ^{234}U), this concentration is less than 1% of the maximum permissible concentration for release to unrestricted areas as defined by 10 CFR Pt. 20. Because the activity is actually from low enriched uranium, which consists of a combination of the aforementioned isotopes, this comparison is conservative.

Table 4.2. Radiological monitoring data from onsite air particulate monitors at the Westinghouse NFCS, 1981–1983

Station[b]	Gross alpha[a]			
	1981	1982	1983	3-year average
1	3.8	1.5	2.4	2.6
2	4.1	2.8	2.4	3.1
3	4.4	4.4	2.8	3.9
4	6.2	3.4	2.7	4.1

[a]Annual average concentrations from monthly analysis of gross alpha activity. Values are given as 10^{-15} μCi/mL.

[b]Locations shown in Fig. 4.1.

Source: Westinghouse 1984.

Groundwater. Until recently, four onsite wells (W-1-W-4; see Figs. 3.8 and 3.9) were monitored routinely in accordance with NRC license requirements. These wells were sampled monthly and analyzed for gross alpha and gross beta activity. Well W-1 is an upgradient Tuscaloosa well. [The open-hole portion of this well collapsed below the bottom of the casing at 22 m (71 ft).] Wells W-2 and W-3 are located upgradient and downgradient, respectively, of the sludge ponds (see Fig. 3.9). Both of these wells are completed in the Black Mingo Formation. Well W-4 is located adjacent to W-3 and is completed in the shallow terrace aquifer.

Water quality samples, which are obtained by bailing, are collected in a two-step procedure. First, the well is bailed dry or 38 L (10 gal) are withdrawn (whichever comes first), and the bailed water is discarded. Then, the well is allowed to recover for 24 hours before water quality samples are taken. Recent monitoring results from wells W-1-W-4 show insignificant gross alpha contamination or none at all (Westinghouse 1984). The highest concentration reported is 12 pCi/L gross alpha (Well W-4 in February 1982), which is below the EPA drinking water standard of 15 pCi/L. Other sample results from these wells are typically much lower or have been below the Westinghouse minimum detectable level for radioactivity (2.2 pCi/L gross alpha). For Wells W-1-W-3, the deeper wells, insignificant gross beta concentrations were also found. The

maximum concentration observed in these wells for the period 1982-1984 was 19 pCi/L gross beta, which is well below the EPA drinking water standard of 50 pCi/L. Well W-4, like the other shallow wells (Sect. 3.5.2.2), has shown gross beta contamination with a maximum concentration (in 1982) of 330 pCi/L (R. Fischer, Westinghouse, telephone communication with S. Wyngarden, NRC, March 25, 1985).

A modification to the plant's NPDES permit (Appendix B), effective September 1, 1984, requires that 11 additional onsite wells (W-7, 10, 13, 15, 16, 18, 22, 24, 29, 30, and 32 in Figs. 3.8 and 3.9) be monitored quarterly for gross alpha and gross beta activities. Most of these wells are completed in the shallow terrace aquifer down the groundwater gradient from the sludge ponds toward Sunset Lake (Davis and Floyd 1982).

As discussed in Sect. 3.5.2.2, contamination in the shallow aquifer was discovered in 1980, and considerable groundwater monitoring has been conducted since that time. This monitoring has included occasional radiological monitoring of several other wells in addition to those currently tested as required by either NRC or the state.

The most recent radiological monitoring results from these wells (April 1983) were presented in Table 3.9. Results from pre-1983 sampling (January 1981, May 1981, and July 1982) are similar to those shown in Table 3.9 (Westinghouse 1984). Wells immediately adjacent to the liquid waste treatment plant and holding ponds, which were originally identified as the sources of contamination, have generally maintained levels of radioactivity in excess of federal drinking water standards (15 pCi/L gross alpha and 50 pCi/L gross beta). There are no identifiable trends, and the results have varied sharply from one sampling time to the next. This variation is also true of the remaining wells further downgradient, which occasionally show elevated levels of radioactivity as contamination moves through the groundwater flow path outlined in Section 3.5.2.1.

Surface water. As part of the routine environmental monitoring program at NFCS, three onsite surface water samples (Fig. 4.1) are analyzed monthly for gross alpha and gross beta activity. Samples are taken at the spillway of Lower Sunset Lake, at the point where Mill Creek exits the NFCS property and meets the canal, and from a storm drain that receives runoff from the paved plant areas (sample locations 4, 5, and 6 in Fig. 3.7). Monitoring data from these locations for the period 1981-1983 are presented in Table 4.3.

Table 4.3. Radiological monitoring data from onsite surface water monitoring stations at the Westinghouse NFCS, 1981–1983[a]

Station[b]	Gross alpha (pCi/mL)			
	1981	1982	1983	3-year average
4	0.0043	0.0012	0.0015	0.0023
5	0.0065	0.0008	0.0012	0.0026
6	0.0277	0.0071	0.0216	0.0188

[a]Annual average values based on monthly sampling.
[b]Locations shown in Figs. 3.7 and 4.1.
Source: Westinghouse 1984.

The annual average gross alpha concentrations at Stations 4 and 5 are, at most, 0.02% of the 10 CFR Pt. 20 limit for discharge of aqueous wastes containing uranium impurities (30 pCi/mL). The annual average gross alpha concentrations at Station 6 (storm drain) are, at most, 0.09% of the 10 CFR Pt. 20 limit. The highest monthly measurements during the period were 0.011, 0.071, and 0.087 pCi/mL for Stations 4, 5, and 6, respectively. The highest value, 0.087 pCi/mL, is just 0.29% of the 10 CFR Pt. 20 limit.

In addition to sampling at the stations listed in Table 4.3, Westinghouse analyzes a sample taken where Mill Creek enters Upper Sunset Lake, which is presumed to be representative of the background. Data from 1981-1983 indicate that the gross alpha concentrations at Station 6 have been 5 to 10 times greater than background levels, presumably because of deposition of airborne radioactive particulates. However, as mentioned earlier, by the time onsite surface water exits the NFCS property (Station 5), gross alpha activity has decreased to less than half the actively measured at the storm drain. Likewise, for the period 1982-1984, gross beta concentrations measured at the point where Mill Creek exits the NFCS property were roughly equal to concentrations at the background sampling station (R. Fischer, Westinghouse, telephone communication with S. Wyngarden, NRC, March 25, 1985).

Vegetation. Samples of grass (hay) or an agricultural crop appropriate to the growing season are required to be collected semiannually and analyzed for gross alpha and gross beta activity. Most recently, Westinghouse has measured gross alpha and gross beta activity and isotopic uranium. Samples are usually obtained at locations near the air monitors (see Fig. 4.1). Table 4.4 reports monitoring data as annual averages of combined uranium isotopes in onsite vegetation for the period 1981-1983.

The annual and 3-year averages of uranium concentrations at each of the four vegetation sampling stations (Table 4.4) are comparable to the reported background uranium concentration in onsite vegetation, <1 pCi/g (Sect. 3.8.2). The highest individual measurement of total uranium in onsite vegetation was 0.96 pCi/g in a sample obtained at Station 1 in May 1983. This value is still within the range of the background uranium concentration in onsite vegetation. A subsequent sample taken at Station 1 in September 1983 indicated a uranium concentration of 0.50 pCi/mL.

Table 4.4. Radiological monitoring data from analysis of onsite vegetation at the Westinghouse NFCS, 1981–1983

Station[b]	Total uranium (pCi/g)[a]			
	1981	1982	1983	3-year average
1	0.08	0.08	0.75	0.30
2	0.08	0.08	0.64	0.27
3	0.20	0.08	0.15	0.14
4	0.17	0.08	0.17	0.14

[a]Annual average of two samples.
[b]Locations shown in Fig. 4.1.
Source: Westinghouse 1984.

On the basis of these results, the staff concludes that no significant change in the total uranium concentration of onsite vegetation has resulted from NFCS operations. Because of this, any human ingestion of milk or beef produced by cattle that have ingested hay harvested onsite at NFCS would not likely result in individual doses above background levels.

Soil. Samples are required to be collected semiannually and analyzed for gross alpha and gross beta activity. Most recently, Westinghouse has measured isotopic uranium in addition to gross alpha and gross beta activity. Samples are usually obtained at locations near the air monitors (see Fig. 4.1). Table 4.5 reports monitoring data as annual averages of combined uranium isotopes in onsite soil for the period 1981-1983.

Table 4.5. Radiological monitoring data from analysis of onsite soil at the Westinghouse NFCS, 1981–1983

Station[b]	Total uranium (pCi/g)[a]			
	1981	1982	1983	3-year average
1	0.24	0.18	0.38	0.27
2	0.18	0.17	0.72	0.36
3	0.37	1.18	0.40	0.65
4	0.13	0.17	0.40	0.23

[a]Annual average of two samples.
[b]Locations shown in Fig. 4.1.
Source: Westinghouse 1984.

The annual and 3-year-average uranium concentrations for each of the four soil sampling stations (Table 4.5) are, at most, 4% of the limit of 30 pCi of enriched uranium per gram of soil allowed for disposal with no restriction on the method of burial (NRC 1981). The highest individual measurements of total uranium in onsite soil were 2.14 pCi/g (Station 3 in September 1982) and 1.30 pCi/g (Station 2 in May 1983). Both of these exceeded the background uranium concentration in onsite soil, <1 pCi/g (Sect. 3.8.2); however, the values are still well below the 30-pCi/g limit mentioned earlier. Subsequent samples from Station 2 (September 1983) and Station 3 (May and September 1983) indicated total uranium concentrations less than 1 pCi/g. On the basis of these results, the staff concludes that no significant changes in the total uranium concentration of onsite soil has resulted from NFCS operations.

Direct radiation. In addition to the applicant's monitoring program described in Table 4.1, the South Carolina State Department of Health and Environmental Control (SC-DHEC) maintains thermoluminescent dosimenters (TLDs) near the NFCS boundaries. The TLDs in the following locations provide a measure of direct radiation:

- 685 m (2250 ft) east,
- 915 m (3000 ft) northeast, and
- 685 m (2250 ft) northwest.

Quarterly data from 1981 and early 1982 (Westinghouse 1983) indicated that the direct (gamma) radiation near the site boundaries was equivalent to a total body dose of 77-84 millirem/year. This range is the same as that measured by TLDs located offsite (Sect. 3.8), indicating that the Westinghouse facility was not contributing measurable gamma radiation to locations beyond the site boundaries. The state has indicated that it will continue this monitoring using TLDs.

Offsite

Surface water. In accordance with minimum requirements of the NRC license, the Congaree River is sampled quarterly at three locations and analyzed for gross alpha and gross beta activity. The sample locations are: No. 1, the Blossom Street Bridge located 16 km (10 miles) above the NFCS outfall; No. 2, 0.5 km (500 yd) upstream of the outfall; and No. 3, 0.5 km (500 yd) downstream of the outfall (see Fig. 3.7). Supplemental river samples are taken at the plant discharge, at the confluence of Mill Creek and the Congaree River, and at a point 40 km (25 miles) downstream of the NFCS outfall. Data from river sampling, which has been conducted monthly rather than quarterly, have been reported for the period 1981-1983 (Westinghouse 1984). All samples from the period had gross alpha and gross beta concentrations less than the minimum detectable level (2.2 pCi/L gross alpha and 25 pCi/L gross beta). Therefore, there has been no observable effect of NFCS radiological discharges on the Congaree River. Section 4.2.5 provides a more detailed discussion of radiological impacts to the Congaree River from past plant operations and those expected to result from expansion of the plant up to 1600 t/year of uranium.

Sediment. A sediment sample from the Congaree River is taken at least annually and analyzed for gross alpha, gross beta, and total uranium. In 1981 and 1982, gross alpha concentrations in samples collected at the plant outfall were 1.08 pCi/g and 1.94 pCi/g, respectively. In 1982, a sample was taken 16 km (10 miles) upstream from the outfall to indicate background levels of gross alpha activity. The sample had a gross alpha concentration of 1.30 pCi/g, which is comparable to those of samples taken at the outfall. Total uranium concentrations in background and outfall sediments also compared favorably and demonstrated no buildup caused by the plant effluent.

Fish. Samples of fish are taken annually from the Congaree River downstream of the plant discharge and analyzed for gross alpha and gross beta activity and isotopic uranium. For the period 1980-1983, the uranium concentrations ranged from 0.0 to 0.4 pCi/g. The average concentration (0.16 pCi/g) was significantly greater than the staff would expect on the bases of (1) the calculated annual average uranium in the river due to NFCS operation (Sect. 4.2.5.1) and (2) the normal concentration factor for the assimilation of uranium by fish (NRC Regulatory Guide 1.109). In addition, the isotopic ratio of $^{234}U/^{238}U$ measured was ≈ 1, whereas the staff would expect the ratio to be ≈ 6 if the NFCS effluent containing low-enriched uranium were the source of the uranium in the fish. Because of the above, the staff does not believe that the uranium detected in the fish from the Congaree River can be attributed to the effluent discharged by the NFCS.

4.1.2.2 Nonradiological

Following is a description of the nonradiological monitoring program and recent data (Westinghouse 1984).

Onsite

Air. The principal nonradiological contaminants that may be released to the atmosphere from NFCS operations are fluorides and ammonia. Source monitoring and atmospheric dispersion calculations have shown that ambient air concentrations of fluoride at the NFCS are well below standards established by the state of South Carolina (Sect. 4.2.1.2). Although there are no state or federal air standards for ammonia, calculated ambient atmospheric concentrations of ammonia are below levels that could result in harmful impacts to vegetation and wildlife (Sect. 4.2.2.2). As discussed in Sect. 4.2.1, the atmospheric concentrations of these contaminants are also expected to be insignificant after expansion of the plant up to 1600 t/year of uranium. Consequently, ambient air monitoring for fluoride and ammonia is not required.

Soils and vegetation. Samples of soil and vegetation that are analyzed on a semiannual basis for radiological parameters are also analyzed for total fluorides. The vegetation selected for analysis usually consists of Bermuda grass and a variable mixture of native plant species [telephone conversation, R. Kroodsma, Oak Ridge National Laboratory (ORNL), with R. E. Fischer, Westinghouse, October 19, 1984]. This monitoring provides a relative estimate of atmospheric fluoride levels as well as an estimate of potential impacts to foraging animals. Monitoring data for 1981-1983 and an impact analysis are presented in Sect. 4.2.2.1.

Surface water. There is no direct discharge from the Westinghouse plant to onsite surface waters. Three onsite locations (Fig. 4.1) are monitored quarterly for ammonia, fluoride, and pH. The applicant also routinely monitors pH, ammonia, and fluorides at two other onsite locations—the dam causeway between Upper and Lower Sunset Lake and the entrance of Mill Creek to Sunset Lake. Data from onsite surface water monitoring are presented in Table 4.6.

