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**Environmental Assessment  
for Renewal of Special Nuclear Material  
License  
SNM-1227  
Docket 70-1257**

**Siemens Power Corporation  
Richland, Washington**

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**U.S. Nuclear Regulatory Commission**  
Fuel Cycle Safety and Safeguards

June 1995

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## ABBREVIATIONS AND ACRONYMS

|                                |  |
|--------------------------------|--|
| ADU                            | ammonium diuranate                     |
| ALARA                          | as low as is reasonably achievable     |
| ANSI                           | American National Standards Institute  |
| ARF                            | ammonia recovery facility              |
| CaF <sub>2</sub>               | calcium fluoride                       |
| CEDE                           | committed effective dose equivalent    |
| CEQ                            | Council on Environmental Quality       |
| CFR                            | Code of Federal Regulations            |
| CO                             | carbon monoxide                        |
| D&D                            | decontamination and decommissioning    |
| DC                             | dry conversion                         |
| DOC                            | U.S. Department of Commerce            |
| DOE                            | U.S. Department of Energy              |
| DOI                            | U.S. Department of Interior            |
| DOT                            | U.S. Department of Transportation      |
| EA                             | environmental assessment               |
| EDE                            | effective dose equivalent              |
| ELO                            | engineering laboratory operations      |
| EPA                            | U.S. Environmental Protection Agency   |
| F <sub>2</sub>                 | fluorine                               |
| Gd <sub>2</sub> O <sub>3</sub> | gadolinium oxide                       |
| H <sub>2</sub>                 | hydrogen                               |
| HEPA                           | high efficiency particulate air        |
| HDPE                           | high density polyethylene              |
| HF                             | hydrogen fluoride                      |
| kph                            | kilometers per hour                    |
| LLD                            | lower limit of detection               |
| LUR                            | lagoon uranium recovery                |
| μCi/mL                         | microcurie per milliliter              |
| μg/m <sup>3</sup>              | microgram per cubic meter              |
| mg                             | milligram                              |
| mgd                            | million gallons per day                |
| mg/L                           | milligrams per liter                   |
| mrem                           | millirem                               |
| MSL                            | mean sea level                         |
| MTU                            | metric tons uranium                    |
| NAAQS                          | National Ambient Air Quality Standards |
| NaF                            | sodium fluoride                        |
| NAF                            | neutron absorber fuel                  |
| NaOH                           | sodium hydroxide                       |
| NaNO <sub>3</sub>              | sodium nitrate                         |

## ABBREVIATIONS AND ACRONYMS (Continued)

|                                |   |
|--------------------------------|---|
| NDA                            | non-destructive assay   |
| NEPA                           | National Environmental Policy Act                                 |
| NESHAP(s)                      | National Emissions Standards for Hazardous Air Pollutants         |
| NH <sub>3</sub>                | ammonia   |
| NH <sub>4</sub> OH             | ammonium hydroxide  |
| NOAA                           | National Oceanic and Atmospheric Administration                   |
| NO <sub>x</sub>                | nitrous oxides  |
| NO <sub>2</sub>                | nitrogen dioxide  |
| NPDES                          | National Pollutant Discharge Elimination System                   |
| NR                             | nearest resident  |
| NRC                            | U.S. Nuclear Regulatory Commission                                |
| O <sub>3</sub>                 | ozone   |
| Pb                             | lead  |
| pCi/L                          | picocuries per liter  |
| PDTF                           | product development test facility                                 |
| PM-10                          | particulate matter with aerodynamic diameter less than 10 microns |
| POG                            | process offgas  |
| ppm                            | parts per million   |
| Ra                             | radium  |
| RCRA                           | Resource Conservation and Recovery Act                            |
| SF                             | specialty fuels   |
| SNM                            | special nuclear material  |
| SO <sub>2</sub>                | sulfur dioxide  |
| SPC                            | Siemens Power Corporation   |
| SWUR                           | solid waste uranium recovery                                      |
| TBP                            | tributyl phosphate  |
| TEDE                           | total effective dose equivalent                                   |
| TSP                            | total suspended particulates                                      |
| U                              | uranium   |
| UF <sub>4</sub>                | uranium tetrafluoride   |
| UF <sub>6</sub>                | uranium hexafluoride  |
| UNH                            | uranyl nitrate hexahydrate  |
| UO <sub>2</sub>                | uranium dioxide   |
| UO <sub>2</sub> F <sub>2</sub> | uranyl fluoride   |
| U <sub>3</sub> O <sub>8</sub>  | triuranium octoxide   |
| WHSE                           | warehouse   |
| WSO                            | Weather Service Office  |

## 1. PURPOSE AND NEED FOR ACTION

### 1.1 Introduction

On August 25, 1992, Siemens Power Corporation (SPC) Nuclear Division requested the renewal of its Special Nuclear Material (SNM) License (SNM-1227) for 10 years. The U.S. Nuclear Regulatory Commission (NRC) has prepared this environmental assessment (EA) pursuant to the Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508 [Ref. 1]) and NRC regulations (10 CFR Part 51 [Ref. 2]), which implement the requirements of the National Environmental Policy Act (NEPA) of 1969 (Ref. 3). The purpose of this document is to assess the environmental consequences of the proposed license renewal.

### 1.2 Operating Mission

The SPC facility at Richland, Washington, is authorized under SNM-1227 and Washington State Materials License No. WN-1062-1 to possess nuclear materials for the conversion of uranium hexafluoride ( $UF_6$ ) to uranium dioxide ( $UO_2$ ), and to fabricate and assemble nuclear fuel assemblies for light-water reactors. The role of the SPC site in the overall fuel cycle leading to production of fuel elements for nuclear reactors is shown in Figure 1.1. This includes receipt, possession, storage, transfer, and all operational steps from  $UF_6$  to  $UO_2$  conversion to packaging finished fuel elements, to associated uranium scrap recycling, and to waste treatment and disposal. The licensed facility produces about 700 metric tons (772 tons) per year of  $UO_2$  from  $UF_6$  (Ref. 4). The plant feed is enriched (less than or equal to 5 weight percent uranium-235)  $UF_6$  and the primary product is fuel assemblies for use in nuclear power reactors. This EA addresses the impacts of those activities authorized under SNM-1227.

The SPC operation uses either a wet ammonium diuranate (ADU) process or a dry conversion process to convert  $UF_6$  into  $UO_2$  powder. The  $UO_2$  powder is pressed into pellets, which are sintered and then loaded into fuel rods. The fuel rods are placed in storage and are withdrawn as needed and fabricated into fuel assemblies.

The SPC engineering and manufacturing facility consists primarily of an office building complex, a  $UO_2$  building, specialty fuels (SF) building, engineering laboratory operations (ELO) building, product development test facility (PDTF), process chemical waste storage lagoon system, materials warehouses, and ancillary facilities. These facilities are shown on Figure 1.2. The office building complex is located in the northwestern corner of the site. The majority of the fuel fabrication activities are performed in the  $UO_2$  building and the SF building in the central area of the site. Six liquid waste storage lagoons occupy the eastern portion of the site (Figure 1.2). Warehouses and other storage areas occupy most of the remainder of the site.

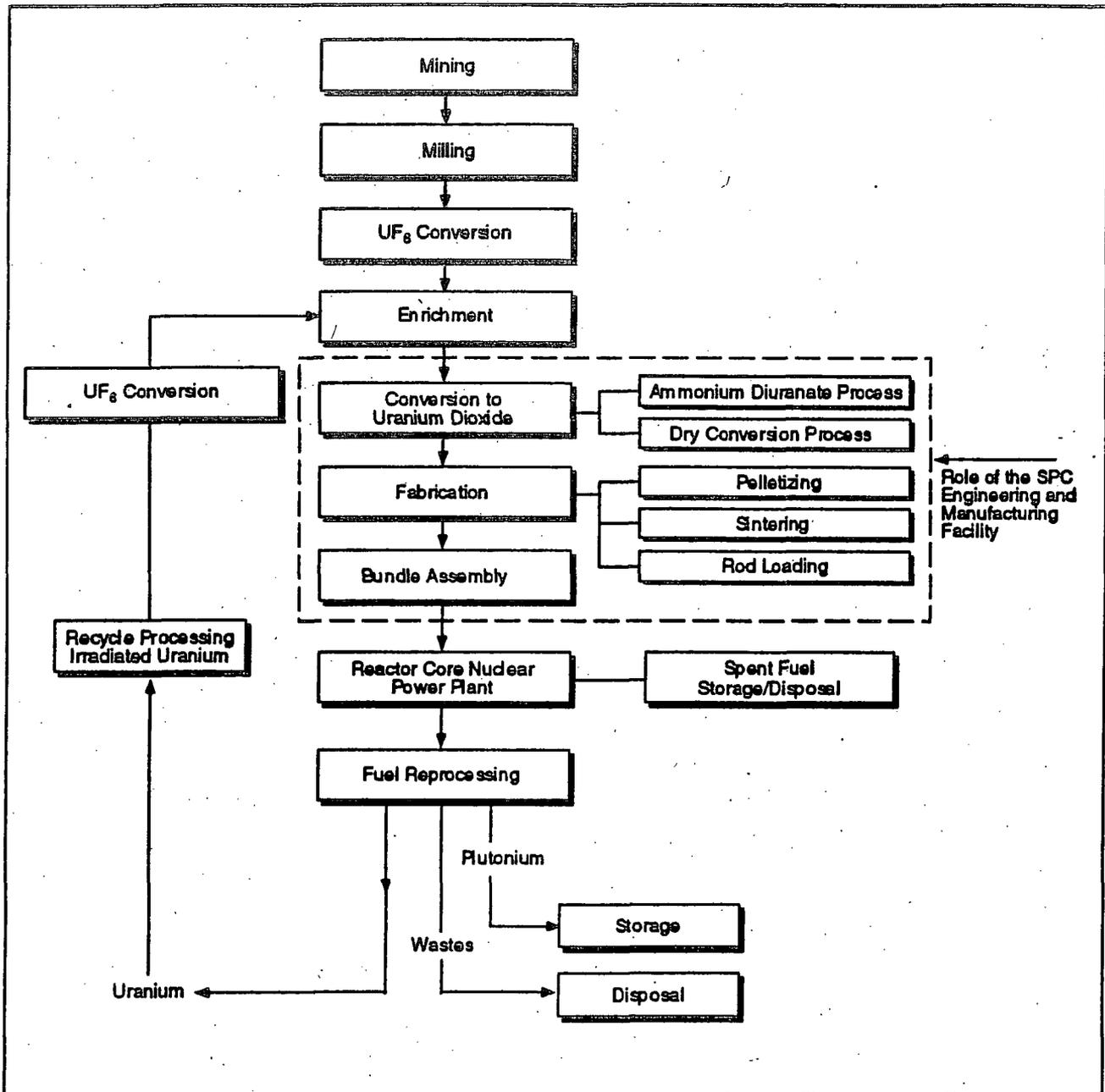


Figure 1.1 Nuclear fuel cycle and role of the SPC facility

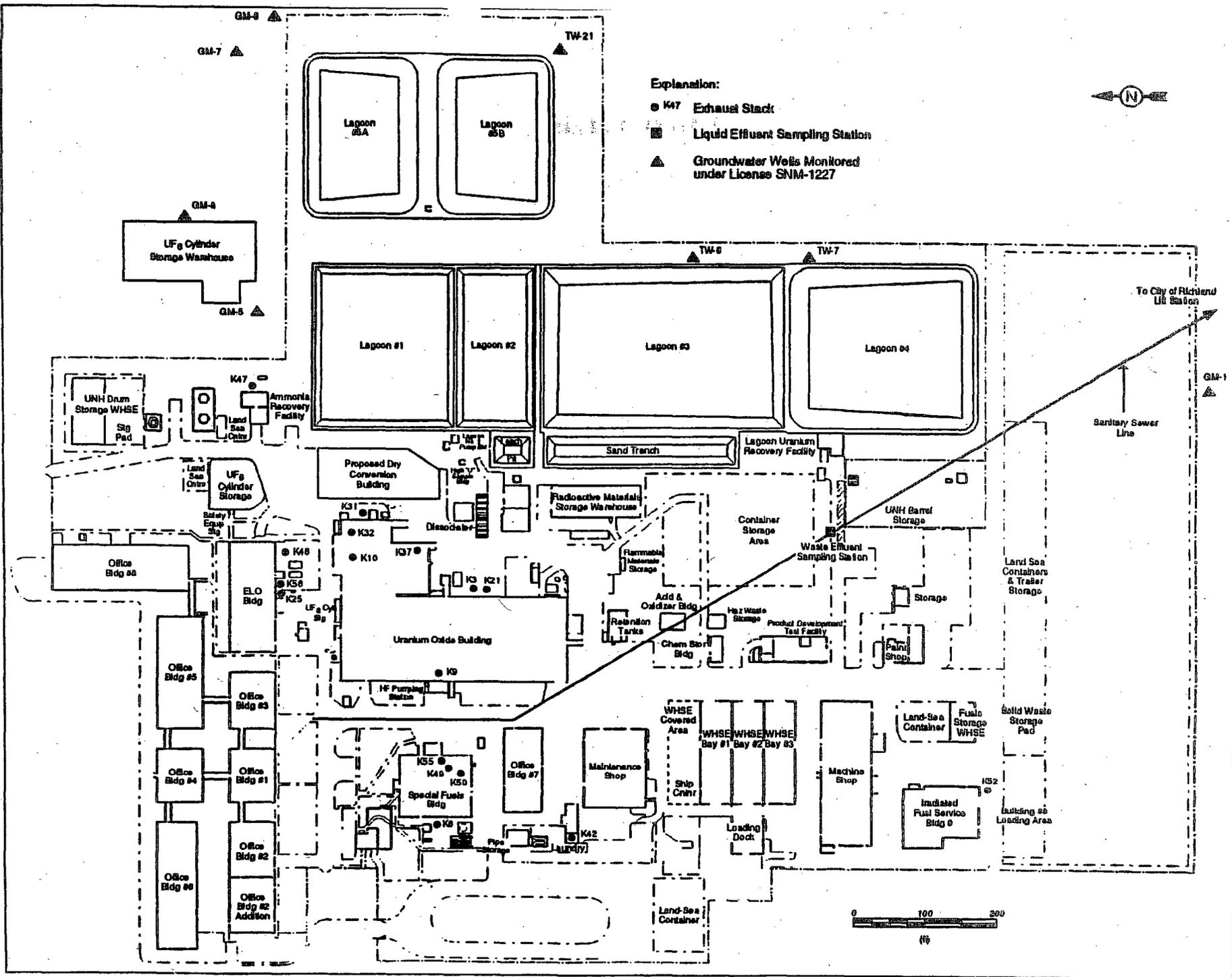


Figure 1.2 Facilities located at the SPC site, Richland, Washington

Ancillary facilities are used for the cleaning of contaminated clothing in the laundry facility; the storage of packaged special nuclear materials in the fuels storage warehouse and the radioactive materials warehouse; the handling and storage of  $UF_6$  cylinders in the  $UF_6$  receiving and storage facility; recovery of ammonia from the lagoon system at the ammonia recovery facility (ARF); recovery of uranium from the lagoons at the lagoon uranium recovery (LUR) facility; incineration of combustible waste and uranium recovery at the solid waste uranium recovery (SWUR) facility in the SF building; and storage of plutonium-contaminated waste in the SF building.

The present application for license renewal involves expanding the dry conversion process to increase conversion capacity and to provide facilities capable of handling higher enrichments. As additional dry conversion capacity is brought on line, the wet ADU conversion process will be reduced to one line for scrap reprocessing. The dry conversion process equipment will be housed in a new building located east of the  $UO_2$  building (Ref. 5) (see Figure 1.2).

Changes to the physical plant since the last license renewal include the addition of the uranyl nitrate hexahydrate (UNH) drum storage warehouse; an ion exchange system added to the ARF; an enlargement of the powder storage facility; an enlargement of the contaminated laundry facility and the conversion of the cleaning process from freon to water; the addition of an enclosed shipping dock to warehouse #2; the construction of the  $UF_6$  cylinder storage warehouse north of the lagoons; and the addition of the irradiated fuel service facility, composed of an office building and a process area for the development and maintenance of nuclear reactor service tooling (Ref. 4). The irradiated fuel service facility is licensed by Washington State.

### **1.3 Description of the Proposed Action**

The proposed action is the renewal of the SPC License SNM-1227 for 10 years with expansion of the dry conversion process. With this renewal, SPC will expand the capacity of the dry conversion process to convert  $UF_6$  to  $UO_2$  and will continue to manufacture fuel assemblies for light-water reactors.

### **1.4 Need for the Proposed Action**

The SPC facility performs a necessary service for the commercial nuclear power industry by converting  $UF_6$  to  $UO_2$  and by fabricating nuclear fuel assemblies. Currently, the SPC facility is one of four such producers of low-enriched uranium fuel operating within the United States. Denial of the license renewal for the Richland SPC facility is an alternative available to the NRC, but would require expansion of production capacity at an existing site or transfer of fuel production activities to a new site.

## 1.5 References for Section 1

1. *U.S. Code of Federal Regulations*, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," Parts 1500-1508, Chapter 5, Title 40, "Protection of Environment."
2. *U.S. Code of Federal Regulations*, "Environmental Protection Regulations for Domestic Licensing and Regulatory Functions," Part 51, Chapter 1, Title 10, "Energy."
3. National Environmental Policy Act, as amended, 42 U.S.C. §4321 et seq., 1970.
4. Siemens Power Corporation—Nuclear Division, "Application for Renewal of Special Nuclear Material License No. SNM-1227 (NRC Docket No. 70-1257)," August 1992.
5. Edgar, J.B., Siemens Power Corporation—Nuclear Division, letter to R.C. Pierson, U.S. Nuclear Regulatory Commission, October 21, 1994.

## 2. THE PROPOSED ACTION AND ALTERNATIVES

Alternative actions identified for the Siemens Power Corporation (SPC) facility include the proposed action of license renewal to continue present activities or cessation of fuel fabrication to be followed by decontamination and decommissioning. Description of activities for each alternative are presented in this section.

### 2.1 The License Renewal Alternative

Implementing the license renewal alternative involves continued operation of the facility at production levels comparable with past practice but with new construction of a building to house expansion of the dry conversion process (Ref. 1). The manufacturing and waste management operations described in this section are adapted from the Siemens license renewal application (Ref. 2), a non-proprietary description of the dry conversion process (Ref. 1), and the Emergency Plan (Ref. 3).

#### 2.1.1 Description of Current Operations

The SPC facility manufactures fuel assemblies for light-water reactors. The plant is licensed to receive low-enriched uranium (< 5 weight percent uranium-235) in the form of uranium hexafluoride ( $UF_6$ ), which is converted to uranium dioxide ( $UO_2$ ) powder by either a wet or a dry conversion process. Presently, the conversion capability includes a single dry line and three wet conversion lines. The dry conversion line has operated at production rates of 360 metric tons uranium (MTU) per year but the plant nominal capacity of 700 MTU per year, is provided primarily by the wet conversion process. By 1997, Siemens expects to complete an expansion of the dry conversion process comprising three additional conversion lines with a combined production capability of 1,200 MTU per year.

The  $UO_2$  powder produced in the conversion processes is pressed into pellets, sintered in a reducing atmosphere, and ground to a finished shape. Finished pellets are inspected and loaded into zirconium fuel rods. Loaded rods are fitted with end caps, welded, and assembled in bundles. The fuel assemblies are temporarily stored and then shipped to reactor sites. Rejected fuel pellets and miscellaneous scrap uranium are recovered and recycled. In addition to fuel assemblies containing only  $UO_2$ , the SPC facility fabricates neutron absorber fuel (NAF) in which gadolinium oxide ( $Gd_2O_3$ ) is blended with the  $UO_2$  powder. Fuel fabrication procedures for NAF are similar to those used for  $UO_2$  fuel. The steps in the fuel fabrication process are shown in Figure 1.1 and described in more detail in the following paragraphs.

### 2.1.1.1 Feed Receipt, Storage, and Movement

Enriched  $UF_6$  is delivered to the site by trucks carrying Model 30B cylinders enclosed in steel overpacks. The cylinders are unloaded by crane, weighed, and stored on site in a dedicated area north of the lagoons (see Figure 1.2). Model 30B cylinders have a capacity of 2,277 kilograms (2.5 tons) and are designed, fabricated, and tested in accordance with the American National Standards Institute (ANSI) N14.1-1990 standard. Possession limits are 25,000 kilograms (27.6 tons) of uranium-235 at less than 5 weight percent enrichment. The load, unload, and storage system has a capacity of 180  $UF_6$  cylinders. Feed cylinders are moved from storage areas to process buildings using forklifts. Within the buildings, cylinders are moved using overhead monorail systems.

### 2.1.1.2 Conversion of $UF_6$ to $UO_2$

Gaseous  $UF_6$  may be converted to  $UO_2$  through either of two processes: a wet ammonium diuranate (ADU) process, or a dry conversion process. Each process produces dry  $UO_2$  powder which is the feed for the balance of the fuel fabrication process. Flow schematics showing the wet and dry conversion processes are provided in Figure 2.1. The initial step in both processes is vaporization of the feed  $UF_6$  in electrically heated chests. The air space of the vaporization chest is vented to a scrubber designed to hydrolyze any escaped  $UF_6$  to uranyl fluoride ( $UO_2F_2$ ), thus preventing uncontrolled release to the atmosphere of accidentally released  $UF_6$  from the air space of the vaporization chest. In normal operation, small quantities of  $UF_6$  are released to the atmosphere through a process offgas (POG) system containing a scrubber and two high efficiency particulate air (HEPA) filters.

The ADU process uses chemical reaction and physical separation steps to convert  $UF_6$  to  $UO_2$ . Gaseous  $UF_6$  is reacted with water in a contactor to form a  $UO_2F_2$  solution that is collected in cylindrical tanks. Ammonium hydroxide ( $NH_4OH$ ) is added to the  $UO_2F_2$  to precipitate ADU from the solution. The solution containing the ADU precipitate is centrifuged and the removed solids are dried. The ADU solids are calcined in a hydrogen-nitrogen atmosphere to convert the ADU to  $UO_2$  powder. The ADU conversion process tanks and vessels are vented through a series of scrubbers, driers, and HEPA filters to remove corrosive gases, entrained liquid, and uranium particulates. The centrifuge liquids contain ammonia and are transferred to lagoon 2 for treatment.

In the dry conversion process,  $UF_6$  gas is reacted directly with a hydrogen-nitrogen-steam atmosphere in a fluidized bed to form  $UO_2$  powder. A rotary calciner removes residual fluoride from the  $UO_2$  powder. Offgas from the hydrolysis reactor and calciner are filtered to remove particulates and passed through a condenser where hydrogen fluoride (HF) and water are recovered as a liquid stream. The by-product acid containing approximately 50 weight percent HF is stored in two 19,000-liter (5,020-gallon) tanks. Residual HF in the offgas is



removed by contact with a caustic solution in a scrubber. The offgas is exhausted through HEPA filters to the atmosphere.

#### 2.1.1.3 Powder Preparation

UO<sub>2</sub> powder is transferred from the calciners under negative pressure to blending, milling, compaction, and granulation equipment. The ventilated hammermill, powder compactor, and rotary screen granulator improve the sintering and pressing characteristics of the powder. Powder that has been prepared is stored until used in the pelletizing process. Air from these process area ventilation systems is released to the atmosphere through HEPA filters.

#### 2.1.1.4 Pelletizing

UO<sub>2</sub> from the powder storage area is blended with a lubricant and a poreformer and then pressed into cylindrical pellets. Freshly pressed pellets are loaded into an electrically heated furnace and sintered in a nitrogen-hydrogen atmosphere. Sintered pellets are sized in a grinder, water washed to remove grinding dust, dried on a moving conveyor belt, and inspected for dimensions and flaws. Acceptable pellets are loaded onto open plastic and metal trays which are stacked and weighed before storage.

Finely divided UO<sub>2</sub> from the grinding operation is caught in the grinder coolant, centrifuged and removed as a wet cake. The UO<sub>2</sub> cake is dried in a ventilated oven and removed from the centrifuge bowl in a hood attached to the bowl-drying oven. All scrap pellets and dried sludge from grinding are weighed and handled in safe batch quantities. Enclosures and hoods are used to control contamination. Ventilation air is filtered through HEPA filters before it is released to the atmosphere.

#### 2.1.1.5 Rod Fabrication

Fabrication of UO<sub>2</sub> fuel rods involves pellet outgassing; rod loading, assaying, and welding; and final inspection and storage. Residual gases are removed from sized pellets in roller hearth furnaces. Outgassed pellets are stored in an enclosed storage cabinet before the rod loading operation. The pellets are loaded into rods in glovebox hoods. The loaded rods are decontaminated, seal welded, assayed, x-rayed, and transferred to storage in trays. Loaded rods are etched in an HF solution, heated in an autoclave with a steam atmosphere, and stored awaiting bundling into assemblies. General ventilation air, glovebox air, and furnace offgas are filtered through HEPA filters before release to the atmosphere. Rod etching offgas is scrubbed with caustic, HEPA-filtered, and released to the atmosphere. Sintered pellet wash water and offgas scrubber liquors are transferred to the lagoon system for treatment.

#### **2.1.1.6 Fuel Assembly Fabrication**

Fabrication of fuel assemblies consists of positioning rods into the assembly matrix. Rods are removed from the storage tray and placed on an order-picker which delivers rods in the required sequence to a powered X-Y table. This system inserts rods into the proper position in a fuel assembly. The completed assembly is inspected, cleaned by washing (if warranted), and dried with warm air. A protective plastic sleeve is placed around each completed assembly. The sleeved assembly is moved to either hanging storage or to the packaging station. During packaging, fuel assemblies are secured in a vertical position in inner shipping containers or strongboxes and lowered to a horizontal position inside the outer shipping container. The loaded and sealed outer containers are moved by forklift from the building to the shipping/storage area.

#### **2.1.1.7 Uranium Recovery and Recycle**

Scrap  $UO_2$  powder and pellets are recycled by a variety of proprietary process steps depending on the material form and purity.

#### **2.1.2 Waste Management and Effluent Controls**

Gaseous, liquid, and solid wastes are produced at the SPC site. These wastes are categorized as low-level radioactive, nonradioactive, hazardous, or mixed wastes. A description of each of these waste categories, control strategies, and an estimate of release quantities is presented in this section.

##### **2.1.2.1 Gaseous Waste Management**

Gases released to the atmosphere from the SPC facility include general ventilation air and process offgases from  $UF_6$  conversion and  $UO_2$  fuel fabrication processes. General ventilation air may contain uranium particulates emitted from process enclosures and hoods or dispersed during powder handling operations. POG systems, including process vessel vents and furnace and calciner offgases, may contain uranium particulates as well as HF and ammonia ( $NH_3$ ) compounds. HEPA filters are used in the general ventilation and POG systems to control emissions of uranium particulates. The POG systems use scrubbers to control emissions of volatile acidic (HF) and basic ( $NH_3$ ) compounds and driers to control emissions of entrained aerosols. Air is recirculated by the general ventilation systems from areas of low potential for contamination to areas for higher potential for contamination and HEPA-filtered before being returned to work areas. Uranium process areas are maintained at negative pressure relative to the atmosphere and surrounding clean work areas. Offgas from ADU conversion processing and triuranium octoxide ( $U_3O_8$ ) uranium recovery process vessels are released through stack K-10. Offgas from dry conversion process and uranyl nitrate hexahydrate (UNH) uranium recovery process vessels are released through stack K-32.

Corrosive fumes from the rod etch process are released through stack K-9. Stack identifiers, release heights, flow rates, and pollution control equipment are listed in Table 2.1. Annual average release rates of uranium for these systems for 1989 to 1993 are presented in Table 2.2. The stack locations are shown on Figure 1.2. This same gaseous effluent control approach of air flow control and filtration will be used in the dry conversion additions, and emissions are expected to decrease.

