Chapter 3 Plant Description

This chapter describes the plant design and the potential impacts of that design on the ESP site. The specific plant type to be constructed at the site has not been selected, and in its place a list of parameters describing a bounding plant design, the PPE, has been provided. The PPE is a comprehensive list of plant data developed from a variety of plant types available or proposed for the U.S. market. Section 3.1 provides details on the development of the PPE and the PPE data itself.

New units for which the site might be used, to be designated Units 3 and 4, would be located adjacent to the existing units. The site design would make the maximum use of existing permanent site support structures. Detailed information about the new units is presented in this section.

This chapter is organized into the following sections:

- External Appearance and Plant Layout (Section 3.1)
- Reactor Power Conversion System (Section 3.2)
- Plant Water Use (Section 3.3)
- Cooling System (Section 3.4)
- Radioactive Waste Management System (Section 3.5)
- Nonradioactive Waste Systems (Section 3.6)
- Power Transmission System (Section 3.7)
- Transportation of Radioactive Materials (Section 3.8)

3.1 External Appearance and Plant Layout

3.1.1 Existing Site Development

The existing NAPS site development consists of two operational pressurized water reactors (PWRs) furnished by Westinghouse, a shared turbine building, and other supporting structures. These structures include a switchyard, intake and discharge structures, and support buildings. The site is located on the shore of Lake Anna. Lake Anna is divided into the North Anna Reservoir, which serves as the source for cooling water for the existing units, and the WHTF, which receives their heated discharge. The existing units use a spray pond for an ultimate heat sink (UHS). A radioactive waste disposal system, a fuel handling system, and the auxiliaries, structures, and other onsite facilities required for a complete nuclear power station also exist on the NAPS site. The tallest existing structures on the NAPS site are each existing units' containment building, rising 157 feet, 6 inches above grade.

The NRC issued operating licenses in April 1978 and August 1980 for Units 1 and 2, respectively. Unit 1 started commercial operation in June 1978 and Unit 2 in December 1980. In April 2003, the NRC renewed the operating licenses for Units 1 and 2. A complete description of the power station is provided in the NAPS UFSAR, NRC Dockets 50-338/339. (Reference 1)

An ISFSI is also located on the NAPS site. A complete description of the ISFSI is provided in the North Anna ISFSI Safety Analysis Report, NRC Docket 72-16. (Reference 2)

The existing NAPS site development is shown in Figure 3.1-1.

With the exception of a few support buildings that may be relocated, the existing NAPS site development would remain as is.

3.1.2 Power Plant Design

No specific plant design has been chosen for the new units. Instead, a set of bounding plant parameters is presented to envelop ESP site development. This PPE is based on the addition of power generation in two distinct units, designated North Anna Units 3 and 4.

Each new unit would represent a portion of the total generation capacity to be added and may consist of one or more reactors or reactor modules. These multiple reactors or modules (the number of which may vary depending on the reactor type selected) would be grouped into distinct operating units. Each new unit would be a stand-alone plant, with its own support systems and structures. These new units would share ancillary support structures such as maintenance facilities, office centers or waste and water treatment plants. Section 3.1.3 provides a description of the PPE and describes its development.

3.1.2.1 **Module Description**

Depending on the reactor type selected, new units would be developed and constructed in a conventional style as individual large capacity reactors, or in modules, with each module being a small, self-contained reactor and power conversion unit. These modules would be grouped together around a single common support building, containing multi-unit support systems and a control area. This common support building would provide a means for controlling access to the individual modules. The individual modules would be constructed as needed, with much of the fabrication and construction work performed at a central location. The individual modules could then be easily integrated into the common support building and supporting systems.

The module sizes may vary, depending on the reactor type. Some gas-cooled reactors have a thermal output of as little as 400 MWt while other pressurized water module designs may be as large as 1000 MWt. Multiple modules would be grouped into units around the common support building to provide an economical single source of electricity.

3.1.2.2 **New Unit Description**

Not all of the reactor types are designed as modules. Some of the possible designs are conventional style plants, based on single-reactor or dual-reactor construction. These plants are designed with individual turbine buildings and reactor buildings for each unit, and some of the designs share some systems and facilities. The layout of these plants is such that the numbers of secondary structures is minimized and overall land area of the plant is controlled to the extent practical.

The unit sizes of these conventional plants also vary, with some individual units having reactor ratings of as much as 4300 MWt. The conventional style plants that are based on dual-reactor construction have individual power ratings significantly less than that stated above, and the 4300 MWt rating bounds these dual-reactor designs.

The common support buildings for both the modular and the conventional plants would be designed to integrate into the overall station design. Each support building and associated modules would be called an operating unit, with a single control room and operating staff.

An operating unit or group of modules typically has a maximum total thermal power rating of not greater than 4300 MWt, with a maximum electrical capacity of about 1500 MWe. The structure would consist of between 1 and 8 reactors or reactor modules structured around a common support building and/or conventional turbine building. The ESP site can accommodate construction and operation of various numbers of new reactors and/or modules, configured as two operating units, up to a total of 8600 MWt or 3000 MWe.

Structure height would vary depending upon the reactor design chosen. The PPE states that the highest expected structure for the power plant itself (excluding any potential cooling towers) would be approximately 234 feet above grade level. Buildings for the new facility would generally be

shorter than 234 feet, and constructed of concrete, metal with metal siding, or, in a few cases, wood with metal, vinyl, or other aesthetically acceptable siding.

Figure 3.1-2 provides an artist's conception of the ESP site, with the new units superimposed.

Cooling water for the first of the new units, Unit 3, would be provided from Lake Anna. Intake and discharge structures would be constructed near the existing Unit 1 and 2 intake and discharge structures. Unit 4 would use natural-draft or mechanical-draft cooling towers, either of which could be placed on the ESP site. Mechanical-draft towers would be fitted with drift reduction features to minimize the visual impact. Natural-draft towers would be the tallest structures on the site, at approximately 500 feet tall. Mechanical draft towers would be considerably shorter, approximately 60 feet tall.

3.1.3 **Plant Parameters Envelope**

The PPE was developed to characterize the installation of new nuclear generating units at the site without specifying a specific design. The PPE parameters were selected to provide an overall and thorough technical description of the bounding plant; that is, a combination of design parameters that, taken together, encompasses the addition of a maximum amount of generation of various reactor types.

Section 1.3 of the Site Safety Analysis Report (SSAR) includes technical data characterizing the installation of one or two new units. The values presented are for a single unit addition (where a unit may be made up of multiple modules or reactors). The ESP site can accommodate two of these units.

This PPE was developed from reviews of technical data from seven designs. These designs included five water-cooled reactors: the single-unit Westinghouse AP-1000; the dual-unit Atomic Energy Canada, Ltd., ACR-700; the single-unit General Electric ABWR; the single-unit General Electric ESBWR; and the three-unit design of the Westinghouse-led International Reactor Innovative and Secure (IRIS). Two gas-cooled reactors were also included in the reviewed designs: the four-module General Atomics Gas Turbine Modular Helium Reactor (GT-MHR) and the eight-module Pebble Bed Modular Reactor (PBMR) Pty (LTD). The PPE is not intended to be limited to these designs, but rather to provide a broad overall outline of a design concept and to include other potential designs if they can be demonstrated to fall within the parameter values provided in the PPE.

The PPE is reproduced from the SSAR beginning with Table 3.1-1.

3.1.4 **Plant Appearance**

The reactor type that would be constructed at the ESP site has not been selected, but a general description of the new units can be presented. Figure 3.1-3 shows the location where Units 3 and 4 would be installed.

The current NAPS site has two operating units with concrete containment buildings next to a steel and siding common turbine building. These are connected by a common concrete auxiliary building and a steel- and metal-sided fuel building.

The new units at the ESP site would be designed to emphasize the two-power-unit concept. The new units, along with their support structures, would be kept separate from each other and from the existing units. Each new unit would have its own control room and structure, but could share radwaste and other waste handling facilities. Paved site roadways would connect the new units to the rest of the NAPS site, providing routine and non-routine access to current and new plants with minimal disturbance of the area.

The modules and multi-unit designs would be fully integrated into the design of each new unit. Where possible, building lines would be blended to minimize the visual effect and reduce the multiple module visual images. This aesthetically pleasing visual effect would be accomplished by connecting turbine and support buildings and blending multiple containment structures together where possible. A separate control area for each unit would be used to further enhance the single unit concept. The use of common and shared support systems would reduce the number of ancillary buildings and connecting structures.

3.1.5 Site Development and Improvements

The existing capacity of Lake Anna would allow Unit 3 (up to 1500 MWe) to be cooled by the lake. Cooling capacity of the lake is discussed in Section 3.4. To extract water from the lake, new intake and discharge structures would be constructed, near the existing intake and discharge structures for the operating units. These structures would be designed to be complementary in appearance to the existing structures.

Mechanical- or natural-draft cooling towers would provide cooling for Unit 4. These towers are tall structures, with the natural-draft towers being larger. Typical natural-draft towers have a hyperbolic shape and are sized such that one or two would be required to remove the expected waste heat from Unit 4. Mechanical-draft towers are much shorter than the natural-draft towers and have a more rectangular shape. Tower height is discussed in Section 3.1.2.2. The proposed tower locations, indicated in Figure 3.1-3, are west of the proposed locations for new units.

Some plant designs require additional cooling space for safety systems, sometimes called UHS cooling. These cooling requirements are small compared to normal heat rejection requirements and are met through the use of mechanical draft towers. The area required for these towers is approximately 0.5 acres per unit (see Table 3.1-1) and the towers are no more than 60 feet high. Ample space exists near Units 3 and 4 to locate these towers.

Since the ESP site has some distinct elevation changes, use of topographical elements to shield and screen the site structures would be encouraged. The grade elevation for the new units would approximate the grade of the existing units where possible. This positioning would provide a single

station visual effect and promote a more consistent overall aesthetic view of the station. These topographical elements would also serve to reduce noise impacts on the surrounding area.