A comparison of the data in the table indicates little, if any, change in concentrations of ammonia and fluorides in onsite surface waters as a result of NFCS operations. The entrance sample, which has low levels of ammonia and fluorides, is representative of background concentrations in Mill Creek and Upper Sunset Lake. As expected, the road (drain) sample, which is obtained at a point where runoff is received from paved areas of the plant, has the highest concentration of contaminants and the widest range of pH values. The drain, which has a low volume and flow except in periods of heavy precipitation, ultimately discharges into a ditch that drains into Sunset Lake. The lake, with a volume of 1.6×10^5 m^3 (4.3×10^7 gal) and a flow from 0.003 to 0.2 m^3/s (0.1 to 0.6 ft^3/s) readily dilutes the drainage entering it. As a result, samples taken from the lake show only a minor increase in ammonia and fluorides over background (entrance sample) levels, and samples taken downstream of the spillway at the exit of Mill Creek from the NFCS are at or below background levels. Thus, it is apparent from the data that no significant impacts to onsite surface waters result from NFCS operations. For further discussion of surface water impacts, refer to Sect. 4.2.3.

Groundwater. SC-DHEC requires that Westinghouse monitor onsite groundwater as a condition of the plant's NPDES permit (see Appendix B). Accordingly, the 11 monitor wells being analyzed for radioactivity (see Sect. 4.1.2.1) must also be analyzed for nonradiological contaminants and have water level elevations measured quarterly. Nonradiological parameters to be monitored include total dissolved solids (or specific conductance), pH (field), ammonia, nitrate, and fluoride. In addition, water samples from the wells must be analyzed on a one-time basis for dissolved organic carbon, chloride, and sulfate-soluble metals to include calcium, magnesium, sodium, potassium, cadmium, chromium, lead, and nickel. Additional quarterly analyses may be required if the one-time analysis indicates that any new groundwater problems exist.

Table 4.6. Annual average and maximum concentrations (mg/L) of ammonia and fluorides and average and range of pH at onsite surface water sampling stations at NFCS

Station[a]	1981						1982						1983					
	$NH_3(N)$[b]		F[c]		pH[d]		$NH_3(N)$[b]		F[c]		pH		$NH_3(N)$[b]		F[c]		pH	
	Av	Max	Av	Max	Av	Range	Av	Max	Av	Max	Av	Range	Av	Max	Av	Max	Av	Range
Entrance of Mill Creek to Sunset Lake	≤1	≤1	≤0.4	≤1	ND	ND	≤1	≤1	≤1	1.5	6.2	5.8-6.7	≤1	≤1	≤2	≤10	6.1	5.7-7.0
Road—storm drain	≤9	150	≤4	23	6.9	5.6-10.2	≤4	23	≤4	32	6.8	2.2-7.8	≤4	21	≤4	12.2	6.7	5.0-7.7
Dam causeway between Upper and Lower Sunset Lake	≤1	2	≤1	≤10	ND	ND	<1	1.3	<1	3	6.4	6.0-7.1	≤1	1.4	≤3	≤10	6.3	6.0-7.6
Spillway of Lower Sunset Lake to Mill Creek	≤1.5	2	≤1	≤10	ND	ND	<1	1.7	<1	3	6.6	6.0-7.6	≤1	1.2	≤3	≤10	6.5	6.1-8.6
Exit of Mill Creek from NFCS property at canal	≤1	1.2	≤0.5	1.5	ND	ND	<1	1	<1	1.4	6.3	6.2-6.4	≤1	≤1	≤2	≤10	6.2	6.0-6.6

[a]Shown on Fig. 3.7: spillway = No. 4, exit = No. 5, and road = No. 6.

[b]Ammonia values in Westinghouse (1984) were occasionally reported as <10 mg/L for $NH_3(N)$, which represented the sensitivity of the method of analysis. These values were conservatively applied as 10 mg/L in calculations of annual averages. They were not, however, considered as representative of maximum $NH_3(N)$ concentrations; therefore, maximum values given in the table are for specific measured values only.

[c]Fluorides.

[d]ND = No data.

Source: Westinghouse 1983 and 1984.

This comprehensive groundwater monitoring became a requirement in September 1984; thus, data for all the required parameters are not yet available. However, data for 13 sampling dates during 1981-1984 have been reported (Westinghouse 1984). Typical values observed over this period are shown in Tables 3.6, 3.7, and 3.8. The maximum values of contaminants were 165 mg/L fluoride (Well W-28 on September 25, 1983) and 900 mg/L ammonia (Well W-7 on January 23, 1981), although most measured concentrations were much less than these values.

Even though results have often varied from one sample time to the next, over the longer term since 1981, concentrations have generally decreased. This is particularly true for the wells closest to the storage ponds. Data for wells farther downgradient have either remained constant or have decreased only slightly. Well W-20, which is across Sunset Lake from the NFCS facilities, showed an elevated ammonia concentration (115 mg/L) the last time it was sampled (May 27, 1984). This is believed to be an anomaly because the piezometric gradient is near zero beyond the lake. Nevertheless, this matter will be pursued by the staff to determine whether or not the contaminant plume has extended beyond south of Sunset Lake. (A discussion of the impacts of the shallow groundwater contamination is presented in Sect. 4.2.3.2.) Well W-3 is the only well completed in the deeper Black Mingo Formation that has been routinely monitored for nonradiological parameters. No contamination in this well has been observed.

Offsite

Westinghouse analyzes monthly samples from the Congaree River for pH, ammonia, and fluoride. The sampling stations include three required by NRC for radiological analyses (Nos. 1, 2, and 3 shown in Fig. 3.7) and three supplemental stations located at the plant outfall, the confluence of Mill Creek and Congaree River, and a point 40 km (25 miles) downstream of the plant outfall. Data from 1981-1983 (Westinghouse 1984) indicate a range in the parameters measured as follows:

pH	6.0-7.5,
$NH_3(N)$	0.2-1.2 mg/L, and
F	0.2-0.6 mg/L.

The variation in data for these parameters over the 3-year period was not noticeably different from the expected seasonal fluctuations. A comparison of data from samples taken at 450 m (500 yd) upstream and downstream of the plant outfall shows no discernible effect attributable to effluent discharge. Because the effluent released to the river must meet the water quality limits set forth in the plant NPDES permit, no effect would be expected.

4.2 DIRECT EFFECTS AND THEIR SIGNIFICANCE

4.2.1 Air Quality

4.2.1.1 Criteria pollutants

At the Westinghouse NFCS, atmospheric emissions of nonradiological criteria pollutants (SO_2, NO_x, CO, and particulates), for which national air quality standards have been promulgated (40 CFR Pt. 50), are insignificant. Space heating is accomplished by combustion of relatively clean-burning natural gas and by electric heaters. Gases and particulates from combustion in the incinerator

(Sect. 2.2.2) are passed through a scrubbing system before they are released to the atmosphere. The incinerator is permitted by the state of South Carolina (SC-DHEC 1983a). Nitrogen oxides are released as a result of natural gas combustion for space and process heating. The staff does not expect that emissions of criteria pollutants from the plant will violate either national or South Carolina ambient air quality standards. Four small cooling towers at the plant emit insignificant quantities of drift, vapors, corrosion inhibitors, and biocides. These emissions will not significantly affect offsite air quality.

4.2.1.2 Ammonia and fluorides

Other nonradiological atmospheric emissions from the Westinghouse facility are ammonia (gaseous) and fluoride (particulate and gaseous). For operation of only the ADU process at the proposed maximum production rate of 1600 t/year of uranium, Westinghouse conservatively estimated that the ammonia emissions rate would average about 4.9 g/s, with a maximum of 6.2 g/s. However, the staff expects that the ammonia emissions will actually be about 30% less (or 3.4 and 4.3 g/s, respectively) because of the combined processing of uranium using the IDR process, which has no ammonia emissions, and the existing capability of the ADU process.

Since there are no federal or South Carolina air quality standards for ammonia, ambient concentrations at the site were not considered with regard to potential impacts to air quality. Rather, the possible impacts of ammonia emissions on vegetation, land use, and wildlife are discussed in Sect. 4.2.2 using the staff's estimate for the 1600 t/year of uranium processing.

Emissions of fluorides at a maximum production rate of 1600 t/year of uranium were estimated by the staff for the combined operation of ADU and IDR production lines. The recent average of measured fluoride emissions from the existing ADU processing lines at a nominal 700 t/year of uranium processing was 81.6 μg/s (Sect. 2.2.2.1). Operating the existing lines at the proposed expanded capacity would result in an average emission rate of about 130 μg/s. Westinghouse (1981) has conservatively estimated fluoride emissions from the proposed IDR process to be about 2125 μg/s. [In reality, the fluoride scrubbers and HEPA filters should remove most of the fluorides (Sect. 2.2.2.1).] The combined processes operating at the maximum proposed production rate of 1600 t/year, if unmitigated, could result in total fluoride emissions of 2255 μg/s. The applicant has not proposed expanding the ADU process capability to 1600 t/year of uranium, so no estimate of fluoride emissions has been made for this case.

Using annual average χ/Q values based on those provided in Table 3.2 and a fluoride emissions rate of 81.6 μg/s, the staff estimates that the annual average airborne concentration at the nearest site boundary for operation at 700 t/year is 0.0013 $\mu g/m^3$.

For operation at 1600 t/year with the combined processes, the estimated annual average ambient fluoride concentrations are:

- At the nearest boundary [550 m (0.3 mile) NNW] — 0.035 $\mu g/m^3$
- At the nearest neighbor [1000 m (0.6 mile) NE] — 0.017 $\mu g/m^3$

These concentrations, which are based on χ/Q values in Table 3.2 and a fluoride emissions rate of 2255 μg/s, are less than the South Carolina one-month-average standard of 0.8 $\mu g/m^3$ for

ambient fluoride concentrations (Table 3.3). Further, because the Westinghouse fluoride emissions are a mixture of particulates (NH_4F) and gas (HF) and because the South Carolina air quality standards apply only to gaseous fluorides, the impact of NFCS emissions relative to the standards will be even less.

4.2.2 Land Use

Land uses at the plant site (refer to Sect. 3.4.1) should not change significantly, because no new buildings or major external modifications to existing facilities are proposed as part of this license-renewal application. Thus, the project will have no construction-related effects on floodplains, wetlands, historic or archaeological sites, or natural landmarks.

Agricultural and pastoral uses of nearby land could potentially be affected by fluoride and ammonia emissions on crops, pasture grasses, and cattle. However, analysis of past projected fluoride and ammonia emissions associated with the proposed plant expansion (up to 1600 t/year of uranium) indicates that there will be no significant or observable impacts. The basis for this determination is provided in the following discussion.

4.2.2.1 Effects of fluoride emissions

Accumulation of fluorides in vegetation has been known to cause reduced productivity or death of plants and to cause fluorosis in grazing animals (NAS 1971). Uptake of airborne fluorides by foliage is the primary pathway to elevated fluoride levels in vegetation, whereas plant-root uptake of fluorides from soils is of little importance where fluoride levels in soils are not extremely high (NAS 1971), such as at the Westinghouse site. Emissions of fluoride from the NFCS elevate ambient levels of fluoride in air, soils, and biota in the vicinity. Projected annual average emissions of fluoride from the plant operating at a level of 1600 t/year of uranium and the estimated fluoride concentrations in the air at the nearest site boundary and the nearest neighbor were discussed in Sect. 4.2.1.

Although the impacts of airborne fluorides on vegetation cannot be reliably predicted (NAS 1971), air quality criteria to protect particularly sensitive plant species have been suggested: 1.2 $\mu g/m^3$ for a 24-h period and 0.4 $\mu g/m^3$ for a 100-d period (see Fig. 7-13 in NAS 1971), primarily for gaseous forms of fluorides with which various plant species were fumigated in field or laboratory studies reviewed by the NAS report. Estimates of annual average ambient atmospheric fluoride concentrations at the NFCS at the nearest boundary and nearest neighbor (0.035 and 0.017 $\mu g/m^3$, respectively) are below these values. Moreover, the fluoride concentrations do not consist entirely of the relatively toxic gaseous fluorides, but also include fluorides in relatively nontoxic particulate forms, thus reducing the potential for impacts. Therefore, fluorides emitted as a result of the operation of the Westinghouse plant at 1600 t/year of uranium should have no detectable effect on the appearance, and no significant effect on the productivity of plants.

Onsite soil and vegetation have also been analyzed for fluoride. Fluoride concentrations in soil ranged from 5 to 280 ppm, with an average of about 100 ppm during the years 1981-1983. This level is not considered important for the uptake of fluoride by vegetation (NAS 1971). A summary of fluoride concentrations in vegetation (principally Bermuda grass) collected from four onsite sampling locations (Westinghouse 1984) during 1981, 1982, and 1983 is presented in Table 4.7. The vegetation samples averaged 26 ppm, although 5 of 23 samples exceeded 40 ppm of fluoride, the tolerance level for mature dairy cattle (Table 4.8). Although the three tons of hay

Table 4.7 Annual average fluoride concentrations in onsite vegetation at NFCS for the period 1981–1983

Year	Fluoride (mg/L)			
	Station 1[b]	Station 2[b]	Station 3[b]	Station 4[b]
1981	12	22	28	10
1982	25	38	20	21
1983	36	30	34	31

[a]Reported values are the average of two samples taken in May and September of each year, except for Station 1 in 1981, which was only one sample.

[b]Sample locations shown in Fig. 4.1.

Source: Westinghouse 1984.

Table 4.8. Fluoride tolerance levels (ppm) in feed and water for domestic animals based on clinical signs and lesions[a]

Species	Feed[b] (mg/kg)	Water[c] (mg/L)
Cattle		
Dairy and beef heifers	30	2.5-4.0
Dairy, mature	40	3-6
Beef, mature	50	4-8
Finishing	100	12-15
Sheep, breeding	60	5-8
Lambs, feeder	150	12-15
Horses	60	4-8
Swine, growing	70	5-8
Turkeys, growing	100	10-12
Chickens, growing	150	10-13
Dogs, growing	50	3-8

[a]Values should be reduced proportionally when both water and feed contain appreciable amounts of fluorides.

[b]A suggested guide when fluoride in the feed is essentially the sole source of fluoride; tolerances based on sodium fluoride or other fluorides of similar toxicity.

[c]The average ambient air temperatures and the physical and biological activity of the animals influence the amount of water consumed and hence the wide range of tolerance levels suggested. For active animals in a warm climate, the lower values should be used as critical level indicators.