#### 2.1.2.2 Liquid Waste Management

All SPC facility process water containing uranium or potentially hazardous chemicals is treated in a lagoon system before it is released to the Richland sewage treatment system. The wastewaters are generated primarily from the conversion process, but include etch room wastewater, laundry wastewater, incinerator scrubber wastewater, and the analytical laboratory wastewater. The lagoon system is designed to manage the uranium, fluoride, and ammonia which are the primary hazardous constituents in the wastewaters. The origin and fate of the liquid waste streams are summarized in Figure 2.2. The lagoon layout and numbering are summarized in Figure 1.2. Annual flow rates and uranium content of the treated discharge are summarized in Table 2.3.

Sanitary wastewater from the office complex, outlying rest rooms, and the non-contact cooling water are mixed with the lagoon system effluent before release to the Richland sewage system. Water treated in the Richland system is released to the Columbia River. The production change of shifting to the proposed new dry conversion process lines is expected to reduce ADU conversion process wastewater from  $2.6 \times 10^7$  liters ( $1.6 \times 10^6$  gallons) per year to  $1.9 \times 10^6$  liters ( $5.0 \times 10^5$  gallons) per year and increase dry conversion process wastewater from  $3.8 \times 10^4$  liters ( $1.0 \times 10^4$  gallons) per year to  $7.6 \times 10^5$  liters ( $2.0 \times 10^5$  gallons) per year. Thus, a net reduction of process wastewater flow is expected for future operations.

#### Lagoons and Lagoon Systems

The wastewater treatment system includes six lagoons, a sand trench, a leach pit, two uranium recovery systems, and an ammonia recovery system. Each lagoon is double lined with either hypalon or high density polyethylene (HDPE) and two of the lagoons have an HDPE covering. Leak detection systems are located between the liners and below the bottom liner as described in Section 4.2.4. The wastes are segregated according to their source and chemical content for processing to reclaim usable constituents.

Table 2.1 Stack height, flow rates, and pollution control equipment on facilities at the SPC facility

| Stack No. | Description                   | Height <sup>a</sup> (ft) | Flow (ft <sup>3</sup> /min) <sup>b</sup> | Pollution Control Equipment                                       |
|-----------|-------------------------------|--------------------------|--|---|
| K-3       | Room 100                      | 50                       | 44,000                                   | HEPA Filters  |
| K-6       | NAF                           | 50                       | 16,000                                   | HEPA Filters  |
| K-9       | Etch                          | 37                       | 6,000                                    | Scrubber/Dryer/HEPA Filters                                       |
| K-10      | Line 1 POG                    | 53                       | 1,200                                    | Scrubber/Dryer/HEPA Filters                                       |
| K-21      | Room 182                      | 50                       | 17,000                                   | HEPA Filters  |
| K-25      | ELO                           | 20                       | 3,000                                    | HEPA Filters  |
| K-31      | Line 2                        | 50                       | 50,000                                   | HEPA Filters  |
| K-32      | Line 2 POG                    | 53                       | 1,000                                    | Scrubber/Dryer/HEPA Filters                                       |
| K-37      | U <sub>3</sub> O <sub>8</sub> | 50                       | 19,300                                   | HEPA Filters  |
| K-42      | Laundry                       | 25                       | 6,300                                    | HEPA Filters  |
| K-46      | ELO Addition                  | 35                       | 18,000                                   | HEPA Filters  |
| K-47      | ARF                           | c                        | "slight vacuum"                          | Scrubber  |
| K-49      | SWUR Room                     | 50                       | 7,500                                    | HEPA Filters  |
| K-50      | SWUR POG                      | 42                       | 950                                      | Quench Column/Scrubber/Packed Column Mist Eliminator/HEPA Filters |
| K-55      | SWUR Shroud                   | 42                       | 1,200                                    | HEPA Filter   |
| K-56      | GSUR                          |                          |  | HEPA Filters  |
| K-58      | UO <sub>2</sub> Lab           | 50                       | 16,000                                   | Scrubber/HEPA Filters   |

a. Elevation above ground level. 1 foot = 0.3048 meter.

b. 1 ft<sup>3</sup>/min = 0.0283 m<sup>3</sup>/min.

c. Incomplete information.

Source: Siemens Power Corporation—Nuclear Division, "Application for Renewal of Special Material License No. SNM-1227 (NRC Docket No. 70-1257)," August 1992 (Ref. 2).

Table 2.2 Release characteristics for gaseous effluents 1989-1993

| Stack No.          | Description                   | Uranium emissions ( $\mu\text{Ci}/\text{yr}$ ) |        |       |       |                   | 1989-1993 Average Discharge Rate ( $\mu\text{Ci}/\text{yr}$ ) |
|--------------------|-------------------------------|--|--------|-------|-------|-------------------|---|
|                    |                               | 1989   | 1990   | 1991  | 1992  | 1993              |   |
| K-3                | Room 100                      | <2.45  | <2.31  | 2.18  | 0.43  | 2.14              | <1.90   |
| K-6                | NAF                           | <0.51  | <0.44  | 0.36  | 0.55  | 0.09              | 6.39  |
| K-9                | Etch                          | <0.31  | <0.33  | 0.14  | 0.24  | 0.28              | <0.26   |
| K-10               | Line 1 POG                    | <1.07  | <0.76  | 0.53  | 0.53  | 0.46              | <0.67   |
| K-21               | Room 182                      | <1.03  | <1.19  | 0.88  | 1.00  | 0.37              | <0.89   |
| K-25               | ELO                           | <0.13  | <0.10  | 0.08  | 0.13  | 0.05              | <0.10   |
| K-31               | Line 2                        | <2.48  | <2.80  | 1.95  | 3.05  | 0.68              | <2.19   |
| K-32               | Line 2 POG                    | <3.50  | <5.58  | 2.84  | 1.18  | 1.24              | <2.87   |
| K-37               | U <sub>3</sub> O <sub>8</sub> | <2.18  | <2.52  | 2.61  | 3.82  | 3.25              | <2.88   |
| K-42               | Laundry                       | <0.02  | <0.04  | 0.04  | 0.11  | 0.05              | <0.05   |
| K-46               | ELO Addition                  | <0.51  | <0.54  | 0.34  | 0.27  | 0.09              | <0.35   |
| K-47               | ARF                           | --- <sup>a</sup>                               | ---    | ---   | ---   | 0.03 <sup>b</sup> | 0.03  |
| K-49               | SWUR Room                     | <0.51  | <0.31  | 0.28  | 0.54  | 0.38              | <0.40   |
| K-50               | SWUR POG                      | <0.07  | <0.08  | 2.70  | 7.40  | shut down         | <2.56   |
| K-52 <sup>c</sup>  | Building #9                   | <3.53  | <0.91  | 1.67  | 1.48  | 0.90              | <1.70   |
| K-55               | SWUR Shroud                   | ---  | ---    | ---   | ---   | shut down         | 0   |
| Total <sup>c</sup> |                               | <14.77   | <17.00 | 14.93 | 19.25 | 9.11              | <15.01  |

a. --- = No data available.

b. Stack sampled for only 8 months in 1993.

c. K-52 values are for gross beta and are excluded from the total. Facility licensed by Washington State.

Source: Advanced Nuclear Fuels Corporation (Currently Siemens Power Corporation), Semiannual "Required Reporting of Effluents per 10 CFR 70.59," submitted to U.S. Nuclear Regulatory Commission (Ref. 4).

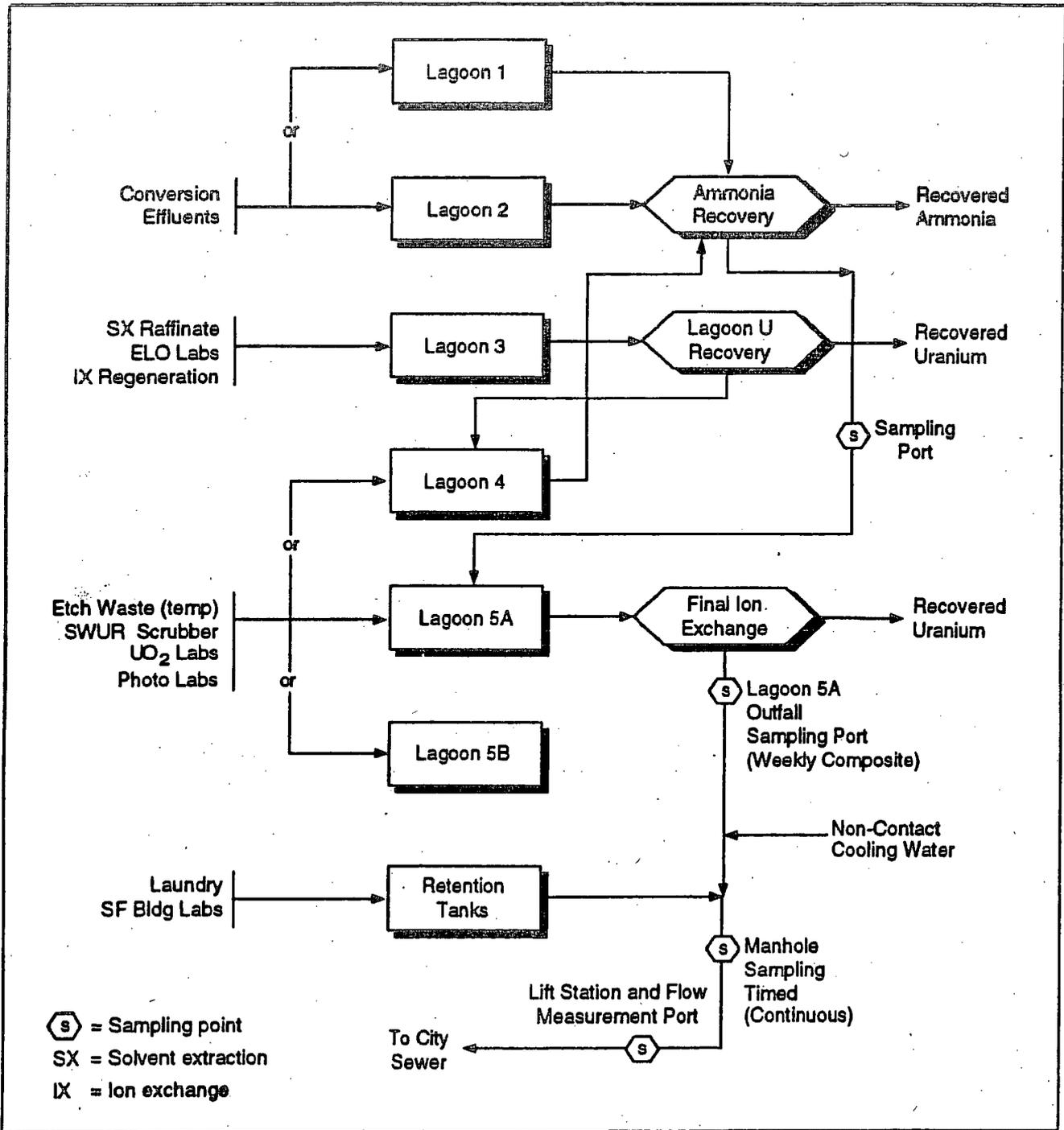


Figure 2.2 Schematic of the lagoon liquid effluent treatment system

**Table 2.3 Semiannual average uranium concentrations and discharges in liquid effluent from the SPC facility**

| Period             | Average Uranium Concentration<br>( $\mu\text{Ci/mL}$ ) | Total Uranium Discharged to Sewer<br>(Ci) |
|--------------------|--|---|
| 1/1/89 to 12/31/89 | $<1.7 \times 10^{-7}$                                  | $<0.067$                                  |
| 1/1/90 to 12/27/90 | $<1.95 \times 10^{-7}$                                 | $<0.052$                                  |
| 12/27/90 to 1/1/92 | $<2.05 \times 10^{-7}$                                 | $<0.058$                                  |
| 1/1/92 to 1/1/93   | $<2.05 \times 10^{-7}$                                 | $<0.08$                                   |
| 1/1/93 to 1/1/94   | $<1.5 \times 10^{-7}$                                  | $<0.048$                                  |

Source: Advanced Nuclear Fuels Corporation (Siemens Power Corporation); Semiannual "Required Reporting of Effluents per 10 CFR 70.59," submitted to U.S. Nuclear Regulatory Commission (Ref. 4).

Lagoons 1 and 2 receive ammonia-bearing solutions from the wet conversion process at a rate of 109,000 liters (28,800 gallons) per day. This waste stream has a high pH (11-12.5) and contains fluorides (2,000 milligrams per liter of sodium fluoride [NaF]), ammonia (160 milligrams per liter of  $\text{NH}_3$ ), nitrate (4,000 milligrams per liter of sodium nitrate [ $\text{NaNO}_3$ ]), and less than 1 milligram per liter uranium (Ref. 5). Lagoons 3 and 5B receive high uranium concentration wastewaters (e.g., from the gadolinia scrap recovery laboratories in the engineering laboratory operations [ELO] building) and serve as feed lagoons to the lagoon uranium recovery (LUR) facility. Wastewaters from the gadolinia scrap recovery have a pH of 1 from nitric acid and/or aluminum nitrate dissolving solutions and contain low concentrations of dodecane and tributylphosphate. The lagoon 3 and 5B sludge has uranium concentrations greater than 50 milligrams per kilogram (Ref. 5).

Wastewater from the LUR facility is stored in lagoon 4 before being routed to the ammonia recovery facility (ARF). Wastewaters from fuel rod etching, the solid waste uranium recovery (SWUR) incinerator, and laundry operations contain less than 1 milligram per liter uranium (Ref. 5) and are typically routed to lagoon 5A but may be routed to lagoon 4 or 5B (Ref. 3). Etching wastewaters are generated at a rate of 16,000 liters (4,300 gallons) per day and have a pH of 1-2 from hydrofluoric and nitric acids. The laundry, laboratory, and SWUR scrubber wastewaters have pHs ranging from 7 to 10 and are generated at rates of 34,000, over 300, and 33,000 liters (9,000, a few hundred, and 8,600 gallons) per day, respectively (Ref. 5). It has been proposed to remove the high uranium content waste currently in lagoon 5B and to use it as a batching lagoon in conjunction with lagoon 5A to discharge to the municipal sewer system (Ref. 2). Currently, lagoon 5A is the final holding lagoon before treatment in the lagoon 5A ion exchange system and discharge to the municipal sewer.

## Solids Uranium Recovery Facility

A sand trench/leach pit system has been used for solids recovery (i.e., inorganic salts, sands, silts, and clays) from the six lagoons. A solids processing facility has been proposed to replace this system. Under the new process, lagoon solids would be collected, dissolved, and processed through multiple solid separation steps. Clarified liquid from the process would be routed to the LUR facility for uranium recycle. Residual solids would be disposed of as either nonregulated solids, low-level radioactive waste, or mixed waste depending upon the effectiveness of the solids treatment process (Ref. 2).

## Lagoon Uranium Recovery Facility

Uranium is recovered by pumping lagoon 3 solution to tanks in the LUR facility, where sodium hydrosulfite is added to precipitate the uranium (other metal impurities may also precipitate). The slurry is centrifuged to produce a liquid which is pumped to lagoon 4 and solids which are drummed. The solids are subsequently dissolved with aluminum nitrate and the uranium is recovered by solvent extraction. The LUR facility is not freeze-protected and is therefore shut down during cold weather.

## Lagoon 5A Ion Exchange System

Effluent from lagoon 5A is fed to the lagoon 5A ion exchange column to remove residual uranium before the effluent is discharged to the Richland public sewer system. After contact with the ion exchange column, the uranium concentration in effluent is less than 0.1 ppm. All liquid streams from regeneration of the ion exchange resin are sent to lagoon 3.

## Ammonia Recovery

Liquids from lagoons 1, 2, and 4 are heated and processed through an ammonia steam-stripping column designed to produce 20 or 30 wt percent ammonia product solution and waste effluent at less than 100 milligrams per liter of ammonia. The waste effluent is routed to lagoon 5A (or in the future to 5B), back to the ammonia recovery feed tank, or the feed lagoon depending upon the ammonia concentration, temperature, and pH. Condensate from the stripper overheads are routed to the distillate tank. A scrubber removes ammonia from the ammonia recovery offgas. The scrubber solution is routed to the feed tank and the scrubbed offgas is vented to the atmosphere via stack K-47.

## Cooling and Sanitary Wastewaters

The largest sources of wastewater at the SPC facility are non-contact cooling water and sanitary sewage. Of the approximately 756,000 liters (200,000 gallons) of water used each day for cooling purposes, 378,000 liters

(100,000 gallons) are recycled and 378,000 liters (100,000 gallons) are discharged to the sewage system. About 87,700,000 liters (23,178,000 gallons) per year of sanitary sewage are generated at the SPC facility (Ref. 6).

### 2.1.2.3 Solid Waste Management

Solid wastes generated at the SPC site include low-level radioactive, nonradioactive, hazardous, and mixed wastes. A combination of incineration, on-site storage, and off-site disposal are used in the management of these wastes as described in the following sections.

#### Solid Radioactive Waste

Approximately 30 cubic meters (1,100 cubic feet) of solid radioactive waste are generated at the SPC facility each month (Ref. 7). Several outdoor container storage areas shown on Figure 1.2 store dry and wet wastes in polyethylene and steel containers of various sizes and configurations (Ref. 5). Shift of production to the dry conversion process is expected to reduce monthly radioactive waste generation rates to approximately 23 cubic meters (800 cubic feet). Combustible solid waste may be processed in the SWUR facility, an incinerator located in the specialty fuels (SF) building (Ref. 6). The ash is stored in steel drums in container storage areas for future recovery of uranium.

Incoming drums to the incinerator are sorted into combustible and noncombustible. The combustible material, including about 91 kilograms (200 pounds) per day of Zircaloy and zirconium shavings, turnings, and small scrap, may be incinerated in the SWUR facility (Ref. 7). The cardboard incinerator boxes are weighed and non-destructive assay (NDA)-counted to determine the U-235 inventory. Noncombustible material is loaded back into a 208-liter (55-gallon) drum, weighed, NDA-counted, and the amount of total uranium and U-235 recorded on the drum manifest.

Ash from the SWUR facility is discharged into 114-liter (30-gallon) U.S. Department of Transportation (DOT)-approved 17-H metal drums. Each ash drum is homogenized, sampled for uranium and U-235 isotopic content, and weighed. When combustibles are not incinerated on site, they may be compacted on site or off site, before disposal at a licensed low-level radioactive waste disposal facility.

Noncombustible waste is disposed of off site. Specialized facilities are being considered to allow future, on-site decontamination of noncombustible waste. The frequency of waste shipments depends upon the waste generation rate and the accumulation of cost-effective shipment sizes. In order to reduce the amount of radioactive waste stored on site, off-site disposal of solid radioactive waste has increased from no shipments in 1989 and 1990 to shipping 479 cubic meters (17,000 cubic feet) for the first 6 months in 1994, excluding wind blown sand recovered from the lagoon system (Ref. 7).

## Plutonium-Contaminated Waste Storage

A below-grade room in the SF building is used to store plutonium-contaminated waste that remains from decontamination of the mixed oxide fuel fabrication facility. This waste is classified as greater than Class C, and there is no disposal site for this type of waste. The room contains a sump for liquid collection which is monitored by a liquid level alarm. The room is ventilated. Exhausted air is sampled continuously, monitored weekly, and passed through a HEPA filter before joining the SF building exhaust system (stack K-6).

### **2.2 The No License Renewal Alternative**

The alternative of no license renewal for SPC at the Richland, Washington, site implies cessation of manufacturing and commencement of decontamination and decommissioning (D&D) of the facility. However, since the SPC facility is one of four producers of low-enriched uranium fuel for light-water reactors and the demand for such fuel would remain unchanged, selection of this alternative would involve transfer of fuel production activities to another site. Environmental impacts at the other site would be expected to be similar to those described in Section 5 for the license renewal alternative.

### **2.3 Decommissioning**

At the end of plant operations, SPC will decontaminate and decommission the facilities to provide for protection of the environment and public health and safety. Contamination will be reduced to levels which allow for release of the facility for unrestricted use. These levels are specified in "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated April 1993 (Ref. 8) and in the radiological criteria for decommissioning being developed for the 10 CFR Part 20 regulations.

The D&D plan addresses the major production facilities (the UO<sub>2</sub> and SF buildings), ancillary facilities, storage areas, the lagoons, and the containerized waste facilities, which are all contaminated with radioactive material. No radioactive materials have been buried on site.

The residual contamination levels in facilities to be unconditionally released would have to meet the criteria provided in the above regulations and guidelines. Equipment or facilities that could not be decontaminated to those levels will be transferred to another facility or demolished, packaged, and disposed of at a licensed low-level radioactive waste disposal site (Ref. 9).

The lagoons and certain portions of the containerized waste storage areas manage mixed wastes, i.e., wastes that are radiologically contaminated and also contain chemical constituents that cause them to be designated as dangerous wastes

under the State of Washington Dangerous Waste Regulations. These wastes are regulated both by the U.S. Nuclear Regulatory Commission (NRC) and the Department of Ecology and the units are subject to the decommissioning requirements of the NRC (10 CFR 70.25) and the closure requirements of the Department of Ecology (WAC 713-303-610 and -650). The detailed decommissioning procedures for the lagoons and containerized mixed waste storage areas will address the requirements of both regulatory agencies (Ref. 9).

Following completion of decontamination activities, a comprehensive radiological survey will be completed and a report documenting cleanup to the target levels will be prepared. The completed decontamination activities and final survey will be reviewed and verified by the NRC before termination of the license.

## 2.4 References for Section 2

1. Edgar, J.B., Siemens Power Corporation—Nuclear Division, letter to R.C. Pierson, U.S. Nuclear Regulatory Commission, October 21, 1994.
2. Siemens Power Corporation—Nuclear Division, "Application for Renewal of Special Nuclear Material License No. SNM-1227 (NRC Docket No. 70-1257)," August 1992.
3. Siemens Power Corporation Richland Engineering and Manufacturing Facility, "Emergency Plan," Part I-IV, EMF-32, May 1993.
4. Advanced Nuclear Fuels Corporation (Siemens Power Corporation), Semiannual "Required Reporting of Effluents per 10 CFR 70.59," submitted to U.S. Nuclear Regulatory Commission, 1989-1993.
5. Advanced Nuclear Fuels Corporation (Siemens Power Corporation), Fact Sheet regarding State Waste Discharge Permit No. ST 3919, January 1990.
6. Edgar, J.B., Siemens Power Corporation—Nuclear Division, letter to R.C. Pierson, U.S. Nuclear Regulatory Commission, March 31, 1995.
7. Siemens Power Corporation—Nuclear Division, "Siemens Power Corporation's Response to NRC's Request for Additional Information," December 29, 1994.
8. U.S. Nuclear Regulatory Commission, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," April 1993.
9. Siemens Power Corporation—Nuclear Division, "Siemens Decommissioning Funding Plan," EMF-1772, August 1994.

### **3. THE AFFECTED ENVIRONMENT**

#### **3.1 Site Description**

The Siemens Power Corporation (SPC) facility is located on a 131-hectare (320-acre) site just inside the northern boundary of the City of Richland in Benton County, Washington (Figure 3.1). The site consists of 36 buildings plus various outside facilities. The uranium handling and processing facilities are located within a restricted 21.5-hectare (53-acre) area. The facility is located within a 2,470-hectare (6,100-acre) land parcel known as the Horn Rapids Triangle, which was part of the U.S. Department of Energy's (DOE) Hanford Site until 1967 when it was annexed by the City of Richland. The Horn Rapids Triangle is bounded to the north by Horn Rapids Road, to the south by the Horn Rapids Irrigation Ditch, to the east by the DOE 1100 Area, and on the southeast by the Port of Benton Skypark and Richland Airport (Figure 3.1).

The site region is characterized as a semi-arid desert of generally flat terrain except for wind-formed ridges from 1.5 to 9 meters (5 to 30 feet) high. The site is located between the Columbia and the Yakima Rivers at an elevation of 114 meters (373 feet) above mean sea level (MSL). At their closest points, the nominal elevation of the Columbia and Yakima Rivers are approximately 107 and 113 meters (350 and 370 feet) MSL, respectively.

#### **3.2 Meteorology and Air Quality**

##### **3.2.1 Climatology**

The SPC site region has a dry, continental climate with large temperature variations between winter and summer caused by the mountain ranges to the west and the orientation of the Rocky Mountains. The maximum temperatures of 33°C (95°F) occur in July and the minimum temperatures of 7°C (20°F) occur in January. The temperature falls below freezing an average of about 100 days per year. The record high and low temperatures are 46°C (115°F) and -33°C (-27°F), respectively (Ref. 1). The site is within the rain shadow of the Cascade Mountains, and the average annual precipitation is 16.3 centimeters (6.4 inches). Rainfall is more frequent in the winter months; averaging about 2.5 centimeters (1.0 inch) per month in November, December, and January and about 0.5 centimeters (0.2 inches) in July and August. Snowfalls of 2.5 centimeters (1.0 inch) or more occur twice each month in December and January on average.