Some services and support structures that are suited to support multiple units, including the current operating plant facilities - such as office facilities, warehouse space, switchyard, and water and sewage treatment - would be at locations on the NAPS site. To the extent practical, efforts would be made to use and expand the existing facilities, including the training center, for these functions. Expansion of these facilities to support the additional generation and plant population would reduce the overall impact to the site, compared to the construction of new and separate stand-alone facilities. Figure 3.1-3 shows the integration of the new and existing units as well as site roadways and access.

After the completion of new unit construction, areas used for construction support would be landscaped and planted where appropriate to match the overall site appearance. Previously forested areas would be planted with seedlings and harsh topographical features created during construction would be contoured to match the surrounding areas. These areas include equipment laydown and module fabrication areas, areas around completed structures, and construction parking that is not required following the completion of construction.

Construction of Units 3 and 4 could occur in a single time frame (back to back) or could be separated by a significant amount of time. In the event of a time separation, efforts would be made to landscape and plant the unused portion of the site to control erosion and restore those disturbed areas to green space. The interim plantings would consist of not less than grass seeding with a mix appropriate for the area.

Section 3.1 References

1. *North Anna Power Station UFSAR*, Revision 38.

2. *North Anna ISFSI Safety Analysis Report*, Revision 3.

Figure 3.1-1 Existing North Anna Power Station Site

Figure 3.1-2 Artist's Conception of New Units Adjacent to Existing Units

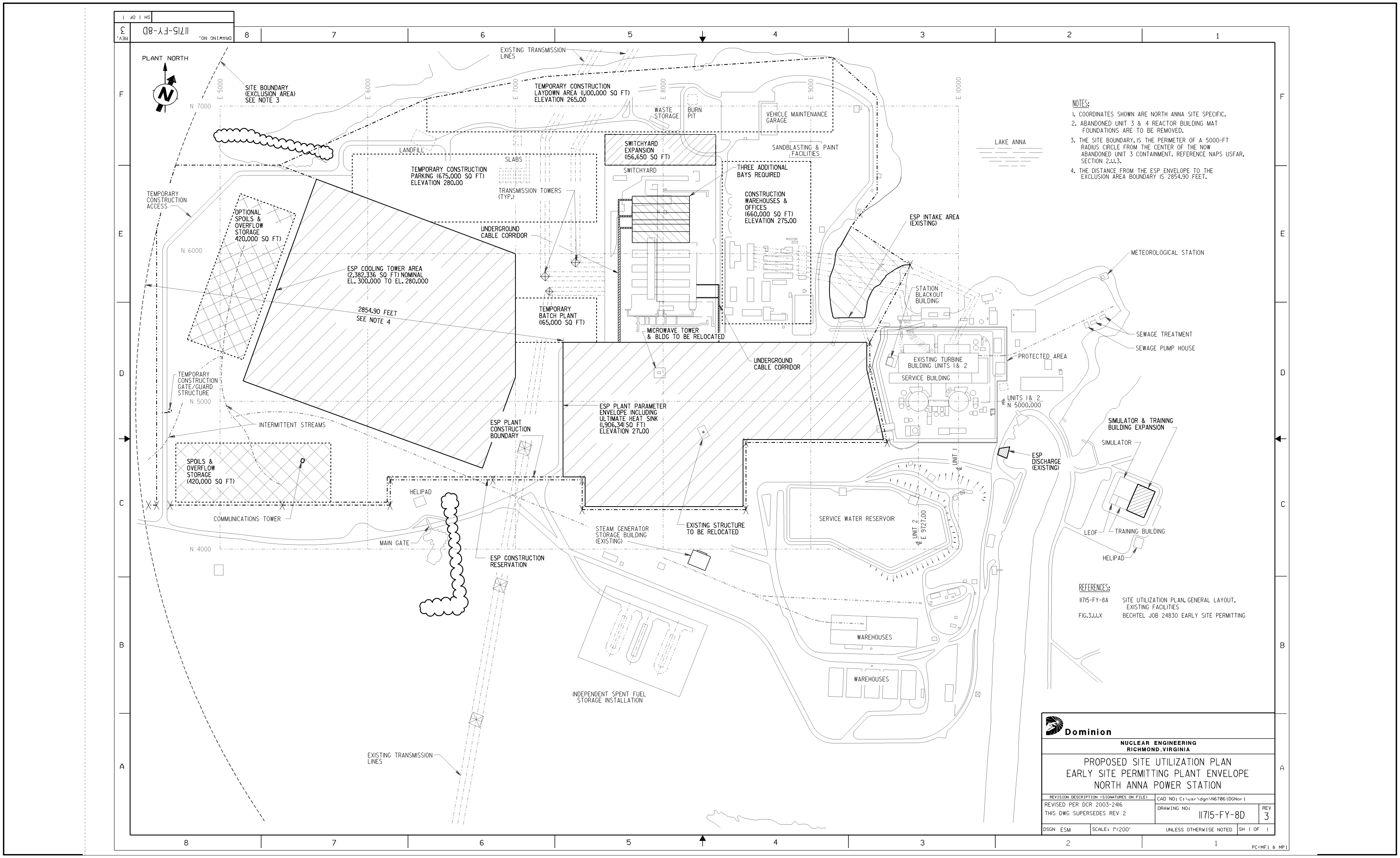


Figure 3.1-3 ESP Site Utilization Plan

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
1. Structures			c	
1.1 Building Characteristics				
1.1.1 Height	234 ft-0 in. [Same for 2nd unit/group]	1		The height from finished grade to the top of the tallest power block structure, excluding cooling towers.
1.1.2 Foundation Embedment	140 ft [Same for 2nd unit/group]	2		The depth from finished grade to the bottom of the basemat for the most deeply embedded power block structure.
1.2 Precipitation (for Roof Design)				
1.2.1 Maximum Rainfall Rate	19.4 in/hr (6.2 in/5 min) [Same for 2nd unit/group]	2, 3, 4, 5		The probable maximum precipitation (PMP) value that can be accommodated by a plant design. Expressed as maximum precipitation for 1 hour in 1 square mile with a ratio for five minutes to the 1 hour PMP of 0.32 as found in National Weather Service Publication HMR No. 52. **A site specific value is used for this parameter.**
1.2.2 Snow and Ice Load	50 lb/sq ft [Same for 2nd unit/group]	2, 3, 4		The maximum load on structure roofs due to the accumulation of snow and ice that can be accommodated by a plant design.
1.3 Safe Shutdown Earthquake (SSE)				
1.3.1 Design Response Spectra	RG 1.60 [Same for 2nd unit/group]	6		The assumed design response spectra used to establish a plant's seismic design. **A site specific value is used for this parameter.**
1.3.2 Peak Ground Acceleration	0.30g [Same for 2nd unit/group]	6		The maximum earthquake ground acceleration for which a plant is designed; this is defined as the acceleration which corresponds to the zero period in the response spectra taken in the free field at plant grade elevation. **A site specific value is used for this parameter.**
1.3.3 Time History	Envelope SSE Response Spectra [Same for 2nd unit/group]	6		The plot of earthquake ground motion as a function of time used to establish a plant's seismic design. **A site specific value is used for this parameter.**
1.3.4 Capable Tectonic Structures or Sources	No fault displacement potential within the investigative area [Same for 2nd unit/group]	1		The assumption made in a plant design about the presence of capable faults or earthquake sources in the vicinity of the plant site (e.g., no fault displacement potential within the investigative area).

Table 3.1-1 Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
1.4 Site Water Level (Allowable)					
1.4.1	Maximum Flood (or Tsunami)	1 ft below plant grade [Same for 2nd unit/group]	2, 3, 4		Design assumption regarding the difference in elevation between finished plant grade and the water level due to the probable maximum flood and probable maximum precipitation (defined in ANSI/ANS 2.8-1992) used in the plant design. **A site specific value is used for this parameter.**
1.4.2	Maximum Ground Water	1 meter below grade (i.e., 3.3 feet below grade) [Same for 2nd unit/group]	7		Design assumption regarding the difference in elevation between finished plant grade and the maximum site ground water level used in the plant design. **A site specific value is used for this parameter.**
1.5 Soil Properties Design Bases					
1.5.1	Liquefaction	None at Site-Specific SSE [Same for 2nd unit/group]	6		Design assumption regarding the presence of potentially liquefying soils at a site (e.g., none at Site-Specific SSE). **A site specific value is used for this parameter.**
1.5.2	Minimum Bearing Capacity (Static)	15 ksf [Same for 2nd unit/group]	2, 3		Design assumption regarding the capacity of the competent load-bearing layer required to support the loads exerted by plant structures used in the plant design. **A site specific value is used for this parameter.**
1.5.3	Minimum Shear Wave Velocity	≥3,500 fps [Same for 2nd unit/group.]	1		The assumed limiting propagation velocity of shear waves through the foundation materials used in the plant design. **A site specific value is used for this parameter.**
1.6 Tornado (Design Bases)					
1.6.1	Maximum Pressure Drop	2.0 psi [Same for 2nd unit/group]	6		The design assumption for the decrease in ambient pressure from normal atmospheric pressure due to the passage of the tornado. **A site specific value is used for this parameter.**
1.6.2	Maximum Rotational Speed	240 mph [Same for 2nd unit/group]	6		The design assumption for the component of tornado wind speed due to the rotation within the tornado. **A site specific value is used for this parameter.**
1.6.3	Maximum Translational Speed	60 mph [Same for 2nd unit/group]	6		The design assumption for the component of tornado wind speed due to the movement of the tornado over the ground. **A site specific value is used for this parameter.**