Source: U.S. Environmental Protection Agency. 1980. Reviews of the environmental effects of pollutants: IX. Fluoride. EPA-600/1-78-050. Cincinnati, Ohio.

harvested annually from the site is fed to a dairy herd of 150 head (Westinghouse 1984), this amount of hay would supply only a very small portion of the winter season food requirement; therefore, fluorosis should not be a major problem for these cattle. Concentrations in offsite vegetation should be lower than in onsite vegetation. Domestic animals grazing on the offsite vegetation should not be affected by fluorides, provided the fluoride concentration in their drinking water is not particularly high (Table 4.8).

The concentration of fluorides in soybeans grown on the site, which are sold to a commercial mill and processed for both livestock feed meal and soybean oil for human consumption, has not been monitored, but might be expected to be similar to that in the onsite vegetation. Concentrations of fluoride consistently greater than 40 ppm in the human diet have been projected to cause loss of body weight (NAS 1971, p. 239). Because the commercial mill mixes the soybeans from the NFCS with the soybeans harvested from other regional farms, the fluoride level in the final soybean products would be significantly less than in the NFCS soybeans alone and would not be of concern.

Expansion of the plant facilities from 700 to 1600 t/year of uranium with the additional use of the IDR process will result in increased emissions of fluorides (Sect. 4.2.1), which may result in increased fluoride content of vegetation on and near the site. The applicant's program of monitoring fluorides in onsite grasses should be continued to detect any such increases. However, the staff does not believe the current timing of sampling onsite grass (May and September; Westinghouse 1984) is adequate for an assessment of fluoride impacts on a dairy herd. Therefore, the staff will require that grass samples for fluoride analysis be taken at least twice a year when the grass is being cut for hay. In addition, the current grass monitoring program does not enable an assessment of whether the measured fluoride concentrations are the result of the plant operation, because there are no offsite baseline data. Therefore, the staff will require that grass samples from farms or roadsides (sufficiently removed from NFCS to not be influenced by NFCS emissions) be taken on the same day as the onsite samples. Similarly, the staff will require that samples of soybeans from onsite fields and from distant offsite fields be taken at harvest time so that an assessment of the impact of fluoride emissions on the soybean crop and on the ultimate user can be provided.

The sampling program for the grasses and for the soybeans should be continued until a complete assessment can be performed after the IDR process has been operating in combination with the existing ADU systems through at least two growing seasons.

4.2.2.2 Effects of ammonia emissions

Although ammonia is a plant nutrient and is used in fertilizers, a very high atmospheric concentration of ammonia can adversely affect vegetation. Calculated from the staff's estimate of ammonia emissions (3.4 g/s average and 4.3 g/s maximum: Sect. 4.2.1) and an annual average χ/Q value derived from the values in Table 3.2, the ammonia concentrations for the operating level of 1600 t/year of uranium are projected to be 52 $\mu g/m^3$ average and 66 $\mu g/m^3$ maximum at the nearest site boundary (550 m or 1800 ft NNW). Information on the effects of high concentrations of ammonia is meager, but available data indicate that short-term (e.g., up to 30 days) concentrations over 1 to 2 mg/m^3 may cause reduced productivity in plant species that are particularly sensitive to ammonia (e.g., mustard; National Research Council 1979). Although annual average concentrations will be well below 1 to 2 mg/m^3, combination of a maximum emission rate and short-term adverse meteorological conditions could result in ambient ammonia concentrations

within this range and could cause slight loss of productivity for ammonia-sensitive plant species at the site. However, the staff considers this combination of circumstances unlikely.

Ammonia emissions from the plant should not present a hazard to domestic or wild animals or to public health. Although chronic exposure limits for the general public in populated areas have not been set or recommended for the western world, the USSR has defined 0.3 ppm (0.2 mg/m^3) as the maximal allowable long-term concentration in populated areas. The USSR value is conservative and is intended to prevent exposures that produce slight changes in human central nervous system reflex activity, such as eye sensitivity to light and electroencephalogram-evoked response (National Research Council 1979). The maximum annual average ammonia concentration at the nearest NFCS boundary (66 $\mu g/m^3$) is less than the USSR standard of 0.2 mg/m^3 (200 $\mu g/m^3$).

For significant impacts to occur on domestic animals and on land uses involving these animals, concentrations of ammonia would have to be much higher than the suggested guidelines for the protection of human health. Because the predicted ammonia concentrations at and beyond the nearest site boundary are below the conservative USSR limit, no impact should occur.

4.2.3 Water

4.2.3.1 Surface water

Congaree River

Quality. Liquid waste streams from NFCS operations include sanitary wastes and process wastes. Process wastewaters are primarily contaminated by ammonia and fluorides. Both waste streams are treated onsite prior to their combined discharge into the Congaree River (see Sect. 2.2.2.2). The discharge of the plant effluent to the Congaree River must comply with limitations set forth in an NPDES permit issued by the SC-DHEC (see Appendix B). Because of this requirement, nonradiological environmental impacts to the water quality of the Congaree River should be insignificant at any level of production capacity. Likewise, as discussed in Sect. 4.2.5, radiological impacts to the Congaree River are not expected to be significant.

Table 4.9 indicates the daily average discharge of chemical and biological constituents in the NFCS effluent during 1982. The NPDES limitations for the daily average discharge are provided as a comparison. From the table, it is obvious that the effluent discharged from the plant was well below the permit limitations. No reported instances of noncompliance with the NPDES permit have been reported since November 25, 1982, when the 5-day BOD level [22.6 kg (50.2 lbs) per day] exceeded the daily maximum limit in effect at that time [18 kg (40 lb) per day] (Westinghouse 1982). Previous noncompliance instances (1981-1982) included four total suspended solids exceedances, three BOD_5 exceedances and one ammonia exceedance (Westinghouse 1983, Table 5.4). All but the ammonia violation were less than twice the maximum daily limit (the ammonia violation exceeded the limit by five times). In all cases, however, dilution upon mixing in the river (Sect. 3.5.1.1) probably precluded any adverse impacts to downstream water quality.

Daily average discharge concentrations of chemical constituents in the NFCS plant effluent are not expected to increase significantly with an increase in NFCS production capacity to 1600 t/year of uranium. At this capacity, the final effluent discharged to the Congaree River would also be required to meet NPDES limitations; therefore, no significant water quality impacts would result.

Consumption of water. The present water consumption at the NFCS for processing 700 t/year of uranium is 0.008 m^3/s (0.3 ft^3/s). The water obtained from the Columbia Municipal

Table 4.9 Comparison of current NPDES permit limits and the daily average discharge (1982) from the NFCS to the Congaree River, lb/d (unless listed)[a,b,c]

Parameter	NPDES daily average limitation	NFCS daily average discharge (1982)
Biological oxygen demand (BOD_5)	25	14.6
Total suspended solids (TSS)	32	17.2
Fluoride	40	14.9
Ammonia (NH_3N)	60	14.8
Oil and grease	10 mg/L	3.5 mg/L
Fecal coliform	200 MPN/100 ml	51 colonies/100 ml
pH, units	6.9 (minimum)	8.7

[a]lb/day × 0.45 = kg/day

[b]NPDES permit reprinted in its entirety in Appendix B.

[c]Data from Westinghouse 1983, Table 5.5.

Water System is used for potable and process cooling requirements. Approximately 45% of this water is released to the atmosphere in the form of water vapor from the lagoons and cooling towers, and the remainder is discharged to the Congaree River as treated liquid waste (see Sect. 2.2.2.2). Half of the discharge is from the process stream and half from the sanitary treatment plant (Westinghouse 1983, Sect. 5.2.2.2).

The projected maximum water consumption at the expanded capacity of 1600 t/year of uranium is 0.014 m^3/s (0.5 ft^3/s). This consumption represents 1% of the Columbia Municipal Water System's water use (Westinghouse 1983, Sect. 5.2.2.1); therefore, the effect on the city water availability should be negligible. This level of water use should also have a negligible effect on the quantity of water available for downstream water use.

Onsite surface water

Surface waters onsite at the NFCS include Mill Creek, Sunset Lake, and a small pond (see Fig. 4.1). The small pond south of the plant has previously received contaminated input from groundwater (see Sect. 4.2.3.2), but it has been isolated so that there is no interchange with Sunset Lake. Concentrations of ammonia and fluoride in samples taken weekly since the contaminated groundwater plume was discovered have been as much as 300 times background levels. Recent (1983) levels have decreased to 50 to 100 times background (Westinghouse 1984). The volume of the pond is periodically reduced by pumping water back to the facility's west lagoon and then into the south lagoon for treatment to help prevent contamination of the lake (R. Fischer, Westinghouse, personal communication with V. R. Tolbert, ORNL, September 19, 1984). Because of the large volume of Sunset Lake [1.6×10^5 m^3 (4.3×10^7 gal)] and a flow ranging from 0.003 to 0.02 m^3/s (0.1 to 0.6 ft^3/s) (Westinghouse 1983, Sect. 5.2.2.5), any small volume leakage to Sunset Lake should be insignificant.

Westinghouse routinely monitors onsite surface waters for radiological and nonradiological parameters (Sect. 4.1). Sampling stations (Table 4.6) were selected to indicate background water quality (entrance sample), to reflect the quality of drainage and runoff from the plant's paved areas (road), and to detect any contamination of Sunset Lake or Mill Creek that might result from onsite drainage (causeway, spillway, and exit).

Mill Creek is classified by the state as Class A, freshwater suitable for primary contact recreation and, as such, is protected from degradation by state water quality standards (SC-DHEC 1983b). The standards are primarily used as the basis for limitations set forth in NPDES permits issued for point discharges to a Class A receiving stream. Although no point discharges to Mill Creek occur from the NFCS, the standards were used for comparison in an assessment of onsite surface water quality. Data presented in Table 4.6, Sect. 4.1.2.2, clearly indicate that the quality of Mill Creek and Sunset Lake water is not significantly affected by contaminated runoff and drainage at the NFCS. In addition, pH and concentrations of ammonia at all stations along the creek and lake have been below EPA guidance limits for protection of aquatic life (EPA 1976).

4.2.3.2 Groundwater contamination

Shallow groundwater contamination was discovered in mid-1980 and has since that time been the subject of considerable investigation. Although it is difficult to pinpoint, the original leakage that caused the contamination may have started as early as 1972. The primary suspected sources were the concentrated waste treatment tank area and the ammonia storage tank area. Westinghouse has since constructed improved concrete dikes and internment pads for storage of process waste and raw materials. The waste treatment lagoons were also suspected of being a source of contamination, so during 1981-1982, all lagoons were relined with 36-mil hypalon and underdrain systems were installed to detect lagoon leakage. The improvements have apparently been effective in eliminating leakage from these sources. Although there appears to be considerable residual groundwater contamination immediately adjacent to the waste treatment tank area, recent groundwater monitoring indicates that leakage from this source no longer exists (Sect. 4.1.2.2).

Currently, groundwater contaminants appear to be contained within the shallow terrace aquifer inside the NFCS boundary. No contamination of the deeper Tuscaloosa aquifer has been observed. Because the piezometric head in the Tuscaloosa aquifer is probably equal to or greater than in the shallow aquifer (Sect. 3.5.2.3) and because the intervening Black Mingo formation (Fig. 3.13) has a low permeability (Sect. 3.5.2.1), contamination is not expected to move from the shallow into the deeper aquifer. However, poorly completed or abandoned wells that penetrate through the confining Black Mingo strata, as identified in Sect. 3.5.2.1, could permit flow of contaminated water from the surface aquifer into the Tuscaloosa aquifer. Mitigating action for this potential problem is discussed in Sect. 4.2.6.

In 10 years, the groundwater contaminants (concentrated enough to produce a fish kill) have migrated south approximately 200 m (650 ft) from the plant area to Sunset Lake. Further migration south of Sunset Lake is nil because the piezometric gradient is near zero beyond the lake. Assuming that the piezometric gradient to the southeast is half that for the area between the plant and Sunset Lake, it is estimated that contaminants will reach the southeastern site boundary in about 60 years. The concentration of contaminants at the site boundary will be diluted by perhaps tenfold by dispersion. Now that the sludge ponds have been relined, one source of contaminants and high piezometric head has been removed. Thus, the estimated time of arrival of contaminants at the site boundary is considered to be conservative.

There are no downgradient offsite wells within 5 km (3 miles) of the site boundary. The likelihood of developing groundwater resources in nearby downgradient areas is remote because the Congaree Swamp and adjacent marshlands are not suitable for agricultural development. Furthermore, industry is not likely to be sited on the 100-year floodplain of the Congaree River. As a consequence, mitigation of groundwater contamination is not currently required. However, the staff will require continued monitoring of appropriate downgradient wells in the shallow aquifer in order to study the behavior of the contaminant plume. This monitoring will also provide an early warning of changes that may require mitigating action.

If the need for mitigation should ever arise, there is sufficient time to develop and implement an appropriate methodology because the buffer zone between the contaminated zone and the NFCS boundary is approximately 600 m (2000 ft) wide, and the nearest downgradient offsite well is about 5 km (3 miles) to the southeast. Of the several methodologies available, the simplest is a pump-back system in which contaminated groundwater is retrieved and placed in an evaporation pond. Unfortunately, evaporation ponds are not very efficient in humid climates such as that of South Carolina, and consumptive use of groundwater is a problem. These problems can be reduced by pumping the contaminated groundwater through a water treatment plant. Contaminants can be removed by reverse osmosis, electrodialysis, or ion exchange. These processes produce two streams: (1) purified water, which is returned to the aquifer, and (2) a concentrated brine, which is discharged to an evaporation pond. The above treatments reduce consumptive water use by as much as 80%, with a corresponding reduction in evaporation pond requirements. Another approach to decontamination of groundwater is in situ treatment. Ammonium may require in situ treatment because it becomes fixed on clay minerals by cation exchange and, thus, is not easily withdrawn with the groundwater. Several in situ ammonium-removal methodologies are currently being investigated, including: (1) chemical oxidation, (2) biological oxidation, and (3) cation elution. Results from in situ methodology have only been marginally effective because of geochemical side reactions and a tendency to plug the aquifer. Deutsch et al. (1984) provides a comprehensive summary of surface and in situ treatment methodologies.

4.2.4 Ecology

4.2.4.1 Terrestrial

Because expansion of the existing Westinghouse facilities is not proposed, there will be no loss of terrestrial habitat or reductions in wildlife populations resulting from construction-related activities or from conversion of wildlife habitat to industrial uses. Noticeable impacts to the appearance or productivity of onsite vegetation have not been observed as a result of fluoride and ammonia emissions from the NFCS at the present production capacity. With the proposed increase in capacity using the IDR process (Sect. 2.1), fluoride emissions will increase (Sects. 4.2.1 and 4.2.2). However, because the increased emissions will likely be in the form of particulate fluorides (Sect. 4.2.2), which are less damaging than gaseous, no significant impacts to onsite vegetation or herbivorous animals are expected. Impacts to offsite vegetation and terrestrial biota are unlikely.