Climatological data are collected on site and at two meteorological stations located within 5 kilometers (3 miles) of the SPC site. Wind roses generated from these stations are shown in Figure 3.2 and indicate that the prevailing wind is from the southwest. Secondary direction frequency maxima are from the northwest and southeast along the axis of the Columbia River and the lowest frequencies are from

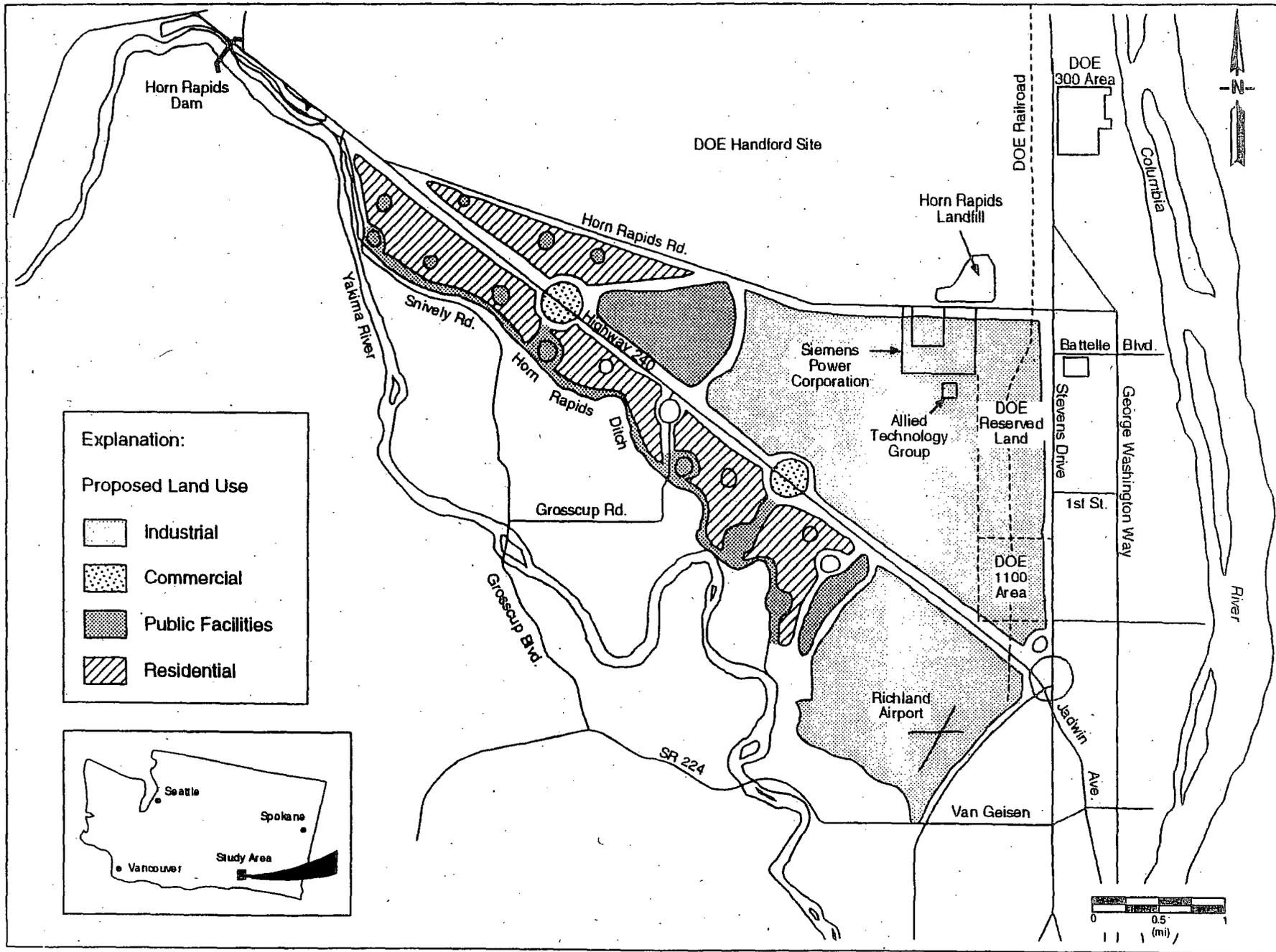


Figure 3.1 Location of SPC site and proposed land use

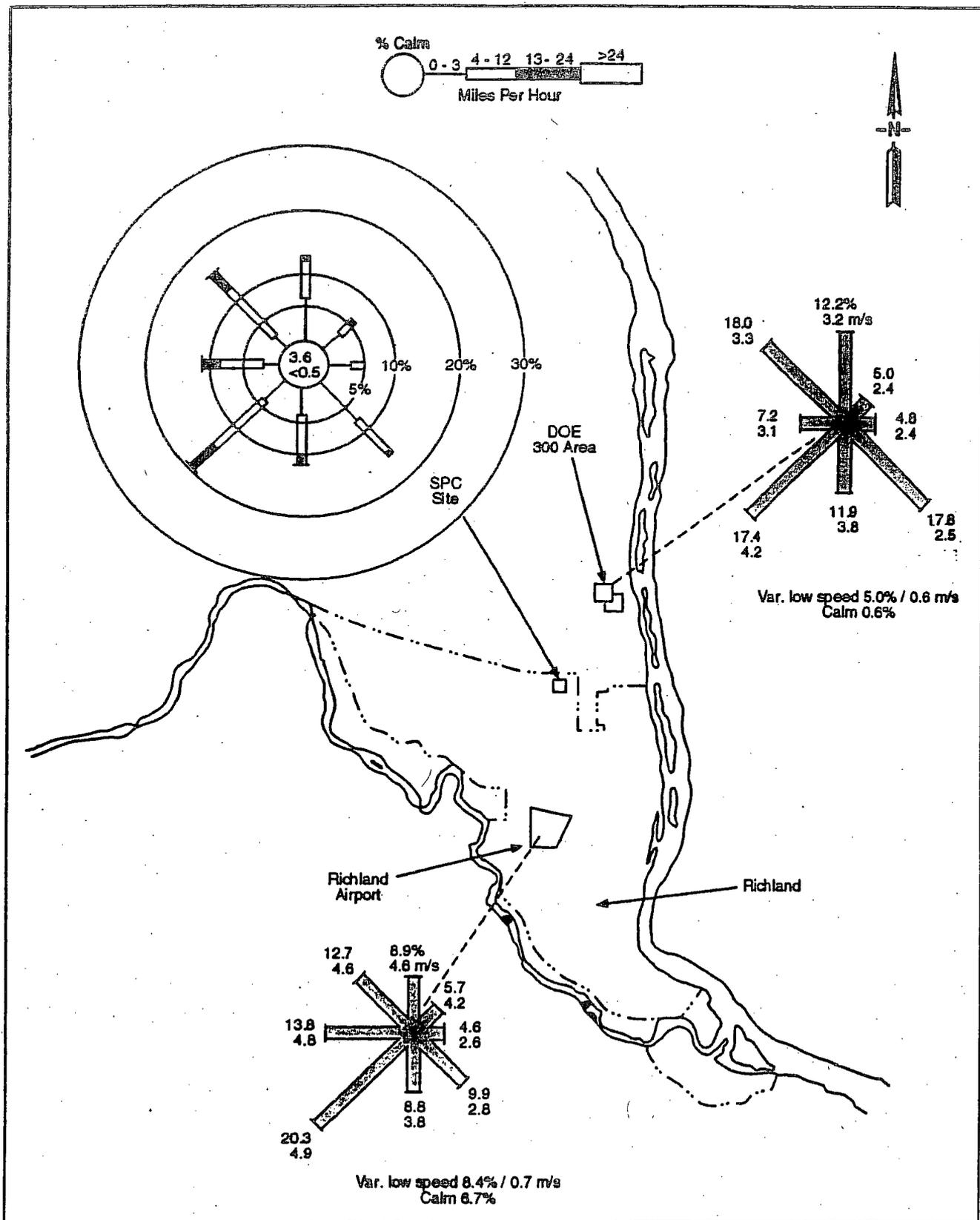


Figure 3.2 Wind roses for the SPC site and vicinity

the east and northeast. Meteorological data on wind direction, wind speed, and air mass stability from the Hanford Site 300 Area are shown in Table 3.1.

### 3.2.2 Winds, Tornadoes, and Storms

Severe weather in the Columbia Basin consists of wind, thunderstorms, and occasionally a tornado. Wind speeds of about 97 kilometers per hour (60 miles per hour) are expected one year out of two, and speeds in excess of 80 kilometers per hour (50 miles per hour) are expected every year. About 11 thunderstorms occur annually in the Richland area. No tornadoes have been recorded within 32 kilometers (20 miles) of the SPC site. Based on review of tornado occurrences from 1950-1969 and on preferential paths of individual storms through the mountains in the northwestern states, Battelle Pacific Northwest Laboratory conservatively concluded (Ref. 1):

1. The expected number of tornadoes is 0.4 per year within a 161-kilometer (100-mile) radius of the SPC site.
2. The mean (or expected) probability that a tornado would strike the SPC site in any given year is  $6.1 \times 10^{-6}$ .
3. There is a 95 percent probability that the wind speed would not exceed 270 kilometers per hour (168 miles per hour) in any given tornado, and over a 40-year period, a maximum wind speed of 280 kilometers per hour (174 miles per hour) is the best estimate.

### 3.2.3 Air Quality

Air quality is measured against the National Ambient Air Quality Standards (NAAQS). The U.S. Environmental Protection Agency (EPA) established the NAAQS primary standards to protect human health and secondary standards to protect against damage to the environment and facilities. The pollutants regulated under NAAQS are total suspended particulates (TSP), defined as inhalable particulate matter with aerodynamic diameter less than 10 microns (PM-10); ozone ( $O_3$ ); nitrous oxides ( $NO_x$ ); sulfur oxides (e.g., sulfur dioxide [ $SO_2$ ]); carbon monoxide (CO); and lead (Pb). Air quality at the site is good—within the air quality standards set by the EPA and the State of Washington. Washington State regulates for PM-10, nitrogen dioxide ( $NO_2$ ), radionuclides, and fluorides. The local air authority, Benton-Franklin Counties Clean Air Authority enforces General Regulation 80-7, which pertains to detrimental effects, fugitive dust, incineration products, odor, opacity, asbestos, and sulfur oxide emissions (Ref. 2).

Table 3.1 Percent of occurrence of wind speed as a function of stability class and direction at the SPC site

| Wind Toward | Stability Class | Wind Speed (miles/hr) <sup>a</sup> |       |      |       |       |       |       |       |
|-------------|-----------------|------------------------------------|-------|------|-------|-------|-------|-------|-------|
|             |                 | 0-0.5                              | 0.5-3 | 4-7  | 8-12  | 13-19 | 19-24 | 25-31 | 32-38 |
| N           | C               | 0.20                               | 1.28  | 1.32 | 0.47  | 0.14  |       |       |       |
| NE          |                 | 0.10                               | 0.66  | 0.54 | 0.19  | 0.082 |       |       |       |
| E           |                 | 0.11                               | 0.69  | 0.58 | 0.12  |       |       |       |       |
| SE          |                 | 0.26                               | 1.71  | 1.75 | 0.49  | 0.097 |       |       |       |
| S           |                 | 0.14                               | 0.90  | 1.18 | 0.47  | 0.26  | 0.12  | 0.047 |       |
| SW          |                 | 0.12                               | 0.81  | 1.63 | 1.38  | 1.04  | 0.50  | 0.21  | 0.092 |
| W           |                 | 0.058                              | 0.38  | 1.06 | 1.09  | 0.46  | 0.13  | 0.021 |       |
| NW          |                 | 0.097                              | 0.63  | 1.42 | 1.48  | 0.74  | 0.30  | 0.17  |       |
| N           | D               | 0.065                              | 0.43  | 0.44 | 0.16  | 0.048 |       |       |       |
| NE          |                 | 0.033                              | 0.22  | 0.18 | 0.063 | 0.027 |       |       |       |
| E           |                 | 0.035                              | 0.23  | 0.19 | 0.04  |       |       |       |       |
| SE          |                 | 0.087                              | 0.57  | 0.58 | 0.16  | 0.032 |       |       |       |
| S           |                 | 0.046                              | 0.30  | 0.39 | 0.16  | 0.087 | 0.039 | 0.016 |       |
| SW          |                 | 0.042                              | 0.27  | 0.54 | 0.46  | 0.35  | 0.10  | 0.070 | 0.031 |
| W           |                 | 0.019                              | 0.13  | 0.35 | 0.36  | 0.16  | 0.043 | 0.007 |       |
| NW          |                 | 0.032                              | 0.21  | 0.47 | 0.49  | 0.25  | 0.10  | 0.057 |       |
| N           | F               | 0.20                               | 1.28  | 2.64 | 0.94  | 0.29  |       |       |       |
| NE          |                 | 0.10                               | 0.66  | 1.08 | 0.38  | 0.16  |       |       |       |
| E           |                 | 0.11                               | 0.69  | 1.17 | 0.24  |       |       |       |       |
| SE          |                 | 0.26                               | 1.71  | 3.49 | 0.97  | 0.19  |       |       |       |
| S           |                 | 0.14                               | 0.90  | 2.36 | 0.95  | 0.52  | 0.24  | 0.095 |       |
| SW          |                 | 0.12                               | 0.81  | 3.26 | 2.76  | 2.09  | 1.00  | 0.42  | 0.18  |
| W           |                 | 0.58                               | 0.38  | 2.12 | 2.18  | 0.93  | 0.26  | 0.043 |       |
| NW          |                 | 0.097                              | 0.63  | 2.84 | 2.96  | 1.47  | 0.60  | 0.34  |       |
| N           | G               | 0.20                               | 1.28  |      |       |       |       |       |       |
| NE          |                 | 0.10                               | 0.66  |      |       |       |       |       |       |
| E           |                 | 0.11                               | 0.69  |      |       |       |       |       |       |
| SE          |                 | 0.26                               | 1.71  |      |       |       |       |       |       |
| S           |                 | 0.14                               | 0.90  |      |       |       |       |       |       |
| SW          |                 | 0.12                               | 0.81  |      |       |       |       |       |       |
| W           |                 | 0.058                              | 0.38  |      |       |       |       |       |       |
| NW          |                 | 0.097                              | 0.63  |      |       |       |       |       |       |

a. 1.0 mile per hour = 1.6 kilometers per hour.

Source: Siemens Power Corporation—Nuclear Division, "Supplement to Applicant's Environment Report," EMF-14, Revision 4, July 1994 (Ref. 1).

### 3.3 Demography and Socioeconomic Profile

The SPC facility is located in the City of Richland, which along with Pasco and Kennewick, make up the Tri-Cities metropolitan area. Table 3.2 provides the historic and 1990 population data for Benton and Franklin Counties. The projected population growth in Benton and Franklin Counties from 1980 to 1990 was less than that of Washington State, which averaged 1.66 percent annually for the same period (Ref. 2). The incremental 1990 population distribution within a 80-kilometer (50-mile) radius of the site is presented in Table 3.3. Table 3.4 provides the cumulative population distribution for the same region. The data are presented as a function of direction and distance for a combination of 16 directional sectors and 16 radial distances. The total population within an 80-kilometer (50-mile) radius of the facility is approximately 269,943 (Table 3.4). The data presented in Table 3.3 indicate that from 1980 to 1990 the population within an 80-kilometer (50-mile) radius increased by 7.9 percent over the 10 years from 1980 to 1990. However, the population within 16.1 kilometers (10 miles) of the SPC site decreased by 21 percent, indicating a trend of more people living away from the City of Richland.

**Table 3.2 Population distribution of Benton and Franklin Counties and projected growth**

| Year | Benton County<br>(percent growth) | Franklin County<br>(percent growth) |
|------|-----------------------------------|-------------------------------------|
| 1960 | 62,070                            | 23,342                              |
| 1970 | 67,540 (8.81)                     | 25,816 (10.6)                       |
| 1980 | 109,444 (62.0)                    | 35,025 (35.7)                       |
| 1990 | 112,560 (2.85)                    | 37,473 (6.70)                       |
| 1995 | 121,328 (7.79)                    | 41,336 (10.31)                      |
| 2000 | 128,752 (6.12)                    | 44,630 (7.97)                       |
| 2005 | 136,982 (6.32)                    | 48,213 (8.03)                       |
| 2010 | 145,452 (6.25)                    | 52,388 (8.66)                       |

Sources: Siemens Power Corporation—Nuclear Division, "Supplement to Applicant's Environmental Report," EMF-14, Revision 4, July 1994 (Ref. 1) and U.S. DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement, June 1994 (Ref. 2).

**Table 3.3 Incremental 1990 population within 80 kilometers (50 miles) of the SPC site**

| Sector                 | Distance (miles) <sup>a</sup> |               |                |               |                |                | Total          |
|------------------------|-------------------------------|---------------|----------------|---------------|----------------|----------------|----------------|
|                        | 0-5                           | 5-10          | 10-20          | 20-30         | 30-40          | 40-50          |                |
| N                      | 0                             | 11            | 288            | 984           | 7,787          | 1,370          | 10,440         |
| NNE                    | 29                            | 270           | 1,009          | 1,449         | 932            | 2,222          | 5,911          |
| NE                     | 77                            | 291           | 690            | 1,541         | 1,136          | 221            | 3,956          |
| ENE                    | 88                            | 274           | 255            | 221           | 216            | 230            | 1,284          |
| E                      | 278                           | 331           | 146            | 297           | 184            | 259            | 1,495          |
| ESE                    | 382                           | 543           | 3,509          | 749           | 583            | 14,152         | 19,918         |
| SE                     | 3,161                         | 3,049         | 61,817         | 1,940         | 547            | 699            | 71,213         |
| SSE                    | 10,505                        | 11,262        | 13,235         | 107           | 2,398          | 2,035          | 39,542         |
| S                      | 5,987                         | 5,607         | 961            | 1,725         | 19,371         | 1,090          | 34,471         |
| SSW                    | 1,318                         | 890           | 693            | 109           | 1,858          | 2,010          | 6,878          |
| SW                     | 615                           | 1,190         | 1,091          | 181           | 187            | 153            | 3,471          |
| WSW                    | 152                           | 1,703         | 2,432          | 11,419        | 9,608          | 488            | 25,802         |
| W                      | 100                           | 507           | 932            | 1,001         | 17,937         | 17,526         | 38,003         |
| WNW                    | 2                             | 60            | 30             | 211           | 757            | 522            | 1,582          |
| NW                     | 0                             | 0             | 0              | 163           | 936            | 679            | 1,778          |
| NNW                    | 0                             | 0             | 30             | 371           | 1,116          | 2,466          | 3,983          |
| <b>Total</b>           | <b>22,694</b>                 | <b>25,988</b> | <b>87,118</b>  | <b>22,468</b> | <b>65,553</b>  | <b>46,122</b>  | <b>269,943</b> |
| <b>1980 Population</b> | <b>32,960</b>                 | <b>28,430</b> | <b>78,400</b>  | <b>21,100</b> | <b>53,650</b>  | <b>35,680</b>  | <b>250,220</b> |
| <b>Percent Change</b>  | <b>(-31.1)</b>                | <b>(-8.6)</b> | <b>(+11.1)</b> | <b>(+6.5)</b> | <b>(+22.2)</b> | <b>(+29.3)</b> | <b>(+7.9)</b>  |

a. 1.0 mile = 1.6 kilometers.

Source: U.S. Department of Commerce (DOC) Bureau of the Census, Economic and Statistics Administration, "Summary Tape File 3 on CDROM," 1990 Census of Population and Housing, May 1992 (Ref. 3).

**Table 3.4 Cumulative 1990 population within 80 kilometers (50 miles)  
of the SPC site**

| Sector       | Distance (miles) <sup>a</sup> |            |              |               |               |               |                |                |                |                |
|--------------|-------------------------------|------------|--------------|---------------|---------------|---------------|----------------|----------------|----------------|----------------|
|              | 0-1                           | 0-2        | 0-3          | 0-4           | 0-5           | 0-10          | 0-20           | 0-30           | 0-40           | 0-50           |
| N            | 0                             | 0          | 0            | 0             | 0             | 11            | 299            | 1,283          | 9,070          | 10,440         |
| NNE          | 0                             | 0          | 0            | 8             | 29            | 299           | 1,308          | 2,757          | 3,689          | 5,911          |
| NE           | 0                             | 0          | 15           | 42            | 77            | 368           | 1,058          | 2,599          | 3,735          | 3,956          |
| ENE          | 0                             | 2          | 25           | 53            | 88            | 362           | 617            | 838            | 1,054          | 1,284          |
| E            | 34                            | 141        | 175          | 224           | 278           | 609           | 755            | 1,052          | 1,236          | 1,495          |
| ESE          | 16                            | 219        | 263          | 315           | 382           | 925           | 4,434          | 5,183          | 5,766          | 19,918         |
| SE           | 2                             | 304        | 1,598        | 3,081         | 3,161         | 6,210         | 68,027         | 69,967         | 70,514         | 71,213         |
| SSE          | 2                             | 35         | 1,181        | 7,120         | 10,505        | 21,767        | 35,002         | 35,109         | 37,507         | 39,542         |
| S            | 5                             | 10         | 19           | 1,584         | 5,987         | 11,594        | 12,555         | 14,280         | 33,651         | 34,741         |
| SSW          | 2                             | 7          | 16           | 326           | 1,318         | 2,208         | 2,901          | 3,010          | 4,868          | 6,878          |
| SW           | 2                             | 7          | 74           | 435           | 615           | 1,805         | 2,896          | 3,077          | 3,264          | 3,417          |
| WSW          | 2                             | 7          | 15           | 40            | 152           | 1,855         | 4,287          | 15,706         | 25,314         | 25,802         |
| W            | 1                             | 5          | 13           | 25            | 100           | 607           | 1,539          | 2,540          | 20,477         | 38,003         |
| WNW          | 0                             | 0          | 0            | 0             | 2             | 62            | 92             | 303            | 1,060          | 1,582          |
| NW           | 0                             | 0          | 0            | 0             | 0             | 0             | 0              | 163            | 1,099          | 1,778          |
| NNW          | 0                             | 0          | 0            | 0             | 0             | 0             | 30             | 401            | 1,517          | 3,983          |
| <b>TOTAL</b> | <b>66</b>                     | <b>737</b> | <b>3,394</b> | <b>13,253</b> | <b>22,694</b> | <b>48,682</b> | <b>135,800</b> | <b>158,268</b> | <b>223,821</b> | <b>269,943</b> |

a. 1.0 mile = 1.6 kilometers.

Source: U.S. Department of Commerce (DOC) Bureau of the Census, Economic and Statistics Administration, "Summary Tape File 3 on CDROM," 1990 Census of Population and Housing, May 1992 (Ref. 3).

Three major sectors have driven the economy in the Tri-Cities area since the early 1970s: the U.S. Department of Energy (DOE) and its operating contractors at the Hanford Site, the Washington Public Power Supply System in its construction and operation of nuclear power plants, and the agricultural community (Ref. 2).

Table 3.5 summarizes the employment sectors in Benton and Franklin Counties. In 1991, the Hanford Site was the dominant employer in the area, accounting for 24 percent of total nonagricultural employment in Benton and Franklin Counties and for an estimated 42 percent of the payroll dollars earned in the area. The Washington Public Power Supply System is also a major employer although in the Tri-Cities area construction activity ceased with completion of the WNP-2 reactor in 1983 (Ref. 2). In 1990, agricultural activities were responsible for nearly 12,900 jobs or 17 percent of the area's total employment (Ref. 2). There are three other components of the economic base in addition to the three major employment sectors: other major employers including SPC, tourism, and retirees. SPC employs 1,000 people or approximately 1.5 percent of the 68,174 people employed within the Tri-Cities area (Ref. 4).

**Table 3.5 Employment sectors, Benton and Franklin Counties, 1988**

| Basic  | Employment    | Payroll<br>(\$ million) |
|--|---------------|-------------------------|
| DOE and contractors (Hanford)                            | 16,100        | 653.0                   |
| Local procurement (direct employment)                    | 818           | 31.2                    |
| Washington Public Power Supply System<br>and Contractors | 1,700         | 80.4                    |
| Agriculture  | 12,900        | 221.8                   |
| Proprietors  | 2,200         | 121.0                   |
| Employees  | 7,600         | 42.0                    |
| Agri-Business  | 900           | 13.8                    |
| Food Processing  | 2,500         | 45.0                    |
| Other major employers                                    | 1,450         | 58.3                    |
| Tourism  | 1,900         | 15.0                    |
| Retirees   | 15,093        | 197.8                   |
| <b>Total Employment</b>                                  | <b>68,174</b> | <b>1,484.0</b>          |

Sources: U.S. DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement, June 1994 (Ref. 2) and Battelle, Pacific Northwest Laboratory, Hanford Site National Environmental Policy Act (NEPA) Characterization, September 1988 (Ref. 5).

### **3.4 Land Use**

Most developed land within a 16.1-kilometer (10-mile) radius of the site is used for agriculture, light industry, or residences. The undeveloped area directly north of the site is the DOE Hanford Site (Figure 3.1). The nearest neighbors to the SPC site are Allied Technology Group, Richland Corporation, about 0.6 kilometers (0.4 miles) to the southeast; the Thayer Wiser Farms which cultivate fields on the south and west sides of the site; the Richland Disposal Site and Horn Rapids ORV Park about 3 kilometers (2 miles) to the west; the Hanford Patrol Training Academy about 2.6 kilometers (1.6 miles) to the northwest; DOE laboratories and fuel fabrication facilities on Hanford in the 300 Area located about 2.9 kilometers (1.8 miles) to the northeast; and the Battelle Northwest Laboratories complex, which is about 2.9 kilometers (1.1 miles) east of the site. The nearest residential dwellings are about 3.4 kilometers (2.1 miles) to the southeast, the nearest highway (Washington State Highway 240) is about 3 kilometers (2 miles) to the southwest, and the nearest heavily traveled street (Stevens Drive) is about 1.4 kilometers (0.9 miles) to the east and paralleled by a DOE railroad line.

The City of Richland has developed a comprehensive plan for the area. A residential development, located adjacent to Highway 240 began development in 1994. This community will encompass 338 hectares (835 acres) with over 3,000 homes, a village center, school, golf course, parks, etc. In addition, the Kingsgate Parkway, a major road connecting Horn Rapids Road and Hanford Highway, is planned for construction in 1994. The plan proposes 10-20 percent of the Horn Rapids Triangle be developed for industry. Most of this industrial development will be south to southwest of the SPC site.

Approximately 28 hectares (70 acres) of land are being farmed for alfalfa and grain east-southeast of the facility and an additional field of about 26 hectares (65 acres) lies southeast of the plant. In addition, it is estimated that there are a few hundred head of cattle within 8 kilometers (5 miles) of the plant in Benton County. The closest herd of about 50 beef cattle are located about 4.8 kilometers (3 miles) southwest of the plant (Ref. 1). Property directly west, south and southwest of the plant is irrigated and is used to grow crops such as potatoes and alfalfa.

#### **3.4.1 Historic Significance**

Review of the *National Register of Historic Places* 1966-1991 indicates there are 28 registered historic sites within Benton and Franklin Counties as listed in Table 3.6. The first nuclear reactor (B reactor) constructed and operated at the Hanford Site was designated as a historic site of national significance in 1992. The Waniwasha Indian Cemetery located about 5.6 kilometers (3.5 miles) southwest of the SPC site (within the Horn Rapids Triangle) has been acquired for preservation by the Confederate Tribes of the Yakama Indian Nation.

**Table 3.6 National Register of Historic Places in Benton and Franklin Counties**

| County | City/Vicinity  | Property   | Status          |
|--------|--|--|-----------------|
| Benton | Kennewick/Spans Columbia River (also in Franklin County)                         | Pasco-Kennewick Bridge (Historic Bridges/Tunnels in Washington State TR) | (N.R. 7/16/82)  |
|        | Paterson Vicinity/2 miles <sup>a</sup> Southwest of Paterson on Telegraph Island | Telegraph Island Petroglyphs   | (N.R. 3/10/75)  |
|        | Prosser/Dudley Avenue and Market Street  | Benton County Courthouse   | (N.R. 12/12/76) |
|        | Prosser/Spans Yakima River   | Prosser Steel Bridge (Historic Bridges/Tunnels in Washington State TR)   | (N.R. 7/16/82)  |
|        | Prosser vicinity/Southeast of Prosser  | Glade Creek Site   | (N.R. 10/21/77) |
|        | Richland vicinity/18 miles north of Richland                                     | Hanford Island Archaeological Site                                       | (N.R. 8/28/76)  |
|        | Richland vicinity/22 miles north of Richland                                     | Hanford North Archaeological District                                    | (N.R. 8/28/76)  |
|        | Richland vicinity/about 25 miles north of Richland (also in Grant County)        | Locke Island Archeological District                                      | (N.R. 8/28/76)  |
|        | Richland vicinity/Northwest of Richland (also in Grant County)                   | Paris Archaeological Site  | (N.R. 9/20/78)  |
|        | Richland vicinity/25 miles north of Richland                                     | Rattlesnake Springs Sites  | (N.R. 5/4/76)   |
|        | Richland vicinity/In Hanford Works Reservation, along the Columbia River         | Ryegrass Archaeological District   | (N.R. 1/31/76)  |
|        | Richland vicinity/about 25 miles northwest of Richland                           | Snively Canyon Archaeological District                                   | (N.R. 8/28/76)  |
|        | Richland vicinity/7 miles north of Richland                                      | Wooden Island Archaeological District                                    | (N.R. 7/19/76)  |
|        | Prosser/Byron Road   | Carey, J.W., House   | (N.R. 12/7/89)  |

**Table 3.6 National Register of Historic Places in Benton and Franklin Counties (Continued)**

| County   | City/Vicinity  | Property   | Status          |
|----------|--|--|-----------------|
| Franklin | Lyons Ferry vicinity/1 mile north of Lyons Ferry on west side of Palouse River | Marmes Rockshelter   | (N.R. 10/15/66) |
|          | Pasco/1016 North 4th Street  | Franklin County Courthouse   | (N.R. 2/8/78)   |
|          | Pasco/Off U.S. 12  | Moore, James, House  | (N.R. 5/31/79)  |
|          | Pasco/305 North 4th Street   | Pasco Carnegie Library (Carnegie Libraries of Washington TR)             | (N.R. 8/3/82)   |
|          | Pasco/Spans Columbia River (also in Benton County)                             | Basco-Kennewick Bridge (Historic Bridges/Tunnels in Washington State TR) | (N.R. 7/16/82)  |
|          | Pasco/Northeast of Pasco   | Allen Rockshelter  | (N.R. 11/16/78) |
|          | Pasco/In Lower Snake River near its confluence with the Columbia River         | Strawberry Island Village Site, 45-FR-5                                  | (N.R. 8/21/80)  |
|          | Richland vicinity/15 miles north of Richland                                   | Savage Island Archaeological District                                    | (N.R. 8/28/76)  |
|          | Walker vicinity/North of Walker  | Burr Cave  | (N.R. 12/15/78) |
|          | Pasco vicinity   | Lower Snake River Archaeological District                                | (N.R. 10/29/84) |
|          | Starbuck vicinity  | Palouse Canyon Archaeological District                                   | (N.R. 10/29/84) |
|          | Richland vicinity  | Tri-Cities Archaeological District                                       | (N.R. 10/29/84) |
|          | Windust vicinity   | Windust Caves Archaeological District                                    | (N.R. 10/29/84) |

a. 1 mile = 1.6 kilometers.