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
1.6.4 Maximum Wind Speed	300 MPH [Same for 2nd unit/group]	6		The design assumption for the sum of maximum rotational and maximum translational wind speed components. **A site specific value is used for this parameter.**
1.6.5 Missile Spectra	Spectrum II from NUREG-0800 SRP Section 3.5.1.4 [Same for 2nd unit/group]	4, 8		The design assumptions regarding missiles that could be ejected either horizontally or vertically from a tornado. The spectra identify mass, dimensions and velocity of credible missiles.
1.6.6 Radius of Maximum Rotational Speed	150 ft [Same for 2nd unit/group]	6		The design assumption for distance from the center of the tornado at which the maximum rotational wind speed occurs.
1.6.7 Rate of Pressure Drop	1.2 psi/sec [Same for 2nd unit/group]	6		The assumed design rate at which the pressure drops due to the passage of the tornado. **A site specific value is used for this parameter.**
1.7 Wind				
1.7.1 Basic Wind Speed	110 mph [Same for 2nd unit/group]	2, 3, 4		The design wind, or “fastest mile of wind” with a 100-year return period (NUREG-0800, Sections 2.3.1 and 3.3.1) for which the facility is designed. **A site specific value is used for this parameter.**
1.7.2 Importance Factors	1.0 (non-safety related)/ 1.11 (safety related) [Same for 2nd unit/group]	2, 3		Multiplication factors (as defined in ANSI A58.1-1982) applied to basic wind speed to develop the plant design. **A site specific value is used for this parameter.**
2. Normal Plant Heat Sink				
2.1 Ambient Air Requirements				
2.1.1 Normal Shutdown Max Ambient Temp (1% Exceed)	100°F db / 77°F wb coincident [Same for 2nd unit/group]	6		Assumption used for the maximum ambient temperature that will be exceeded no more than 1% of the time, to design plant systems capable of effecting normal shutdown under the assumed temperature condition.
2.1.2 Normal Shutdown Max Wet Bulb Temp (1% Exceed)	80°F wb non-coincident [Same for 2nd unit/group]	6		Assumption used for the maximum wet bulb temperature that will be exceeded no more than 1% of the time – used in design of plant systems that must be capable of effecting normal shutdown under the assumed temperature condition.

Table 3.1-1 Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
2.1.3	Normal Shutdown Min Ambient Temp (1% Exceed)	-10°F [Same for 2nd unit/group]	6		Assumption used for the minimum ambient temperature that will be exceeded no more than 1% of the time to design of plant systems that must be capable of effecting normal shutdown under the assumed temperature condition.
2.1.4	Rx Thermal Power Max Ambient Temp (0% Exceed)	115°F db/80°F wb coincident [Same for 2nd unit/group]	6		Assumption used for the maximum ambient temperature that will never be exceeded – used in design of plant systems that must be capable of supporting full power operation under the assumed temperature condition.
2.1.5	Rx Thermal Power Max Wet Bulb Temp (0% Exceed)	81°F wb non-coincident [Same for 2nd unit/group]	6		Assumption used for the maximum wet bulb temperature that will never be exceeded – used in design of plant systems that must be capable of supporting full power operation under the assumed temperature condition.
2.1.6	Rx Thermal Power Min Ambient Temp (0% Exceed)	-40°F [Same for 2nd unit/group]	6		Assumption used for the minimum ambient temperature that will never be exceeded – used in design of plant systems that must be capable of supporting full power operation under the assumed temperature condition.
2.2 Condenser					
2.2.1	Max Inlet Temp Condenser/ Heat Exchanger	91°F [Same for 2nd unit/group.]	1, 7		Design assumption for the maximum acceptable circulating water temperature at the inlet to the condenser or cooling water system heat exchangers. **A site specific value is used for this parameter.**
2.2.2	Condenser / Heat Exchanger Duty	9.7 E9 btu/hr [Additional 9.7 E9 btu/hr for 2nd unit/group]	3, 5		Design value for the waste heat rejected to the circulating water system across the condensers.
2.3 Mechanical Draft Cooling Towers				d	
2.3.1	Acreage	50 acres [100 acres]	3, 5	e	The land required for cooling towers or ponds, including support facilities such as equipment sheds, basins, canals, or shoreline buffer areas. **A site specific value is used for this parameter.**
2.3.2	Approach Temperature	10°F [Same for 2nd unit/group]	1, 4, 7		The difference between the cold water temperature and the ambient wet bulb temperature. **A site specific value is used for this parameter.**

Table 3.1-1 Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
2.3.3	Blowdown Constituents and Concentrations	See Table 3.1-3 [Twice that shown in table]		f	The maximum expected concentrations for anticipated constituents in the cooling water systems blowdown to the receiving water body. **A site specific value is used for this parameter.**
2.3.4	Blowdown Flow Rate	6400 gpm expected (24,500 gpm max) [12,800 gpm expected (49,000 gpm max)]	1, 5	g	The normal (and maximum) flow rate of the blowdown stream from the cooling water systems to the receiving water body for closed system designs. **A site specific value is used for this parameter.**
2.3.5	Blowdown Temperature	100°F [Same for 2nd unit/group]	1, 2, 3, 4, 5	g	The maximum expected blowdown temperature at the point of discharge to the receiving water body.
2.3.6	Cycles of Concentration	4 [Same for 2nd unit/group]	6	f	The ratio of total dissolved solids in the cooling water blowdown streams to the total dissolved solids in the makeup water streams. **A site specific value is used for this parameter.**
2.3.7	Evaporation Rate	17,550 gpm expected (19,500 gpm max) [35,100 gpm expected (39,000 gpm max)]	3	h	The expected (and maximum) rate at which water is lost by evaporation from the cooling water systems. **A site specific value is used for this parameter.**
2.3.8	Height	60 ft [Same for 2nd unit/group]	1, 3, 4, 5, 7	c	The vertical height above finished grade of either natural draft or mechanical draft cooling towers associated with the cooling water systems.
2.3.9	Makeup Flow Rate	23,950 gpm expected (44,000 gpm max) [47,900 gpm expected (88,000 gpm max)]	9	g	The expected (and maximum) rate of removal of water from a natural source to replace water losses from closed cooling water system. **A site specific value is used for this parameter.**
2.3.10	Noise	55 dba at 1000 ft [Same for 2nd unit/group]	6	i	The maximum expected sound level produced by operation of cooling towers, measured at 1000 feet from the noise source.
2.3.11	Cooling Tower Temperature Range	23°F [Same for 2nd unit/group]	7		The temperature difference between the cooling water entering and leaving the towers or ponds. **A site specific value is used for this parameter.**
2.3.12	Cooling Water Flow Rate	800,000 gpm [1,600,000 gpm]	5		The total cooling water flow rate through the condenser/heat exchangers.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
2.3.13 Heat Rejection Rate (Blowdown)	6,400 gpm expected (19,500 gpm max) @100°F [12,800 gpm expected (39,000 gpm max)]	3, 5		The expected heat rejection rate to a receiving water body, expressed as flow rate in gallons per minute at a temperature in degrees Fahrenheit. **A site specific value is used for this parameter.**
2.3.14 Maximum Consumption of Raw Water	30,000 gpm [60,000 gpm]	1		The expected maximum short-term consumptive use of water by the cooling water systems (evaporation and drift losses).
2.3.15 Monthly Average Consumption of Raw Water	23,000 gpm [46,000 gpm]	10		The expected normal operating consumption of water by the cooling water systems (evaporation and drift losses). **A site specific value is used for this parameter.**
2.3.16 Stored Water Volume	11,800,000 gal [23,600,000 gal]	5		The quantity of water stored in cooling water system impoundments, basins, tanks and/or ponds.
2.4 Natural Draft Cooling Towers			d	
2.4.1 Acreage	34.5 acres [69 acres]	7	e	The land required for cooling towers or ponds, including support facilities such as equipment sheds, basins, canals, or shoreline buffer areas. **A site specific value is used for this parameter.**
2.4.2 Approach Temperature	10°F [Same for 2nd unit/group.]	1, 4, 7		The difference between the cold water temperature and the ambient wet bulb temperature. **A site specific value is used for this parameter.**
2.4.3 Blowdown Constituents and Concentrations	See Table 3.1-3 [Twice that shown in table]		f	The maximum expected concentrations for anticipated constituents in the cooling water systems blowdown to the receiving water body. **A site specific value is used for this parameter.**
2.4.4 Blowdown Flow Rate	6,400 gpm expected (24,500 gpm max) [12,800 gpm expected (49,000 gpm max)]	1, 5	g	The normal (and maximum) flow rate of the blowdown stream from the cooling water systems to the receiving water body for closed system designs. **A site specific value is used for this parameter.**
2.4.5 Blowdown Temperature	100°F [Same for 2nd unit/group]	1, 3, 4, 5	g	The maximum expected blowdown temperature at the point of discharge to the receiving water body.

Table 3.1-1 Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
2.4.6	Cycles of Concentration	4 [Same for 2nd unit/group]	1, 3, 4, 5, 7	f	The ratio of total dissolved solids in the cooling water blowdown streams to the total dissolved solids in the makeup water streams. **A site specific value is used for this parameter.**
2.4.7	Evaporation Rate	17,550 gpm expected (19,500 gpm max) [35,100 gpm expected (39,000 gpm max)]	3	h	The expected (and maximum) rate at which water is lost by evaporation from the cooling water systems. **A site specific value is used for this parameter.**
2.4.8	Height	550 ft [Same for 2nd unit/group]	3, 5, 7	j	The vertical height above finished grade of either natural draft or mechanical draft cooling towers associated with the cooling water systems.
2.4.9	Makeup Flow Rate	23,950 gpm expected (44,000 gpm max) [47,900 gpm expected (88,000 gpm max)]	9	g	The expected (and maximum) rate of removal of water from a natural source to replace water losses from closed cooling water systems. **A site specific value is used for this parameter.**
2.4.10	Noise	55 dba at 1000 ft [Same for 2nd unit/group]	1, 3, 4, 5, 7	i	The maximum expected sound level produced by operation of cooling towers, measured at 1000 feet from the noise source.
2.4.11	Cooling Tower Temperature Range	23°F [Same for 2nd unit/group]	7		The temperature difference between the cooling water entering and leaving the towers or ponds. **A site specific value is used for this parameter.**
2.4.12	Cooling Water Flow Rate	800,000 gpm [1,600,000 gpm]	5		The total cooling water flow rate through the condenser/heat exchangers.
2.4.13	Heat Rejection Rate (Blowdown)	6,400 gpm expected (19,500 gpm max) @ 100°F [12,800 gpm expected (39,000 gpm max) @ 100°F	3, 5		The expected heat rejection rate to a receiving water body, expressed as flow rate in gallons per minute at a temperature in degrees Fahrenheit.
2.4.14	Maximum Consumption of Raw Water	33,720 gpm [67,440 gpm]	4		The expected maximum short-term consumptive use of water by the cooling water systems (evaporation and drift losses).