4.2.4.2 Aquatic

A comparison of the water quality of the Congaree River upstream and downstream (Sect. 4.1.2.2) of the NFCS indicated only minor differences between the locations. After dilution

of the effluent discharge there should be minimal effect on water quality outside the mixing zone (Sect. 4.2.3.1), and resulting concentrations should be within the range of values established for protection of aquatic life (EPA 1976). Ammonia concentrations upstream of the site occasionally exceed the EPA limitation of 0.9 mg/L established for protection of aquatic life; however, the discharge from the NFCS plant (9.4 mg/L), upon dilution, would contribute less than 0.002 mg/L to the ammonia concentration in the river. Resulting impacts to aquatic life would be negligible.

After the sanitary stream mixes with the process waste stream, the residual chlorine concentration of the effluent could be as high as 1 mg/L. Mixing of the discharge with the river at a minimum flow of 45 m^3/s (1590 ft^3/s) would cause a maximum rise of 0.0002 mg/L residual chlorine which is 7% of the recommended maximum concentration of 0.003 mg/L (EPA 1973). At an average river flow rate of 266 m^3/s (9388 ft^3/s), the increase in chlorine concentration would be 0.00003 mg/L, or 1% of the recommended maximum concentration. Because complete mixing will not occur instantaneously and because toxic levels of residual chlorine could occur at the outfall, relatively immobile aquatic life that could not avoid the chlorine, such as benthic invertebrates and periphyton, would be killed. Most fish would be able to avoid the high chlorine concentrations at the outfall. Therefore, because of the limited extent of the discharge plume, the limited likelihood of low flow (7-d, 10-year), and the limited number of aquatic organisms that would be directly affected, the impact of the residual chlorine in the NFCS effluent on aquatic biota would be negligible. Because the effluent discharged from the NFCS must comply with NPDES limitations (Appendix B; Sect. 4.2.3.1), the staff concludes that there should be no adverse impact to aquatic biota in the Congaree River.

Ammonia- and fluoride-contaminated water in the pond south of the plant is pumped to the west lagoon to prevent transport of toxic levels of these constituents in Sunset Lake, the discharge and treatment lagoons have been lined to prevent leakage, and the walls have been fortified to prevent rupture. Because there is no direct discharge to Sunset Lake from the NFCS plant, there should be no adverse impacts to the lake from normal plant operation. In the event of lagoon leakage or rupture, there could potentially be a fish kill in Sunset Lake; however, because the lagoons contain treated rather than raw liquids and only employees fish in the lake (Sect. 3.7.2), any impacts should be minimal.

4.2.4.3 Threatened and endangered species

No endangered or threatened terrestrial or semiaquatic species should be jeopardized by operation of the Westinghouse plant at 1600 t/year of uranium. Any alligators that may inhabit Sunset Lake on the site should not be affected, because no effluents are or will be discharged to this lake. Liquid discharges to the Congaree River do not significantly affect the quality of the river (Sect. 4.2.3) and should, therefore, not affect alligators or their important prey species. Because there are apparently no colonies of red-cockaded woodpeckers on or near the site (Sect. 3.7.3), this species should also be unaffected. Emissions of fluoride and ammonia to the atmosphere would not be likely to affect any vegetation important to these woodpeckers off the site. Because no habitat on the site appears to be particularly important to migrating species or species that occasionally visit the area (Sect. 3.7.3), such species should also not be affected.

There are no known threatened or endangered aquatic species in Sunset Lake. The short-nosed sturgeon could occur in the Congaree River in the Columbia vicinity (Sect. 3.7.3.2); however, because there is no thermal discharge and the levels of chemical discharge to the river is low and

well within EPA limitations (Sect. 4.2.3), there should be no adverse impacts from the NFCS liquid effluent on endangered species.

4.2.5 Radiological Impacts

The radiological impacts of the Westinghouse facility were assessed by calculating the maximum dose to the individual adult living at the nearest residence and to the local population living within an 80-km (50-mile) radius of the plant site. Where site-specific information was not available, assumptions that would tend to maximize the dose were used in the calculations. It is only when such conservative assumptions yield a dose near or exceeding the applicable limit that Westinghouse would be required to obtain appropriate data for a more realistic evaluation. Except where specified, the term "dose" as referred to in this EA is actually a 50-year dose commitment for all exposures; that is, the total dose to the reference organ that will accrue from 1 year of intake of radionuclides during the remaining lifetime (50 years) of the individual. Estimates were also made of the dose to an infant younger than 1 year old living at the nearest residence and to both an adult and infant assumed to reside at the nearest site boundary.

The doses were calculated using radioactive effluent release rates measured during recent operation at the NFCS and those estimated for the proposed higher production rate. Measured airborne uranium releases at 700 t/year processing have averaged at 27 μCi/week (Sect. 2.2.2.1). Westinghouse (1983) estimated that operation of the plant at 1600 t/year of uranium with additional ADU process lines would triple the emissions to about 81 μCi/week, which is 12% greater than the projected emissions rate (71.9 μCi/week) used in the previous environmental assessment for license renewal (NRC (1977a). Because the applicant has not proposed additional ADU process lines to obtain the higher production capability, the staff estimated the following uranium emissions for operation of the combined ADU and IDR facilities at a capacity of 1600 t/year of uranium. Operation of the ADU process would result in emissions of about 42.4 μCi/week at the expanded operating level. The applicant estimated the uranium emissions rate to be about 3.5 μg/s or 2.1 g/week for the IDR process (Westinghouse 1981). This is equivalent to about 5 μCi/week, on the basis of a specific activity of 2.4 μCi/g for uranium enriched to 5% ^{235}U. The total emissions at the 1600-t/year capability with the combined processes would therefore be 47.4 μCi/week.

For the airborne emissions, source terms are coupled with atmospheric dispersion factors (Table 3.2) generated by the use of the Gaussian Plume Model and diffusion coefficients for Pasquill-type turbulence as in Regulatory Guide 1.111 (NRC 1977b). Doses via significant pathways are determined on the basis of models presented in Regulatory Guide 1.109 (NRC 1977c), with the exception that, for the inhalation and ingestion pathways, dose conversion factors for various organs were used (Dunning 1981). The inhalation dose factors were produced by the ICRP Task Group Lung Model and depend on the particle size and solubility of released compounds. Because the particle size and solubility of airborne emissions have not been determined, conservative assumptions for these parameters have been made. Namely, the particles passing through HEPA filters are assumed to have an Activity Median Aerodynamic Diameter (AMAD) of 0.3 μm. The released particles are further assumed, first, to be completely in an insoluble form (Class Y) to provide a maximum calculated lung dose for the inhalation pathway and, then, completely in a soluble form (Classes D and W) to provide a maximum calculated bone dose for the ingestion pathway. See Appendix A for additional discussion and tables of dose conversion factors.

For the liquid effluents discharged into the Congaree River, it was conservatively assumed that the uranium is in a soluble form.

4.2.5.1 Doses to the maximally exposed individual

The nearest residence to the Westinghouse plant is located about 1000 m (3300 ft) to the northeast. For airborne emissions, the pathways considered in the individual dose estimates were: (a) direct irradiation from ground deposition; (b) immersion in the airborne plume; (c) direct inhalation; and (d) ingestion of vegetation, meat, and milk that are conservatively assumed to be produced at the nearest residence. For liquid effluents, the pathways include: (a) ingestion of aquatic food (fish) and (b) submersion by swimming in the Congaree River. The river is not used as a drinking water supply downstream of the NFCS; so potable water was excluded as a possible exposure pathway. The models and various assumptions involved in the above pathways can be referred to in greater detail in Regulatory Guide 1.109 (NRC 1977c). Table 4.10 summarizes the calculated maximum doses from airborne and liquid effluents to the nearest adult resident when the facility is processing 700 t/year of uranium.

When the doses are compared to the EPA standards for uranium fuel cycle facilities (40 CFR Pt. 190), the total body dose of 6.2×10^{-2} millirem/year is only about 0.25% of the limit of 25 millirem/year. The highest organ dose of 2.0 millirem to the lung is about 8% of the applicable EPA standard, the bone dose of 3.1×10^{-2} millirem is about 0.12% of the standard, and the kidney dose of 7.5×10^{-3} millirem is about 0.03% of the standard.

As shown in Table 4.10, the critical pathway is through inhalation resulting in a maximum dose to the lung of 2.0 millirem/year. The above calculations assume a normal adult, but the staff has

Table 4.10. Estimated maximum annual dose from airborne and liquid effluents to the nearest adult resident

Pathway	Organ Dose (millirem/year)			
	Total body	Lung	Bone	Kidney
Air effluents				
Direct irradiation	2.8×10^{-5}	2.4×10^{-5}	3.6×10^{-5}	2.2×10^{-5}
Immersion in air	7.4×10^{-9}	6.7×10^{-9}	1.0×10^{-8}	6.3×10^{-9}
Direct inhalation[a]	6.2×10^{-2}	2.0	2.8×10^{-2}	6.0×10^{-3}
Ingestion[b]	3.5×10^{-4}	1.0×10^{-5}	4.7×10^{-3}	1.0×10^{-3}
Liquid effluents				
Submersion	6.7×10^{-7}	6.2×10^{-7}	9.3×10^{-7}	5.7×10^{-7}
Aquatic food[c]	1.6×10^{-4}	4.7×10^{-6}	2.2×10^{-3}	4.7×10^{-4}
Total	6.2×10^{-2}	2.0	3.1×10^{-2}	7.5×10^{-3}

[a]Assumes 80% residence time.

[b]Since site-specific information is not available, it is assumed that 100% of the vegetables consumed are grown at the nearest residence.

[c]Fish.

also considered a critical individual (an infant of 0-1 years of age) at the nearest residence. The lung dose to an infant would be 1.9 times the adult dose (Hoenes and Soldot 1977), equivalent to 3.8 millirem/year. This dose is about 15% of the EPA standard. Therefore, normal operation of the plant over the past 5 years has resulted in maximum annual doses at the nearest residence that are well below 40 CFR Pt. 190 limits.

At the proposed maximum operating level of 1600 t/year of uranium using the combination of ADU and IDR process lines with an emissions rate (47.4 μCi/week) about 75% greater than for 700 t/year, the estimated maximum doses would be 3.5 millirem/year for the lungs of an adult and 6.6 millirem/year for the infant. These doses are 14% and 27%, respectively, of the EPA standard.

The maximum impact on an unrestricted area resulting from emissions at the NFCS might be at the nearest site boundary [550 m (1800 ft) north-northwest of the fuel manufacturing building] rather than at the nearest residence. The χ/Q at this boundary is about a factor of 2 higher than the χ/Q at the nearest residence. The resulting maximum annual doses to an infant at the boundary would be 7.6 millirem and 13.3 millirem, at the processing rates of 700 and 1600 t/year of uranium, respectively. These doses are still well below the EPA limit.

Additional staff analysis indicates that emissions of over 9000 μCi/year would be necessary to exceed the 25-millirem/year limit to the critical individual at the nearest residence. In order that the requirements of ALARA are met, License SNM-1107 currently requires Westinghouse to report to NRC if plant gaseous effluents exceed 1500 μCi/quarter (6000 μCi/year). This release rate results in an annual lung dose to an infant at the nearest residence of about 16 millirem/year; however, such an annual release may cause a lung dose to an infant at the nearest boundary that exceeds the 25-millirem limit. Accordingly, the license also requires Westinghouse to notify NRC of any changes in parameters important to a dose assessment (e.g., a family moving to the nearest boundary) and to estimate the resultant change in dose commitment. In the event that the calculated dose to any member of the public is about to exceed 25 millirem/year, Westinghouse is required to take immediate steps to reduce emissions and ensure compliance. Even though Westinghouse's average annual emission over the last 5 years has been about 1300 μCi/year, these requirements will be continued in the renewed license as added assurance that the requirements of 40 CFR Pt. 190 are met.

The staff analysis of the radiological dose to the nearest resident (Table 4.10) did not include the use of potable water from the Congaree River. Also, no downstream consumers of potable water from the Congaree River were identified. However, in case there are downstream consumers, the staff has calculated the dose to an individual obtaining 100% of his requirements from the river immediately downstream of the plant discharge. The radioactivity concentrations in the river due to plant operation, shown in Table 4.11, are based on the effluent concentrations shown in Table 2.4.

The maximum individual doses in millirem/year are shown in Table 4.12. All the doses are less than 1 millirem/year, which is a small percentage of the EPA standards.

4.2.5.2 Doses to the population within 80 km (50 miles) of the plant site

The 1980 population within a 50-mile radius of the plant is shown in Table 3.4. About 783,000 people live within this area. Population doses were calculated on the basis of the dose estimates at the nearest residence for operation of the plant at 700 t/year of uranium, the ratio of χ/Q at the nearest residence and at various segments within the 80-km (50-mile) radius, and

Table 4.11. Annual average and daily maximum concentrations of radioactivity in the Congaree River[a] below the NFCS discharge[b] for plant operation[c] at 700 and 1600 t/year of uranium

Radioactivity	Operation at 700 t/year		Operation at 1600 t/year[d]	
	Annual average (pCi/mL)	Daily maximum (pCi/mL)	Annual average (pCi/mL)	Daily maximum (pCi/mL)
Alpha	1.4×10^{-5}	1.9×10^{-4}	5.7×10^{-5}	7.9×10^{-4}
Beta	6.7×10^{-6}	9.2×10^{-5}	2.7×10^{-5}	3.7×10^{-4}

[a]Annual average river flow is 266 m^3/s (9388 ft^3/s), and the daily minimum flow has been 19 m^3/s (662 ft^3/s).

[b]Average discharge rate of the combined effluent is 5.7×10^{-3} m^3/s (0.2 ft^3/s) at 700 t/year and 8.5×10^{-3} m^3/s (0.3 ft^3/s) at 1600 t/year.

[c]Concentration of radioactivity in the discharge is given in Table 2.4.

[d]Estimated values.