Source: Siemens Power Corporation—Nuclear Division, "Supplement to Applicant's Environmental Report," EMF-14, Rev. 4, July 1994 (Ref. 1).

### 3.4.2 Floodplains and Wetlands

The SPC site is at an elevation of 114 meters (373 feet) above MSL between the Yakima and Columbia Rivers and is not located within a 100-year floodplain. The Columbia River has flooded in the past, but the construction of flood control/water storage dams upstream of the site has reduced the likelihood of large-scale flooding. The maximum historical flood on record for the Columbia River occurred June 7, 1894, with a peak discharge of 21,000 cubic meters per second (742,050 cubic feet per second) along the Hanford Site located north of the SPC site (Ref. 5). This flood did not affect the SPC site. There have been fewer than 20 major floods on the Yakima River since 1862 (Ref. 5). The greatest discharge on the Yakima River, as measured at Kiona, Washington, 16.1 kilometers (10 miles) southwest of the SPC site, was 1,900 cubic meters per second (67,138 cubic feet per second) in December 1933. The development of irrigation reservoirs within the Yakima River Basin has reduced its flood potential. The maximum probable flood from the Columbia River has been calculated to be 40,000 cubic meters per second (1,413,428 cubic feet per second) which would flood the SPC site to a depth of 2.1 meters (7 feet) (Ref. 5).

There are no wetlands at the SPC site.

## 3.5 Geology, Mineral Resources, and Seismicity

### 3.5.1 Geology and Soils

The SPC site is located on the southwestern margin of the Pasco Basin, the largest basin on the Columbia Plateau. Basalt flows more than 3,048 meters (10,000 feet) thick underlie the Pasco basin. Unconsolidated silts, sands, and gravels of the Ringold and Hanford Formations, totaling tens to hundreds of feet in thickness, overlie the basalts. The depth to basalt below the SPC site has not been determined. Well P-3 on the SPC site was drilled to a total depth of 22 meters (73.5 feet) below land surface, and it did not penetrate the basalt (Figure 3.3). The basalt flows and some of the overlying materials in the Pasco basin are gently deformed into very broad folds that dip toward the basin center. Several east-west trending linear zones of discontinuous folds and small faults marked by ridges and chains of buttes are present within the basin (see Figure 3.4).

The shallow stratigraphy at the SPC site has been characterized from borehole data collected as part of the groundwater monitoring program. The site is underlain by poorly and well-graded sands and gravels of the Pasco Gravels in the Hanford formation (informal) and the Ringold Formation. Figure 3.3 shows the formations that were encountered during drilling of the wells. The base of the sequence consists of sands and gravels in the Ringold Formation overlain by a 9- to 11-meter (30- to 35-foot) section of silt with interbedded sandy layers ("silt aquitard"). The aquitard lies within the upper portions of the Ringold Formation and separates the unconfined aquifer from the underlying confined aquifer. The Pasco Gravels,



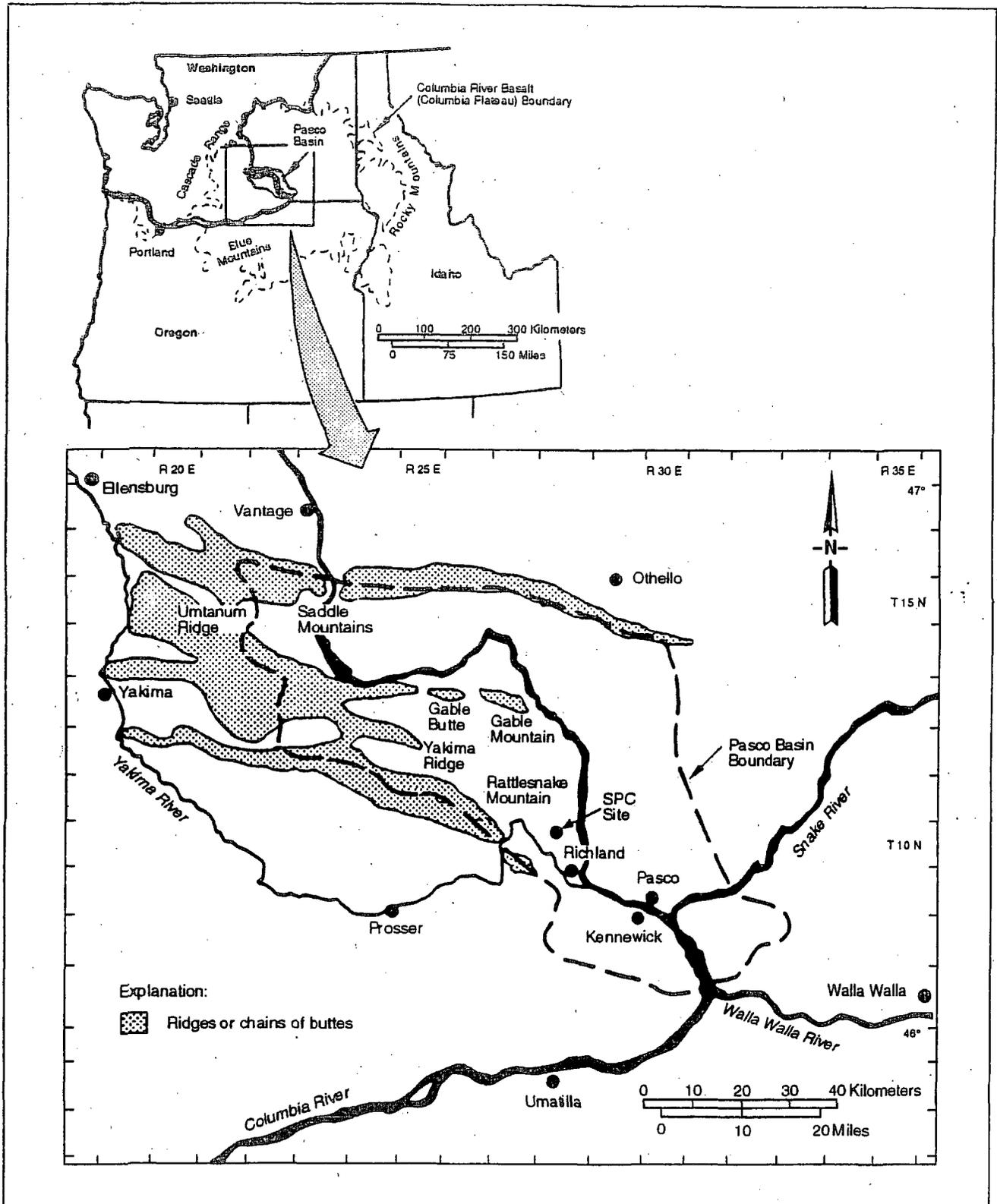


Figure 3.4 SPC site and environs (modified from Ref. 5)

characterized by their basalt content, overly the Ringold Formation and vary from 7.6 to 9 meters (25 to 30 feet) in thickness at the SPC site.

Suspected fill materials were encountered during the drilling of some boreholes (see Boreholes GM-3, GM-14, and GM-15 on Figure 3.3). The fill material was composed of sands and gravels similar to the surrounding native soils and reached a maximum depth of approximately 6 to 7.3 meters (20 to 24 feet) below land surface in Borehole GM-3, extending below the water table. The fill may have been placed during the installation of the nearby underground storage tanks in 1970.

### **3.5.2 Mineral Resources**

The Ringold and Hanford formations are good sources of sand and gravel for the construction industry. Two sand and gravel pits on the Hanford Site are located within 3 kilometers (2 miles) of the SPC site. The Horn Rapids landfill, located immediately north and across the street from the SPC site (see Figure 3.1), was originally a sand and gravel pit.

### **3.5.3 Seismicity**

The distribution and intensity of historical earthquakes indicate that the Columbia Plateau is an area of moderate seismicity (Figure 3.5). Seismic activity above magnitude 3.0 on the Richter scale has occurred in this region, but activity above magnitude 3.5 is most commonly found around the northern and western portions of the Columbia Plateau, with a few events occurring along the border between Washington and Oregon (Ref. 6). It has been estimated that the maximum historical earthquake at the SPC site was approximately a Modified Mercalli V, producing a maximum horizontal ground acceleration of 0.02 g.

Swarms of small, shallow earthquakes are the predominant seismic events of the Columbia Plateau (Ref. 6). Earthquake swarms, as detected by a regional seismograph network, may contain from 4 to more than 100 earthquakes of magnitude 1.0 to 3.5 (Ref. 6). Shallow earthquake swarm activity in the central Columbia Plateau is concentrated principally north and east of the SPC site where earthquake magnitudes greater than 3.0 can occur. The swarm event of perhaps the largest magnitude was recorded instrumentally on December 20, 1973, as a magnitude 4.4 earthquake located in the Royal Slope area, north of the SPC site (Ref. 6).

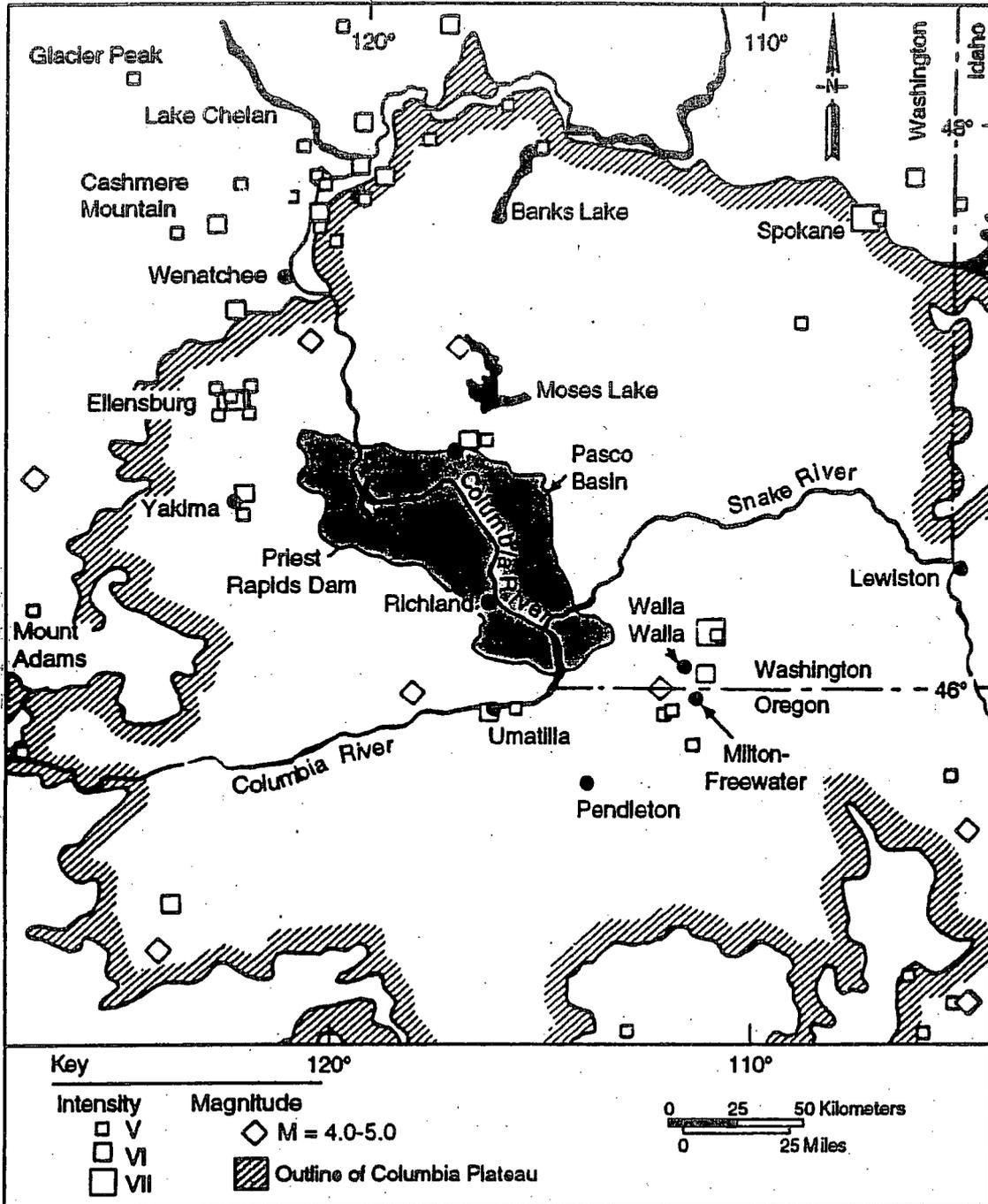


Figure 3.5 Historical seismicity of the Columbia Plateau. All earthquakes between 1850 and 1969 with modified Mercalli intensity equal to or greater than V are shown (modified from Ref. 5)

Deeper earthquakes (to a depth of 28 kilometers [17 miles]) occur in the central Columbia Plateau, although at much lower frequencies than the shallower swarm events. Deep seismic activity generally occurs randomly and is not associated with known geologic structures or with patterns of shallow seismicity (Ref. 6).

### 3.6 Hydrology

#### 3.6.1 Surface Water

Primary surface water features associated with the SPC site are the Columbia and Yakima rivers. The confluence of the Yakima and Columbia Rivers is located about 5 kilometers (3 miles) south of Richland and about 8 kilometers (5 miles) south of the SPC site. Flow on both rivers is regulated by dams to control flooding as described in Section 3.4. The Horn Rapids Dam is located on the Yakima River about 13 kilometers (8 miles) west of the facility, and the Priest Rapids Dam is the nearest upstream dam on the Columbia River located about 80 kilometers (50 miles) northwest of the SPC site (see Figure 3.5).

The Yakima River, bordering the southern portion of the Horn Rapids Triangle, has a lower annual flow than the Columbia River. For a recorded period of 57 years, the average annual flow of the Yakima River is about 104 cubic meters per second (3,675 cubic feet per second) with monthly maximum and minimum flows of 490 cubic meters per second (17,314 cubic feet per second) and 4.6 cubic meters per second (163 cubic feet per second), respectively. Recorded flow rates of the Columbia River have ranged from 4,500 to 18,000 cubic meters per second (159,011 to 636,043 cubic feet per second) during the runoff in spring and early summer, to 1,000 to 4,500 cubic meters per second (35,336 to 159,011 cubic feet per second) during the low flow period of late summer and winter (Ref. 5). The average annual Columbia River flow in the Hanford reach, based on 65 years of record, is about 3,400 cubic meters per second (120,141 cubic feet per second) (Ref. 6). The normal river elevation on the Columbia River near the Hanford 300 Area site, approximately 3 kilometers (2 miles) northeast of the SPC site, is approximately 104 meters (341 feet) which is 9 meters (30 feet) below the site elevation.

The Columbia River in the vicinity of the site is classified as Class A (excellent) which requires that industrial uses of this water be compatible with other uses including drinking water, wildlife, and recreation (Ref. 5). The water is used for irrigation, power generation, municipal water supplies, transportation, fishing and water sports. The primary source for water in Richland and at the SPC site is from the Columbia River. The City of Richland water system has a water storage capacity of 90 million liters (23.81 million gallons) in 10 reservoirs (Ref. 1). Six well fields are also tied into the water supply system.

Routine releases and monitoring of treated process fluids, sanitary wastewater and non-contaminated cooling water to the municipal sewer system are discussed in

Section 2.1.2. There is no storm water runoff from the facility to water bodies, rivers, streams or the municipal sewer system. Surface runoff from the plant is very limited because of the desert environment and surface runoff percolates into the soil.

### 3.6.2 Groundwater

There are three distinct aquifer systems that underlie the SPC site (see Figure 3.6). The deepest aquifer consists of highly productive water-bearing zones within thick basalt flows. A confined aquifer occurs in silt, gravel, and sand layers in the lower portion of the Ringold Formation which overlies the basalt. An unconfined aquifer system, consisting of the sands and gravels in the Hanford Formation and in the upper portion of the Ringold Formation, is the shallowest aquifer and the one that is monitored at the SPC site.

The water table in the unconfined aquifer occurs at depths ranging from 3 to 11 meters (10 to 35 feet) below ground surface and slopes at a gradient of approximately  $9.0 \times 10^{-6}$  to 0.0015 meters per meter ( $3.0 \times 10^{-5}$  to 0.005 feet) per foot to the northeast (see Figure 3.7). Recharge to the unconfined aquifer at the SPC site is from the Yakima River. The recharge volume from the Yakima River is 10 to 40 times more than that from infiltrating precipitation (Ref. 7).

Groundwater contamination at the site has resulted from lagoon leakage before the lagoon liner system described in Section 4.2.4 was installed. Above background concentrations of gross alpha and gross beta radioactivity and hazardous constituents have been detected. The nature and extent of contamination at the site has been characterized through a remedial investigation and feasibility study initiated by SPC in October 1991 as an independent action under the State of Washington Model Toxics Control Act (MTCA). The MTCA is implemented as part of the facility permitting under the Resource Conservation and Recovery Act and the Washington State Dangerous Waste Management Act. Wells GM-1 and GM-2 are located up-gradient and cross-gradient, respectively, from the lagoons and provide background water quality relative to the lagoons. The water quality downgradient of the lagoons is monitored by wells GM-5, GM-6, GM-7, GM-8, and GM-16 as shown on Figure 3.7. These seven wells are analyzed quarterly for the following parameters: alkalinity, ammonia, aluminum, calcium, chloride, fluoride, gross alpha, gross beta, nitrate, phosphate, sodium, sulfate, tributyl phosphate, trichloroethene (TCE), and zirconium. Groundwater monitoring required by NRC is described in Section 4.2.3 together with the monitoring results from the NRC-licensed network over the 5-year reporting period.

The Washington State Department of Ecology (WDOE) has determined that no corrective action is required for TCE, nitrate or fluoride in groundwater (Ref. 8). An environmental risk assessment is being conducted by WDOE to determine if corrective action is required for gross alpha and gross beta in groundwater.

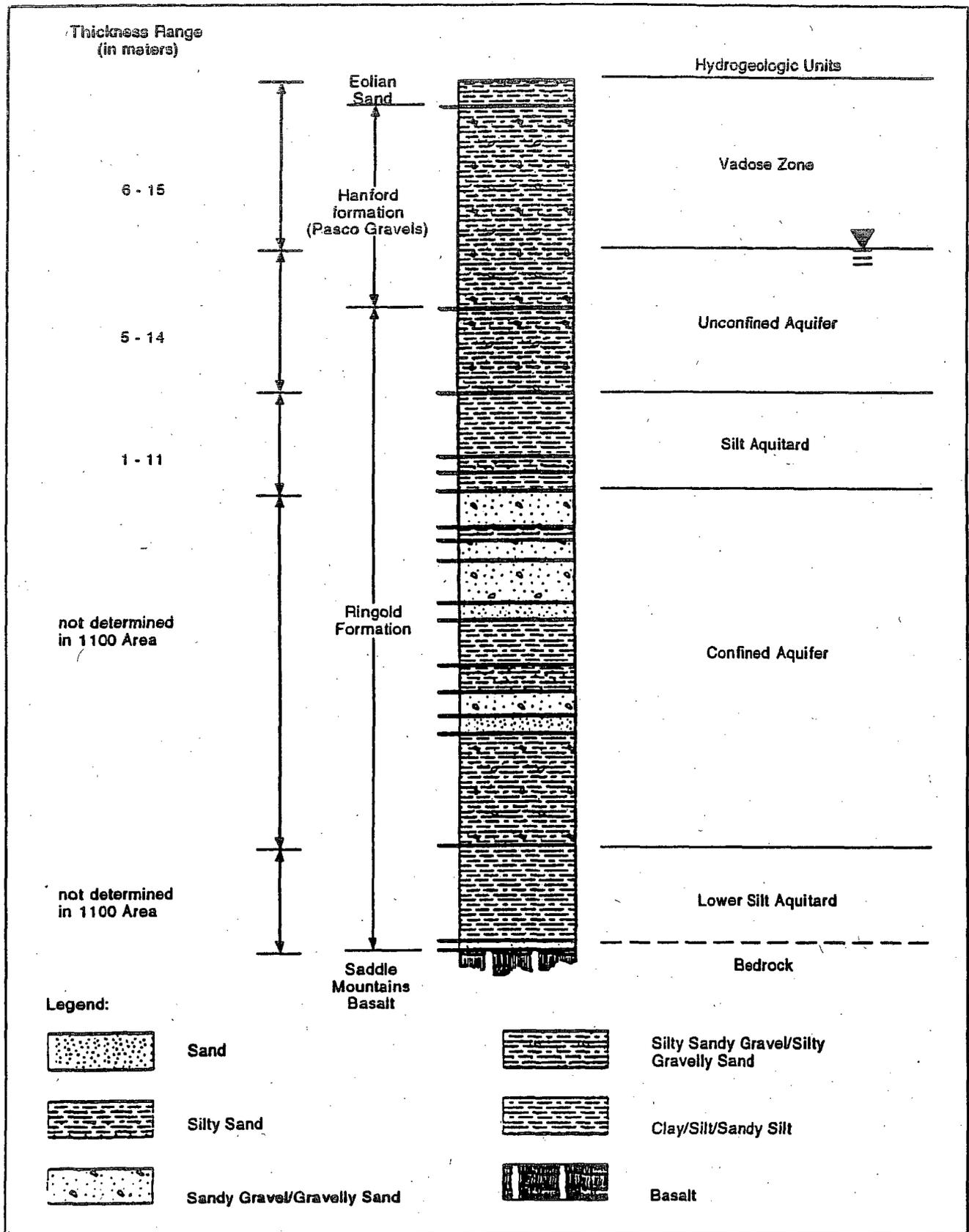


Figure 3.6 Generalized hydrostratigraphic column for the DOE 1100 area in the vicinity of the SPC site (modified from Ref. 7)

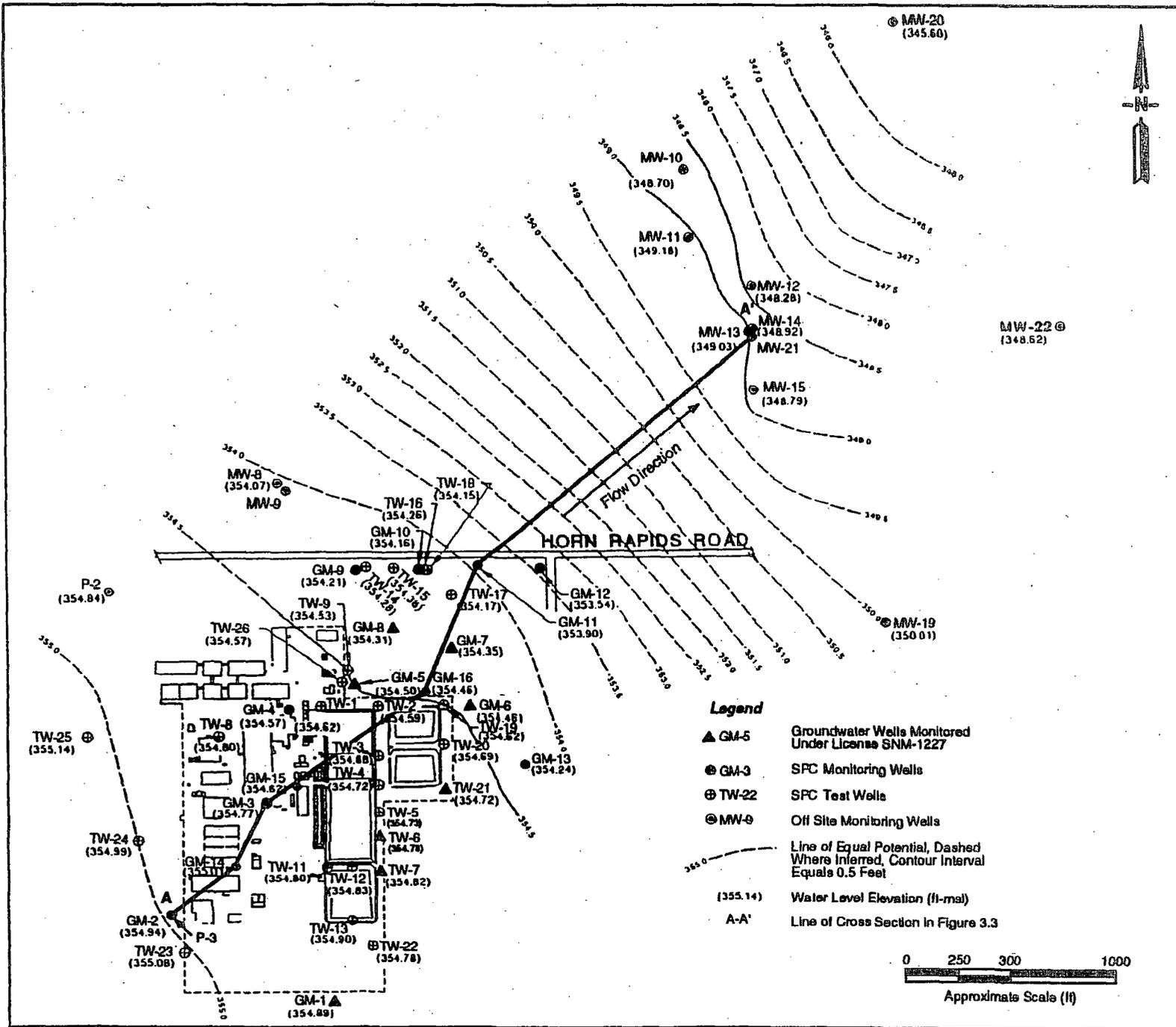


Figure 3.7 Water table contour - June 1993 (modified from Ref. 8)

The unconfined aquifer is used to supplement and for the treatment of Columbia River water. For example, Columbia River water is pumped to the North Richland well field, located about 0.9 kilometers (1.5 miles) southeast of the SPC site, and percolates through the soil creating a groundwater mound. The water is extracted by wells from the mounded area as needed to supplement the water supply from the water treatment plant. This process reduces turbidity and improves water quality. In 1988 and 1989, the monthly totals for recharge ranged from about 76,000 to 1,520,000 kiloliters (20,000,000 to 400,000,000 gallons) (Ref. 7).

### 3.7 Biota

#### 3.7.1 Terrestrial Resources

The SPC site is located on a relatively flat, desert steppe made up of a variety of plant communities. Native vegetation in the area is predominantly sagebrush (*Artemisia tridentata*) and antelope bitterbrush (*Purshia tridentata*) communities.

Cheatgrass (*Bromus tectorum*), brome, and Sandberg's bluegrass (*Poa sandbergii*), are found in the understory. The local vegetation has been disturbed over the years from homesteading, fire, and grazing, leaving areas exposed to wind erosion and dune formation. As a result, Russian thistle (*Salsola kali*), mustard (*Sisymbrium altissimum*), and rabbitbrush (*Crysothamplus nauseous*) have encroached on the native vegetation.