Table 3.1-1 Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
2.4.15	Monthly Average Consumption of Raw Water	23,000 gpm [46,000 gpm]	10		The expected normal operating consumption of water by the cooling water systems (evaporation and drift losses).
2.4.16	Stored Water Volume	11,800,000 gal [23,600,000 gal]	5		The quantity of water stored in cooling water system impoundments, basins, tanks and/or ponds.
2.5 Once-Through Cooling				d	
2.5.1	Cooling Water Discharge Temperature	127°F [Same for 2nd unit/group.]	2	g	Expected temperature of the cooling water at the exit of the condenser/heat exchangers. **A site specific value is used for this parameter.**
2.5.2	Cooling Water Flow Rate	1,140,000 gpm [2,280,000 gpm]	5	g	Total cooling water flow rate through the condenser (also the rate of withdrawal from and return to the water source).
2.5.3	Cooling Water Temperature Rise	18°F [Same for 2nd unit/group.]	1, 3, 5	g	Temperature rise across the condenser (temperature of water out minus temperature of water in).
2.5.4	Evaporation Rate	10,550 gpm expected (11,700 gpm max) [21,100 gpm expected (23,400 gpm max)]	3	h	The expected (and maximum) rate at which water is lost by evaporation from the receiving water body as a result of heating in the condenser. **A site specific value is used for this parameter.**
2.5.5	Heat Rejection Rate	9.7 E9 Btu/hr [19.4 E9 Btu/hr]	3, 5		The expected heat rejection rate to a receiving water body.
3. Ultimate Heat Sink				k	
3.1 Ambient Air Requirements					
3.1.1	Maximum Ambient Temp (0% Exceedance)	115°F db/80°F wb coincident [Same for 2nd unit/group]	2, 3, 5, 7		Assumption used for the maximum ambient temperature in designing the UHS system to provide heat rejection for 30 days under the assumed temperature condition.

Table 3.1-1 Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
3.1.2	Maximum Wet Bulb Temp (0% Exceedance)	81°F wb (non-coincident) [Same for 2nd unit/group]	2, 3, 5, 7		Assumption used for the maximum wet bulb temperature in designing the UHS system to provide heat rejection for 30 days under the assumed temperature condition.
3.1.3	Minimum Ambient Temp (0% Exceedance)	-40°F [Same for 2nd unit/group]	2, 3, 5, 7		Assumption used for the minimum ambient temperature in designing the UHS system to provide heat rejection for 30 days under the assumed temperature condition.
3.2 CCW Heat Exchanger					
3.2.1	Maximum Inlet Temp to CCW Heat Exchanger	95°F [Same for 2nd unit/group]	3, 5, 7		The maximum temperature of safety-related service water at the inlet of the UHS component cooling water heat exchanger.
3.2.2	CCW Heat Exchanger Duty	420 E6 Btu/hr (shutdown) [Additional 420 E6 Btu/hr (shutdown) for 2nd unit]	3		The heat transferred to the safety-related service water system for rejection to the environment in UHS heat removal devices.
3.3 Mech Draft Cooling Towers					
3.3.1	Acreage	0.5 acre [1.0 acre]	3, 5	k	The land required for UHS cooling towers or ponds, including support facilities such as equipment sheds, basins, canals, or shoreline buffer areas.
3.3.2	Approach Temperature	15°F [Same for 2nd unit/group]	3, 5		The difference between the cold water temperature and the ambient wet bulb temperature.
3.3.3	Blowdown Constituents and Concentrations	See Table 3.1-3 [Twice that shown in table]		k	The maximum expected concentrations for anticipated constituents in the UHS blowdown to the receiving water body.
3.3.4	Blowdown Flow Rate	144 gpm expected (850 gpm max) [288 gpm expected (1700 gpm max)]	3, 7	k	The normal (and maximum) flow rate of the blowdown stream from the UHS system to receiving water body for closed system designs.
3.3.5	Blowdown Temperature	95°F [Same for 2nd unit/group]	3, 5	k	The maximum expected UHS blowdown temperature at the point of discharge to the receiving water body.
3.3.6	Cycles of Concentration	4 (2 Minimum) [Same for 2nd unit/group]	3, 5, 7	k	The ratio of total dissolved solids in the UHS system blowdown streams to the total dissolved solids in the makeup water streams.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
3.3.7 Evaporation Rate	411 gpm normal 850 gpm shutdown [822 gpm normal 1700 gpm shutdown]	3, 7	k	The expected (and maximum) rate at which water is lost by evaporation from the UHS system.
3.3.8 Height	60 ft [Same for 2nd unit/group]	3, 5, 7	k	The vertical height above finished grade of mechanical draft cooling towers associated with the UHS system.
3.3.9 Makeup Flow Rate	555 gpm 1700 gpm max [1,110 gpm, 3,400 gpm max]	3, 7, 9	k	The expected (and maximum) rate of removal of water from a natural source to replace water losses from the UHS system
3.3.10 Noise	55 dba at 1000 ft [Same for 2nd unit/group]	2, 3, 5, 7	k	The maximum expected sound level produced by operation of mechanical draft UHS cooling towers, measured at 1000 feet from the noise source.
3.3.11 Cooling Tower Temperature Range	16°F [Same for 2nd unit/group]	5		The temperature difference between the cooling water entering and leaving the UHS system.
3.3.12 Cooling Water Flow Rate	26,125 gpm (normal) 52,250 gpm (shutdown/ accident) [52,250 gpm (normal), 104,500 (shutdown/ accident)]	3		The total cooling water flow rate through the UHS system.
3.3.13 Heat Rejection Rate (Blowdown)	100 gpm expected (850 gpm max) @ 95°F [200 gpm expected (1,700 gpm max) @ 95°F]	3		The expected heat rejection rate to a receiving water body, expressed as flow rate in gallons per minute at a temperature in degrees Fahrenheit.
3.3.14 Maximum Consumption of Raw Water	900 gpm [1800 gpm]	7		The expected maximum short-term consumptive use of water by the UHS system (evaporation and drift losses).

Table 3.1-1 Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
3.3.15	Monthly Average Consumption of Raw Water	533 gpm [1066 gpm]	10		The expected normal operating consumption of water by the UHS system (evaporation and drift losses).
3.3.16	Stored Water Volume	30,600,000 gal [61,200,000 gal]	3		The quantity of water stored in UHS impoundments, basins, tanks and/or ponds.
4. Containment Heat Removal System (Post-Accident)					
4.1 Ambient Air Requirements					
4.1.1	Maximum Ambient Air Temperature (0% Exceedance)	115°F db/80°F wb coincident [Same for 2nd unit/group]	1, 7		Assumed maximum ambient temperature used in designing the containment heat removal system.
4.1.2	Minimum Ambient Temperature (0% Exceedance)	-40°F [Same for 2nd unit/group]	1, 7		Assumed minimum ambient temperature used in designing the containment heat removal system.
5. Potable Water/Sanitary Waste System					
5.1 Discharge to Site Water Bodies					
5.1.1	Flow Rate	60 gpm expected (105 gpm max) [120 gpm expected (210 gpm max)]	7	I	The expected (and maximum) effluent flow rate from the potable and sanitary waste water systems to the receiving water body.
5.2 Raw Water Requirements					
5.2.1	Maximum Use	120 gpm [240 gpm]	5	I	The maximum short-term rate of withdrawal from the water source for the potable and sanitary waste water systems.
5.2.2	Monthly Average Use	90 gpm [180 gpm]	5	I	The average rate of withdrawal from the water source for the potable and sanitary waste water systems.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
6. Demineralized Water System				
6.1 Discharge to Site Water Bodies				
6.1.1 Flow Rate	110 gpm expected (150 gpm max) [220 gpm expected (300 gpm max)]	5, 7	I	The expected (and maximum) effluent flow rate from the demineralized system to the receiving water body.
6.2 Raw Water Requirements				
6.2.1 Maximum Use	720 gpm [1440 gpm]	5	I	The maximum short-term rate of withdrawal from the water source for the demineralized water system.
6.2.2 Monthly Average Use	550 gpm [1100 gpm]	5	I	The average rate of withdrawal from the water source for the demineralized water system.
7. Fire Protection System				
7.1 Raw Water Requirements				
7.1.1 Maximum Use	2,500 gpm [5,000 gpm]	11	I	The maximum short-term rate of withdrawal from the water source for the fire protection water system.
7.1.2 Monthly Average Use	675,000 gal/mo [1,350,000 gal/mo]	7	I	The average rate of withdrawal from the water source for the fire protection water system.
7.1.3 Stored Water Volume	2,325,000 gallons [4,650,000 gallons]	7		The quantity of water stored in fire protection system impoundments, basins or tanks.
8. Miscellaneous Drain				
8.1 Discharge to Site Water Bodies				
8.1.1 Flow Rate	100 gpm expected (150 gpm max) [200 gpm expected (300 gpm max)]	3, 7	I	The expected (and maximum) effluent flow rate from miscellaneous drains to the receiving water body.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
9. Unit Vent/Airborne Effluent Release Point				
9.1 Atmospheric Dispersion (CHI/Q) (Accident)				The atmospheric dispersion coefficients used in the design safety analysis to estimate dose consequences of accident airborne releases.
9.1.1 0-2 hr @EAB	0.61 E-3 sec/m^3 [Same for 2nd unit/group]	1		**A site specific value is used for this parameter.**
9.1.2 0-8 hr @LPZ	1.30 E-4 sec/m^3 [Same for 2nd unit/group]	5		**A site specific value is used for this parameter.**
9.1.3 8-24 hr @LPZ	1.0 E-4 sec/m^3 [Same for 2nd unit/group]	1, 5		**A site specific value is used for this parameter.**
9.1.4 1-4 day @LPZ	4.18 E-5 sec/m^3 [Same for 2nd unit/group]	3		**A site specific value is used for this parameter.**
9.1.5 4-30 day @LPZ	9.24 E-6 sec/m^3 [Same for 2nd unit/group]	3		**A site specific value is used for this parameter.**
9.2 Atmospheric Dispersion (χ/Q) (Annual Average)	1.17 E-6 sec/m^3 [Same for 2nd unit/group]	3		The atmospheric dispersion coefficients used in the safety analysis for the dose consequences of normal airborne releases. **A site specific value is used for this parameter.**
9.3 Dose Consequences			m	
9.3.1 Normal	10 CFR 20, 10 CFR 50 App I [Same for 2nd unit/group]	6		The estimated design radiological dose consequences due to gaseous releases from normal operation of the plant.
9.3.2 Post-Accident	10 CFR 20, 10 CFR 50 APP I, 10 CFR 100 [Same for 2nd unit/group]	1, 3, 4, 5, 7		The estimated design radiological dose consequences due to gaseous releases from postulated accidents.
9.3.3 Severe Accidents	25 rem wb in 24 hr 0.5 mi <1E-6/rx-yr [Same for 2nd unit/group]	1, 3, 7		