Table 4.12. Estimated maximum individual doses in millirem/year from drinking Congaree River water downstream of the NFCS discharge, for operation at both 700 and 1600 t/year of uranium[a]

Organ	Operation at 700 t/year	Operation at 1600 t/year
Total body	3.0×10^{-3}	1.2×10^{-2}
Lung	8.7×10^{-5}	3.5×10^{-5}
Bone	4.0×10^{-2}	1.6×10^{-1}
Kidney	8.7×10^{-3}	3.5×10^{-2}

[a]Annual average concentrations of plant-induced radioactivity in the river (Table 4.11) were used.

the population in the corresponding segments. The population dose estimates considered the exposure pathways via airborne effluents. The population dose commitments from routine releases from the NFCS are shown in Table 4.13. The natural background dose rate to the total body is 117 millirem/year near Columbia, S.C. (Sect. 3.8), which results in a population dose within 80 km (50 miles) of the NFCS of 9.2×10^4 man-rem. The total body dose rate of 0.28 man-rem shown in Table 4.13 is negligible compared to this background value. Operation at 1600 t/year of uranium would not alter this conclusion.

4.2.6 Mitigatory Measures

The effluent and environmental monitoring programs that have been established for the Westinghouse facility are needed to measure the impacts of plant emissions on the environment during normal operations or following an accident situation. The monitoring programs, as well as recent results for plant operations at 700 t/year of uranium, were outlined in Sect. 4.1. A brief analysis of the results was also provided. A discussion of the impacts observed from past plant

Table 4.13. Dose commitments from airborne discharges to the population within 80 km (50 miles) of the NFCS

Pathway	Dose (man-rem)[a]			
	Total body	Lung	Bone	Kidney
Direct irradiation	7.7×10^{-4}	6.6×10^{-4}	6.5×10^{-4}	6.2×10^{-4}
Immersion in air	2.1×10^{-8}	1.4×10^{-8}	1.8×10^{-8}	1.8×10^{-8}
Direct inhalation	2.8×10^{-1}	1.5×10^{1}	1.1×10^{-1}	2.0×10^{-2}
Ingestion[b]	1.5×10^{-4}	6.4×10^{-7}	2.0×10^{-3}	3.4×10^{-4}
Total	2.8×10^{-1}	1.5×10^{1}	1.1×10^{-1}	2.1×10^{-2}

[a]Assumes all adults.

[b]Ingestion of vegetables, meat, and milk with the same radioactivity concentrations as postulated food produced at the nearest residence.

operations, and those expected to result from expanded operations up to 1600 t/year of uranium, was presented in Sects. 4.2.1 through 4.2.5. On the basis of these analyses, operations of the Westinghouse NFCS since the last license renewal have not resulted in any significant environmental impacts. Further, no significant impacts are expected to result from plant operations at the expanded level. The staff will require that the existing monitoring programs be continued in order to confirm this conclusion. The frequency of surface water monitoring will be decreased from monthly to quarterly, and soil monitoring will be permitted annually rather than semiannually. This decreased monitoring, which is considered adequate, is based on the existing data base provided by Westinghouse, which demonstrates no significant impact to either surrounding surface water or soil. In areas of potential concern, particularly with the expanded plant operations, the staff will require expanded, modified, or both expanded and modified environmental monitoring.

As discussed in Sect. 4.2.3.2, the shallow aquifer at the NFCS site has been contaminated as a result of past operations. The applicant has taken corrective action that has effectively eliminated the leakage that was the source of the contamination. Although there appears to be considerable residual groundwater contamination in the shallow aquifer near the operations area, the contaminant plume has remained on the NFCS property. No contamination of the deeper Tuscaloosa aquifer has been observed, and contamination is generally not considered likely (Sects. 3.5.2.1 and 4.2.3.2). Given these conditions and the fact that there are not downgradient offsite wells that are likely to be impacted by the plume, no mitigatory measures are currently necessary. However, the staff will require Westinghouse to expand its routine groundwater monitoring to include appropriate shallow wells and at least one well completed in the deeper aquifer (e.g., Well W-3). The purpose of this monitoring will be to study the plume and to provide an early warning of any changes that may warrent mitigating action.

The quality of monitor well completions is variable (Davis and Floyd 1982). Existing wells W-6 through W-17 (Figs. 3.8 and 3.9) were originally installed as temporary observation wells and contain neither bentonite seals nor cemented casings [(Fig. 4.2(a)]. Although these wells are suitable for measuring water levels, they are not satisfactory for determining water quality, because of potential dilution from rainwater infiltration through the well annulus. Figure 4.2(b) shows a properly completed well for monitoring groundwater quality. Wells W-18 through W-33 are all

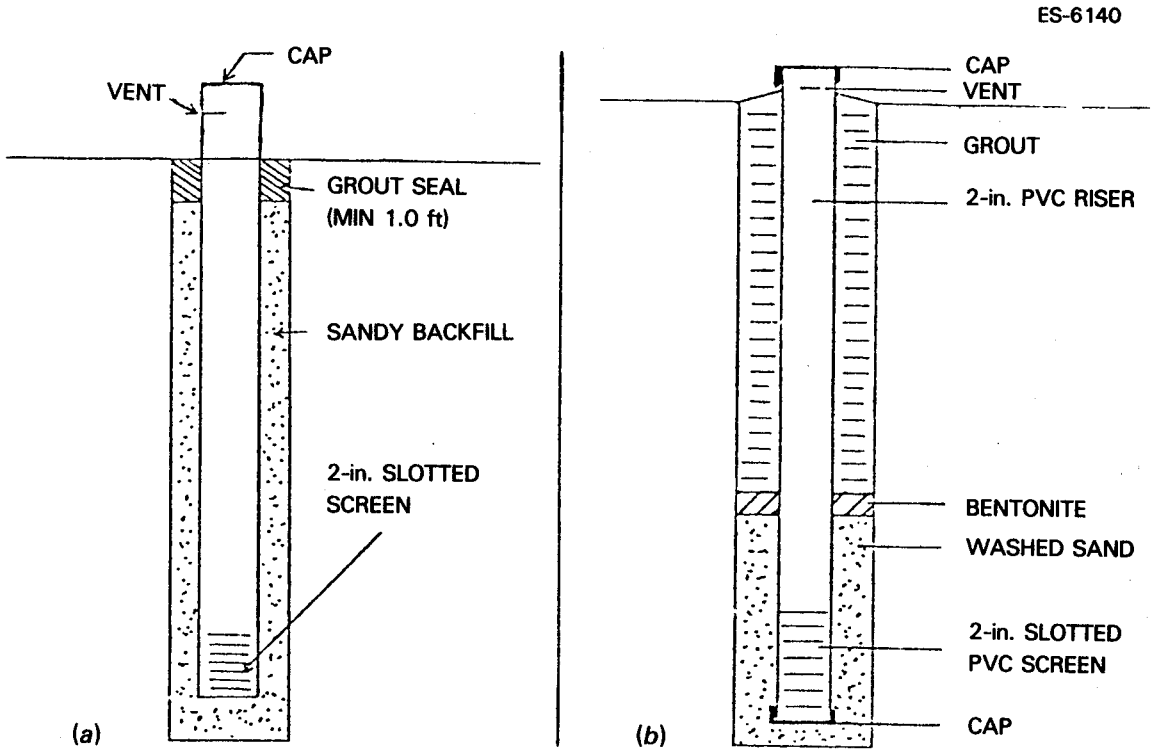

Fig. 4.2. Well completion suitable for (*a*) water level measurement only and (*b*) sampling water quality.

properly completed. Well completion methodologies for wells W-1 through W-5 are not well known and appear to be open-hole completions below variable lengths of steel surface casings. The staff will require routine sampling of properly completed wells to more accurately monitor behavior of the contaminant plume. In addition, the staff will require well W-3, which is completed in the deeper aquifer, to be upgraded to the state-of-the-art design. This will provide greater protection for the deep aquifer (by eliminating possible contaminant seepage down the well casing) as well as improved monitoring capability.

As discussed in Sects. 4.1.2.2 and 4.2.1, operation of the Westinghouse plant at about 700 t/year of uranium has resulted in estimated air concentrations of fluoride that are below air quality standards set by the state of South Carolina. This is also expected to be true for plant operations at 1600 t/year of uranium, even though the proposed IDR lines will result in increased fluoride emissions. However, occasional vegetation samples taken onsite (5 out of 23 samples from 1981 through 1983) have exceeded 40 ppm, which is about the maximum safe level in the total ration fed to dairy cows. Some areas of the Westinghouse site are cut for hay for dairy cow feed, but the hay derived from NFCS property will constitute only a small portion of the herd's total ration. Therefore, it is very unlikely that these cows would develop fluorosis as a result of either the existing or expanded plant operations. The staff will nevertheless require the applicant to modify its existing monitoring program to provide a better assessment of fluoride impacts. Specifically, Westinghouse will take grass samples for fluoride analysis at least twice a year, when the grass is being cut for hay. Soybean crops, if grown onsite will also be monitored for fluoride at

harvest. Appropriate background samples of grass and soybeans will be taken at harvest time for fluoride analysis.

4.3 INDIRECT EFFECTS AND THEIR SIGNIFICANCE

4.3.1 Socioeconomic Effects

As discussed in Sect. 3.3, employment at the Westinghouse NFCS is not a major factor in the economy of Richland County, South Carolina. Neither continued operation nor discontinuance would have a significant impact on socioeconomic conditions.

4.3.2 Potential Effects of Accidents

Accidents that could occur at the Westinghouse NFCS are both radiological and nonradiological in nature. The fabrication of fuel for nuclear reactors involves the chemical processing of low-enriched uranium. Significant radioactive materials present at the fuel fabrication facility are the UO_2 pellets for fuel rod fabrication and the UF_6 stored in cylinders. The $\leq$5% enriched uranium that is used has a low specific activity of 2.4 μCi/g. Thus, with the exception of a criticality accident and the potential rupture of UF_6 cylinders, the environmental impacts which would result from postulated accidents at the Westinghouse fuel fabrication plant should be similar to the impacts of a manufacturing plant in which nonradioactive chemicals are stored. The radiological environmental impacts of the more probable postulated accidents are insignificant at this facility.

A spectrum of possible accidents related to the operation of the NFCS and their potential consequences are presented in Table 4.14. Accident severity is classified into three categories. Category 1 accidents are those most likely to occur during normal plant operations, and have the least environmental impacts of the three. Category 2 events, which would occur infrequently during the plant's operating life, could release concentrations of radiological and nonradiological pollutants to the onsite (and possibly offsite) environment that would exceed normal effluent releases and could cause significant impacts, if not controlled or mitigated. Category 3 accidents are those not expected to occur during the life of the plant but which could result in significant releases of radioactive or toxic pollutants to the onsite and offsite environment. Westinghouse (1975 and 1983) has analyzed the radiological and nonradiological consequences of several accident scenarios, both inside the manufacturing plant and outside the plant (i.e., storage areas, lagoons, etc.).

4.3.2.1 Radiological accidents

Although several minor accidents are likely to happen during the life of the plant (e.g., a small leak in a pipeline or a small spill), most will not result in a significant release of uranium to the environment. Therefore, the accident analysis in support of this assessment is limited to the consideration of severe, low-probability accidents that could potentially result in the release of large quantities of radioactivity—a UF_6 release or a criticality accident. The radiological consequences of a major fire and a transportation accident are also evaluated.

UF_6 release

Shipping cylinders of UF_6 (2 1/2 tons) are stored inside the manufacturing building or in a secured outdoor area. The UF_6 is a solid at ambient temperatures (sublimes at 132°F) and is only

Table 4.14. A spectrum of accidents that could occur at the Westinghouse NFCS

Area and material involved	Typical accidents	Severity class	Pollutant(s) of concern
Tank farm			
Ammonium hydroxide Anhydrous ammonia Sodium hydroxide Nitric acid	Pipeline or tank leak or rupture, spills, fire	1,2	Ammonia Nitrate Caustic and acid solutions
Lagoons			
Ammonium nitrate Calcium fluoride Uranium	Leak, massive dike/liner failure, flooding	1,2	Ammonia Nitrate Fluoride Uranium
Outside storage/inside vaporization area			
Uranium hexafluoride (solid) (liquid/vapor)	Ruptured cylinder, vapor release	1,2	Uranium, hydrogen fluoride
Uranyl nitrate	Ruptured drum	2	Uranium Nitrate
Chemical and manufacturing areas			
Uranium Uranium dioxide Ammonium diuranate Hydrogen fluoride	Pipeline or container rupture, spills, explosions, fires, filter failure, criticality	1,2,3	Uranium Ammonia Fluoride
Hydrogen	Explosion	3	Uranium
Transportation	Container rupture, spills	1,2	Uranium Miscellaneous chemicals

heated and vaporized inside. Therefore, the possibility of an outdoor release of liquid UF_6 is extremely remote. If a cylinder of solid UF_6 were to fail outside, for any reason, the UF_6 would vaporize very slowly. Because UF_6 reacts with atmospheric moisture to form uranyl fluoride (UO_2F_2), which is a nonvolatile solid, such a leak would tend to be self-sealing. Therefore, the quantity of material released from such an accident involving a cylinder of solid UF_6 would not contribute significantly to the plant's normal emissions, and the potential offsite consequences would not be a concern.

Although very unlikely, an accident resulting in a massive outdoor release of UF_6 was postulated as the maximum credible UF_6 accident. Such an accident would involve a fire in the UF_6 outside storage area when a truck crashes there and ruptures two of the UF_6 cylinders. A fire results when the truck's fuel tank is ruptured by the crash. The resulting release of UF_6 is estimated to be about 1260 kg over a one-hour period, assuming no remedial action is taken. This equates to a total release of 860 kg of low-enriched ($\leq$5% ^{235}U) uranium.

The UF_6 gas volatilized by the fire would react with water vapor in the air to form hydrogen fluoride (HF) gas, and uranyl fluoride (UO_2F_2) particulates. The resultant cloud would rise at least 30 m (100 ft) above the site, primarily driven by the thermal expansion of heated air and combustion products from the burning truck fuel (Klett and Galeski 1975). The accident is assumed to occur under adverse meteorological conditions including an F type of atmospheric stability and a light wind blowing at 1 m/s. With a ground-level release and a dilution effect caused by building wake turbulence, the χ/Q at the nearest residence (1000 m to the northeast) is 2.33×10^{-4} s/m^3. Under these atmospheric conditions, UO_2F_2 and HF could move downwind in a narrow, unwavering plume. The plume would be a dense white cloud which would be highly visible at the nearest residence during the day. The average concentration of uranium and HF as the plume passes through this location would be about 60 mg/m^3 and 20 mg/m^3, respectively.

Hydrogen fluoride is a corrosive vapor, and exposure to concentrations of 25 mg/m^3 for several minutes is known to cause respiratory discomfort (NAS 1971). Brief exposure to 40 mg/m^3 of HF is dangerous to life (Sax 1963); exposure to 100 mg/m^3 of HF for 1 minute is considered epidemiologically significant (Sunshine 1972). Therefore, the calculated HF concentration at the nearest residence may cause some respiratory discomfort (prompting a person to flee), but would not be life-threatening.