Pocket mice (*Perognathus parvis*) and deermice (*Peromyscus maniculatus*) are common in the site vicinity. Jackrabbits (*Lepus californicos*) and coyotes (*Canis latrans*) are also relatively common. Mule deer (*Odocoileus hemionus*) forage upon cheatgrass shoots and on leaves and twigs of bitterbrush.

Amphibian species are relatively rare at the SPC site because of their moisture requirements. Reptiles are more abundant than amphibians since they are physiologically adapted to the semiarid desert environment. The most abundant reptile in the vicinity of the site is the side-blotched lizard (*Uta stansburiana*). Gopher snakes (*Pituophis melanoleucus*) and the Pacific rattlesnake (*Croalus irridus*) are occasionally observed.

Birds are not abundant in this environment. Resident birds include meadowlarks (*Sturnella neglecta*) and horned larks (*Eremophila alpestris*). The loggerhead shrike (*Lanius ludovicianus*), game birds such as the chukar partridge (*Alectoris chukar*), quail (*Callipepla californica*), ringed-neck pheasant (*Phasianus colchicus*), and the mourning dove (*Zenaida macroura*) can also be found. The area is used for seasonal hunting by birds of prey including: the marsh hawk (*Circus cyanius*), the golden eagle (*Aquila chrysaetos*), Swainson's hawk (*Buteo swainsoni*) and the burrowing owl (*Athene cunicularia*). There are occasional sitings of the bald eagle (*Haliaeetus leucocephalus*). Canadian geese (*Branta canadensis moffitti*) can be seen foraging on local vegetation during migration.

Waterfowl are prevalent on the Columbia River. Pairs of Canadian geese reside on the Columbia River islands and produce roughly 700 goslings annually. Approximately 6000 nesting pairs of California (*Larus californicus*) and ring-billed (*Larus delawarensis*) gulls produce 10,000 to 20,000 young annually.

### 3.7.2 Aquatic

There are no naturally occurring surface-water bodies at the SPC site that support aquatic species. The Columbia River supports a diverse community of plankton, benthic invertebrates, fish, and other communities.

Diatoms, golden or yellow-brown algae, green algae, blue-green algae, red algae, and dinoflagellates are the dominant phytoplankton species. Macrophytes and zooplankton are sparse in the Columbia River because of the strong currents, rocky bottom, and frequently fluctuating water levels. Benthic organisms are found either attached to or closely associated with the substrate. All major freshwater benthic species are represented in the Columbia River, including insect larvae, limpets, snails, sponges, and crayfish (Ref. 5).

Forty-four species of fish have been identified in the Columbia River in the site vicinity. Of these, the chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. Shad may also spawn in the Hanford reach of the river. Other fish of importance to sport fishermen are the whitefish, sturgeon, smallmouth bass, crappie, catfish, walleye, and perch. Large populations of rough fish including carp, shiners, suckers, and squawfish are also present.

### 3.7.3 Threatened and Endangered Species

There are no threatened and endangered species known to occur on the SPC site.

Threatened and endangered plants and animals known to occur in the vicinity of the SPC site, as listed by both the federal government and the State of Washington, are shown in Table 3.7. The bald eagle and the peregrine falcon are the only species known to be on the Federal list of Threatened and Endangered Species.

Table 3.7 Federally- and State-listed threatened and endangered species located near the SPC site

| Common Name                     | Scientific Name  | Federal | State |
|---------------------------------|--|---------|-------|
| Bald eagle                      | <i>Haliaeetus leucocephalus</i>                                  | T & E   | T     |
| Peregrine falcon                | <i>Falco peregrinus</i>  | T & E   | T & E |
| Aleutian Canada goose           | <i>Branta canadensis leucopareia</i>                             | T       | E     |
| White pelican                   | <i>Pelecanus erythrorhychos</i>                                  | NL      | E     |
| Sandhill crane                  | <i>Grus canadensis</i>   | NL      | E     |
| Ferruginous hawk                | <i>Buteau regalis</i>  | NL      | T     |
| Pygmy rabbit                    | <i>Brachylagus idahoensis</i>                                    | NL      | E     |
| Columbia milk-vetch             | <i>Astragalus columbianus</i>                                    | NL      | T     |
| Columbia yellowcress            | <i>Rorippa columbiae</i>   | NL      | E     |
| Dwarf evening (desert) primrose | <i>Oenothera pygmaea</i>   | NL      | T     |
| Hoover's desert parsley         | <i>Lomatium tuberosum</i>  | NL      | T     |
| Northern wormwood               | <i>Atermisia campestris borealis</i><br><i>var. wormskialdii</i> | NL      | E     |

T = Threatened  
E = Endangered  
NL = Not Listed

Source: Battelle, Pacific Northwest Laboratory, "Hanford Site Environmental Report for Calendar Year 1993," June 1994 (Ref. 9).

### 3.8 Background Radiological Characteristics

#### 3.8.1 External Radiation

External background radiation in the vicinity of the SPC site averages about 80-90 millirem per year (Ref. 9). Natural radiation sources of cosmic and terrestrial origin each account for approximately half of the total. The natural background radiation at a given location can vary substantially from year to year because of variations of up to 10 percent in the annual cosmic radiation and 15 to 25 percent in terrestrial radiation (Ref. 10). Variations in the measured external background radiation from one monitoring location to another are largely attributable to differences in the terrestrial component. These differences are the result of natural variations in the concentrations of potassium-40 (K-40) and thorium isotopes in the underlying soil and rock (Ref. 11). A small but undetermined fraction of the external background may be from past and current operations on the DOE Hanford Site adjacent to the SPC property.

### 3.8.2 Internal Radiation

Additional background radiation dose to people living in the vicinity of the SPC site results from naturally-occurring radionuclides that are taken into the body. Inhalation of radon progeny accounts for the majority of this internal dose, approximately 200 millirem (effective dose equivalent) to the average U.S. resident. Approximately 40 millirem per year results from other internal emitters, primarily K-40, with cosmogenic radionuclides contributing about 1 millirem per year (Ref. 10).

### **3.9 References for Section 3**

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5. C.E. Cushing, Editor, "Hanford Site National Environmental Policy Act (NEPA) Characterization," Battelle, Pacific Northwest Laboratory, Prepared for the U.S. Department of Energy, Document No. PNL-6415 Rev. 1, September 1988.
6. U.S. Department of Energy, "Draft Environmental Assessment, Reference Repository Location, Hanford Site, Washington," DOE/RW-0070, 1986.
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9. Dirkes, R.L., R.W. Hanf, and R.K. Woodruff, eds., "Hanford Site Environmental Report for Calendar Year 1993," Battelle, Pacific Northwest Laboratory, PNL-9823, Richland, Washington, June 1994.
10. National Council on Radiation Protection and Measurements, "Ionizing Radiation Exposure of the Population of the United States," NCRP Report No. 93, Bethesda, Maryland, 1987.
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## **4. EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAMS**

Monitoring programs at the Siemens Power Corporation (SPC) facility comprise effluent monitoring of air and water and environmental monitoring of various media (air, soil, vegetation, and groundwater). This program provides a basis for evaluation of public health and safety impacts, for establishing compliance with environmental regulations, and for development of mitigation measures if necessary. Monitoring activities are described in more detail in the following subsections. Waste management and effluent controls are described in subsection 2.1.2.

### **4.1 Effluent Monitoring Program**

The SPC facility produces gaseous, liquid, and solid effluent streams. Each of these effluent streams is monitored at or just prior to the point of release. SPC has a set of action levels for both gaseous and liquid effluent streams. Results from the radiological effluent monitoring program are reviewed quarterly by the plant's as low as is reasonably achievable (ALARA) Committee and reported annually to the Siemens Health and Safety Council to determine trends in effluent releases; to determine if effluent controls are being properly used, maintained, and inspected; and to determine if effluents could be reduced using the ALARA concept (Ref. 1). Results from the monitoring program are also reported in the semiannual effluent reports submitted to the Nuclear Regulatory Commission (NRC).

#### **4.1.1 Gaseous Release Monitoring**

Gaseous effluents released from the SPC facility contain both radiological and nonradiological constituents as described in Section 2.1.1. Stack monitoring is the primary method used to measure gaseous effluents containing uranium. Eighteen stacks (see Figure 1.2) are used for release of radiologically-contaminated streams. These release points are sampled continuously at isokinetic flow conditions, and the samples are analyzed weekly for radioactive content (Ref. 1). Seven of the 18 stacks are also sampled for fluoride and oxides of nitrogen. The parameters monitored in the gaseous effluent and the frequency of sampling for each stack are shown in Table 4.1.

Samples of gaseous effluents potentially containing uranium are analyzed for gross alpha activity. Action levels for gaseous uranium emissions (measured as alpha emissions) are applied to individual stack concentrations and to the combined gaseous effluents. Action levels for both individual stack concentrations and total effluents are summarized in Table 4.2. SPC uses a computer model to calculate alpha radioactivity from individual stack concentrations at the site boundary (Ref. 1). For an individual stack, if the calculated alpha emissions at the site boundary exceeds a concentration of  $5 \times 10^{-15}$   $\mu\text{Ci/mL}$  in a weekly sample, then

**Table 4.1 Exhaust air monitoring and sampling frequency**

| Stack No. <sup>a</sup> | Description/ Location         | Average Exhaust | Radioactivity (U) | Fluoride (F)     | Oxides of Nitrogen (NO <sub>x</sub> ) |
|------------------------|-------------------------------|-----------------|-------------------|------------------|---------------------------------------|
|                        |                               | Flow Rate       |                   |                  |                                       |
| K-3                    | Room 100                      | W <sup>b</sup>  | C <sup>c</sup>    | C,S <sup>d</sup> | — <sup>e</sup>                        |
| K-6                    | NAF                           | W               | C                 | —                | —                                     |
| K-9                    | Etch                          | W               | C                 | C,S              | —                                     |
| K-10                   | Line 1 POG                    | W               | C                 | C,S              | M <sup>f</sup>                        |
| K-21                   | Room 182                      | W               | C                 | —                | —                                     |
| K-25                   | ELO                           | W               | C                 | —                | —                                     |
| K-31                   | Line 2                        | W               | C                 | C,S              | —                                     |
| K-32                   | Line 2 POG                    | W               | C                 | C,S              | M                                     |
| K-37                   | U <sub>3</sub> O <sub>8</sub> | W               | C                 | —                | —                                     |
| K-42                   | Laundry                       | W               | C                 | —                | —                                     |
| K-46                   | ELO Addition                  | W               | C                 | —                | M                                     |
| K-47                   | ARF                           | W               | C                 | —                | —                                     |
| K-49                   | SWUR Room                     | W               | C                 | —                | —                                     |
| K-50                   | SWUR POG                      | W               | C                 | —                | —                                     |
| K-52                   | Building #9                   | W               | C Gross beta only | —                | —                                     |
| K-55                   | SWUR Shroud                   | W               | C                 | —                | —                                     |
| K-56                   | GSUR                          | W               | C                 | —                | M                                     |
| K-58                   | UO <sub>2</sub> Lab           | W               | C                 | —                | —                                     |

a. Refer to Figure 1.2 for stack locations.

b. W = may be recorded more often, but results are averaged weekly.

c. C = continuous isokinetic sampling.

d. S = total fluoride determined semiannually.

e. — = not sampled.

f. M = monthly.

Source: Siemens Power Corporation—Nuclear Division, "Siemens Supplement to Applicant's Environmental Report," EMF-14, Rev. 4, July 1994 (Ref. 2).

**Table 4.2 Action levels for gaseous effluents**

| Action Levels Based on Calculated Weekly Site Boundary Concentrations ( $\mu\text{Ci/mL}$ -alpha radioactivity) <sup>a,b</sup> | Required Actions <sup>c</sup>  |
|--|--|
| $> 5 \times 10^{-15}$  | Recount sample(s); check operations for possible source if activity is confirmed. Increase sampling frequency to daily until the concentration falls below the action level of 7 consecutive days; check pressure drop across all exhaust high efficiency particulate air (HEPA) filters; reevaluate all relative exhaust sampler results; check for proper seating of related HEPA filters. |
| $> 2 \times 10^{-14}$  | Update summation of quantity of radioactive material released via gaseous effluents on a weekly basis until a discharge concentration below this action level is sustained for a full calendar quarter.  |
| $> 5 \times 10^{-13}$  | Evaluate shutting down associated intake fans and reduce exhaust flow rates; prepare to shut down associated processes; inspect all related HEPA filters and replace all that exhibit any indication of inadequacy; if final HEPA filters exhibit any deficiencies, replace them and DOP (in-place) test the final filter bank.  |
| $> 1 \times 10^{-9}$   | Initiate orderly shutdown associated processes for repair or correction of substandard conditions. Initiate environmental air sampling in downwind sector(s).  |
| $> 1 \times 10^{-9}$   | Shut down associated processes and heating, ventilation, and air conditioning systems immediately; notify NRC Region V, in accordance with 10 CFR 20.2202.   |
| Action Levels Based on Summation of Weekly Monitoring Results ( $\mu\text{Ci}$ -alpha radioactivity) <sup>a</sup>              | Required Actions <sup>c</sup>  |
| $> 25$ per calendar quarter  | Evaluate all gaseous effluent sampling data for the previous quarter to identify potential problems; investigate identified sources of elevated concentrations of radioactive material in gaseous effluents as described above.  |
| $> 50$ per calendar quarter  | Update summation of quantity of radioactive material released via gaseous effluents on a weekly basis until a weekly discharge rate of less than or equal to $1 \mu\text{Ci}$ has been sustained for a full calendar quarter.  |
| $> 50$ per calendar quarter  | Submit report to NRC within 30 days identifying cause, along with corrective actions taken, to reduce release rate; prepare to petition the NRC for a variance in accordance with the conditions of 40 CFR 190.11.   |

- a. Concentration at site boundary calculated using "TSCREEN—A Model for Screening Toxic Air Pollutant Concentrations," Ver. 1.0 (Ref. 2).
- b. If it can be determined that the concentrations are at least 99 percent due to transportable compounds, the action levels are increased by a factor of 60.
- c. Actions required at any one action level include all actions that would have been undertaken at lower action levels.

Source: Siemens Power Corporation—Nuclear Division; Application for Renewal of Special Material License No. SNM-1227 (NRC Docket No. 70-1257), August 1992 (Ref. 1).

the sample is recounted and successive daily samples are analyzed until the calculated boundary concentration falls below the action level for seven consecutive days. If boundary concentrations for an individual stack exceed the higher action levels shown in Table 4.2, processing at the plant may be shut down.

If the calculated radioactivity for the combined gaseous effluents exceeds 25  $\mu\text{Ci}$  per calendar quarter at the site boundary, then data from the previous sampling quarter are reviewed to identify potential problems and discharges are monitored on a weekly basis until an activity of less than or equal to 1  $\mu\text{Ci}$  has been sustained for a calendar quarter. For the combined gaseous effluents, if the calculated radioactivity in the total gaseous effluents at the site boundary exceeds 50  $\mu\text{Ci}$  per calendar quarter, then SPC must submit a written report to NRC within 30 days identifying the cause for exceeding the limit and the corrective actions to be taken to reduce the radioactivity release rates (Ref. 1).

The cumulative discharge of gaseous uranium (as gross alpha) and fluoride effluent by stack are summarized in Table 4.3. Review of the tabulated annual values indicates that there have been no exceedances of the 25  $\mu\text{Ci}$  action level over any year—and therefore over any calendar quarter—during the 5 years of operation from 1989 to 1993. Off-site environmental air monitoring is also conducted to demonstrate compliance with applicable environmental air quality standards as described in Section 4.2.1.

Table 4.3 Summary of annual gaseous effluent data from the SPC facility<sup>a</sup>

| Year | U <sup>b</sup><br>( $\mu\text{Ci}$ ) | FP <sup>c</sup><br>( $\mu\text{Ci}$ ) | Maximum Fluoride <sup>d</sup> (ppm) |             |              |              |              |
|------|--------------------------------------|---------------------------------------|-------------------------------------|-------------|--------------|--------------|--------------|
|      |                                      |                                       | Stack<br>K3                         | Stack<br>K9 | Stack<br>K10 | Stack<br>K31 | Stack<br>K32 |
| 1989 | <15                                  | <4.2                                  | 0.006                               | 0.10        | 0.24         | 0.04         | 0.43         |
| 1990 | <17                                  | <0.9                                  | 0.01                                | 0.10        | 0.47         | 0.009        | 0.51         |
| 1991 | <17                                  | <1.7                                  | 0.005                               | 0.11        | 0.47         | 0.008        | 0.04         |
| 1992 | <22                                  | <1.5                                  | 0.008                               | 0.07        | 0.13         | 0.009        | 0.02         |
| 1993 | <10                                  | <0.9                                  | 0.006                               | 0.11        | 0.12         | 0.006        | 0.02         |

- a. See Figure 1.2 for stack locations.
- b. Cumulative discharges from 17 stacks assuming that all the gross alpha activity is from uranium.
- c. FP refers to fission products and activation products that pertain only to stack K-52 which is regulated by the Washington State Department of Health.
- d. Only stacks K3, K9, K10, K31, and K32 are monitored for fluoride.

Source: Siemens Power Corporation—Nuclear Division, "Siemens Supplement to Applicant's Environmental Report, EMF-14," Rev. 4, July 1994 (Ref. 2).

As shown in Table 4.3, uranium emissions have averaged approximately 16  $\mu\text{Ci}$  per year over the last 5 years. Uranium emissions directly attributable to the "wet" conversion processing step have averaged less than 1  $\mu\text{Ci}$  per year (see Table 2.2) over the same period. After commencement of the "dry" conversion process, SPC estimates that uranium emissions associated with the conversion step will be 0.8  $\mu\text{Ci}$  per year when operating at maximum capacity (Ref. 3). Emissions of HF are expected to increase but remain well below release rates which could produce measurable off-site impacts.

#### 4.1.2 Liquid Release Monitoring

The site has no storm drains that lead to the sewer or public waterway. Liquid wastes generated at the SPC facility include sanitary wastes, process cooling wastewater, and process chemical/radioactive wastes. Sanitary wastes are discharged directly to the sanitary sewer system (Ref. 2). Process chemical/radioactive wastes are routed to the on-site lagoon system for treatment before entering the sewer system. Process cooling wastewater may be either first routed to the lagoon system or discharged directly to the sanitary sewer. (Leak detection monitoring of the lagoons is addressed in Section 4.2.4). Released liquid wastes are combined and discharged to the SPC-City lift station where the total combined liquid effluent from the SPC facility is pumped to the Richland Municipal Sewerage System.

The combined liquid effluent is continuously sampled at the SPC effluent station, which is controlled by a State of Washington Liquid Waste Discharge Permit. A composited sample is collected weekly and analyzed for total suspended solids and uranium (Ref. 1). The action level to initiate an investigation is  $1.6 \times 10^{-7}$   $\mu\text{Ci}/\text{mL}$  (0.1 ppm) uranium (Refs. 1 and 2). The action level requiring shutdown is  $1.6 \times 10^{-6}$   $\mu\text{Ci}/\text{mL}$  (1.0 ppm). Data from the semiannual effluent monitoring reports are summarized in Table 4.4. Review of this data indicates that uranium concentrations in liquid effluent are typically at the lower limit of detection.

The composited samples from the SPC effluent station are also monitored for ammonia, nitrate, suspended solids, fluoride, and pH in accordance with the State discharge permit. Table 4.5 summarizes the State discharge permit requirements and the monitoring results for the past five years (1989-1993). A review of the chemical discharges shows a general increase in nitrate and fluoride from 1989 to 1993. These increases are associated with the controlled release of low uranium liquids from the lagoon system (Ref. 3).

**Table 4.4 Semiannual average uranium concentrations and the lower limit of detection in liquid effluent from the SPC facility**

| Period              | Range of Uranium Concentrations ( $\mu\text{Ci/mL}$ ) <sup>a</sup> | Lower Limit of Detection ( $\mu\text{Ci/mL}$ ) |
|---------------------|--|--|
| 1/1/89 to 6/30/89   | $<1.7 \times 10^{-7}$  | $1.7 \times 10^{-7}$                           |
| 7/1/89 to 12/31/89  | $<1.7 \times 10^{-7}$  | $1.7 \times 10^{-7}$                           |
| 1/1/90 to 6/30/90   | $<1.7 \times 10^{-7}$  | $1.7 \times 10^{-7}$                           |
| 7/1/90 to 12/27/90  | $<2.2 \times 10^{-7}$  | $1.8 \times 10^{-7}$                           |
| 12/27/90 to 6/27/91 | $<1.9 \times 10^{-7}$  | $1.6 \times 10^{-7}$                           |
| 7/1/91 to 1/1/92    | $<2.2 \times 10^{-7}$  | $1.6 \times 10^{-7}$                           |
| 1/1/92 to 7/1/92    | $<1.9 \times 10^{-7}$  | $1.6 \times 10^{-7}$                           |
| 7/1/92 to 1/1/93    | $<2.2 \times 10^{-7}$  | $1.7 \times 10^{-7}$                           |
| 1/1/93 to 7/1/93    | $<1.7 \times 10^{-7}$  | $1.4 \times 10^{-7}$                           |
| 7/1/93 to 1/1/94    | $<1.4 \times 10^{-7}$  | $1.6 \times 10^{-7}$                           |

a. Investigation level for uranium in liquid effluent =  $1.6 \times 10^{-7} \mu\text{Ci/mL}$ . Action level for uranium in liquid effluent =  $1.6 \times 10^{-6} \mu\text{Ci/mL}$ .

Source: Advanced Nuclear Fuels Corporation (currently Siemens Power Corporation), Semiannual "Required Reporting of Effluents per 10 CFR 70.59," submitted to U.S. Nuclear Regulatory Commission, 1989-1993 (Ref. 4).

Since 1989, there have been seven excursions from the State discharge permit limit as shown in Table 4.5. These exceedances were reported to the Washington State Department of Ecology and NRC. Four pH excursions above the City of Richland pretreatment ordinance limits were also reported.

Current operations generate an estimated 26,063,510 liters (6,886,000 gallons) and 37,850 liters (10,000 gallons) per year of wastewater from the wet and dry conversion processes, respectively. After the dry conversion process is fully implemented, SPC estimates that wastewater from the wet conversion process will decrease approximately 93 percent to 1,862,220 liters (492,000 gallons) per year, and wastewater from the dry conversion process will increase 20-fold to 757,000 liters (200,000 gallons) per year (Ref. 3). The uranium concentration in wastewater from the dry conversion process is expected to be below detection limits. The uranium concentration in wastewater from the wet conversion process will remain the same. Therefore, the uranium activity released to the sewer is not expected to decrease after the processing change to dry conversion.

**Table 4.5 Summary of State discharge permit requirements and monitoring results for liquid effluent for 1989 to 1993**

| Parameter                                   | State Discharge Permit Limit               |                             | 1989       |                         | 1990             |                    | 1991       |            | 1992       |                       | 1993       |                        |
|---|--|-----------------------------|------------|-------------------------|------------------|--------------------|------------|------------|------------|-----------------------|------------|------------------------|
|   | Daily Avg.                                 | Daily Max.                  | Daily Avg. | Daily Max.              | Daily Avg.       | Daily Max.         | Daily Avg. | Daily Max. | Daily Avg. | Daily Max.            | Daily Avg. | Daily Max.             |
| NH <sub>3</sub> as N (mg/L)                 | 25   | 30                          | 5.5        | 22.5                    | 8.9              | 34.2               |            |            |            |                       |            |                        |
| NH <sub>4</sub> as N <sup>a</sup> (lbs/day) | 80 <sup>a</sup>                            | 125 <sup>a</sup>            |            |                         | 12.5             | 67.9               | 26.6       | 104.5      | 21.3       | 96.6                  | 14.8       | 116                    |
| NO <sub>3</sub> as N (lbs/day)              | 600<br>750 <sup>a</sup>                    | 700<br>875 <sup>a</sup>     | 226        | 724                     | 294<br>288       | 567.7<br>632.0     | 385.4      | 913.5      | 475.5      | 349.1                 | 533.5      | 919                    |
| Fluoride (lbs/day)                          | 2,500<br>2,500 <sup>a</sup>                | 3,500<br>3,150 <sup>a</sup> | 743.1      | 1,854.8                 | 1,208.4<br>990.0 | 3,119.4<br>2,583.9 | 1,547.1    | 3,603.4    | 1,601.1    | 3,168.2               | 1,630.8    | 3,058                  |
| Suspended Solids (mg/L)                     | 300  | 600                         | 43.4       | 150.4                   | 53.0             | 127.1              | 77.5       | 203        | 64.9       | 223.7                 | 60.5       | 124                    |
| pH  | ≥6.0 <sup>b</sup><br>5.0-10.0 <sup>c</sup> | 6.0 (min.)<br>5.0 (min.)    | 9.5        | 6.4 (min.)<br>and >11.1 | 9.0              | 6.4 (min.)         | 8.3        | 4.5 (min.) | 8.7        | 7.1 (min.)<br>and >10 | 8.9        | 6.8 (min.)<br>and 11.6 |

- a. Permit limits were changed starting July 1990.
- b. Limit required by State waste discharge permit.
- c. Limits required by the City of Richland pretreatment ordinance.

Sources: Siemens Power Corporation—Nuclear Division, "Supplement to Applicant's Environmental Report," July 1994 (Ref. 2); and Monthly waste liquid effluent reports from Advanced Nuclear Fuels Corporation/L.J. Maas, Siemens Power Corporation, to K.H. Sherwood, Washington State Department of Ecology (Ref. 5)

### **4.1.3 Solid Release Monitoring**

Sanitary sewer sludge from the SPC facility is discharged to the Richland sewage treatment facility, where it is de-watered to a semi-dry solid. SPC collects monthly sludge samples that are analyzed for uranium. The action level for the uranium concentration in sludge is greater than 25 picocuries per gram (pCi/g) for a running average over a 6-month period or a single monthly sample in excess of 30 pCi/g (Ref. 2). If these action levels are exceeded, an action plan would be prepared to reduce the discharge to the sewer until sludge samples contained less than 25 pCi/g uranium. Any confirmed monthly sludge sample with a concentration greater than 25 pCi/g would be reported to NRC.

Since January 1991, the volume of solid waste generated over a 6-month period has been about 300 cubic meters (10,600 cubic feet) or an average of 50 cubic meters (1,770 cubic feet) per month. Volumes and activities for solid wastes for a 5-year period are presented in Table 4.6. SPC estimates that dry conversion processing will generate 27 cubic meters (800 cubic feet) of solid waste monthly (Ref. 3). Therefore, the concentration of uranium in solid effluent is expected to decrease after startup of the dry conversion process.

Solid waste potentially contaminated with radioactive material is generated from routine operations in the engineering and manufacturing facility. Contamination surveys are performed on all materials and equipment removed from contaminated areas and on areas or facilities to be released from radiation protection requirements. Decontamination of equipment prior to release for unrestricted use is done in accordance with NRC (1993)(Ref. 6). All outgoing shipments of radioactive materials are packaged and surveyed in accordance with 10 CFR Part 71 and 49 CFR 173.443. These wastes are segregated into noncombustible and combustible types, sealed in containers, labeled, and stored in designated areas with controlled access. In the event that these containers are stored outside for extended periods, the integrity of the containers are visually inspected and the accumulation is surveyed for radiation at least quarterly.

### **4.2 Environmental Monitoring Program**

SPC conducts an environmental monitoring program that samples soil, vegetation, air, and groundwater at locations on or near the facility as summarized in Table 4.7. The frequency of sampling and the constituents sampled as part of this program are also summarized in Table 4.7. The location of sampling points for soil, vegetation, and air are shown on Figure 4.1. The location of the groundwater sampling points are shown on Figure 1.2.