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
9.4 Release Point			n	
9.4.1 Configuration (Horiz vs. Vert)	Horizontal	2		The orientation of the release point discharge flow.
9.4.2 Elevation (Normal)	95.5 ft [Same for 2nd unit/group]	2		The elevation above finished grade of the release point for routine operational releases.
9.4.3 Elevation (Post Accident)	Ground level [Same for 2nd unit/group]	1, 2, 3, 5, 7		The elevation above finished grade of the release point for accident sequence releases.
9.4.4 Minimum Distance to Site Boundary	0.5 mi exclusion area [Same for 2nd unit/group]	1, 3, 7		The minimum lateral distance from the release point to the site boundary.
9.4.5 Temperature	No value bounds, overall range is 35-120°F [Same for 2nd unit/group]			The temperature of the airborne effluent stream at the release point.
9.4.6 Volumetric Flow Rate	118,000 scfm for 2 units (normal operation) [for 2 units]	5		The volumetric flow rate of the airborne effluent stream at the release point.
9.5 Source Term			o	
9.5.1 Gaseous (Normal)	13,070 Ci/yr [26,140 CI/yr] See Table 3.1-8 for isotopic breakdown	12		The annual activity, by isotope, contained in routine plant airborne effluent streams.
9.5.2 Gaseous (Post-Accident)	See Chap 15 Tables RG 1.70 [Same for 2nd unit/group]	1, 3	p	The activity, by isotope, contained in post-accident airborne effluents.
9.5.3 Tritium	3530 ci/yr [7060 ci/yr]	5		The annual activity of tritium contained in routine plant airborne effluent streams.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
10. Liquid Radwaste System				
10.1 Dose Consequences			q	
10.1.1 Normal	10 CFR 50, Appendix I, 10 CFR 20	1, 3, 4, 5		The estimated design radiological dose consequences due to liquid effluent releases from normal operation of the plant.
10.1.2 Post-Accident	10 CFR 20, 10 CFR 100 [Same for 2nd unit/group]	1, 3, 4, 5		The estimated design radiological dose consequences due to liquid effluent releases from postulated accidents.
10.2 Release Point			r	
10.2.1 Flow Rate	100 gpm + 10,000 gpm dilution [200 gpm + 20,000 gpm dilution]	3		The discharge (including minimum dilution flow, if any) of liquid potentially radioactive effluent streams from plant systems to the receiving water body.
10.3 Source Term			s	
10.3.1 Liquid	0.313 ci/yr [0.626 ci/yr] See Table 3.1-7 for isotopic breakdown	13		The annual activity, by isotope, contained in routine plant liquid effluent streams.
10.3.2 Tritium	3100 ci/yr [6200 ci/yr]	5		The annual activity of tritium contained in routine plant liquid effluent streams.
11. Solid Radwaste System			t	
11.1 Acreage				
11.1.1 Low Level Radwaste Storage	2 years in radwaste building @ expected generation rate [Same for 2nd unit/group]	1		The land usage required to provide onsite storage of low level radioactive wastes.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
11.2 Solid Radwaste				
11.2.1 Activity	2700 ci/yr [5400 ci/yr]	3		The annual activity contained in solid radioactive wastes generated during routine plant operations.
11.2.2 Volume	9041 cu ft/yr [18,646 cu ft/yr]	4		The expected volume of solid radioactive wastes generated during routine plant operations.
12. Auxiliary Boiler System				
12.1 Exhaust Elevation	110 ft above plant grade [Same for 2nd unit/group]	5	u	The height above finished plant grade at which the flue gas effluents are released to the environment.
12.2 Flue Gas Effluents	See Table 3.1-4 [Twice that shown in table]		u	The expected combustion products and anticipated quantities released to the environment due to operation of the auxiliary boilers, diesel engines and gas turbines.
12.3 Fuel Type	No. 2 [Same for 2nd unit/group]	1, 3, 5, 7	u	The type of fuel oil required for proper operation of the auxiliary boilers, diesel engines and gas turbines.
12.4 Heat Input Rate (btu/hr)	156,000,000 Btu/hr [312,000,000 Btu/hr]	1		The average heat input rate due to the periodic operation of the auxiliary boilers.
13. Heating, Ventilation and Air Conditioning System				
13.1 Ambient Air Requirements				
13.1.1 Non-safety HVAC max ambient temp (1% Exceed)	100°F db/77°F wb coincident [Same for 2nd unit/group]	6		Assumption used for the maximum ambient temperature that will be exceeded no more than 1% of the time, to design the non-safety HVAC systems.
13.1.2 Non-safety HVAC min ambient temp (1% Exceed)	-10°F [Same for 2nd unit/group]	6		Assumption used for the minimum ambient temperature that will be exceeded no more than 1% of the time, to design the non-safety HVAC systems.
13.1.3 Safety HVAC max ambient temp (0% Exceed)	115°F db/80°F wb coincident [Same for 2nd unit/group]	1, 3, 5, 7		Assumption used for the maximum ambient temperature that will never be exceeded, to design the safety-related HVAC systems.

Table 3.1-1 Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
13.1.4	Safety HVAC min ambient temp (0% Exceed)	-40°F [Same for 2nd unit/group]	1, 3, 5, 7		Assumption used for the minimum ambient temperature that will never be exceeded, to design the safety-related HVAC systems.
13.1.5	Vent System max ambient temp (5% Exceed)	95°F dry bulb/ 77°F wb coincident), 79°F wb (non-coincident) [Same for 2nd unit/group]	3, 5		Assumption used for the maximum ambient temperature that will be exceeded no more than 5% of the time to design the non-HVAC ventilation systems.
13.1.6	Vent System min ambient temp (5% Exceed)	- 5°F [Same for 2nd unit/group]	3		Assumption used for the minimum ambient temperature that will be exceeded no more than 5% of the time to design the non-HVAC ventilation systems.
14. Onsite/Offsite Electrical Power System					
14.1 Acreage					
14.1.1	Switchyard	15 acres [30 acres]	7	e	The land usage required for the high voltage switchyard used to connect the plant to the transmission grid.
15. Standby Power System					
15.1 Diesels					
15.1.1	Diesel Capacity	4 x 6500 kw [8 x 6500 kw]	5		The capacity of diesel engines used for generation of standby electrical power.
15.1.2	Diesel Exhaust Elevation	30 ft [Same for 2nd unit/group]	4	u	The elevation above finished grade of the release point for standby diesel exhaust releases.
15.1.3	Diesel Flue Gas Effluents	See Table 3.1-5 [Twice that shown in table]		u	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby diesel generators.
15.1.4	Diesel Noise	55 dba at 1000 ft [Same for 2nd unit/group.]	1, 3, 4, 5, 7	i	The maximum expected sound level produced by operation of diesel engines turbines, measured at 1000 feet from the noise source.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
15.1.5 Diesel Fuel Type	No. 2 per ASTM D975-1974 [Same for 2nd unit/group]	1, 3, 4, 5, 7		The type of fuel oil required for proper operation of the diesel engines.
15.2 Gas Turbines				
15.2.1 Gas Turbine Capacity (kw)	20 MWe at limiting site conditions [40 MWe at limiting site conditions]	3		The capacity of gas turbines used for generation of standby electrical power.
15.2.2 Gas Turbine Exhaust Elevation	60 ft [Same for 2nd unit/group]	3	u	The elevation above finished grade of the release point for standby gas turbine exhaust releases.
15.2.3 Gas Turbine Flue Gas Effluents	See Table 3.1-6 [Twice that shown in table]		u	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby gas-turbine generators.
15.2.4 Gas Turbine Noise	55 dba at 1000 ft [Same for 2nd unit/group]	2, 3	i	The maximum expected sound level produced by operation of gas turbines, measured at 1000 feet from the noise source.
15.2.5 Gas Turbine Fuel Type	Distillate [Same for 2nd unit/group]	2, 3	u	The type of fuel oil required for proper operation of the gas turbines.
16. Plant Characteristics				
16.1 Access Routes				
16.1.1 Heavy Haul Routes	7 acres [Same for 2nd unit/group]	3, 7	e	The land usage required for permanent heavy haul routes to support normal operations and refueling.
16.1.2 Spent Fuel Cask Weight	150 tons [Same for 2nd unit/group]	3	v	The weight of the heaviest expected shipment during normal plant operations and refueling.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
16.2 Acreage	87 acres [174 acres]	2	w	The land area required to provide space for plant facilities. **A site specific value is used for this parameter.**
16.2.1 Office Facilities	1.8 acres [2.18 acre (95,200 sq ft)]	2		**A site specific value is used for this parameter.**
16.2.2 Parking Lots	3.86 acres [7.72 acres]	3		**A site specific value is used for this parameter.**
16.2.3 Permanent Support Facilities	12 acres [8.4 acres]	2		**A site specific value is used for this parameter.**
16.2.4 Power Block	11.64 acres [23.3 acres]	7		**A site specific value is used for this parameter.**
16.2.5 Protected Area	40 acres [80 acres]	7		**A site specific value is used for this parameter.**
16.3 Megawatts Thermal	4300 MWt [8600 MWt.]	3		The thermal power generated by one unit (may be the total of several modules).
16.4 Plant Design Life	60 years [Same for 2nd unit/group]	1, 2, 3, 5, 7	x	The operational life for which the plant is designed.
16.5 Plant Population				
16.5.1 Operation	580 people [1160 people]	5	x	The number of people required to operate and maintain the plant. **A site specific value is used for this parameter.**
16.5.2 Refueling / Major Maintenance	1000 people [Same for 2nd unit/group]	1	x	The additional number **A site specific value is used for this parameter.**of temporary staff required to conduct refueling and major maintenance activities.
16.6 Station Capacity Factor	96% [Same for 2nd unit/group]	2		The percentage of time that a plant is capable of providing power to the grid.