If an adult at the nearest residence stood in the plume and endured this discomfort for an entire hour, there would be an intake of soluble uranium of approximately 50 mg. The chemical toxicity of this intake would likely cause kidney injury (Eve 1964) but would be well below the potentially fatal uranium intake of 160 mg (Luessenhop et al. 1958). The radiation dose associated with this intake would be insignificant.

Criticality accident

The effects of a postulated criticality accident have been considered, although the possibility of such an accident is remote. Historically, no accident of this kind has ever occurred in a low-enrichment fuel fabrication facility. Achievement of criticality with low-enrichment uranium requires carefully controlled conditions and is not likely to happen accidentally. In addition, at the NFCS, programs of design, review, procedural control, engineered safeguards, and audits are implemented routinely to prevent a criticality accident of this kind.

The postulated criticality accident has the following characteristics (NRC Regulatory Guide 3.34, Rev. 1):

- The accident results in 10^{19} fissions produced in a series of pulses within a supercritical liquid system over an 8-h period.
- The accident releases only the volatile fission products produced by the above number of fissions. At this time, radioactive decay begins.

In addition, it was assumed that 25% of the halogens and 100% of the noble gases were released from the manufacturing building. No credit for removal of radionuclides was given for the existing filters, scrubber, or other installed controls. Furthermore, the accident was assumed to occur under adverse meteorological conditions (an F-type atmospheric stability and a wind speed of 1 m/s). Given these conditions, and considering a building wake effect, the χ/Q at the nearest residence would be 2.33×10^{-4} s/m^3. The offsite consequences from this accident at the nearest residence are shown in Table 4.15. The doses also are well below recommended protective action

Table 4.15. Maximum 50-year dose commitment to the nearest resident from a criticality accident[a,b]

Exposure type	Dose (millirem)	
	Total body	Thyroid
Airborne radioactivity	102	950
Prompt gamma	3.8	3.8
Prompt neutron	1.6	1.6
Total	107.4	955.4

[a]Nearest resident is 1000 m from the accident site.
[b]Accident parameters and calculations are based on information in NRC Regulatory Guide 3.34, Rev. 1.

guides (1-5 rem for total body and 5-25 rem for thyroid) given by the Environmental Protection Agency (EPA 1980).

Transportation accidents

Transportation of special nuclear materials is strictly regulated by the U.S. Department of Transportation (NRC 1977d and 10 CFR Pts. 50 and 71), and package design and specifications must be approved by NRC. Containers must be designed to withstand hypothetical accident conditions applied sequentially in an order specified in the regulations to determine the cumulative effect on the container being tested. Criteria include free drops, punctures, thermal stress, and water immersion tests. These tests, which are more severe than any expected transportation accidents, make the probability of release of contents or accidental criticality very small. In addition, to ensure that all packages are properly prepared for shipment, the applicant must establish, maintain, and execute a quality assurance program (10 CFR Pt. 71) that satisfies applicable criteria (10 CFR Pt. 50). The special nuclear materials are transported in dedicated vehicles specifically designed for the purpose of assuring nuclear safety and material accountability and security.

The environmental effects of transportation accidents involving properly packaged radioactive materials have been thoroughly analyzed and documented (AEC 1972 and 1974; NRC 1975 and 1977e). These analyses show that the radiological risk from transportation accidents involving radioactive materials does not contribute appreciably to the accident consequences. The few shipments required would add very little to public injuries or fatalities in case of accidents.

Major fire

A major fire would involve complete burning of operational HEPA filters servicing exhaust from conversion and scrap recovery processes. The filters are housed in wooden boxes and located on the roof of the manufacturing building. Westinghouse (1975) stated that at the expanded operating level of 1600 t/year of uranium, conversion process exhausts are expected to contribute the largest single portion (35%) of the plant's total radioactivity emissions. This projection considered plant expansion using only the ADU conversion process, which emits greater activity to the

atmosphere than an equivalent level of operation using the IDR process. However, when the IDR lines become operational, conversion process exhausts might actually constitute a slightly lower percentage of the plant's total release.

Nevertheless, on the basis of the estimated release rate of 47.4 μCi/week (Sect. 4.2.5), a filtering efficiency of 99.97%, and a maximum time between filter changes of 26 weeks, the maximum uranium activity accumulated in these filters would be 1.4 Ci. NRC provides a release fraction of various radioactive materials in unsealed form for accidental source terms in case of a major fire (NRC 1984). The assigned release fractions for different materials are based on studies conducted by Battelle Northwest Laboratory (Mishima et al. 1968; Sutter and Mishima 1981; Mishima and Schwendiman 1973). For uranium in an unsealed form, the assigned release fraction is 0.001 (NRC 1984). The general rationale for this assigned fraction is that the material is not a volatile powder; a small fraction of the powder (a few percent) is of respirable-size, and experiments conducted usually found releases of respirable size particles of about 0.001 or less. Therefore, the total quantity released during a fire lasting one hour would be 3.9×10^{-1} μCi/s. Using a conservative χ/Q of 2.3×10^{-4} s/m^3 for accident situations (NRC 1979), the average uranium concentration at the nearest residence would be 9.1×10^{-5} μCi/m^3. An adult at this location exposed to the plume for one hour would receive, through the inhalation pathway, an effective whole body dose commitment of about 9×10^{-3} rem. This value is well below the EPA's Protective Action Guide of 1-5 rem for emergency preparedness (EPA 1980). No evaluation of this same accident on the basis of chemical toxicity was performed, because the fire would convert any soluble uranium to the insoluble, biologically nontransportable form.

4.3.2.2 Nonradiological accidents

Environmental impacts that may occur at a low-level-enrichment nuclear fuel fabrication plant would most likely result from possible accidents associated with potentially harmful chemicals rather than from radioactive materials. Thus, the Westinghouse NFCS can be considered in the same class as any other manufacturing plant where significant quantitites of nonradioactive chemicals are processed. The location and quantity of chemicals stored onsite are listed in Table 4.16.

Category 1. Category 1 accidents within the manufacturing building in the chemical processing area would be typified by minor liquid spills [i.e., 0.04 m^3 (10 gal) or less] of acids, ammonium diuranate, uranyl nitrate, and oil. Operators can quickly detect these spills and take corrective action (such as isolation of the leaking section). The spilled liquids would be quickly cleaned up and transferred to appropriate waste containers or, if appropriate, returned to the process for recovery. No floor drains are present in the processing area of the main plant building; therefore, there would be no release to the environment through either airborne or liquid pathways.

Category 1 accidents external to the manufacturing building that are likely to happen during the life of the plant include minor process-equipment leaks or small spills [0.2 m^3 (50 gal) or less]. A leak of this type would be located rapidly by operators, and corrective action would be implemented. Another Category 1 accident could result from the release of chemicals by a leak in the liner of a waste-holding lagoon. Such a release, as in the past (Sect. 3.5.2.2), would contaminate underlying soil and groundwater. The contaminated groundwater would discharge into Sunset Lake and the small onsite pond. Depending on the magnitude of the release and the contaminants present, concentrations could rise to levels that are hazardous to aquatic life.

Table 4.16. Location and quantities of bulk gas and liquid chemical storage at the Westinghouse NFCS

	Storage location	Quantity stored at 1600 MTU[a]/year production capacity			
		Tank size (gal)	Total (gal)	ft^3	lb
Ammonium hydroxide (liquid)	Tank farm	5,700	20,700		
Anhydrous ammonia	Tank farm	18,000	60,000		
Sodium hydroxide	Tank farm		20,000		
Nitric acid (68%)	Tank farm	5,000	10,000		
Hydrogen (liquid)	Tank farm	18,000	36,000	2,044,000	
Nitrogen (liquid)	Tank farm	6,000	12,000	541,000	
Argon (gas)	Tank farm	600	1,200	116,000	
Helium (liquid)	Tank farm			276,000	
Uranium hexafluoride	Outside pad				1,100,000
Hydrofluoric acid	Outside pad	20,000; 7,500			
Uranyl nitrate (liquid)	Outside plant		30,000		
Lime (CaO)	Waste treatment hopper				200,000
Zinc stearate	Inside plant				5,000
Acetone	55-gal drums (oil house)		825		
Sulfuric acid (66 Baume + 45°)	South pad		700		
Nitric acid (68%)	55-gal drums (north pad)		275		
Muriatic acid (22% HCl)	55-gal drums (north pad)				800
Sodium carbonate	Plating room				800
Caustic soda (50% NaOH solution)	North pad (100-lb drums)				500
Nickel sulfate	Plating room				500

[a]MTU = metric tons of uranium.

Source: Westinghouse 1983, Table 7.3; R. Fischer, Westinghouse, personal communication with S. Wyngarden, NRC, March 25, 1985.

Category 2. Category 2 accidents occurring in the chemical storage areas outside the manufacturing building could result in complete or partial emptying of a bulk chemical storage tank. Such a release is considered very unlikely because storage vessels are designed using good engineering practices and are filled according to safe operating procedures. To experience a rupture or failure, some unforeseen catastrophic disaster would have to occur, or all current safety systems would have to deteriorate simultaneously. Nevertheless, the most conceivable release scenarios involve (1) exposure of the storage vessels to an intense, prolonged fire with subsequent release of vapors through pressure relief valves and (2) tank rupture caused by a projectile from an adjacent explosion.

As part of the 1975 plant improvement program, protective dikes that could contain approximately 136 m^3 (36,000 gal) of a liquid release in the event of complete tank failure were placed around the chemical tank farm. The largest bulk storage tank is for hydrofluoric acid and has a capacity of 76 m^3 (20,000 gal). The dikes were further upgraded in 1982 to assure that leaks do not reach the groundwater. Any overflow would run through the storm drainage ditch to Upper Sunset Lake, where it would mix and flow into Lower Sunset Lake via a causeway. Lower Sunset Lake drains into Mill Creek, which eventually enters the Congaree River via a meandering route of about 11 km (7 miles). In the event of a major spill, the upper lake can be closed off at the causeway and then diluted by increasing the diverted flow of incoming Mill Creek water. The continuous chemical monitoring and prompt dilution of these waters can prevent significant liquid releases to the offsite environment.

Airborne concentrations of vapors in the release area could be excessive, but after dispersion in the atmosphere, concentrations at the site boundary would not likely require isolation of offsite areas or temporary evacuation of residents. Some of the potential vapors, such as ammonia and hydrogen fluoride, have pungent suffocating odors which would force capable people away and aid in limiting offsite exposures.

Category 3. These accidents are catastophic in magnitude and are not expected in the plant's lifetime. All are extremely unlikely; they would involve either container rupture, failure, explosion, fire, natural disaster, or an extremely improbable criticality-type accident. The potential consequences of such accidents have been discussed previously.

4.3.3 Possible Conflicts Between the Proposed Action and the Objectives of Federal, Regional, State, and Local Plans and Policies

At this time, the staff is not aware of any conflict between the proposed action and the objectives of federal, regional, state, or local plans, policies, or controls for the action proposed as long as proper agencies are contacted, proper applications are submitted, and proper monitoring and mitigatory measures are taken to protect the environment and public health and safety.

4.3.4 Effects on Urban Quality, Historical and Cultural Resources, and Society

The environmental effects of the proposed license renewal action as discussed above are considered to be insignificant. There may be adverse effects on urban quality if reactor fuel were not available.

The facility has not affected historical or cultural resources. The short-term societal effects during operation are and will be minimal, and there will be minimal effects after decommissioning and reclamation because the site then will be required to meet federal standards for unrestricted use.

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Appendix A

METHODOLOGY AND ASSUMPTIONS FOR CALCULATING RADIATION DOSE COMMITMENTS FROM THE RELEASE OF RADIONUCLIDES

Appendix A

METHODOLOGY AND ASSUMPTIONS FOR CALCULATING RADIATION DOSE COMMITMENTS FROM THE RELEASE OF RADIONUCLIDES

A.1 METHODOLOGY AND ASSUMPTIONS FOR AIRBORNE RELEASES

A.1.1 Methodology

The radiation dose commitments resulting from the atmospheric releases of radionuclides are calculated using the AIRDOS-EPA computer code (Moore et al. 1979). The methodology is designed to estimate the radionuclide concentrations in air; rates of deposition on ground surfaces; ground-surface concentrations; intake rates via inhalation of air and ingestion of meat, milk, and fresh vegetables; and radiation doses to man from the airborne releases of radionuclides.

With the code, the highest estimated dose to an individual at the nearest residence and the doses to the population living within an 80-km (50-mile) radius of the plant site can be calculated. The doses may be summarized by radionuclide, exposure mode, or significant organ of the body. In addition, site-specific concentrations of radionuclides in the air obtained at or near the nearest resident property can be used to calculate the highest dose to an individual for comparison with the dose calculated from the atmosphere releases.

Many of the basic incremental parameters used in AIRDOS-EPA are conservative; that is, values are chosen to maximize intake by man. Many factors that would reduce the radiation dose, such as shielding provided by dwellings and time spent away from the reference location, are not considered. The residence time and portion of food produced and consumed at the nearest residence are specified in Sect. 4.2.5.

Meteorological dispersion factors, χ/Q, were estimated using the Gaussian plume model and diffusion coefficients for Pasquill-type turbulence (Slade 1968; Sangendorf and Etnier 1974). Radionuclide concentrations in meat, milk, and vegetables consumed by man are estimated by coupling the output of the atmospheric transport models with the terrestrial food chain model in NRC Regulatory Guide 1.109 (NRC 1977a).

A.1.2 Radiation exposure pathways and dose conversion factors

Environmental transport links the source of release to the receptor by numerous exposure pathways. Figure A.1 is a diagram of the most important pathways that result in the exposure of man to radioactivity released to the environment. The resulting radiation exposures may be either external or internal. External exposures occur when the radiation source is outside the irradiated body, and internal exposures are those from radioactive materials within the irradiated body.

Factors for converting the radiation exposures to estimates of dose are calculated using the latest dosimetric criteria of the International Commission on Radiological Protection (ICRP) and other recognized authorities.

External dose conversion factors. Releases of radioactive gases and particulates to the atmosphere may result in external doses by exposure to and/or immersion in the plume and by exposure to contaminated land surfaces. The dose conversion factors are summarized by Kocher (1981), and those used in this report are shown in Table A.1.