**Table 4.6 Uranium concentrations in solid waste effluent**

| Period             | Volume (m <sup>3</sup> ) | Radioactivity/<br>Uranium (Ci) <sup>a</sup> |
|--------------------|--------------------------|---|
| 1/1/89 to 6/30/89  | 0                        | —   |
| 7/1/89 to 12/31/89 | 0                        | —   |
| 1/1/90 to 6/30/90  | 0                        | —   |
| 7/1/90 to 12/31/90 | 6,400                    | 0.0239                                      |
| 1/1/91 to 7/1/91   | 106                      | 0.2347                                      |
| 7/1/91 to 1/1/92   | 352                      | 0.477                                       |
| 1/1/92 to 7/1/92   | 351                      | 0.180                                       |
| 7/1/92 to 1/1/93   | 600                      | 0.088                                       |
| 1/1/93 to 7/1/93   | 168                      | 0.012                                       |
| 7/1/93 to 1/1/94   | 39                       | 0.003                                       |

a. Based on 3 weight percent enriched uranium.

Source: Advanced Nuclear Fuels Corporation (currently Siemens Power Corporation), Semiannual "Required Reporting of Effluents per 10 CFR 70.59," submitted to U.S. Nuclear Regulatory Commission, 1989-1993 (Ref. 4).

**Table 4.7 Summary of environmental monitoring program<sup>a</sup>**

| Sample Medium | Number of Stations | Analytical Frequency | Sample Type | Type of Analysis  |
|---------------|--------------------|----------------------|-------------|---|
| Air           | 2                  | Monthly              | Continuous  | Fluoride  |
| Soil          | 2                  | Quarterly            | Composite   | Uranium   |
| Vegetation    | 2                  | Monthly <sup>b</sup> | Grab        | Fluoride  |
| Groundwater   | 8                  | Quarterly            | Grab        | Gross alpha, gross beta, fluoride, chloride, nitrate, and ammonia |

a. Refer to Figures 1.2 and 4.1 for sampling locations.

b. During the growing season only, i.e., April through October.

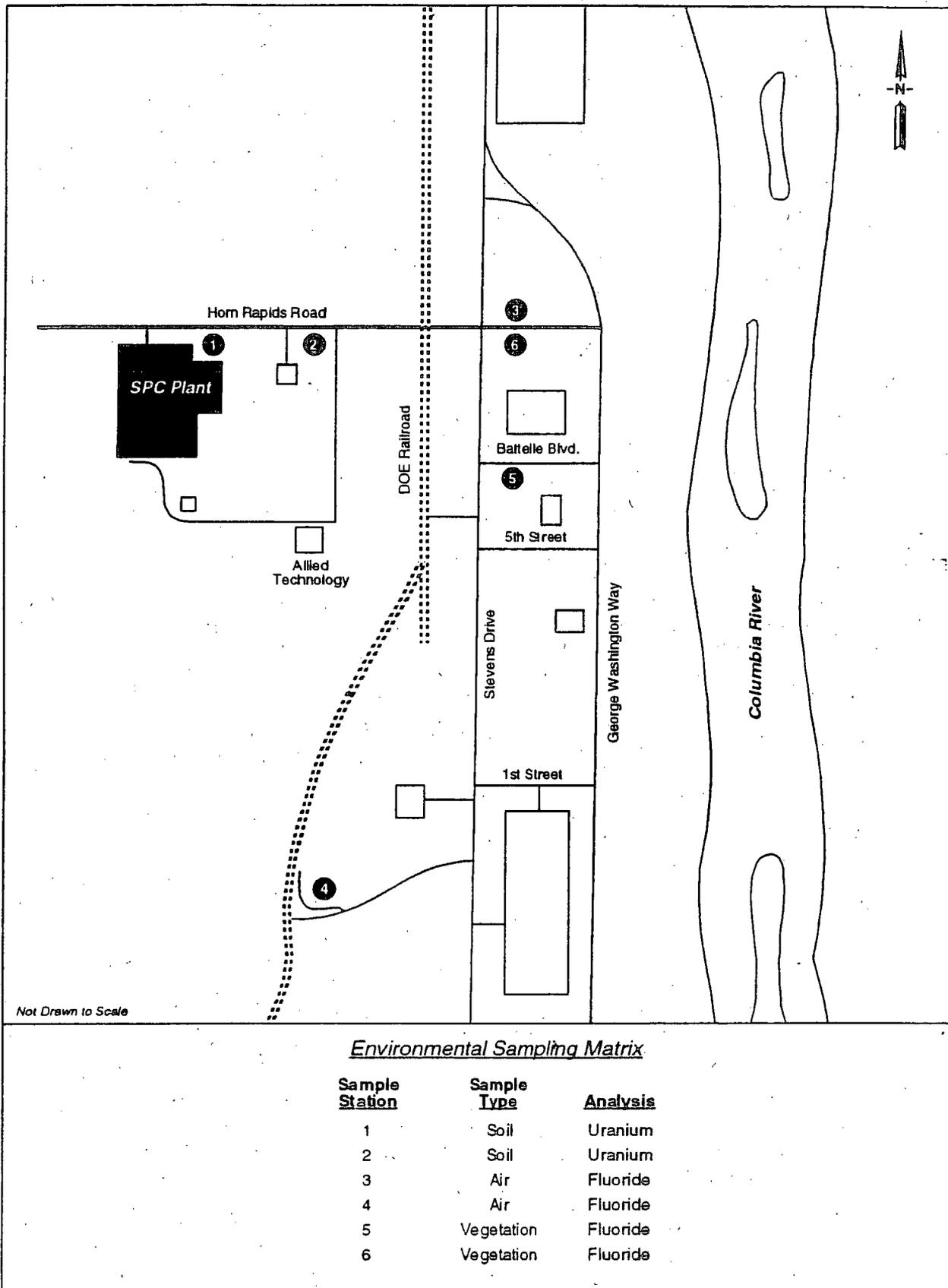


Figure 4.1 Environmental sampling locations near the SPC site for soil, air, and vegetation (modified from Ref. 2)

The plant ALARA Committee meets at least semiannually to review and evaluate data from the environmental monitoring program. Formal reports are issued at least annually to the Health and Safety Council.

#### **4.2.1 Air Monitoring**

Ambient air is sampled continuously on an absorbent media at two off-site points, one location approximately 2.2 kilometers (1.4 miles) northeast of the SPC facility in the prevailing wind direction (sample station no. 3) and one location approximately 3.4 kilometers (2.1 miles) southeast of the SPC facility (sample station no. 4) on a secondary wind maxima (see Figure 4.1). Composite samples are collected monthly and analyzed for fluoride.

The results of the environmental air monitoring for fluoride for the period from 1989 to 1993 are summarized in Table 4.8. During this period the highest annual average fluoride concentration was 0.3 parts per billion (ppb) at sampling station no. 3 in 1993. The quarterly average of sampling results for fluoride for the period from 1989-1993 during the growing season (March 1 to October 31) was below the applicable Washington State standard of 0.5 ppb; however, the monthly standard for fluoride in ambient air (0.84 ppb) was exceeded during the first quarter of 1993 (Ref.2). Trends based on the five-year averages shown in Table 4.8 indicate a general increase in fluoride concentrations in ambient air compared to the 1984-1988 average.

#### **4.2.2 Soil and Vegetation Monitoring**

Two soil samples are collected quarterly near the SPC site and are analyzed for uranium. Sample station no. 1 is adjacent to the northeast corner of the restricted fenced area and sample station no. 2 is approximately 785 meters (2,575 feet) northeast of the center point of the SPC facility (see Figure 4.1). Soil samples are collected from the surface to between 1 and 5 centimeters (0.4 and 2 inches) beneath the ground surface (Ref.2). The annual average uranium concentrations in soil for 1989 to 1993 are presented in Table 4.8. The uranium concentrations in 1993 jumped up from previous years but this reflects a change in the sampling method. The 5-year average from 1989 to 1993 is about the same as that reported for the previous 5-year period.

Two vegetation samples are collected monthly and analyzed for fluoride during the growing season (April to October). The two off-site sample locations are approximately 2.2 kilometers (1.4 miles) east of the SPC site, in the prevailing wind direction (see Figure 4.1). The annual average fluoride concentrations in

**Table 4.8 Average annual concentration of uranium and fluoride in soil, air, and vegetation samples, 1989-1993**

| Type of Sample               | Sampling Station | LLD              | Annual Average |       |      |       |       | 1984-        | 1989-        |
|------------------------------|------------------|------------------|----------------|-------|------|-------|-------|--------------|--------------|
|                              |                  |                  | 1989           | 1990  | 1991 | 1992  | 1993  | 1988 Average | 1993 Average |
| Uranium in soil (ppm)        | No. 1            | 2.0 <sup>a</sup> | 0.75           | 0.32  | 0.30 | 0.37  | <1.32 | 0.6          | <0.61        |
| Uranium in soil (ppm)        | No. 2            | 2.0              | 0.70           | 0.55  | 0.30 | 0.35  | <1.37 | 0.71         | <0.65        |
| Fluoride in air (ppb)        | No. 3            | 0.5              | 0.24           | 0.12  | 0.11 | 0.14  | 0.30  | 0.12         | 0.18         |
| Fluoride in air (ppb)        | No. 4            | 0.5              | 0.097          | 0.082 | 0.09 | 0.072 | 0.21  | 0.095        | 0.11         |
| Fluoride in vegetation (ppm) | No. 5            | 10               | 2.2            | 2.7   | 5.9  | 8.1   | 12.6  | 4.8          | 6.3          |
| Fluoride in vegetation (ppm) | No. 6            | 10               | 2.1            | 2.6   | 4.5  | 5.9   | 14.8  | 5.4          | 6.0          |

a. Previous to 7/93, all soil results that are less than 2.0 ppm should be considered as less than detectable (<2.0 ppm) (Ref. 7).

Source: Siemens Power Corporation-Nuclear Division, "Supplement to Applicant's Environmental Report," August 1992, and July 1994 (Ref. 2).

vegetation samples from 1989 to 1993 are presented in Table 4.8. Fluoride concentrations increased approximately 500 percent over the 5-year period from 1989 to 1993. The 1989-1993 averages (6.3 and 6.0 ppm) also reflect an increase from the 1984-1988 averages (4.8 and 5.4 ppm). The Washington State standard allows a 40 ppm average fluoride concentration during any 12-month consecutive period, and therefore during any growing season (Ref. 8). None of the growing season averages exceeded this standard.

#### 4.2.3 Groundwater Monitoring

There are currently eight groundwater monitoring wells on the plant site located around the periphery of the lagoon system (the number and locations of the wells changed in 1993) that are used to monitor groundwater in accordance with the NRC license. The locations of the wells are shown on Figure 1.2 and Figure 3.7. Groundwater contamination at the site resulted from lagoon leakage before the current lagoon liner system described in Section 4.2.4 was installed.

The wells are primarily monitored to indicate whether upper or lower lagoon liners have leaked, releasing stored liquids to the groundwater. The wells are also used to monitor the concentration of contaminants in groundwater. The wells are sampled quarterly for gross alpha activity, gross beta activity, chloride, fluoride, nitrate (as nitrogen), ammonia (as nitrogen), and pH under the NRC license.

The gross alpha and gross beta quarterly monitoring results for the wells were reviewed for 1989 to 1993 (including the new wells installed in September 1993). Gross beta concentrations in groundwater varied from 1.3 pCi/L to a maximum of 68 pCi/L from 1989 to 1993 (Ref. 2) compared to a background concentration of about 15 pCi/L in well GM-1. Plotting the concentration data over the reporting period indicated that the groundwater concentrations are very cyclic over time, reflecting the variability in naturally-occurring radioactivity as well as the seasonal influence of changing water levels. Beta concentrations in groundwater were highest in the first quarter of each year and lowest in the third quarter. The wells on the northern side (downgradient) of lagoon 1 and lagoon 5A had the highest gross beta concentrations which would be expected since the direction of groundwater flow is from the south-southwest to the north-northeast (Ref. 9).

Gross alpha activities varied from 0.15 to 87.8 pCi/L, compared to background of about 10 pCi/L in well GM-1, over the reporting period with the same cyclic trends and well characteristics as described above for gross beta activity. Fluoride concentrations in groundwater around the perimeter of the lagoon system varied from 0.2 to 13.6 ppm over the same time period and also showed a cyclic trend with time. The background concentration of fluoride is about 0.3 ppm as measured in well GM-1.

Concentrations of up to 64.2 ppm nitrate (as nitrogen) and 71.4 ppm ammonia (as nitrogen), compared to background concentrations of about 4.3 and 0.04 ppm,

respectively, as measured in well GM-1, have been detected in groundwater monitoring wells surrounding the lagoon system. Chloride has been monitored only since the third quarter of 1993. Chloride concentrations in the latter half of 1993 varied from 12.9 to 22.7 ppm.

Groundwater monitoring is conducted according to programs approved by Washington State Department of Ecology. The monitoring program results would be measured against established concentration limits.

#### **4.2.4 Leak Detection of Lagoon System**

The liquid waste management lagoons are monitored by leak detection systems. All of the lagoons have double liners, with leak detection capability between the liners (to detect leakage from the upper liner), and some lagoons have leak detection capability beneath the bottom liners. Sampling tubes are located between the two liners under each of the lagoons.

Liquids are pumped out, measured, and analyzed monthly for uranium and fluoride. If the uranium and fluoride concentrations are above previously measured levels, an investigation would be initiated. Investigative actions taken by SPC would include:

- Additional between-liner sampling.
- Lagoon solution sampling for comparison of the content of the sample to that of the lagoon.
- Checking the integrity of the lower liner of affected lagoons.
- Making use of the lagoon test well system.

The plant has limits that are used to determine if the upper liners of the lagoons are leaking. These limits are presented in Table 4.9. If the upper liner of a lagoon is determined to be leaking, the integrity of the lower liner will be checked as described above. Test wells around the lagoon system are a backup for leak detection. In the event that a leak in an upper liner is confirmed, the liner would be repaired. A written report of the leak, including results of the investigation and corrective actions taken, would be forwarded to NRC within 90 days of detecting a leak.

**Table 4.9 Plant limits used to determine leakage of upper lagoon liners**

| Lagoon | Function  | Containment Characteristics         | Estimated Capacity (gal) | Leak Rate (gal/month) |
|--------|---|-------------------------------------|--------------------------|-----------------------|
| 1      | Receives ammonia-bearing solutions and is the feed for the ammonia recovery process.  | 2 bottom liners<br>1 floating cover | 1,400,000                | 9,120                 |
| 2      | Receives ammonia-bearing solutions and is the feed for the ammonia recovery process.  | 2 bottom liners<br>1 floating cover | 700,000                  | 6,566                 |
| 3      | Stores high uranium content wastes and is the feed for the LUR facility.  | 2 bottom liners                     | 3,500,000                | 8,500                 |
| 4      | Stores low uranium content waste from the LUR process and is the feed for the ARF.  | 2 bottom liners                     | 2,700,000                | 10,944                |
| 5A     | Stores wastes from the ARF and miscellaneous low uranium, low ammonia, chemical wastes. Wastes are treated and then disposed to the sewer.        | 2 bottom liners                     | 1,600,000                | 11,674                |
| 5B     | Stores high uranium content waste and is the feed for the uranium recovery process. (It will serve the same function as lagoon 5A in the future.) | 2 bottom liners                     | 1,600,000                | 8,755                 |

Sources: Siemens Power Corporation—Nuclear Division, "Application for Renewal of Special Material License No. SNM-1227 (NRC Docket No. 70-1257)," August 1992 (Ref. 1) and Siemens Power Corporation, "Siemens Power Corporation's Responses to NRC's Request for Additional Information on License Renewal (TAC No. L21656)," (Ref. 10).

### 4.3 References for Section 4

1. Siemens Power Corporation—Nuclear Division, "Application for Renewal of Special Nuclear Material License No. SNM-1227 (NRC Docket No. 70-1257)," August 1992.
2. Siemens Power Corporation—Nuclear Division, "Supplement to Applicant's Environmental Report, EMF-14," Rev. 4, July 1994.
3. Edgar, J.B., Siemens Power Corporation—Nuclear Division, letter to R.C. Pierson, U.S. Nuclear Regulatory Commission, October 21, 1994.
4. Advanced Nuclear Fuels Corporation (Siemens Power Corporation), Semiannual "Required Reporting of Effluents per 10 CFR 70.59," submitted to U.S. Nuclear Regulatory Commission, 1989-1993.
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7. Law, M.A., Siemens Power Corporation—Nuclear Division, to Tanaka, K.H., Siemens Power Corporation—Nuclear Division, December 14, 1994.
8. Washington State Ambient Air Quality and Environmental Standards for Fluorides, Washington Administrative Code, Chapter 173-481-100, Forage Standards.
9. Geraghty & Miller, Inc., "Second Quarterly Groundwater Monitoring Report, Siemens Power Corporation, Richland, Washington," Volume 1, Redmond, Washington, November 19, 1993.
10. Siemens Power Corporation, "Siemens Power Corporation's Responses to NRC's Request for Additional Information on License Renewal (TAC No. L21656)," September 24, 1994.

## **5. ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED LICENSE RENEWAL AND ALTERNATIVE ACTIONS**

Implementing the proposed action of renewing the Siemens license with a processing change from primarily "wet" to "dry" conversion processing will result in beneficial and negative impacts. The beneficial impacts include those associated with continued use of nuclear power, i.e., decreased dependency on fossil fuels and the associated negative environmental impacts related to production and utilization of fossil fuels. The negative impact from continued plant operations includes releases to air and surface water from plant operation. Implementing either the proposed action or the alternative action, nonrenewal of the license, involves decontamination and decommissioning of the facility with an expected positive environmental impact. Section 5.1 provides an evaluation of the environmental impacts of the proposed action including implementation of full production through the dry conversion process. Section 5.2 presents a discussion of the impacts of the no action alternative.

### **5.1 Environmental Consequences of Proposed License Renewal**

For the proposed action, renewal of the Siemens license, the continued handling of materials and normal operations of the facility will result in the continued release of low levels of hazardous or radioactive constituents. Under accident conditions, the facility may release higher concentrations of materials over a short period of time. This section evaluates the impacts of normal operations and postulated accidents at the Richland facility. The facility will eventually be decontaminated and decommissioned at the end of its useful life, but the evaluation of the impacts of such decontamination and decommissioning are beyond the scope of this Environmental Assessment (EA). The environmental impacts from normal operations are described in Section 5.1.1 and the impacts from postulated accidents are described in Section 5.1.2.

#### **5.1.1 Normal Operations.**

Normal operations at the SPC facility will involve discharges to surface waters, discharges to the atmosphere, and the production of various solid and liquid waste streams. In addition, continued operation of the SPC facility involves employment of personnel at the plant. The impacts of normal operations are discussed in the following paragraphs. Nonradiological impacts are discussed in subsection 5.1.1.1 and radiological impacts are discussed in subsection 5.1.1.2.

##### **5.1.1.1 Nonradiological Impacts**

###### **Air Quality**

Normal operations at the SPC facility result in releases of small quantities of nitrogen oxides and hydrogen fluoride (HF). Hydrogen fluoride levels observed for

the past 5 years are reported in Table 4.3. Conversion of production to the dry process is expected to increase HF emission rates to approximately 9 grams per hour (Ref. 1). Using concentration per unit source (X/Q) factors estimated in accordance with Regulatory Guide 1.111, maximum HF concentrations of  $2 \times 10^{-4}$  milligrams per cubic meter are predicted for the 9 grams per hour release rate. This concentration is a small fraction of human health based limits and is consistent with presently observed levels. Thus, normal operational releases of nonradiological components to the atmosphere are expected to have an insignificant environmental impact.

### Surface Water

No stormwater runoff from the SPC facility is directly discharged to the Columbia River. Stormwater and wastewater is discharged to the sewer system in accordance with a Washington State Liquid Waste Discharge Permit. Although the concentrations of nitrate and fluoride have increased, they have been below the State discharge permit limits and are expected to decrease after the change to dry conversion processing. The infrequent exceedances of the State discharge permit limits are not expected to have a major impact on the surface water quality of the nearby Columbia River.

### Groundwater

During the early years of facility operation, the single-lined lagoons failed resulting in groundwater contamination (Ref. 2). All leaking lagoons have been upgraded with double liners and leak detection systems to detect any unplanned releases. The concentrations of hazardous constituents in groundwater vary over time but have not increased since lagoon repair. Therefore, continued operation of the facility is not expected to result in further degradation of groundwater quality. With increased production through the dry conversion process, liquid effluent rates are expected to decrease, allowing closure of the lagoon treatment system. Liquid radioactive waste would be treated in tanks and enclosed process vessels with discharge of treated water to the sewer system.

### Land Use

There would be no impact on land use from continued operation of the facility because no construction or expansion of the facility requiring additional acreage has been proposed. The expansion for the proposed dry conversion facility will be located at the former cylinder storage area next to the  $UO_2$  building and construction of the  $UF_6$  cylinder storage warehouse in a previously disturbed area. Continued operation of the plant would be consistent with its current land use.

## Biotic Resources

There would be no terrestrial impacts from continued facility operation because the proposed expansion for the dry conversion facility is at a previously disturbed area. Therefore, no construction-related impacts that would disturb existing habitat, increase noise, or result in additional traffic are expected.

Terrestrial. The primary potential impact on the terrestrial resources is from the nonradiological constituents released to the environment. Measured fluoride concentrations in air and vegetation at monitoring locations are below applicable standards as discussed in Sections 4.2.1 and 4.2.2. The 5-year annual average ambient air fluoride concentration has increased compared to the period from 1984-1988 but are still generally below standards. The fluoride concentration in vegetation has increased from approximately 2.15 ppm (5 percent of the State limit) to approximately 6.15 ppm (15 percent of the State limit). Because fluoride can adversely affect vegetation at relatively low concentrations and be hazardous to livestock when it accumulates in forage crops, SPC will continue to monitor fluoride in local vegetation. Implementation of the dry conversion process is not expected to cause significant changes of HF concentrations in the environment.

Aquatic. Because wastewaters from the SPC facility are neither directly discharged nor is there stormwater runoff from the facility to the Columbia River, no adverse impacts to aquatic life in the river are expected from continued operation of the facility.

## Cultural Resources

Operation of the Richland facility has not affected regional historic and cultural resources. Continued normal operation of the facility is also not expected to have any impact on these resources.

## Socioeconomics

The primary socioeconomic impacts of continued operation of the Siemens facility is from local employment. Less than 1.6 percent of the employment sector in Richland (approximately 1,000 out of about 68,174 workers) is employed at the SPC facility. Continued operation will have a positive economic impact for those employed at the site.

### 5.1.1.2 Radiological

The release of radioactive material to air and water from the SPC facility represents a potential negative impact on the health and safety of the surrounding population. The primary component of this impact is an incremental increase in the risk of cancer due to low levels of radiation exposure. This section analyzes and describes the impacts due to long-term releases from normal SPC operations.

The impact is calculated and presented in terms of committed effective dose equivalent and organ doses resulting from a single year of operations. For doses resulting from the inhalation or ingestion of uranium, this quantity is the total effective dose equivalent (or organ dose) that will accrue to an individual over a 50-year period beginning with the year the intake occurs. Doses to a hypothetical maximally exposed individual and collective dose to the population living within an 80-kilometer (50-mile) radius of the SPC facility are summarized in this section. A detailed description of the calculational method used is provided in Appendix A.

#### Applicable Regulatory Criteria

Doses from routine emissions are assessed for compliance with the following regulatory criteria:

40 CFR 61—EPA Air Emission Standards for Radionuclides. This regulation applies to airborne emissions from NRC-licensed facilities such as SPC and requires that emissions of radionuclides (including iodine) to the ambient air be limited such that the effective dose equivalent to any member of the public does not exceed 10 millirem per year (Ref. 3).

10 CFR 20—NRC Standards for Radiation Protection. Subpart D, Section 20.1301 of this regulation contains the requirement that the sum of external and internal doses to any member of the public from the licensed operation not exceed 100 millirem per year exclusive of the dose contribution from the licensee's disposal of radioactive material to sanitary sewage systems in accordance with 10 CFR 20.2003. Because the only aquatic emissions from the SPC facility are by way of the Richland City sanitary sewer, the effect of this regulation is to require that total effective dose to the maximally exposed member of the public from air emissions be less than 100 millirem per year. This subpart also requires facilities subject to 40 CFR Part 190 to comply with those standards (Ref. 4).

40 CFR 190—EPA Environmental Standards for Uranium Fuel Cycle Operation. These standards were promulgated to control the environmental impacts of the commercial nuclear fuel cycle. Under 40 CFR Part 190, the dose equivalent to any member of the public resulting from exposures to planned discharges of radionuclides (excluding radon and its progeny) to the environment from uranium fuel cycle operations and to direct radiation from these operations shall not exceed 25 millirem per year to the whole body, 75 millirem per year to the thyroid, or 25 millirem per year to any other organ (Ref. 5).

## Effluent Release Rates

**Airborne Effluents:** Effluents from the SPC facility exhaust stacks that serve fuel fabrication areas are monitored for uranium concentration and reported semiannually as total activity (microcuries) of uranium discharged. The monitoring results are reported as total microcuries of alpha emitters discharged except for Stack 52. The semiannual and total airborne releases for the 5-year period ending June 30, 1994, are presented in Table 5.1.

Table 5.1 SPC facility emissions from 1989-1994

| Period       | Air<br>( $\mu\text{Ci } \alpha$ ) | Air<br>( $\mu\text{Ci } \beta$ ) <sup>a</sup> | Sewer<br>(Ci U) |
|--------------|-----------------------------------|---|-----------------|
| Jul-Dec 1989 | 7.74                              | 1.59  | 0.032           |
| Jan-Jun 1990 | 9.95                              | 0.14  | 0.027           |
| Jul-Dec 1990 | 7.16                              | 0.77  | 0.025           |
| Jan-Jun 1991 | 6.57                              | 1.14  | 0.025           |
| Jul-Dec 1991 | 10.50                             | 0.53  | 0.033           |
| Jan-Jun 1992 | 10.72                             | 0.77  | 0.050           |
| Jul-Dec 1992 | 10.73                             | 0.72  | 0.033           |
| Jan-Jun 1993 | 5.97                              | 0.51  | 0.027           |
| Jul-Dec 1993 | 3.14                              | 0.39  | 0.021           |
| Jan-Jun 1994 | 3.30                              | 0.43  | 0.014           |
| Totals       | 75.78                             | 6.99  | 0.287           |
| Average      | 15.16 $\mu\text{Ci/yr}$           | 1.4 $\mu\text{Ci/yr}$                         | 0.057 Ci/yr     |

a. Activity for stack K52 which exhausts building 9 licensed by Washington State. Monitored for mixed fission and activation products.

Source: Advanced Nuclear Fuels Corporation (Siemens Power Corporation), Semiannual "Required Reporting of Effluents per 10 CFR 70.59," submitted to U.S. Nuclear Regulatory Commission (Ref. 6).

Many of the effluent values reported by the licensee during the time period covered in the table were at or near the lower limit of detection (LLD) for the sampling and analysis methods used. Where values were reported as "less than" some LLD value, the release was assumed to be at the LLD. Therefore, the totals and averages presented in Table 5.1 overestimate the amounts released to the environment.

The uranium released is estimated to be 3 percent enriched, with 78 percent of the activity in the mixture being U-234, 4 percent U-235, and 18 percent U-238

(Ref. 6). The mixed fission/activation product release is reported only as gross beta activity. For dose calculation purposes, the gross beta activity is conservatively assumed to be 100 percent Sr-90, the fission product beta emitter that produces the greatest committed dose equivalent per unit intake. Using these uranium distribution percentages and the 100 percent assumption, the average radiological airborne emission rates are estimated as shown in Table 5.2.