Table 3.1-1 Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
17. Construction				
17.1 Access Routes				
17.1.1 Construction Module Dimensions	90' (H) x 82' (W) x 93' (L) or 130' (Dia) x 51' (H) [Same for 2nd unit/group]	1, 7	v	The maximum expected length, width, and height of the largest construction modules or components and delivery vehicles to be transported to the site during construction.
17.1.2 Heaviest Construction Shipment	2,200,00 lb. [Same for 2nd unit/group]	2	v	The maximum expected weight of the heaviest construction shipment to the site.
17.2 Acreage				The land area required to provide space for construction support facilities.
17.2.1 Laydown Area	29 acres [58 acres]	3	e	**A site specific value is used for this parameter.**
17.2.2 Temporary Construction Facilities	52 acres [104 acres]	3	e	**A site specific value is used for this parameter.**
17.3 Construction				
17.3.1 Noise	76-101 db @ 50 ft [Same for 2nd unit/group]	1, 3, 4, 5, 7	i	The maximum expected sound level due to construction activities, measured at 50 feet from the noise source.
17.4 Plant Population				
17.4.1 Construction	3150 people max [5,355 for unit simultaneous construction]	3, 14	x	Peak employment during plant construction. **A site specific value is used for this parameter.**
17.5 Site Preparation Duration	18 months [Same for 2nd unit/group]	1, 3, 7	x	Length of time required to prepare the site for construction.

Comments:

a. PPE values should be based on plant designs being considered. The Bounding PPE values provide an envelope (most restrictive values selected) for the ABWR, ESBWR, AP1000, IRIS, GT-MHR, PBMR and ACR-700 designs. A composite PPE should be used for the actual set of plant designs under consideration for the site.

b. The values in brackets reflects the values corresponding to a plant that is twice the vendor's specified standard size plant, i.e., two ABWR units, two ESBWR units, two AP1000 units, six IRIS units, two sets of four GT-MHR modules, two sets of eight PBMR modules and two ACR-700 twin unit plants.
c. Visual resources impacts.
d. Applicants must identify main condenser cooling system alternatives (e.g., mechanical or natural draft cooling towers, cooling ponds, or once-through cooling). To maintain multiple options, the most restrictive value for each cooling system PPE section should be used in the ESP application (e.g., 550-foot cooling tower height selected if both mechanical and natural draft towers are being considered).
e. Construction impacts on ecological resources.
f. Operational impacts on water quality and ecological resources.
g. Operational impacts on water quality and ecological resources. An NPDES permit must be obtained for this blowdown rate, blowdown temperature, withdrawal rate or temperature rise.
h. Operational impacts on water quality and local climatology.
i. Noise impacts.
j. Visual impacts.
k. Impacts of the main condenser cooling system will usually bound impacts from operation of the Ultimate Heat Sink.
l. Operational impacts on water quality and aquatic ecological resources.
m. Values listed for Section 9.3 are regulatory standards for effluent concentrations, doses from routine operations, and doses from postulated accidents. The applicant must demonstrate that the plant is capable of meeting these standards considering the plant design and, for the dose standards, dilution and dispersion conditions at the site.
n. Release point characteristics (Section 9.4.1 - Section 9.4.6) are used to calculate atmospheric dispersion factors used: S - In the Site SAR to demonstrate compliance with requirements listed in Section 9.3, and, E - In the ER to estimate impacts from routine and accident-scenario atmospheric releases.
o. Source term data (Section 9.5.1 -Section 9.5.3) are used to calculate dose consequences used: S - In the Site SAR to demonstrate compliance with requirements listed in Section 9.3, and, E - In the ER to estimate impacts from routine and accident-scenario atmospheric releases.
p. See Section 9.5. Tables in Chapter 15 of RG 1.70 list the design and accident sequence parameters necessary to derive these source terms. Applicants must obtain calculated release values from the vendor/A-E for designs under consideration.
q. Values listed for Section 10.1 are regulatory standards for effluent concentrations, doses from routine operations, and doses from postulated accidents. The applicant must demonstrate that the plant is capable of meeting these standards considering the plant design and, for the dose standards, dilution and dispersion conditions at the site.
r. Flow rate and dilution characteristics (Section 10.2) are used to calculate dilution factors used: S - In the Site SAR to demonstrate compliance with requirements listed in Section 10.1, and, E - In the ER to estimate impacts from liquid effluents.
s. Liquid discharge data (Section 10.3.1 - Section 10.3.2) are used to calculate dose consequences used: S - In the Site SAR to demonstrate compliance with requirements listed in Section 10.1, and, E - In the ER to estimate impacts from liquid effluents.
t. Environmental effects of the uranium fuel cycle, including solid waste management, are set forth in Table S-3 of 10 CFR 51.20. Reference to this Table is made in the applicant's ER.
u. Operational impacts of non-radiological atmospheric emissions.
v. Transport requirements for component delivery.
w. Total acreage footprint for site facilities is used to estimate construction impacts on ecological resources.
x. Socio-economic impacts of plant construction and operation.

Table 3.1-2 Bounding Value Notes for Table 3.1-1

1. Bounding value from AP1000 criteria.
2. Bounding value from GT-MHR criteria.
3. Bounding value from ABWR/ESBWR criteria.
4. Bounding value from PBMR criteria.
5. Bounding value from ACR-700 criteria.
6. Bounding value common for the seven designs.
7. Bounding value from IRIS criteria.
8. The Spectrum A missiles were for plants that used the November 24, 1975 version of the SRP; for all plants since, the Spectrum I or II of the July 1981 version of the SRP was to be used.
9. The bounding Makeup Flow Rate is a calculated value based on the sum of the bounding Evaporation rate plus the bounding Blowdown Flow Rate.
10. The bounding value for the Monthly Average Consumption of Raw Water is a calculated value based on the maximum bounding makeup flow rate times the bounding capacity factor (PPE Section 16.6).
11. Bounding value from ESBWR criteria.
12. The Gaseous (Normal) source term bounding value is the sum of the bounding values of the yearly released activity for each nuclide type for each reactor (ABWR, AP1000, ACR-700). These were the only reactor types with adequate information available. See Table 3.1-8.
13. The liquid waste source term bounding value is the sum of the bounding values of the yearly released activity for each nuclide type for each reactor (ABWR, AP1000, ACR-700). These were the only reactor types with adequate information available. The PBMR value was not supported by isotopic data and was not used in the evaluation. See Table 3.1-7.
14. Two-unit simultaneous construction staffing is based on 170% of single unit build. This assumes optimum timing between units and is based on rough estimates by Bechtel. Refined information will be contingent upon type of plant built, and plant location.

Table 3.1-3 Blowdown Constituents and Concentrations[a]

Constituent	Bounding Value Concentration (ppm)[b]			
	River Source	Well/ Treated Water	Envelope	Notes
Chlorine demand	10.1	--	10.1	c , d , e
Free available chlorine	0.5	--	0.5	f
Chromium	--	--	--	
Copper	--	6	6	f
Iron	0.9	3.5	3.5	f
Zinc	--	0.6	0.6	f
Phosphate	--	7.2	7.2	c, d, e
Sulfate	599	3500	3500	f
Oil and grease	--	--	--	
Total dissolved solids	--	17,000	--	c, d, e
Total suspended solids	49.5	150	150	f
BOD, 5-day	--	--	--	

a. See PPE Section 2.3.3, 2.4.3, and 3.3.3.
b. Assumed cycles of concentration equals 4.
c. Bounding value from ABWR/ESBWR criteria.
d. Bounding value from AP1000 criteria.
e. Bounding value from PBMR criteria.
f. Bounding value common for the seven designs.

Table 3.1-4 Yearly Emissions Auxiliary Boilers[a]

	Bounding Value	
Pollutant Discharged[b]	Quantity (lb.)	Notes
Particulates	9,900	c
Sulfur oxides	31,703	d
Carbon monoxide	1749	d
Hydrocarbons	50,100	e
Nitrogen oxides	19,022	d

a. See PPE Section 12.2.
b. Emissions are based on 30 days/yr operation for each of the generators.
c. Bounding value from ABWR/ESBWR criteria.
d. Bounding value from ACR-700 criteria.
e. Bounding value from AP1000 criteria.