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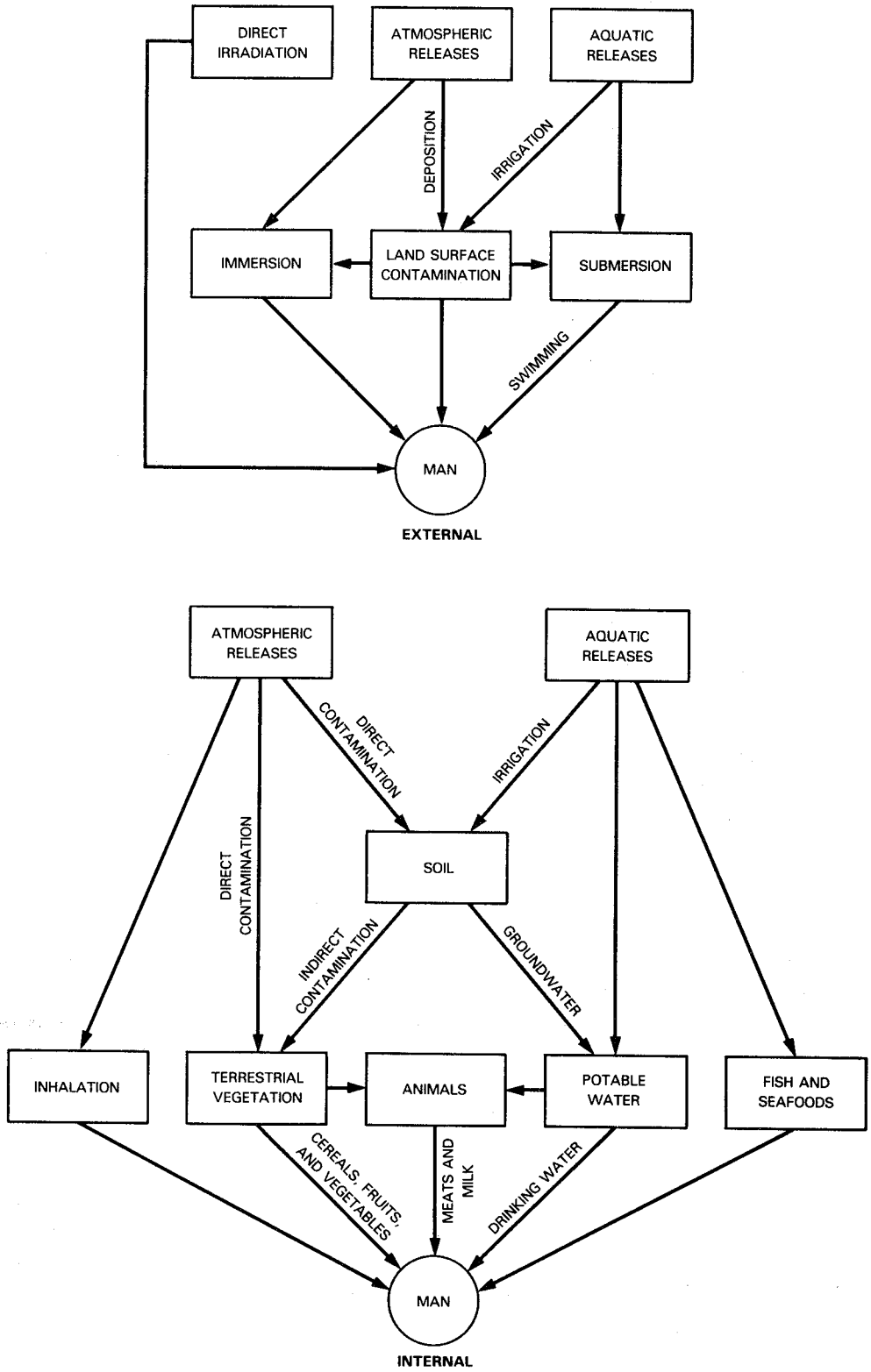

Fig. A.1. Pathways for exposure to man from releases of radioactive effluents.

Table A.1. Dose conversion factors for external exposure pathways

Radionuclide	Organ			
	Total body	Bone	Kidney	Lung
Exposure to ground surfaces (millirem/year per μCi/cm^2)				
^{234}U	7.1×10^2	3.0×10^2	1.0×10^2	1.7×10^2
^{235}U	1.5×10^5	2.1×10^5	1.3×10^5	1.4×10^5
^{236}U	6.4×10^2	2.4×10^2	7.0×10^1	2.4×10^2
^{238}U	5.7×10^2	2.1×10^2	5.9×10^1	1.2×10^2
Immersion in air (millirem/year per μCi/cm^3)				
^{234}U	6.8×10^5	7.1×10^5	3.7×10^5	4.1×10^5
^{235}U	6.8×10^8	9.4×10^8	5.9×10^8	6.3×10^8
^{238}U	5.3×10^5	5.4×10^5	2.6×10^5	3.0×10^5
^{238}U	4.6×10^5	4.5×10^5	2.2×10^5	2.5×10^5
Submersion in water (millirem/year per μCi/cm^3)				
^{234}U	1.7×10^3	1.7×10^3	8.9×10^2	9.8×10^2
^{235}U	1.5×10^6	2.1×10^6	1.3×10^6	1.4×10^6
^{236}U	1.3×10^3	1.3×10^3	6.3×10^2	7.3×10^2
^{238}U	1.1×10^3	1.1×10^3	5.3×10^2	6.1×10^2

Source: D. C. Kocher, *Dose-Rate Conversion Factors for External Exposure to Photons and Electrons,* ORNL/NUREG-79, Oak Ridge National Laboratory, August 1981.

Internal dose conversion factors. Factors for converting internal radiation exposure to estimates of dose have been computed based on recent models (ICRP 1966; Eve 1966) and are summarized by Dunning et al. (1981). The dose conversion factors used in this report are presented in Tables A.2 and A.3. These factors are input data into the AIRDOS-EPA computer code, which is used to calculate the dose from inhaled and ingested radionuclides.

A.1.3 Radiation dose to the individual

Internal exposure continues as long as radioactive material remains in the body, which may be longer than the duration of the individual's residence in the contaminated environment. The best estimates of the internal dose resulting from an intake are obtained by integrating over the remaining lifetime of the exposed individual; such estimates are called "dose commitments." The remaining lifetime is assumed to be 50 years for an adult.

External doses are assumed to be annual doses. The dose rate above the contaminated land surface is estimated for a height of 1 m. Following the initial deposition of radionuclides, the potential for exposure of man may persist, depending on the influence of environmental

Table A.2. Dose conversion factors for inhalation exposure pathways—AMAD[a] = 0.3 μm

Radionuclide	Committed dose equivalent (rem/μCi)			
	Total body	Bone	Kidney	Lung
		Class D		
^{234}U	6.4	8.7×10^{1}	1.9×10^{1}	1.6
^{235}U	5.8	7.9×10^{1}	1.7×10^{1}	1.4
^{236}U	6.1	8.2×10^{1}	1.8×10^{1}	1.5
^{238}U	5.7	7.8×10^{1}	1.7×10^{1}	1.4
		Class Y		
^{234}U	2.9×10^{1}	1.3×10^{1}	2.8	9.3×10^{2}
^{235}U	2.6×10^{1}	1.2×10^{1}	2.5	8.4×10^{2}
^{236}U	2.7×10^{1}	1.2×10^{1}	2.6	8.8×10^{2}
^{238}U	2.5×10^{1}	1.1×10^{1}	2.5	8.3×10^{2}

[a]AMAD = Activity median aerodynamic diameter

Source: D. E. Dunning, Jr., G. G. Killough, S. R. Bernard, J. G. Pleasant, and P. J. Walsh, *Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities, Vol. III,* ORNL/NUREG/TM-190/V3, Oak Ridge National Laboratory, October 1981.

Table A.3. Dose conversion factors for ingestion exposure pathways

Radionuclide	Committed dose equivalent (rem/μCi)			
	Total body	Bone	Kidney	Lung
		Soluble		
^{234}U	5.8×10^{-1}	7.8	1.7	1.7×10^{-2}
^{235}U	5.2×10^{-1}	7.1	1.5	1.6×10^{-2}
^{236}U	5.4×10^{-1}	7.4	1.6	1.6×10^{-2}
^{238}U	5.1×10^{-1}	7.0	1.5	1.5×10^{-2}
		Insoluble		
^{234}U	2.4×10^{-2}	3.1×10^{-1}	6.7×10^{-2}	6.9×10^{-4}
^{235}U	2.2×10^{-2}	2.8×10^{-1}	6.1×10^{-2}	7.4×10^{-4}
^{236}U	2.2×10^{-2}	3.0×10^{-1}	6.3×10^{-2}	6.5×10^{-4}
^{238}U	2.1×10^{-2}	2.8×10^{-1}	6.0×10^{-2}	6.1×10^{-4}

Source: D. E. Dunning, Jr., G. G. Killough, S. R. Bernard, J. G. Pleasant, and P. J. Walsh, *Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities, Vol. III,* ORNL/NUREG/TM-190/V3, Oak Ridge National Laboratory, October 1981.

redistribution, long after the plume leaves the area. Concentrations of radionuclides at the point of deposition normally are reduced by infiltration of radionuclides into the soil, by loss of soil particles because of erosion, and by transport in surface water and in groundwater. When the effects of these processes cannot be quantified, a conservative estimate of the dose resulting from external exposure to a contaminated surface is obtained by assuming that the radionuclide concentrations are diminished by radioactive decay only.

The dose is estimated for individuals at the nearest site boundary or at the nearest residence. The intake parameters used for individual dose determination are shown in Table A.4 and then modified by site-specific estimates of food consumption in Sect. 4.2.5.

Table A.4. Intake parameters (adult)[a] used in lieu of site-specific data

Pathway	Maximum exposed individual	Average exposed individual[b]
Vegetables, kg/year	281[c]	190
Milk, L/year	310	110
Meat, kg/year	110	95
Drinking water, L/year	730	370
Fish, kg/year	21	6.9
Inhalation, m^3/year	8000	8000

[a]From NRC Regulatory Guide 1.109.
[b]Used for calculating population doses.
[c]This value includes leafy vegetables.

A.1.4 Radiation dose to the population

The total dose received by the exposed population is estimated by the summation of individual dose estimates within the population. The area within the 80-km (50-mile) radius of the site is divided into 16 sectors (22.5° each) and into a number of annuli. The average dose for an individual in each division is estimated, that estimate multiplied by the number of persons in the division, and the resulting products are summed across the entire area. The unit used to express the population dose is man-rem. For this report, the population dose estimates are calculated for a population composed entirely of adults. The dose conversion factors and intake parameters used for calculating population doses are the same as those used for the individual doses.

A.2 METHODOLOGY AND ASSUMPTIONS FOR AQUEOUS RELEASES

The methodology used for calculating the 50-year dose commitments to man from the release of radionuclides to an aquatic environment is described in detail by Dunning et al. (1981). Sample problems and bioaccumulation factors for radionuclides in freshwater fish are also given by Dunning et al. (1981). AQUAMAN is a computer code (Shaeffer and Etnier 1979) that can also be used for calculating similar dose commitments from exposures to aquatic pathways.

Three exposure pathways are considered in dose determination: water ingestion, fish ingestion, and submersion in water (swimming). The internal dose conversion factors for converting exposure to dose are discussed in Sect. A.1.2, and the factors are shown in Table A.3. The external dose conversion factors are shown in Table A.1. Intake parameters are shown in Table A.4.

A.3 ATMOSPHERIC DISPERSION

The atmospheric dispersion model used in estimating the atmospheric transport to the terrestrial environment is discussed in detail in NRC Regulatory Guide 1.111, Rev. 1, (NRC 1977b). For particulate release, the meteorological χ/Q values are used in conjunction with dry deposition velocities and scavenging coefficients to estimate air concentrations and steady state ground concentrations. The atmospheric dispersion model estimates the concentration of radionuclides in air at ground surfaces as a function of distance and direction from the point of release. Averages of annual meteorological data from the site or from the nearest weather station, if suitable, are supplied as input for the model. Radioactive decay during the plume travel is taken into account in the AIRDOS-EPA code (Moore et al. 1979). Daughters produced during plume travel are calculated and added to the source term.

The area surrounding the plant site is divided into 16 sectors by compass direction (Sect. 3.3). The meteorological χ/Q values (shown in Table 3.2) are calculated for the midpoint of each sector. Concentrations in the air for each sector are used to calculate dose via inhalation and submersion in the air. The ground deposits result in external dose and, in addition, are assimilated into food and contribute dose upon ingestion via the food chain.

The meteorological data required for the calculations are joint frequency distributions of wind velocity and direction summarized by stability class. Meteorological data from the nearest weather station are used to calculate the concentrations of radionuclides at a reference point per unit of source strength. Depletion of the airborne plume as it is blown downwind is accounted for in the AIRDOS-EPA code by taking into account the deposition on surfaces by dry deposition, scavenging, and radioactive decay.

REFERENCES FOR APPENDIX A

Dunning, D. E., Jr., et al. 1981. *Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel-Cycle Facilities*, Vol. III, ORNL/NUREG/TM-190/V3, Oak Ridge National Laboratory, October. (Also published as NUREG/CR-0150.)

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Sangendorf, J. F. 1974. *A Program Evaluating Atmospheric Dispersion from a Nuclear Power Station*, NOAA Technical Memo ERL-ARL-42.

Shaeffer, D. L., and E. L. Etnier. 1979. *AQUAMAN—A Computer Code for Calculating Dose Commitments to Man from Aqueous Releases of Radionuclides*, ORNL/TM-6618, Oak Ridge National Laboratory, February.

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Appendix B

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT

FOR

WESTINGHOUSE COMMERCIAL NUCLEAR FUEL FABRICATION PLANT

South Carolina Department of Health and Environmental Control

2600 Bull Street
Columbia, S.C. 29201

Commissioner
Robert S. Jackson, M.D.

August 29, 1984

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. M. D'Amore, Plant Manager
Westinghouse Electric Company
P.O. Drawer R
Columbia, SC 29250

Re: NPDES Permit #SC0001848
Westinghouse Elec/Columbia Plant
Richland County

Dear Permittee:

Enclosed is the modification to the National Pollutant Discharge Elimination System (NPDES) Permit for the above-referenced facility.

This modification will become issued and effective on the effective date specified in the modification, provided that no request for an adjudicatory hearing and/or legal decision is subsequently filed with the Department. In the event that such a request is filed, the contested provisions of the modification will be stayed and will not become effective until the administrative review process is complete. All uncontested provisions of the modification will be considered issued and effective on the effective date set out in the modification and must be complied with by the facility.

If you wish to request an administrative adjudicatory hearing, such request must be made in accordance with Regulation 61-72, Volume 25, S.C. Code of Laws, 1976, as amended. As required by this regulation, two (2) copies of the request must be served on the South Carolina Board of Health and Environmental Control, 2600 Bull Street, Columbia, South Carolina 29201, within fifteen (15) days following receipt of this Permit. Service may be effected by personal delivery or by first class mail.