Table 5.2 Annual average radiological emissions to air

| Nuclide | Activity<br>( $\mu\text{Ci}/\text{yr}$ ) |                |
|---------|--|----------------|
|         | Wet Conversion                           | Dry Conversion |
| U-234   | 11.67                                    | 0.62           |
| U-235   | 0.61                                     | 0.032          |
| U-238   | 2.73                                     | 0.15           |
| Sr-90   | 1.40                                     | 1.40           |

From Table 5.1 it can be seen that the uranium emissions for the most recent 12-month period were less than half the 5-year average, which was elevated by the July 1991 - Dec 1992 emissions. A 5-year average value of 15.16  $\mu\text{Ci}/\text{yr}$  is reasonable and a conservative estimate of future annual average emissions.

With the startup of the proposed dry conversion process and shutdown of the existing wet process, it is expected that the airborne releases of uranium will be substantially reduced. An estimated total of 0.8  $\mu\text{Ci}/\text{yr}$  of uranium will be released to the atmosphere as a result of dry conversion process operations at 1,200 MTU per year. This represents about 5.3 percent of the average airborne uranium activity released over the last 5 years. The small mixed fission/activation product release from the SPC facility is not expected to change from implementing dry conversion processing. Table 5.2 also shows the radiological impact of airborne effluents following change to the dry conversion process assuming the same activity percentages in the uranium as cited above.

**Liquid Effluents.** Liquid emissions to the Richland City sewer system during the past 5 years have averaged 0.057 curie per year, or 5.6 percent of the 1 curie per year limit specified in 10 CFR 20.2003(a)(Ref. 4). Using the percentages referenced above, the average annual releases of uranium isotopes to the sewer are summarized in Table 5.3.

Table 5.3 Annual average liquid radiological releases

| Nuclide | Activity<br>( $\mu\text{Ci/yr}$ ) |                |
|---------|-----------------------------------|----------------|
|         | Wet Conversion                    | Dry Conversion |
| U-234   | 0.044                             | 0.013          |
| U-235   | 0.002                             | 0.0006         |
| U-238   | 0.010                             | 0.003          |

The dry conversion process produces only a small fraction of the liquid waste volume produced by the current wet conversion process. However, releases to the sewer system are expected to continue at about the current level until reprocessing of the lagoon contents is completed in about 8 years. After that date, the liquid releases are expected to decline to about 30 percent of the current value as shown in Table 5.3. This estimate is based on the assumption that uranium-contaminated wastewater streams produced by activities other than the conversion of  $\text{UF}_6$  to  $\text{UO}_2$  (i.e., the SWUR scrubber, ELO, and miscellaneous uranium recovery system) wastes will continue to be generated at present rates.

#### Dose to the Maximally Exposed Individual from Atmospheric Releases

The maximally exposed individual is normally assumed to reside at the nearest residence. However, the nearest residence to the SPC facility is 3.2 kilometers (2 miles) southwest of the center of the plant (Ref. 7). Because the prevailing winds are westerly, the annual average dispersion factor is actually larger at the residence located 3.4 kilometers (2.1 miles) southeast of the plant (Ref. 8). Doses to individuals living at both locations are presented. For comparison, doses are also presented for a hypothetical individual residing at the site boundary nearest the center of the plant. The nearest site boundary is a road 284 meters (930 feet) north of the plant center, and the land on the far side of the road is part of the DOE Hanford Site. Thus, no long-term occupancy at that location is possible in the foreseeable future.

Doses to the maximally exposed individuals were calculated using the GENII code described in Appendix A. The total amount of radioactive material released in an average year was modeled as if released from the center of the plant. A conservative approach was taken to calculate the dose by assuming all the material was in the respirable particle size range and of solubility Class Y, which maximizes the dose per unit intake.

The organ doses and effective doses calculated for the site boundary location and the nearest residences for wet conversion operations are presented in Table 5.4. These doses result from the combined air inhalation, ingestion, air immersion, and contaminated ground surfaces pathways. At the site boundary and the southeast and southwest residence locations, the total effective doses are 0.024, 0.0002, and 0.000057 millirems per year, respectively. All of these values are far below

**Table 5.4 Organ/tissue and effective doses (mrem/yr) at site boundary and nearest residences from airborne emissions with the wet and dry conversion processes**

| Organ/Tissue   | Site Boundary        |                      | Nearest Residence (SE) |                      | Nearest Residence (SW) |                       |
|----------------|----------------------|----------------------|------------------------|----------------------|------------------------|-----------------------|
|                | Wet Conversion       | Dry Conversion       | Wet Conversion         | Dry Conversion       | Wet Conversion         | Dry Conversion        |
| Gonads         | $6.4 \times 10^{-6}$ | $3.4 \times 10^{-7}$ | $5.6 \times 10^{-1}$   | $3.0 \times 10^{-9}$ | $1.6 \times 10^{-8}$   | $8.5 \times 10^{-10}$ |
| Breast         | $6.4 \times 10^{-6}$ | $3.4 \times 10^{-7}$ | $5.5 \times 10^{-8}$   | $2.9 \times 10^{-9}$ | $1.5 \times 10^{-8}$   | $8.0 \times 10^{-10}$ |
| Red Marrow     | $3.9 \times 10^{-4}$ | $2.1 \times 10^{-5}$ | $3.4 \times 10^{-6}$   | $1.8 \times 10^{-7}$ | $9.5 \times 10^{-7}$   | $5.0 \times 10^{-8}$  |
| Lung           | $1.9 \times 10^{-1}$ | $1.0 \times 10^{-2}$ | $1.7 \times 10^{-3}$   | $9.0 \times 10^{-5}$ | $4.7 \times 10^{-4}$   | $2.5 \times 10^{-5}$  |
| Thyroid        | $6.4 \times 10^{-6}$ | $3.4 \times 10^{-7}$ | $5.5 \times 10^{-8}$   | $2.9 \times 10^{-9}$ | $1.5 \times 10^{-8}$   | $8.0 \times 10^{-10}$ |
| Bone Surface   | $4.6 \times 10^{-3}$ | $2.4 \times 10^{-4}$ | $3.9 \times 10^{-5}$   | $2.1 \times 10^{-6}$ | $1.1 \times 10^{-5}$   | $5.8 \times 10^{-7}$  |
| Kidney         | $1.8 \times 10^{-3}$ | $9.5 \times 10^{-5}$ | $1.6 \times 10^{-5}$   | $8.5 \times 10^{-7}$ | $4.3 \times 10^{-6}$   | $2.3 \times 10^{-7}$  |
| Effective Dose | $2.4 \times 10^{-2}$ | $1.3 \times 10^{-3}$ | $2.0 \times 10^{-4}$   | $5.3 \times 10^{-6}$ | $5.7 \times 10^{-5}$   | $3.0 \times 10^{-6}$  |

the 40 CFR Part 61 limit of 10 millirem per year to any member of the public and represent less than 0.01 percent of the annual dose a person at these locations would receive from natural background sources. The highest organ dose is to the lung. The estimated lung doses of 0.19, 0.0017 and 0.00047 millirems per year at the site boundary and southeast and southwest residences, respectively, are far below the 25 millirem per year standard of 40 CFR Part 190 for organ doses from fuel cycle operations. The thyroid doses are an even less significant fraction of the 75 millirem per year standard.

Doses from operations with the proposed dry conversion process are also presented in Table 5.4. Because of the expected lower air emission rate, these values are only about 1/20 the corresponding values from the wet conversion process.

From these results, it can be seen that the most exposed residence is 3.4 kilometers (2.1 miles) to the southeast. The air inhalation pathway contributes most significantly to the dose calculated at all three receptor locations. Table 5.5 presents the dose results by pathway using the wet conversion process.

Doses, by pathway, from operations with the proposed dry conversion process are presented in Table 5.6. Because of the lower emission rate, these values are only about 1/20 the corresponding values from Table 5.5.

#### Dose to the Maximally Exposed Individual from Aqueous Releases

Radioactive material released from the SPC facility to the Richland sewer system, and ultimately to the Columbia River, may result in radiation exposure to humans through a variety of pathways. The primary exposure modes considered in this analysis included ingestion of drinking water from the Columbia River, consumption of fish from the river and terrestrial foodstuffs irrigated with river water, and exposure during recreational activities such as swimming and boating. Doses to a maximally exposed individual living near the site and to the population within 80 kilometers (50 miles) downstream were calculated.

The radionuclide release rates used in this analysis are from measurements of the effluent discharged to the sewer system. Because most of the reported effluent concentrations were at or below the lower limits of detection, the aqueous release used in the dose calculation conservatively overstates the actual release. The uranium in the effluent was assumed to be 100 percent soluble material to maximize the committed dose per unit intake for the nuclides of concern. The GENII computer code was used to calculate concentrations in foodstuffs and environmental media and to compute doses to humans. Consumption and exposure period assumptions are consistent with those recommended in Regulatory Guide 1.109 (Ref. 9). The dose conversion factors used in GENII are based on the recommendations of International Commission on Radiological Protection (ICRP)

**Table 5.5 Maximum organ/tissue and effective doses (mrem/yr) for all pathways from airborne emissions using wet conversion process**

| Pathway        | Site Boundary         |                      | Residence (SE) <sup>a</sup> |                      | Residence (SW) <sup>b</sup> |                      |
|----------------|-----------------------|----------------------|-----------------------------|----------------------|-----------------------------|----------------------|
|                | Effective             | Lung                 | Effective                   | Lung                 | Effective                   | Lung                 |
| Inhalation     | $2.3 \times 10^{-2}$  | $1.9 \times 10^{-1}$ | $2.0 \times 10^{-4}$        | $1.7 \times 10^{-3}$ | $5.6 \times 10^{-5}$        | $4.7 \times 10^{-4}$ |
| Ingestion      | $3.1 \times 10^{-4}$  | — <sup>c</sup>       | $2.7 \times 10^{-5}$        | —                    | $7.5 \times 10^{-7}$        | —                    |
| Air Immersion  | $5.5 \times 10^{-10}$ | —                    | $4.8 \times 10^{-12}$       | —                    | $1.3 \times 10^{-12}$       | —                    |
| Ground Surface | $5.8 \times 10^{-8}$  | —                    | $5.2 \times 10^{-10}$       | —                    | $1.4 \times 10^{-10}$       | —                    |
| Total          | $2.4 \times 10^{-2}$  | $1.9 \times 10^{-1}$ | $2.0 \times 10^{-4}$        | $1.7 \times 10^{-3}$ | $5.7 \times 10^{-5}$        | $4.7 \times 10^{-4}$ |

a. Southeast residence.

b. Southwest residence.

c. — = Negligible pathway contribution to lung dose.

**Table 5.6 Maximum organ/tissue and effective doses (mrem/yr) for all pathways from airborne emissions using dry conversion process**

| Pathway        | Site Boundary         |                      | Residence (SE) <sup>a</sup> |                      | Residence (SW) <sup>b</sup> |                      |
|----------------|-----------------------|----------------------|-----------------------------|----------------------|-----------------------------|----------------------|
|                | Effective             | Lung                 | Effective                   | Lung                 | Effective                   | Lung                 |
| Inhalation     | $1.2 \times 10^{-3}$  | $1.0 \times 10^{-2}$ | $1.1 \times 10^{-5}$        | $9.0 \times 10^{-5}$ | $3.0 \times 10^{-6}$        | $2.5 \times 10^{-5}$ |
| Ingestion      | $1.6 \times 10^{-5}$  | — <sup>c</sup>       | $1.4 \times 10^{-7}$        | —                    | $4.0 \times 10^{-8}$        | —                    |
| Air Immersion  | $2.9 \times 10^{-11}$ | —                    | $2.5 \times 10^{-13}$       | —                    | $6.9 \times 10^{-14}$       | —                    |
| Ground Surface | $3.1 \times 10^{-9}$  | —                    | $2.8 \times 10^{-11}$       | —                    | $7.4 \times 10^{-12}$       | —                    |
| Total          | $1.3 \times 10^{-3}$  | $1.0 \times 10^{-2}$ | $1.1 \times 10^{-5}$        | $9.0 \times 10^{-5}$ | $3.0 \times 10^{-6}$        | $2.5 \times 10^{-5}$ |

a. Southeast residence.

b. Southwest residence.

c. — = Negligible pathway contribution to lung dose.

Publications 26 and 30 (Refs. 10 and 11). A description of GENII is presented in Appendix A.

Doses to the maximally exposed individual from liquid releases from the wet conversion process operations are presented in Table 5.7. The effective dose is 0.00056 mrem, an insignificant fraction of the total background dose and well below applicable regulatory standards. Most of the dose is from U-234, and the bone surface receives the highest dose.

Table 5.7 also presents estimates for the effective dose to the maximally exposed individual from liquid releases after reprocessing of the lagoon contents is completed and the processing change to dry conversion has been made. After implementing the dry conversion process, liquid release of uranium is expected to average about 30 percent of current levels.

**Table 5.7 Organ/tissue doses and effective dose (mrem/yr) to maximally exposed individual from SPC liquid releases associated with wet and dry conversion processes**

| Organ/Tissue          | Dose Equivalent (mrem/yr) |                      |
|-----------------------|---------------------------|----------------------|
|                       | Wet Conversion            | Dry Conversion       |
| Gonads                | $1.2 \times 10^{-5}$      | $3.6 \times 10^{-6}$ |
| Breast                | $1.2 \times 10^{-5}$      | $3.6 \times 10^{-6}$ |
| Red Marrow            | $5.4 \times 10^{-4}$      | $1.6 \times 10^{-4}$ |
| Lung                  | $1.2 \times 10^{-5}$      | $3.6 \times 10^{-6}$ |
| Thyroid               | $1.2 \times 10^{-5}$      | $3.6 \times 10^{-6}$ |
| Bone Surface          | $8.4 \times 10^{-3}$      | $2.5 \times 10^{-3}$ |
| Kidney                | $3.4 \times 10^{-3}$      | $1.0 \times 10^{-3}$ |
| Lower Large Intestine | $3.7 \times 10^{-4}$      | $1.1 \times 10^{-4}$ |
| Upper Large Intestine | $1.3 \times 10^{-4}$      | $3.9 \times 10^{-5}$ |
| Small Intestine       | $3.2 \times 10^{-5}$      | $9.6 \times 10^{-6}$ |
| Stomach               | $2.0 \times 10^{-5}$      | $6.0 \times 10^{-6}$ |
| Effective Dose        | $5.6 \times 10^{-4}$      | $1.7 \times 10^{-4}$ |

Tables 5.8 and 5.9 identify the portions of the effective dose and bone surface dose associated with various pathways. The dose impact of uranium releases to the city sewer system is dominated by the consumption of drinking water, fish, and foodstuffs irrigated with water from the Columbia River. It would be highly improbable that the hypothetical individual receiving maximum exposure from the liquid pathway would be the same individual receiving the maximum exposure from airborne emissions, because the nearest residences to the SPC site receive water from the Richland City water system. The city water supply pumping station is located more than 6.4 kilometers (4 miles) upstream from the point at which the SPC liquid releases enter the Columbia River.

**Table 5.8 Effective dose and maximum organ/tissue dose (mrem/yr) to the maximally exposed individual from SPC aquatic releases, by pathway, with existing wet conversion process**

| Pathway          | Effective Dose       | Bone Surface Dose    |
|------------------|----------------------|----------------------|
| Drinking Water   | $8.5 \times 10^{-5}$ | $1.3 \times 10^{-3}$ |
| Aquatic Food     | $3.2 \times 10^{-4}$ | $4.8 \times 10^{-3}$ |
| Terrestrial Food | $1.6 \times 10^{-4}$ | $2.3 \times 10^{-3}$ |
| Recreation       | — <sup>a</sup>       | —                    |
| Total            | $5.6 \times 10^{-4}$ | $8.4 \times 10^{-3}$ |

a. — = Negligible contribution to total dose.

**Table 5.9 Effective dose and maximum organ/tissue dose (mrem/yr) to the maximally exposed individual from SPC aquatic releases, by pathway, with proposed dry conversion process**

| Pathway          | Effective Dose       | Bone Surface Dose    |
|------------------|----------------------|----------------------|
| Drinking Water   | $2.6 \times 10^{-5}$ | $3.9 \times 10^{-4}$ |
| Aquatic Food     | $9.6 \times 10^{-5}$ | $1.4 \times 10^{-3}$ |
| Terrestrial Food | $4.8 \times 10^{-5}$ | $6.9 \times 10^{-4}$ |
| Recreation       | — <sup>a</sup>       | —                    |
| Total            | $1.7 \times 10^{-4}$ | $2.5 \times 10^{-3}$ |

a. — = Negligible contribution to total dose.

### Dose to the Population

Based on the 1990 census data, it was estimated that 281,586 people reside within 80 kilometers (50 miles) of the SPC facility. Since the census, the population distribution remained largely unchanged with the exception of a new residential development located between 3.2 and 4.8 kilometers (2 and 3 miles) southwest of SPC. The population in that sector was estimated at 200 in 1994 and is projected to increase to several thousand by the year 2000. The population distribution used for the population dose estimate is shown in Table 3.4.

The collective dose to the population from routine atmospheric releases at the SPC facility is estimated at 0.0035 person-rem per year. This increment is less than 0.000005 percent of the 85,000 person-rem per year that the same population is exposed to from natural background sources. For the routine liquid releases from the SPC facility, the collective dose to the population residing within 80 kilometers (50 miles) downstream on the Columbia River was estimated at 0.074 person-rem per year, which is less than 0.0004 percent of the 21,000 person-rem per year that this same population receives from natural background radiation sources. Population doses are presented by pathway in Table 5.10 for plant operations with both wet and dry conversion processes.

**Table 5.10 Annual committed population dose equivalent (person-rem) from SPC releases with wet and dry conversion processes**

| Release Type                | Drinking Water       | Aquatic Food         | Terrestrial Food     | Recreation           | Inhalation           | Total                |
|-----------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| <b>Atmospheric</b>          |                      |                      |                      |                      |                      |                      |
| Wet Conversion              | ---                  | ---                  | $2.3 \times 10^{-5}$ | ---                  | $3.5 \times 10^{-3}$ | $3.5 \times 10^{-3}$ |
| Dry Conversion              | ---                  | ---                  | $1.2 \times 10^{-6}$ | ---                  | $1.9 \times 10^{-4}$ | $1.9 \times 10^{-4}$ |
| <b>Liquid</b>               |                      |                      |                      |                      |                      |                      |
| Wet Conversion              | $1.8 \times 10^{-3}$ | $1.2 \times 10^{-2}$ | $6.0 \times 10^{-2}$ | $3.4 \times 10^{-7}$ | ---                  | $7.4 \times 10^{-2}$ |
| Dry Conversion <sup>b</sup> | $5.4 \times 10^{-4}$ | $3.6 \times 10^{-3}$ | $1.8 \times 10^{-2}$ | $1.0 \times 10^{-7}$ | ---                  | $2.2 \times 10^{-2}$ |

a. --- = Negligible contribution to population dose.  
 b. After lagoon cleanup is completed.

### 5.1.2 Evaluation of Potential Accidents

Release of radioactive or hazardous materials under off-normal or accident conditions at the SPC facility poses a potential risk to public health and safety and the environment. The potential consequences of these accidents include personal injury, health effects from acute exposure to toxic materials, non-stochastic effects from acute radiation exposure, and risk of a latent cancer fatality from exposure to radioactive material. To provide a perspective on the potential impacts of facility operation, a set of accidents spanning the range of potential consequences was selected and evaluated. The analysis included an audit of hazards, development of scenarios, and estimation of consequences of occurrence of the selected events. The balance of this section presents a discussion of the methods and results of this accident analysis.

#### 5.1.2.1 Accident Analysis Methods

To evaluate potential accidents, hazardous materials or operations were identified, events that could cause or contribute to release of material or energy were identified, the transport of material in the environment was evaluated, and the intake or dose for potentially exposed individuals was estimated.

The hazard audit of the SPC facility identified radioactive and toxic materials; reactive and energetic materials; and equipment whose operation or nature could contribute to an accident. The radioactive material is uranium, present primarily as uranium hexafluoride (UF<sub>6</sub>) and uranium dioxide (UO<sub>2</sub>) with lesser quantities of triuranium octoxide (U<sub>3</sub>O<sub>8</sub>) and uranyl nitrate hexahydrate (UNH). Toxic material present in large quantities includes anhydrous ammonia (NH<sub>3</sub>), nitric acid (HNO<sub>3</sub>), and sodium hydroxide (NaOH). Potentially flammable or explosive materials include

hydrogen and propane. The equipment with the potential for serious accidents include the  $UF_6$  vaporizers and the  $UO_2$  calciners and furnaces.

The NRC has evaluated the acute radiological and toxic chemical effects of exposure to uranium and hydrogen fluoride (HF) in previous analysis (Ref. 12). Hydrogen fluoride and uranyl fluoride are produced when  $UF_6$  reacts with water. The NRC analysis concluded that the chemical effects of exposure to uranium exceed the acute radiological effects and that the threshold for clinically observable non-stochastic effects correspond to an intake of 10 mg of soluble uranium. Similarly, exposure to HF at a concentration of 25 milligrams per cubic meter for 30 minutes was identified as the level for no significant effects, either short-term or long-term. The threshold concentration level for exposure to HF was found to be inversely proportional to the square root of exposure time. Thus, the criteria for significance of accident impacts is the uranium intake of 10 milligrams and the exposure time-dependent HF concentration.

The development of accident scenarios was based upon review of data and process descriptions presented in the SPC license renewal application (Ref. 2), the site emergency plan (Ref. 13), and observations and data gathered during an NRC site visit. Process operations begin with the handling and vaporization of  $UF_6$ . Potential accidents associated with  $UF_6$  are bounded by catastrophic release of  $UF_6$  from the liquid state. At the SPC facility, this situation could develop during a fire in the storage area or in malfunction of the vaporization equipment. NRC analysis has established that the consequences of this type of event are severe with potential fatality because of exposure to uranium and HF (Ref. 14). Control of combustible material in all plant areas and temperature controls and vent gas scrubbers on the vaporizers make the occurrence of this type of event unlikely at the SPC facility.

Accidents that release smaller quantities of  $UF_6$  include cylinder valve failure and errors in the procedure for connecting or disconnecting a cylinder to the vaporizer piping. Potential accidents associated with  $UO_2$  include ventilation system filter failure and mishaps in handling, such as drop of a pail containing  $UO_2$  powder. Most operations involving dispersible  $UO_2$  are conducted in process enclosures or hoods vented to the atmosphere through high efficiency particulate air (HEPA) filters. Because enriched uranium is present at the SPC facility, occurrence of a criticality event is also possible. Of the hazardous chemicals present at the SPC site,  $HNO_3$  and  $NaOH$  are in relatively non-volatile liquid form and do not pose a severe hazard if spilled. Anhydrous  $NH_3$  is stored under pressure as a liquid but vaporizes on loss of pressure. On the basis of the above considerations, the accidents listed in Table 5.11 were selected for evaluation.

Table 5.11 Accident Scenarios

| Scenario Number | Release Event                            |
|-----------------|--|
| 1               | UF <sub>6</sub> cylinder pigtail venting |
| 2               | UO <sub>2</sub> container drop           |
| 3               | Criticality                              |
| 4               | NH <sub>3</sub> transfer pipe failure    |

Because of the physical properties of the hazardous materials at the SPC facility and the ability to contain liquid spills, releases of concern are expected to occur via the atmospheric pathway. The NRC has provided guidance on evaluation of atmospheric dispersion for accident conditions in Regulatory Guide 1.145 (Ref. 15). Concentrations of airborne contaminants were estimated with procedures consistent with this guidance. Concentrations predicted for all scenarios were those which would be expected to occur less than 5 percent of the time. Intakes and dose were estimated as the product of concentration, inhalation rate, exposure period, and if appropriate, dose conversion factor. Parameters used in the criticality evaluation are those recommended by the NRC in Regulatory Guide 3.34 for fuel fabrication facilities accident analyses (Ref. 16).

The population density in the immediate vicinity of the SPC facility is low. Consequently, potentially exposed individuals considered in the accident evaluations were assumed to be located at the site restricted area fence and at the nearest industrial facility, the ATG Richland Corporation, 645 meters (0.4 miles) southeast of the SPC site. This assumption provides a conservative basis for the evaluation as individuals are not normally present at the restricted area fence at any time or at the ATG Richland Corporation facility at all times.

#### 5.1.2.2 Accident Evaluations

Accident scenarios considered in this evaluation are listed in Table 5.11. The following text describes each scenario and presents estimates of the potential consequences of the event.

##### Inadvertent Venting of a Pigtail

Connection and disconnection of lines potentially containing UF<sub>6</sub> are steps in the UF<sub>6</sub> vaporization operation. Normally, such lines are vented prior to disconnection. However, procedures may be improperly executed with a resulting release into the process area and subsequent release to the environment through the ventilation system. To evaluate this type of event, the line inventory was estimated at 11.6 grams (0.41 ounces) of UF<sub>6</sub>. To allow for uncertainty in the hydrolysis rate of the UF<sub>6</sub>, credit was not taken for uranium removal in the effluent HEPA filter, resulting in a release of 7.9 grams (0.28 ounces) of uranium. For the fenceline

receptor, uranium intake and dose were estimated at 0.04 milligram and 0.25 mrem, respectively. The ratio of predicted HF concentration to the HF concentration limit was estimated at  $5.3 \times 10^{-3}$ . For an individual at the ATG Richland Corporation, uranium intake and dose were estimated at 0.0018 milligram and 0.011 millirem, respectively. The ratio of predicted HF concentration to the HF concentration limit was estimated at  $2.2 \times 10^{-4}$ . The intakes and doses predicted for this scenario are small with negligible associated health impacts.

#### Spill of UO<sub>2</sub> Powder

Uranium dioxide is handled in several forms at the SPC facility. Following calcination and prior to sintering and pressing, UO<sub>2</sub> powder is stored in sealed, metal, 19-liter (5-gallon) pails. Failure to follow procedures used in handling containerized or entrained solids can result in spills of the material. The potential hazards of such spills were evaluated by consideration of a spill of a single 19-liter (5-gallon) pail. NRC analysis has determined that the fraction of spilled material that becomes airborne after a drop event correlates with the available gravitational energy (Ref. 17). For a drop of approximately 1 meter (3.3 feet), the predicted airborne fraction was  $1.0 \times 10^{-5}$ . With a UO<sub>2</sub> density of approximately 11 grams (0.4 ounces) per cubic meter, 1.8 grams (0.06 ounces) of uranium become airborne. The material passes through a HEPA filter and 0.09 grams (0.0003 ounces) of uranium are released to the environment through the K-37 stack. For the fence-line individual, uranium intake and dose were estimated at  $5.1 \times 10^{-4}$  milligrams and 0.15 millirem, respectively. For the ATG Richland Corporation individual, uranium intake and dose were estimated at  $2.1 \times 10^{-5}$  milligram and 0.0062 millirem, respectively. The intakes and doses predicted for this scenario are small with negligible associated health impacts.

#### Uranium Criticality

The postulated occurrence of a criticality may be used to evaluate SPC facility procedures in relation to public health and safety. The procedures described in Regulatory Guide 3.34, "Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant," are used for this purpose (Ref. 16). Enriched uranium is present at all steps in the SPC fuel fabrication process. Geometry, mass, and moderation control are used to ensure that criticality safety is preserved. As an example, a portion of the uranium recovery process was considered. In the UNH uranium recovery process, UO<sub>2</sub> or U<sub>3</sub>O<sub>8</sub> powders are dissolved in a HNO<sub>3</sub> solution. The powder receivers are limited in volume and operate in conjunction with a scale system to ensure criticality safety. Failure of these controls is assumed for the purposes of analysis to quantify potential impacts of facility operation. The maximum number of fissions ( $1 \times 10^{19}$ ) cited in Regulatory Guide 3.34 was used as the basis for the evaluation and because the UNH dissolver is in the interior of the building, an equivalent shielding thickness of 0.46 meters (1.5 feet) of concrete was assumed. A large quantity of energy would be released along with

noble gases, fission products, and heavier radionuclides. Prompt gamma and neutron doses would also occur. Serious health effects could occur in the immediate vicinity of the criticality event. The results of the analysis are summarized in Table 5.12. The total doses are below the level (25 rem) normally assumed for the onset of clinically observed effects.