Table 3.1-5 Yearly Emissions From Standby Diesel Generators[a]

	Bounding Value	
Pollutant Discharged[b]	Quantity (lb.)	Notes
Particulates	<1,230	c
Sulfur oxides	4,608	d
Carbon monoxide	4,600	e
Hydrocarbons	3,070	e
Nitrogen oxides	28,968	d

a. See PPE Section 15.1.
b. Emissions are based on 4 hrs/month operation for each of the generators.
c. Bounding value from IRIS criteria.
d. Bounding value from ABWR/ESBWR criteria.
e. Bounding value from ACR-700 criteria.

Table 3.1-6 Standby Power System Gas Turbine Flue Gas Effluents[a]

Fuel: Distillate 20°F Ambient
9,890 BTU/kWH (LHV)
10,480 BTU/KWH (HHV)

Bounding Value		
Fuel Consumption Rate	**121,200 lb/hr [b]**	
Effluent	**Quantity[c] (lb.)**	**Notes**
NO_X (PPMVD @15% O_2)	42	d
NO_x as NO_2	2016	d
CO (PPMVD)	31	d
CO	912	d
UHC (PPMVD)	3	d
UHC	48	d
VOC	10	b
SO_2	1882	d
$S0_3$	30	b
Sulfur Mist	50	b
Particulates	22	b
Exhaust Analysis	**% Vol**	
Argon	0.87	d
Nitrogen	72.56	b
Oxygen	12.52	d
Carbon Dioxide	5.19	b
Water	9.87	b

a. See PPE Section 15.2.
b. Bounding value from GT-MHR criteria.
c. Emissions are based on 4 hrs/month operation for each of the generators.
d. Bounding value from ABWR criteria.

Table 3.1-7 Radionuclides in Annual Normal Liquid Releases (ci/yr)[a]

Corrosion and Activation Products	Bounding Value	Notes	Fission Products	Bounding Value	Notes	Fission Products	Bounding Value	Notes	Fission Products	Bounding Value	Notes
C-14	0.000440	b	Br-84	0.00002	d	Rh-103m	0.00493	d	Cs-136	0.00063	d
Na-24	0.00281	c	Rb-88	0.00027	d	Ru-106	0.07352	d	Cs-137	0.01332	d
P-32	0.00018	c	Rb-89	0.0000441	c	Rh-106	0.07352	d	Ba-137m	0.01245	d
Cr-51	0.00770	c	Sr-89	0.00011	c	Ag-110m	0.00105	d	Cs-138	0.00019	c
Mn-54	0.0026	c	Sr-90	0.0000351	c	Ag-110	0.00014	d	Ba-140	0.00552	d
Fe-55	0.00581	c	Y-90	0.0000031	c	Sb-124	0.000679	b	La-140	0.00743	d
Mn-56	0.00381	c	Sr-91	0.0009	c	Te-129m	0.00012	d	Ce-141	0.00012	c
Co-56	0.00519	c	Y-91	0.00011	c	Te-129	0.00015	d	Ce-143	0.00019	d
Co-57	0.0000719	c	Y-91m	0.00001	d	Te-131m	0.00009	d	Pr-143	0.00013	d
Fe-59	0.00020	d	Sr-92	0.0008	c	Te-131	0.00003	d	Ce-144	0.00316	d
Co-58	0.00336	d	Y-92	0.0006	c	I-131	0.01413	d	Pr-144	0.00316	d
Co-60	0.00911	c	Y-93	0.0009	c	Te-132	0.00024	d	All others	0.00002	d
Ni-63	0.00014	c	Zr-95	0.00104	b	I-132	0.0026	c	**Total** (except tritium)	0.313	
Cu-64	0.00751	c	Nb-95	0.00191	b	I-133	0.01	c			
Zn-65	0.00041	d	Mo-99	0.000830	c	I-134	0.0017	c	**Tritium release**	3100	b
W-187	0.00013	d	Tc-99m	0.0008	c	Cs-134	0.00993	d			
Np-239	0.00311	c	Ru-103	0.00493	d	I-135	0.00751	c			

a. See PPE Section 10.3.
b. Bounding Value from twin ACR-700 criteria.
c. Bounding Value from design certified ABWR.
d. Bounding Value from AP1000 criteria.

Table 3.1-8 Radionuclides in Annual Normal Gaseous Releases (ci/yr)[a]

Radionuclide	Bounding Value	Notes	Radionuclide	Bounding Value	Notes	Radionuclide	Bounding Value	Notes	Radionuclide	Bounding Value	Notes
Noble Gases			**Iodines**			Cu-64	1.00E-02	c	Ag-110m	2.00E-06	c
Ar-41	3.03E+02	b	I-131	2.59E-01	c	Zn-65	1.11E-02	c	Sb-124	1.81E-04	c
Kr-83m	8.38E-04	c	I-132	2.19E+00	c	Rb-89	4.32E-05	c	Sb-125	6.1E-05	d
Kr-85m	3.6E+01	d	I-133	1.70E+00	c	Sr-89	5.68E-03	c	Te-129m	2.19E-04	c
Kr-85	4.1E+03	d	I-134	3.78E+00	c	Sr-90	1.2E-03	d	Te-131m	7.57E-05	c
Kr-87	2.51E+01	c	I-135	2.41E+00	c	Y-90	4.59E-05	c	Te-132	1.89E-05	c
Kr-88	4.6E+01	d	Others			Sr-91	1.00E-03	c	Cs-134	6.22E-03	c
Kr-89	2.41E+02	c	C-14	9.19E+00	c	Sr-92	7.84E-04	c	Cs-136	5.95E-04	c
Kr-90	3.24E-04	c	Na-24	4.05E-03	c	Y-91	2.41E-04	c	Cs-137	9.46E-03	c
Xe-131m	1.8E+03	d	P-32	9.19E-04	c	Y-92	6.22E-04	c	Cs-138	1.70E-04	c
Xe-133m	8.7E+01	d	Cr-51	3.51E-02	c	Y-93	1.11E-03	c	Ba-140	2.70E-02	c
Xe-133	4.6E+03	d	Mn-54	5.41E-03	c	Zr-95	1.59E-03	c	La-140	1.81E-03	c
Xe-135m	4.05E+02	c	Mn-56	3.51E-03	c	Nb-95	8.38E-03	c	Ce-141	9.19E-03	c
Xe-135	4.59E+02	c	Fe-55	6.49E-03	c	Mo-99	5.95E-02	c	Ce-144	1.89E-05	c
Xe-137	5.14E+02	c	Co-57	8.2E-06	d	Tc-99m	2.97E-04	c	Pr-144	1.89E-05	c
Xe-138	4.32E+02	c	Co-58	2.3E-02	d	Ru-103	3.51E-03	c	W-187	1.89E-04	c
Xe-139	4.05E-04	c	Co-60	1.30E-02	c	Rh-103m	1.11E-04	c	Np-239	1.19E-02	c
			Fe-59	8.11E-04	c	Ru-106	7.8E-05	d	**Total**	1.307E+04	
			Ni-63	6.49E-06	c	Rh-106	1.89E-05	c			

a. See Table 1 Section 9.5.1.
b. Bounding Value from twin ACR700 criteria.
c. Bounding Value from ABWR criteria.
d. Bounding Value from AP1000 criteria.

3.2 Reactor Power Conversion System

For the ESP site, the selection of the reactor and power conversion system has not been made. In its place, a detailed PPE was developed to describe the maximum potential impacts. This PPE is included as Table 3.1-1. The site has a potential development of up to 3000 MWe (gross), which would be achieved with two power blocks to be called Units 3 and 4. Each unit could consist of several reactors or modules, perhaps as many as eight, depending on the reactor technology selected.

3.2.1 Reactor Description

The ESP site has been designed to allow incremental addition of new units. Figure 3.1-3 shows the location for new units. This location, west-southwest of the existing units, is sized to allow construction of two new units.

Each unit would consist of a maximum 4300 MWt, 1500 MWe (gross) reactor(s) and associated turbines and power conversion equipment. Plant and site equipment would require approximately 30–65 MWe, resulting in an approximate maximum net 1435–1470 MWe output.

All of the proposed reactors use uranium as their fissile material. Enrichment of the uranium would vary based on the reactor type deployed, ranging from 2 percent enriched U-235 to 19.9 percent enriched U-235. Discharged fuel burn-up is based on the specific plant design but would be in the range of 20,500 to 133,000 megawatt-days per metric ton of uranium (MWd/MTU).

Fuel design and total quantity of uranium is specific to the reactor design selected. The larger, single-unit-type plants could contain as much as 157 MTU. Smaller modular units would contain considerably less, depending on their size.

3.2.2 Engineered Safety Features

Depending on the plant type selected, a wide range of engineered safety systems could be used. Potential plant designs for the ESP site currently employ both active and passive types of engineered safety features (ESF) systems. Active systems rely on active components, such as pumps, to move coolant to the needed locations, while passive systems use gravity and thermal convection to attain the same result. Active systems are typically powered by redundant power sources, such as an emergency diesel generator or a gas turbine. The passive system designs are based on using gravity to move water, and valves are typically actuated by safety-related dc power sources.

Some designs rely on an UHS to remove heat from safety-related systems and discharge it to the atmosphere. If required for the reactor design selected, the UHS cooling would be by small mechanical draft cooling towers. The towers would require no more than half an acre per unit.

3.2.3 Power Conversion Systems

The type of power conversion system used would depend upon the type of reactor deployed. The gas-cooled reactor uses a gas turbine system to convert the heat energy to mechanical energy, while the water-cooled reactor uses a steam turbine for the same purpose. Waste heat from Unit 3 would be rejected from either turbine type to the WHTF and from Unit 4 to cooling towers. The tube material for the condenser or turbine exhaust cooling heat exchangers (depending on reactor type) has not been selected.