The following elements must, at a minimum, be included with the request:

1. A title indicating the nature of the proceedings and the parties involved;
2. The complete name and address of the party filing the pleading and, if applicable, the organization(s) or interests which he represents;
3. If the requesting party is to be represented by counsel, the name and address of the attorney;
4. A clear and concise statement of the requesting party's affected interest;

South Carolina Department of Health and Environmental Control

Permit No. SC0001848

AUTHORIZATION TO DISCHARGE UNDER THE
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Pollution Control Act of South Carolina (S.C. Sections 48-1-10 et seq., 1976) and with the provisions of the Federal Clean Water Act (PL 92-500, as amended by PL 95-217, Titles III, IV and V) 33 U.S.C. 1251 et seq., the "Act,"

Westinghouse ElectricCorporation

is authorized to discharge from a facility located at

S.C. Highway 48, Columbia, Richland County, South Carolina

to receiving waters named

Congaree River

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective on JAN 1 1982

This permit and the authorization to discharge shall expire at midnight,

DEC 31 1986

signed: DEC 4 1981

Robert A. Goss, P.E.
Bureau of Wastewater and Stream
Quality Control

Modification Date: SEP 1 1984

Bureau of Water Pollution Control

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date and lasting through the expiration date, the permittee is authorized to discharge from outfall(s) serial number(s)001: sanitary & chemical process wastewater

Such discharge shall be limited and monitored by the permittee as specified below:

Effluent Characteristics	Discharge Limitations kg/day (lbs/day)		Other Units (Specify)		Monitoring Requirements	
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Measurement Frequency	Sample Type
Flow-m^3/day (MGD)	-	-	-	-	Daily	Continuous Recorder
Oil & Grease	-	-	10 mg/l	15 mg/l	1/week	24Hr. Composite
BOD_5	11(25)	23(50)	-	-	1/week	24Hr. Composite
Total Suspended Solids	15/32	29/64	-	-	1/week	24Hr. Composite
Fluoride	18(40)	36(80)	-	-	Daily	24Hr. Composite
NH_3-N	27(60)	54(120)	-	-	Daily	24Hr. Composite
Fecal Coliform	-	-	200/100 ml	400/100 ml	1/month	Grab

The pH shall not be less than 6.9 standard units nor greater than 10.5 standard units and shall be monitored: daily by continuous recorder.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): At or near the outfall.

B. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

   N/A

2. No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

PART I

C. MONITORING AND REPORTING

1. *Representative Sampling*

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. *Reporting*

Monitoring results obtained during the previous 3 months shall be summarized for each month and reported on a Discharge Monitoring Report Form postmarked no later than the 28th day of the month following the completed reporting period. The first report is due on APR 28 1982. Duplicate signed copies of these, and all other reports required herein shall be submitted to the state at the following address:

South Carolina Department of Health and Enviornmental Control
ATTN: NPDES Permits Section
2600 Bull Street
Columbia, S.C. 29201

3. *Definitions*

a. The "daily average" discharge means the total discharge by weight during a calendar month divided by the number of days in the month that the production or commercial facility was operating. Where less than daily sampling is required by this permit, the daily average discharge shall be determined by the summation of all the measured daily discharges by weight divided by the number of days during the calendar month when the measurements were made.

b. The "daily maximum" discharge means the total discharge by weight during any calendar day.

4. *Test Procedures*

Test procedures for the analysis of pollutants shall conform to regulations published pursuant to Section 304(g) of the Act, under which such procedures may be required.

5. *Recording of Results*

For each measurement or sample taken pursuant to the requirements of this permit the permittee shall record the following information:

a. The exact place, date, and time of sampling;

b. The dates the analyses were performed;

c. The person(s) who performed the analyses;

d. The analytical techniques or methods used; and

e. The results of all required analyses.

6. *Additional Monitoring by Permittee*

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods are specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report Form . Such increased frequency shall also be indicated.

7. *Records Retention*

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the Department of Health and Environmental Control.

A. MANAGEMENT REQUIREMENTS

1. *Change in Discharge*

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by submission of a new NPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the permit issuing authority of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. *Noncompliance Notification*

If, for any reason, the permittee does not comply with or will be unable to comply with any daily maximum effluent limitation specified in this permit, the permittee shall provide the Department of Health and Environmental Control with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. *Facilities Operation*

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee.

4. *Adverse Impact*

The permittee shall take all reasonable steps to minimize any adverse impact to navigable waters resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. *Bypassing*

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where unavoidable to prevent loss of life or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the Department of Health and Environmental Control in writing of each such diversion or bypass.

6. *Removed Substances*

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering navigable waters.

7. *Power Failures*

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

B. RESPONSIBILITIES

1. *Right of Entry*

The permittee shall allow the Commissioner of the Department of Health and Environmental Control, the Regional Administrator, and/or their authorized representatives, upon the presentation of credentials:

a. To enter upon the permittee's premises where an effluent source is located or in which any records are required to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. *Transfer of Ownership or Control*

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Department of Health and Environmental Control.

3. *Availability of Reports*

Except for data determined to be confidential under Section 308 of the Act, all reports prepared in accordance with the terms of this permit shall be

inspection at the offices of the Department of Health and Environmental Control and the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Act.

4. *Permit Modification*

After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

5. *Toxic Pollutants*

Notwithstanding Part II, B-4 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. *Civil and Criminal Liability*

Except as provided in permit conditions on "Bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. *Oil and Hazardous Substance Liability*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Act.

8. *State Laws*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation under authority preserved by Section 510 of the Act.

MODIFICATION DATE: FEB 1 1983

9. Property Rights

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

10. Severability

The provisions of this permit are severable and if any provisions of this permit or the application of any provision of this permit to any circumstances, is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected thereby.

PART III

A. OTHER REQUIREMENTS

1. This permit shall be modified, or alternatively, revoked and reissued, to comply with any applicable effluent standard or limitation issued or approved under Sections 301(b)(2)(C) and (D), 304(b)(2) and 307(a)(2) of the Clean Water Act, as amended, if the effluent standard or limitation so issued or approved:

   (a) Contains different conditions or is more stringent than any effluent limitation in the permit; or

   (b) Controls any pollutant not limited in the permit.

   The permit as modified or reissued under this paragraph shall also contain any other requirements of the Act, then applicable.

2. The permittee shall develop and implement a Best Management Practices (BMP) Plan to identify and control the discharge of significant amounts of oils and the hazardous and toxic substances listed in 40CFR Part 117 and Tables II and III of Appendix D to 40CFR Part 122. The plan shall include a listing of all potential sources of spills or leaks of these materials, a method of containment, a description of training, inspection and security procedures and emergency response measures to be taken in the event of a discharge to surface waters or plans and/or procedures which constitute an equivalent BMP. Sources of such discharges may include materials storage areas; in-plant transfer, process and material handling areas; loading and unloading operations; plant site run-off; and sludge and waste disposal areas. The BMP plan shall be developed in accordance with good engineering practices, shall be documented in narrative form, and shall include any necessary plot plans, drawings or maps. The BMP plan shall be developed no later than six months after issuance of the final permit (or modification) and shall be implemented no later than one year after issuance of the final permit (or modification). The BMP plan shall be maintained at the plant site and shall be available for inspection by EPA and SCDHEC personnel.

3. If this permit requires continuous measuring of the pH of the effluent, the permittee shall maintain the pH of such effluent within the range set in the permit, except excursions from the range are permitted subject to the following limitations:

   (a) The total time during which the pH values are outside the required range shall not exceed 7 hours and 26 minuts in any calendar month; and,

   (b) No individual excursion from the range of pH values exceed 60 minutes.

4. The sanitary polishing lagoon is allowed to be used on an as-needed basis.

5. Algae control Is the polishing lagoon by means of copper sulfate addition is to be permitted on an as-needed basis only with prior written notification to DHEC as to the time and amount of copper sulfate addition.

6. A ground-water monitoring program is to be implemented with the following requirements:

   (a) Sample wells 7,10,13,15,16,18,22,24,29,30,32 quarterly for total dissolved solids (or specific conductance) pH(field), ammonia, nitrate, fluoride, ground-water elevations, gross alpha and gross beta activities.

   (b) On a one time basis sample the above wells for dissolved organic carbon chloride, sulfate dissolved metals to include calcium, magnesium sodium, potassium, cadmium, chromium, lead and nickel. Should this one time analysis indicate ground-water quality problems other than those already identified additional analysis may be required.

MODIFICATION DATE: SEP 1 1984

James A. Joy, III, P.E.
Bureau of Water Pollution Control

Appendix C

ENVIRONMENTAL REVIEW OF WESTINGHOUSE LICENSE AMENDMENT TO INCLUDE AN INTEGRATED DRY ROUTE (IDR) LINE

MAR 9 1981

DOCKET NO.: 70-1151

LICENSEE: Westinghouse Electric Corporation

FACILITY: Commercial Nuclear Fuel Fabrication Plant (CNFP), Columbia, South Carolina

SUBJECT: ENVIRONMENTAL REVIEW OF WESTINGHOUSE LICENSE AMENDMENT (SNM-1107) TO UPGRADE DRY CONVERSION LINE TO THEIR CNFP IN COLUMBIA, SOUTH CAROLINA

I Background

By letter dated January 9, 1981, Westinghouse Electric Corporation (WEC) requested a license amendment of their Special Nuclear Material License No. SNM-1107 to authorize the installation of a new dry conversion line to replace their existing Dry Conversion Fluidized Bed (DCFB) at their Commercial Nuclear Fuel Plant (CNFP) at Columbia, South Carolina. At the same time Westinghouse (the licensee) submitted environmental information in support of the license amendment application.

II Discussion

A. General Description of the Proposed Upgraded Dry Conversion Line

The proposed upgraded dry conversion line will include an Integrated Dry Route (IDR) line developed and commercially utilized by British Nuclear Fuels Limited (BNFL) and will supplement the plant's existing ADU (wet conversion) process production lines. The proposed IDR process line will replace the DCFB experimental dry process line. According to the licensee, the IDR process line will provide improvement in lowering the quantity of liquid wastes generated per kilogram of uranium produced.

The IDR process will utilize dry methods to convert solid uranium hexafluoride (UF_6) to uranium dioxide (UO_2). UF_6 feed material, received in type 30A/30B cylinders, is vaporized within the cylinders by heating with hot spray. The resulting UF_6 vapor is reacted with superheated steam to form uranyl fluoride (UO_2F_2) powder and hydrogen fluoride (HF) gas. The UO_2F_2 is further contacted with a countercurrent flow of hydrogen, nitrogen, and superheated steam--to strip residual fluoride, and to reduce the uranium powder to uranium dioxide. The UO_2

is discharged into check hoppers, and is then pneumatically conveyed (or otherwise transported) to the powder processing area. Process off-gases [hydrogen (H_2), hydrogen fluoride (HF), nitrogen (N_2), and steam (H_2O)] are removed continuously through off-gas filters which are periodically reverse-purged to remove uranium-bearing solids prior to recovery of hydrofluoric acid. The conversion process is shown schematically in Figure 1. The proposed IDR system and plant changes to accomodate the installation of the total manufacturing automation project (MAP) are shown in Figure 2.

B. Effluents Released from the Proposed Action

The proposed installation and operation of an IDR process line requires minor modifications to the existing licensed facility and will result in minor incremental releases of radioactivity and chemicals to the environment. For gaseous effluents, the licensee projects the overall release of radioactivity and fluorides as shown in Table 1.

Table 1

Estimated Air Effluents Released from Overall Plant Operation

	Uranium (μCi/yr)	Fluoride (kg/yr)
Existing ADU (700 MTU/yr)	1,960	21
Estimated IDR (500 MTU/yr)	221	68
Previous Estimated in Environmental Report in 1975 (1600 MTU/yr)[1]	4,742	757

[1] The projected release of effluents up to 1600 MTU/yr would not result in significant impact to the environment as assessed by NRC in the Environmental Impact Appraisal issued in April 1977.

The radioactivity released in liquid effluents does not constitute a significant pathway for dose to man compared with the air effluents pathway, and the licensee projects only a minor incremental release of radioactivity and chemicals with the addition of the IDR process line. Hydrofluoric acid is a usable byproduct which will be generated

by the process. At the present time, the licensee has no definite plan for the use of the hydrofluoric acid; therefore, the licensee will be required to submit a detailed plan to NRC for review and approval prior to disposing of this material.

C. Environmental Impact of the Proposed Action

The proposed action will require minor modification of the existing licensed facility such as the removal of the DCFB equipment, building modification and relocation of some of the existing plant services. There will be no significant construction impact since the floor area affected by the IDR systems installation will consist of about 22,000 square feet, or only about 6% of the existing manufacturing building floor area, and the roof superstructure will include about 22,000 square feet, or about 6% of the existing roof area. Therefore, the incremental impact temporarily effected by the dismantling, construction, and installation activities is expected to be relatively minor.

The proposed action will result in minor incremental releases of radioactivity and chemicals to the environment (see Table 1). The overall releases are less than the projected release of effluents up to 1600 MTU/yr, and no significant environmental impact was anticipated even with the projected releases based on 1600 MTU/yr capacity as discussed in NRC's EIA issued April 1977. In addition, the applicant's license amendment No. 4 was conditioned that if the radioactivity in plant gaseous effluents exceeds 1,500 μCi per calendar quarter, the licensee shall, within 30 days, prepare and submit to the Commission a report which identifies the cause for exceeding the limit and the corrective actions to be taken by the licensee to reduce release rate. This condition is to provide reasonable assurance that the licensee is in compliance with the environmental radiation standards as specified in Title 40, Code of Federal Regulations, Part 190. As shown in Table 1, the projected overall release, including the proposed action, will not exceed the limit conditioned in license amendment No. 4. For accidental releases, the licensee's proposed action does not change the potential and effects of the spectrums of potential accidents identified and evaluated in NRC's EIA issued in April 1977.

III Conclusion

The staff has evaluated the environmental impact associated with the proposed plant modifications, effluent releases and accident potentials that may result from the licensee's proposed action. Based on the above evaluation, it is concluded that this proposed action would be non-substantive and insignificant

from an environmental imapct standpoint. Thus, pursuant to 10 CFR 51, Section 51.5(d)(3), an environmental impact appraisal need not be prepared. Approval of the license amendment is recommended subject to the following condition:

1. The licensee shall conduct air effluent monitoring on radioactivity and total fluorides as specified in the licensee's application dated January 9, 1981.

Original Signed By:
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This Environmental Assessment is issued by the U.S. Nuclear Regulatory Commission (NRC) in response to an application by the Westinghouse Electric Corporation for the renewal of Special Nuclear Material License No. SNM-1107 which covers the operations of the Columbia plant.

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