Table 5.12 Doses for a hypothetical criticality accident (rem)<sup>a</sup>

| Type of Exposure | Fenceline Individual<br>(100 m) <sup>b</sup> | ATG Richland Corporation Individual<br>(645 m) |
|------------------|--|--|
| Prompt Gamma     | $1.9 \times 10^0$                            | $7.3 \times 10^{-3}$                           |
| Prompt Neutron   | $2.9 \times 10^0$                            | $4.0 \times 10^{-3}$                           |
| External         | $8.2 \times 10^0$                            | $7.5 \times 10^{-2}$                           |
| Internal         | $1.0 \times 10^1$                            | $2.8 \times 10^{-3}$                           |
| Total            | $1.3 \times 10^1$                            | $8.9 \times 10^{-2}$                           |

a. 1 rem = .01 Sv.

b. 1 meter = 3.2808 feet

### Release of Gaseous Ammonia

Anhydrous HF is stored in an above ground tank at the SPC facility. Ammonia, a strong base that can be lethal at high concentrations, was selected as representative of hazards associated with chemicals stored at the facility. The ammonia is stored under pressure as a liquid. Development of a leak in the tank or associated piping could result in an uncontrolled release of this substance. The scenario was assumed to begin with a break in a line equivalent to a 2.5-centimeter (1-inch) hole in the tank vapor space. Release of the material was assumed driven by the vapor pressure at 27°C (81°F), approximately  $1.0 \times 10^6$  pascals (145 pounds per square inch absolute). A release rate of 1,200 grams per second was estimated using momentum balance principles (Ref. 18).

Concentrations for the fenceline and ATG Richland Corporation individuals were estimated at  $1.7 \times 10^4$  and 705 ppm, respectively. Ammonia concentrations above 1,000 ppm for an extended period can be lethal, while concentrations between 25 and 200 ppm produce transient irritation (Ref. 19). Thus, accidents of this type would be expected to produce potentially life-threatening effects on the site and noticeable but non-life-threatening effects off site.

### 5.1.3 Summary of Environmental Effects of the Proposed License Renewal

The environmental impacts from the proposed license renewal at the SPC facility would be small and are expected to be less than those over the past 5 years since

the proposed operational change from wet to dry conversion processing will reduce the environmental impacts.

The impacts from normal operations are expected to be very small. The maximally exposed individual, located 3.4 kilometers (2.1 miles) southeast of the property, would receive an effective dose from all air pathways of 0.0002 millirem per year, with wet conversion processing. The proposed change to dry conversion processing would reduce the effective dose from all air pathways an order of magnitude to about 0.000011 millirem per year.

The effective dose from all liquid pathways is estimated at 0.00056 and 0.00017 for wet conversion and dry conversion processing, respectively. These estimated radiation doses are significantly less than the limits established by EPA in 40 CFR Part 61 (10 millirem), 40 CFR Part 190 (25 millirem), and by the NRC in 10 CFR Part 20 (100 millirem). The collective dose to the population from routine atmospheric releases is estimated at 0.0035 person-rem per year, less than 0.00005 percent of the 85,000 person-rem per year that the same population is exposed to from natural background sources. The dose to the surrounding population is 0.074 person-rem per year (assuming wet conversion processing) from aqueous releases. This dose is less than 0.0004 percent of the 21,000 person-rem per year from natural background radiation sources to the downstream population. Given the small radiation doses from normal operation of the facility, it is concluded that the proposed license renewal will not have a significant impact on the general population.

A suite of four accident scenarios was analyzed. Three of the four scenarios evaluated the accidental release of radioactive materials. The intakes and predicted doses for the three radiological accident scenarios were small with negligible associated health effects or below the level normally assumed for the onset of clinically observed effects. The fourth accident analyzed, the release of gaseous ammonia, would be expected to produce noticeable, but non-life-threatening effects both on site and off site. Given the low likelihood of these accidents, it is concluded that the proposed license renewal will not have a significant impact on the general population.

## **5.2 Environmental Consequences of No License Renewal**

If the license to continue operations were not renewed, the facility would move into the decontamination and decommissioning phase. Siemens would do a thorough survey of the site grounds and buildings and develop a detailed decontamination and decommissioning plan. Such a plan would be expected to include the decontamination of buildings, the generation and off-site shipment of significant quantities of low-level waste, and disturbance of contaminated soils.

It is expected these operations would result in the release of small amounts of activity to the atmosphere and the Columbia River. Specific estimates of the

quantities and associated doses are not available, but the expected range could be from about the same as those associated with continued operation to one order of magnitude (a factor of 10) less. Consequently, the doses to the maximally exposed individual and general population would be expected to be about the same to an order of magnitude less.

The decontamination and decommissioning operations are expected to require fewer people, so there would be a negative socioeconomic impact when processing and fuel fabrication operations ceased.

The cessation of operations would also mean there would be one less operating conversion and fuel fabrication facility with a potential impact on the commercial nuclear fuel industry.

### 5.3 References for Section 5

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2. Siemens Power Corporation—Nuclear Division, "Application for Renewal of Special Nuclear Material License No. SNM-1227 (NRC Docket No. 70-1257)," August 1992.
3. *U.S. Code of Federal Regulations*, "Emission Standards for NRC Licensed Facilities," Part 61, Title 40.
4. *U.S. Code of Federal Regulations*, "Standards for Protection Against Radiation," Part 20, Title 10.
5. *U.S. Code of Federal Regulations*, "Environmental Standards for the Uranium Fuel Cycle," Part 190, Title 40.
6. Advanced Nuclear Fuels Corporation (Siemens Power Corporation), Semiannual "Required Reporting of Effluents per 10 CFR 70.59," submitted to U.S. Nuclear Regulatory Commission, 1989-1993.
7. Siemens Power Corporation, "Supplement to Applicant's Environmental Report, Document Number, EMF-14," Rev. 4, Docket 70-1257, July 1994.
8. Exxon Nuclear Company, Inc., "Supplement to Applicant's Environmental Report, Document Number XN-NF-14," Rev. 1, NRC Docket 70-1257, September 1986.
9. U.S. Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Regulatory Guide 1.109.
10. International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, 1977.
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12. U.S. Nuclear Regulatory Commission, "Chemical Toxicity of Uranium Hexafluoride Compared to Acute Effects of Radiation," NUREG-1391, February 1991.

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14. U.S. Nuclear Regulatory Commission, "A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees," NUREG-1140, January 1988.
15. U.S. Nuclear Regulatory Commission, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," Regulatory Guide 1.145 (Rev. 1), November 1982.
16. U.S. Nuclear Regulatory Commission, "Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant," Regulatory Guide 3.34 (Rev. 1), July 1979.
17. U.S. Nuclear Regulatory Commission, "Nuclear Fuel Cycle Facility Accident Analysis Handbook," NUREG-1320, May 1988.
18. Crowl, D.A. and J.F. Louvar, *Chemical Process Safety: Fundamentals with Applications*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1990.
19. Gephart, L. and S. Moses, "Plant/Operations Progress," v.8, No. 1, pp. 8-11, January 1989.

## 6. REGULATORY CONSULTATION

During preparation of this EA, NRC consulted with various regulatory agencies to discuss the proposed license renewal of the Siemens Power Corporation facility and to gather information. Table 6.1 summarizes city, state, and federal agencies contacted regarding the proposed license renewal and a summary of the discussion. Information contacts are shown in Table 6.2.

Table 6.1 Summary of NRC consultations for the proposed license renewal

| Agency  | Point of Contact                           | Date of Consultation | Summary of Discussion   |
|---|--|----------------------|---|
| City of Richland<br>Water and Waste<br>Department   | Ms. MaryAnn St. Martin<br>Mr. Roger Wright | May 22, 1995         | City has no objection to license renewal. Information on sludge generation and management provided.                               |
| Washington<br>Department of<br>Ecology (WDOE),<br>Water Quality<br>Section                  | Mr. Kim Sherwood                           | May 22, 1995         | No objection to proposed license renewal. Discharge permit is unchanged since 1991 permit, will not be reevaluated for 2-3 years. |
| Washington<br>Department of<br>Ecology, Nuclear<br>Waste Program                            | Mr. Doug Mosich                            | May 24, 1995         | No objection to proposed license renewal. Provided status update of dangerous wastes permitting at the SPC facility.              |
| Washington<br>Department of<br>Health, Radiation<br>Protection Division                     | Ms. Debra McBaugh                          | May 22, 1995         | No objection to license renewal, requested copy of final EA. State radiation permit is unchanged.                                 |
| Benton County<br>Clean Air Authority<br>(BCCAA)   | Mr. Peter Bosserman                        | May 26, 1995         | No objection to proposed license renewal. BCCAA has determined that SPC is a "minor source" of air pollution, order provided.     |
| Department of the<br>Interior, Bureau of<br>Indian Affairs (BIA),<br>Yakama Agency          | Mr. Robert Palmer                          | May 31, 1995         | No objection to proposed license renewal. Requested copy of EA.   |
| Washington State<br>Cultural Program  | Mr. Robert Whitland                        | June 1, 1995         | No objection to proposed renewal with respect to National Historic Preservation.  |
| Yakama Indian<br>Nation,<br>Fisheries Program   | Mr. Dale Bembrick                          | May 31, 1995         | No objection to proposed license renewal. Requested copy of EA.   |
| Yakama Indian<br>Nation,<br>Environmental<br>Restoration and<br>Waste Management<br>Program | Mr. Robert Cook                            | May 31, 1995         | Expressed concern over the groundwater contamination at the site.   |
| U.S. Environmental<br>Protection Agency,<br>Region X  | Mr. Rick Poeton                            | May 22, 1995         | No objection to proposed license renewal. Refer to BCCAA and WDOE.  |

**Table 6.2 Information contacts**

| Agency  | Point of Contact | Date of Contact  | Purpose for Contact   | Summary of Discussion  |
|---|------------------|------------------|---|--|
| Richland Chamber of Commerce                            | LaVon Swensen    | May 3, 1995      | To obtain updated employment information                    | Received 1/20/95 reference for employment in the Tri-Cities area |
| Washington Department of Ecology, Water Quality Section | Judy Weston      | October 14, 1994 | To obtain waste liquid effluent reports for years 1987-1994 | Received copies of reports                                       |

**APPENDIX A**  
**METHODOLOGY AND ASSUMPTIONS FOR CALCULATING**  
**RADIATION DOSE FROM RADIONUCLIDES RELEASED TO THE ENVIRONMENT**

**A.1 Environmental Pathways**

Radioactive material is released to the environment from the Siemens Power Corporation (SPC) nuclear fuel fabrication plant in both airborne and aqueous effluent. The material is transported through the environment by a number of processes and may result in exposure to humans. The radiation doses to humans are estimated by mathematically modeling the transport of the released radioactive material through the environment to the individuals or populations of interest. The environmental pathways considered are presented in Figure A.1. This appendix describes the models and parameters used to estimate the radiation doses to humans.

**A.2 Releases from Normal Operations**

**A.2.1 Airborne Releases**

Radioactive materials are released to the atmosphere by way of 16 separate SPC exhaust stacks serving different buildings and process areas. The stacks exhaust above the roof level of the buildings but are not designed to discharge to an area free from the influence of building-induced turbulence and wake effects. Therefore, the routine emissions are modeled as ground level releases. The exhaust stacks are modeled as a single release point located near the center of the uranium oxide building. This assumption is appropriate because exhaust stacks that account for the great majority of the facility effluent are within about 76 meters (250 feet) of this point.

The radionuclides in the SPC airborne effluent are primarily those found in low enriched uranium. The reference mixture is characterized as a "3 percent enriched," i.e., uranium enriched to 3 percent U-235. The activity distribution of such a mixture is 78 percent U-234, 4 percent U-235, and 18 percent U-238. The dose results are most sensitive to activity released and only minimally sensitive to distribution of isotopes. The uranium released can be a mixture of several different chemical forms including  $UF_6$ ,  $UO_2F_2$ ,  $UO_2(NO_3)_2$ ,  $UO_2$ , and  $U_3O_8$ . For dose calculation purposes, the material is assumed to be in the form of insoluble (inhalation class Y) uranium oxide. A very small amount of beta-emitting fission and activation products is released from exhaust stack 52 serving Building 9. The effluents are monitored and characterized only as "gross beta activity." For dose calculation purposes, it is conservatively assumed that the radioactive material is Sr-90, the beta emitter producing the highest dose commitment per unit intake.

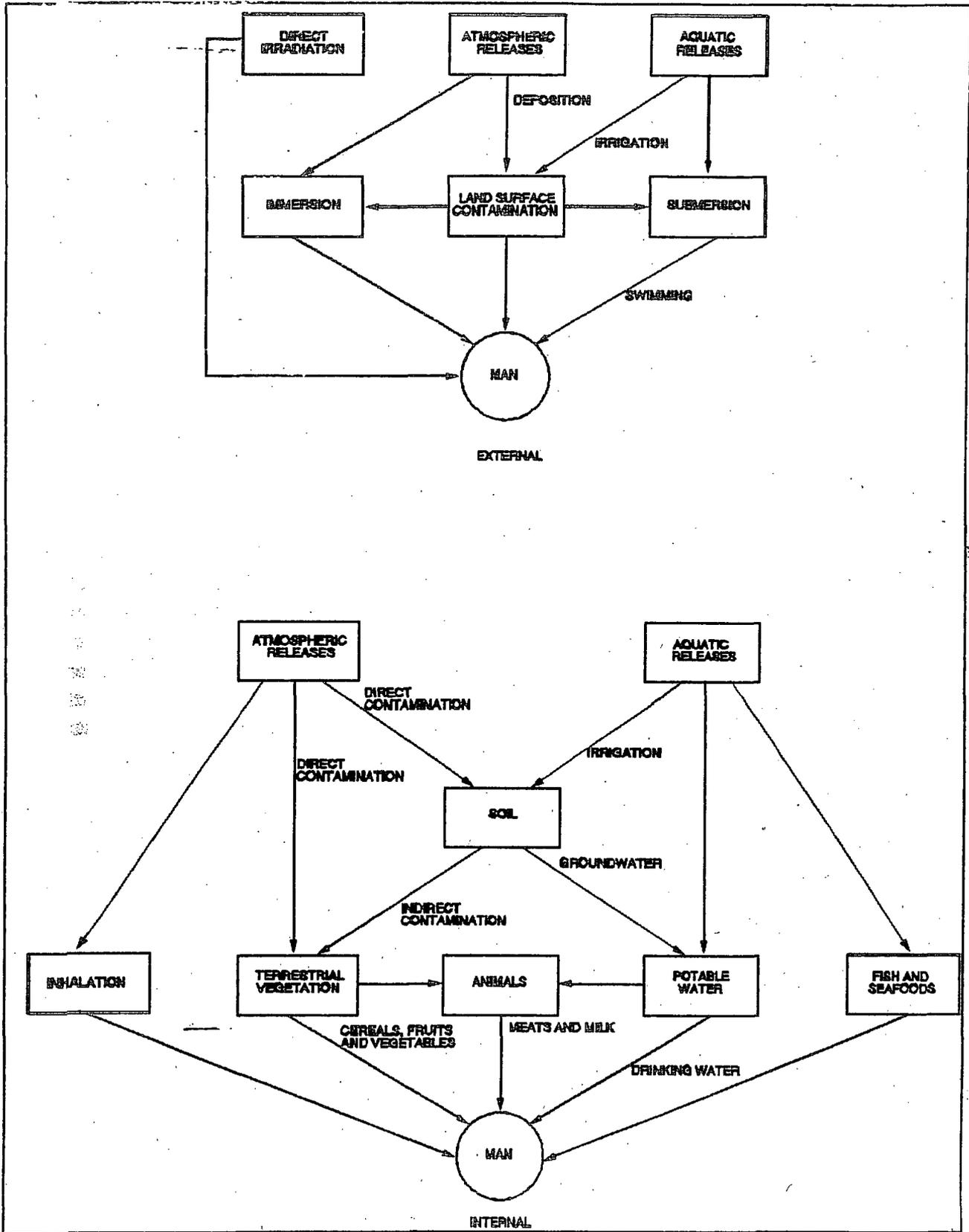


Figure A.1 Pathways for exposure to man from external sources (upper diagram) and from intake of radionuclides released to the environment (lower diagram)

## **A.2.2 Aqueous Releases**

The quantity and isotopic distribution of uranium used as source term for the calculations is derived from the facility aqueous effluent monitoring data discussed in Section 4.1. The aqueous releases consist of an average of 1.5 million liters (400,000 gallons) per day of water containing low concentrations of uranium (less than ten times the proposed U.S. Environmental Protection Agency (EPA) drinking water standard) to the Richland City sewer system. The sewage treatment plant effluent is discharged to the Columbia River. Due to the lack of a recognized source or receptor, the groundwater pathway was not considered in this analysis.

## **A.3 The GENII Environmental Dosimetry Software System**

The radiological impacts of atmospheric and aqueous releases to human receptors are estimated through use of pathway models. The pathway models used in this analysis are the surface water and atmospheric exposure pathways, represented in Figure A.1, as incorporated into the Hanford Environmental Dosimetry Software (GENII) System (Ref. 1). GENII is composed of seven linked computer codes and their associated data libraries. It was developed by the Pacific Northwest Laboratory to incorporate the internal dosimetry models recommended by the International Commission on Radiological Protection (ICRP) (Ref. 2) in updated versions of the environmental pathway analysis models used at the U.S. Department of Energy's (DOE's) Hanford Site. The GENII system was developed under a stringent quality assurance plan based on the American National Standards Institute (ANSI) standard NQA-1 (Ref. 3). It has been extensively documented and tested and subjected to external peer review.

GENII provides capabilities for calculating radiation doses for acute or chronic releases with options for annual, committed and accumulated doses; and for evaluating exposure pathways including direct exposure via water (swimming, boating, fishing), soil (surface or buried sources), air (semi-infinite and infinite cloud geometries), inhalation pathways, and ingestion pathways. Release scenarios can include acute releases to air from ground level or elevated sources, or to water; chronic releases to air from ground level or elevated sources, or to water; and initial contamination of soil or surfaces. The software provides for decay of radionuclides from the time of release until start of the exposure scenario, input of total radioactivity or specified fractions, and input of measured concentrations in various environmental media. There are interfaces between the calculations of atmospheric dispersion, geohydrology, biotic transport, and surface water transport. Receptors are identified by distance and direction for individuals and populations.

### **A.3.1 Atmospheric Pathway Model**

GENII makes use of radionuclide emission rates, atmospheric dispersion factors, and population data to calculate the radioactivity concentration at various

locations, radioactive material concentrations deposited on the ground, intake rates via inhalation and ingestion of foodstuffs, and the committed doses to representative humans and to the entire exposed population within 80 kilometers (50 miles) of the release point.

To calculate the dose from chronic releases, annual average dispersion factors are calculated by GENII from a joint frequency file depicting the wind speed, direction, and stability class conditions over a period of time. For this analysis, joint frequency data representing 9 years of observations at the Hanford 300 Area, located 3 kilometers (2 miles) northeast of the SPC facility, were used. Annual average dispersion (X/Q) values are calculated by GENII for each direction and distance. The population grid used for this analysis was also centered on the Hanford 300 Area.

#### A.3.1.1 External Dose From Plume

Persons submerged in a plume of airborne radioactive material will receive radiation exposure from gamma, x-ray, and beta emissions external to the body. This is generally termed external dose from air submersion and is dependent on the type and energy of the radiation and the spatial distribution of the airborne radionuclides. Using the average rate of release of radioactive material to the atmosphere and the annual average dispersion factors calculated internally, GENII calculates the energy emission per unit volume in air at each receptor location. The semi-infinite plume model is based on the assumption that the extent of the plume is great with respect to the distance the radioactive emissions travel in air, and that the energy deposition per unit volume of air is equal to the energy emission rate per unit volume.

#### A.3.1.2 External Dose From Deposited Material

For the air deposition pathway, the rate of deposition of radioactive material from a plume is calculated using an average deposition velocity. The area concentration of deposited material at a given location is a simple function of the time averaged concentration in air at that location and the deposition velocity. Once deposited, that radioactive material represents a wide-area source of radiation dose to persons residing on that land. The dose to the exposed individual is determined by the type and energy of the radioactive emissions from the deposited material and the area concentration of the material. For this analysis, the dose at a height of 1 meter (3.3 feet) above the ground is calculated.

#### A.3.1.3 Internal Dose From Inhalation

Dose to an individual at a given location from inhalation of radioactive material is modeled using the annual average air concentration computed for that location and representative inhalation rates. Metabolic data from ICRP 30 (Ref. 2) are used to model the distribution of radioactive material throughout the body and calculate the

dose to various organs. The dose from inhalation of radioactive material that becomes airborne from contaminated ground is calculated using resuspension factors and the deposition levels.

#### A.3.1.4 Internal Dose From Ingestion of Terrestrial Foods

A fraction of the food consumed by individuals in area of the facility is assumed to be produced within that area. The deposition of radioactive material onto edible plant materials and the uptake of deposited material from the soil into edible portions constitutes a significant exposure to man. Parameters determined to be representative of the diet and habits of the population in the vicinity of the SPC site were used in this analysis to calculate the dose from the ingestion of locally-produced terrestrial foodstuffs.

#### A.3.2 Liquid Pathway Model

The hazard associated with release of uranium to surface water is exposure to the alpha, beta, and gamma radiation produced in decay of the uranium and its daughter radionuclides. Consequently, for aqueous releases, the pathways of concern are ingestion of contaminated water, ingestion of contaminated aquatic and terrestrial foods, immersion in contaminated water, and air immersion above contaminated soil. The water and air immersion doses are generally associated with recreational activities. The GENII model develops estimates of the concentration of radionuclides in each of the environmental media involved in these pathways and utilizes user-supplied intake rates and times of exposure to estimate dose. Intake rates are those recommended by the U.S. Nuclear Regulatory Commission (NRC) in Regulatory Guide 1.109 (Ref. 4). As in the case of air releases, dose is expressed as the dose received over a 50-year period due to intake or exposure in a single year.

##### A.3.2.1 Dose From Drinking Water Ingestion

Calculation of dose resulting from ingestion of contaminated water requires estimation of concentration of the radionuclide in the water and specification of the quantity of water consumed in the base time period. The GENII model provides the ability to represent dilution both within the facility liquid effluent treatment system and in the receiving water body. The facility aqueous release to the Richland city sewer ultimately is discharged as sewage treatment plant effluent to the Columbia River. For the purposes of this assessment, the release was assumed to be fully diluted in the average flow (3000 cubic meters per second [106,000 cubic feet per second]) of the Columbia River. Concentration at the receptor is then the quotient of the release rate and river flow rate. Each exposed individual was assumed to consume 2 liters (0.5 gallons) of water per day with dose calculated as the product of concentration, consumption rate, and dose conversion factor.

### **A.3.2.2 Dose From Aquatic and Terrestrial Food Ingestion**

Aquatic and terrestrial foods become contaminated through contact with the radionuclides present in the receiving surface water. In the case of aquatic foods, GENII estimates the concentration of radionuclides in the fish, mollusks, or crustaceans as the product of water concentration and an empirical bioaccumulation factor. Dose to an individual is then the product of aquatic food concentration, intake rate, and dose conversion factor. In the case of terrestrial foods, radionuclides are incorporated into plant structure by direct exposure to irrigation water and by uptake from contaminated soil and incorporated into animal products through ingestion of contaminated water and feed. Leafy vegetables, grains, meat, poultry, and milk are the terrestrial foods considered in this assessment. Estimation of radionuclide content of crops includes consideration of contaminated water deposition rate, crop yield, groundwater uptake rates, and redistribution factors. Estimation of radionuclide content of meat, poultry, and milk includes consideration of radionuclide content of water and food crops, consumption rates, and transfer factors. Dose to an individual for the terrestrial food pathway is the product of food radionuclide concentration, consumption rate, and dose conversion factor.

### **A.3.2.3 Dose From Recreational Pathways**

Individuals may receive an external exposure through swimming or boating in contaminated water or through walking on contaminated soil or sand. The contaminated soil is assumed to be on a lake or river shoreline in contact with the contaminated surface water. Water immersion dose is the product of radionuclide concentration in the water, exposure time, and external dose conversion factor. Concentration of radionuclide in shoreline soil is estimated from empirical transfer coefficients observed in river sediments. Dose is estimated as the product of sediment radionuclide concentration, exposure time, and external dose conversion factor.

## **A.4 Radiation Doses**

Internal and external radiation doses are calculated both to the maximally exposed individual and to the surrounding population.

### **A.4.1 Internal and External Doses**

Individuals in the environs of SPC fuel fabrication plant may be exposed to both internal and external sources of ionizing radiation. Internal doses are considered "dose commitments" because long-lived nuclides such as U-234 and U-235 continue to irradiate the body for an extended period of time following an intake. Thus, a person is "committed" to receive a certain cumulative dose from a given intake. In this assessment, the dose commitment is that dose that a person receives over 50 years as a result of an intake which occurs over 1 year. Dose

commitments for each important tissue are calculated, and the products of tissue doses and ICRP 30 (Ref. 2) weighting factors are summed to give the committed effective dose equivalent.

External doses are radiation doses received by individuals from sources outside of the body. In this case, the exposure modes considered are (1) immersion of the body in a "plume" of airborne effluent containing radioactive isotopes and (2) irradiation of the body by radioactive material which has been deposited on ground surfaces. In the latter case, the dose is assessed at 1 meter (3.3 feet) above the ground surface. External doses are considered annual (as opposed to committed) doses in that the calculated dose is that which is received over a period of 1 year.

The total dose to an individual is assessed by adding the committed effective dose equivalent to the external dose to give an effective dose.

#### **A.4.2 Dose to the Maximally Exposed Individual**

The maximally exposed individual is the person who receives the highest dose from facility effluent as a consequence of his location and habits. For atmospheric releases, the maximally exposed individual is normally assumed to be the nearest resident. However in this case, prevailing winds result in a resident other than the nearest one receiving the highest calculated dose. The dose to a hypothetical resident living at the SPC site boundary nearest to the airborne effluent release point was also calculated, even though there is no residence at that location and ownership of that land by the DOE precludes establishment of any residence there in the foreseeable future. For aquatic releases of radioactive material, the maximally exposed individual is a hypothetical person living downstream from the release point whose diet and habits tend to maximize dose received by the drinking water, food, and recreational pathways.

#### **A.4.3 Dose to Surrounding Population**

For atmospheric releases, the population dose is estimated by dividing the area surrounding the site into segments and calculating the dose to a representative individual in each segment. The collective dose to the surrounding population is then estimated as the sum of the products of the effective dose to a representative individual in each segment and the number of individuals who reside in that segment. The points of reference (or "segments") are specific distances in each of 16 different compass directions (22.5 degrees each). The segments used and the population which resides within each segment are provided in Tables 3.3 and 3.4.

For aquatic releases, the dose is calculated for a representative individual living in the region downstream from the point at which the facility effluent are introduced into the Columbia River. Local estimates of the utilization of river for irrigation, drinking water, fishing, and recreation provide the basis for estimating the radiation dose to the representative individual. The population dose is then estimated by

multiplying the population in the downstream region by the estimated dose to the representative individual.

## **A.5 References for Appendix A**

1. Napier, B. A. et al., "GENII - The Hanford Environmental Radiation Dosimetry Software System," PNL-6584, Pacific Northwest Laboratory, Richland, Washington, 1988.
2. International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Pergamon Press, 1979.
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