Section 3.2 References

None

3.3 Plant Water Use

Since no specific design has been selected for the ESP site, plant water use is defined in broad terms, using as a basis the PPE information from Section 3.1.3. This PPE describes a bounding plant design that is intended to accommodate current and future plants. This PPE outlines the water consumption requirements for the bounding plant and is based on representative plant designs that would result in the highest water consumption values.

Plant cooling for the first new unit at the ESP site would use Lake Anna. The second unit would use either mechanical draft or natural draft cooling towers. Cooling tower makeup water necessary to replace the water lost to evaporation would be obtained from the North Anna Reservoir and supplemented, as necessary, from an outside source. Plant water sources would come from two sources – Lake Anna and local wells – depending on the quantity and quality of makeup water required.

3.3.1 **Water Consumption**

Two new units at the ESP site would require the use of additional water for both plant cooling and internal consumption. Unit 3 would use the North Anna Reservoir as the source of cooling water. Unit 4 would use a cooling tower (or towers), either of natural draft or mechanical draft type with makeup from the North Anna Reservoir and supplemented, as necessary, from an external source. The lake would also be used as a source of operating water supply for the fire protection system and the plant demineralized water supply for both units. Potable water supplies would be drawn from groundwater wells. The data listed in Table 3.3-1 and Table 3.3-2 reflect this arrangement.

Hydrological impacts of this arrangement are provided in Section 5.2.1 and water use impacts are provided in Section 5.2.2.

Figure 3.3-1 through Figure 3.3-3 outline the water use for the new units. As stated earlier (Section 3.3), the water balance for the new units is based on data from the PPE. Evaporation estimates for cooling Unit 3 circulating water and the Unit 4 circulating water cooling tower water use are based on site-specific data (see Section 5.2.1 and Section 5.2.2). Any future development would be bounded by the information in this table.

3.3.1.1 **Plant Water Use**

The total water use for new units for which the ESP site may be used is shown in tabular form in Table 3.3-1 and Table 3.3-2. This includes makeup water for the circulating water cooling tower(s), water supply for the potable water system, water supply for the demineralized water system, and the fire protection system requirements. As indicated in the tables, water use for the site would depend on the number of units constructed. The normal values listed are expected limiting values for normal plant operation. The maximum values are those expected for upset or abnormal conditions. Figure 3.3-3 is typical for both new units and illustrates water requirements for the potable water systems, demineralized water supplied systems and the fire protection system. It

should be noted that fire protection water consumption maximums are based on system actuation, which is an event-based activity. Normal water consumption is that required to maintain system availability. Figure 3.3-1 and Figure 3.3-2 illustrate water use for the cooling systems of Units 3 and 4, respectively.

3.3.1.2 Plant Water Releases

The water release estimates for the new units are provided in Table 3.3-1 and Table 3.3-2 as well as in Figure 3.3-1, Figure 3.3-2, and Figure 3.3-3. These estimates include evaporation and blowdown from both the circulating water cooling towers (where needed) and the UHS cooling towers (if needed). The radiological waste, sanitary waste, miscellaneous drains, and demineralizer discharges are also included. The normal values listed are the expected limiting values for normal plant operation. The maximum values are those expected for upset or abnormal conditions.

The release location for the new units would be in the same vicinity as the existing units. Site drainage points would remain largely in place. The majority of the release points are to the discharge canal or the WHTF. There may be some releases to the North Anna Reservoir, depending on service or plant location. Specific release points and quantities would be determined once the plant design has been finalized, and described in the COL application.

3.3.2 Water Treatment

There are several water treatment systems that are used in the existing units' operations. Similarly designed water systems for the new units would exercise similar treatment technologies and methods for generating or replenishing the necessary water supplies. The expected water treatment systems are described in the following subsections.

3.3.2.1 Raw Water

Raw water from the North Anna Reservoir would be the supply for once-through cooling through the Unit 3 condenser and service water loads. This supply would receive no treatment. Raw water from the North Anna Reservoir that could be used to provide makeup for various station secondary systems, however, would require treatment.

Cooling tower makeup water for Unit 4 would be from the North Anna Reservoir and supplemented, as necessary, from an outside source. Any makeup water necessary for cooling tower(s), including the towers supporting Unit 4, would need treatment for biofouling, scaling, and suspended matter, with acceptable biocides, antiscalants, and dispersants, respectively.

3.3.2.2 Makeup Water

Makeup water from the North Anna Reservoir would be treated systematically and thoroughly with a process that includes ultra-filtration, reverse osmosis (RO), and electro-deionization, which results in highly purified water for various plant systems. In the final stages of the purification process, the

treated water passes through ion exchange beds and is then de-oxygenated by gaseous hydrogen passing over a catalytic bed (palladium) (Reference 1). Once purified, the makeup water would most likely to be directed to the following water supplies:

- Condensate
- Primary
- Closed cooling (for various subsystems)

3.3.2.3 **Condensate System**

Treated condensate water would serve as a source of feedwater. Condensate water would also provide component cooling for the removal of residual heat from primary systems during the shutdown mode and recirculates air cooling water from a chilled water subsystem. With the existing units, component cooling water is treated by the chemical addition of chromates for corrosion inhibition and pH control. For the new units, the use of an alternative to chromates (such as molybdate) would be evaluated for treatment and environmental benefit. Chilled water could need additional treatment depending on piping materials.

3.3.2.4 **Domestic Water System**

The domestic water system provides a safe and approved potable water supply (Reference 1). For the new units, the domestic water system would consist of supply from ground water wells, a storage facility, pressure maintenance equipment, and a distribution system. Water treatment would be provided through filtration and disinfection as needed.

Section 3.3 References

1. Updated Final Safety Analysis Report, Revision 38, North Anna Power Station.

Table 3.3-1 Unit 3 Water Consumption

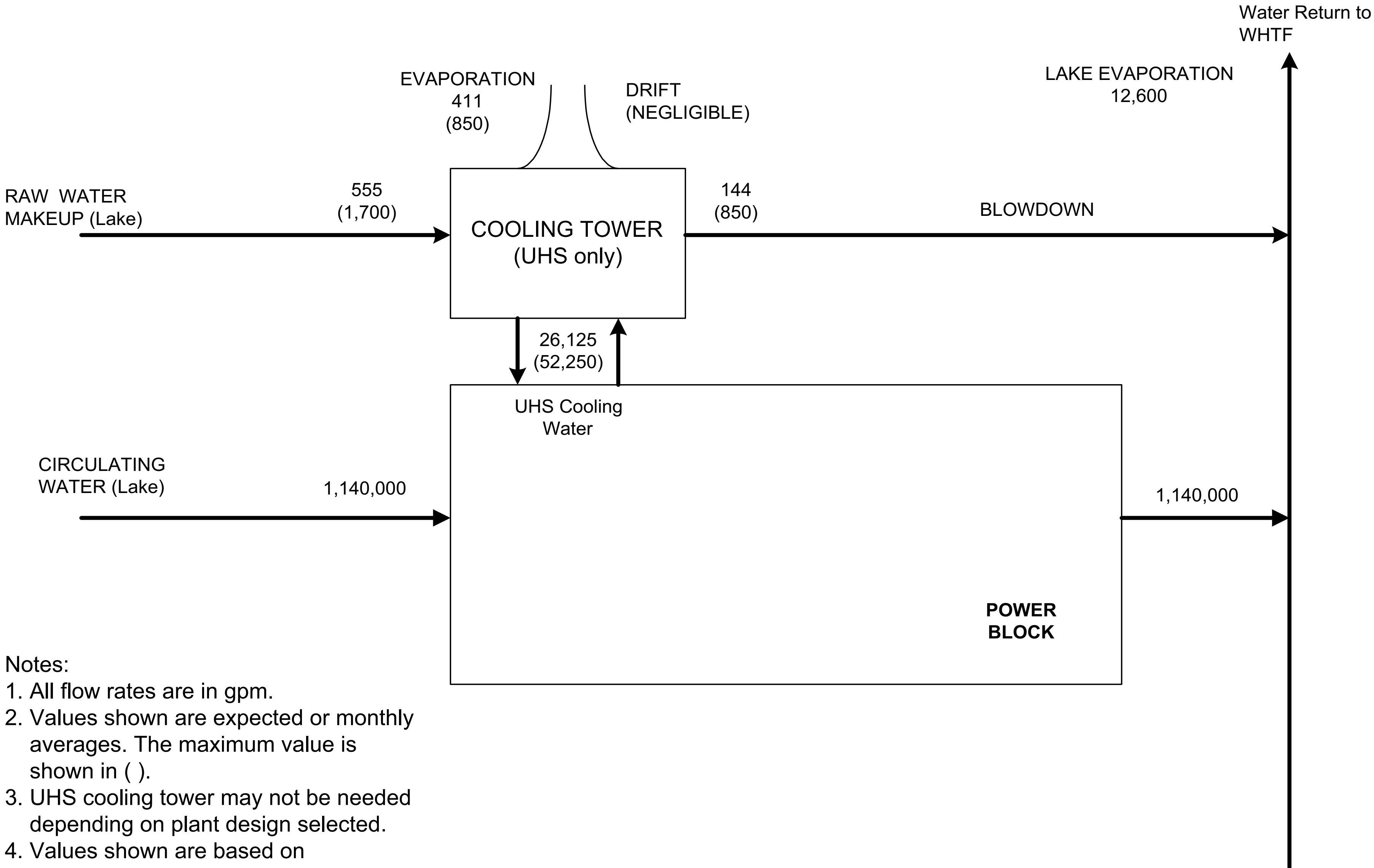
Service	Normal (gpm/cfs)[a]	Maximum (gpm/cfs)[a]	Reference (PPE Section)[b]
Water Supplies			
UHS Cooling Tower Makeup (Lake Water)	555/1.24	1700/3.79	3.3.9
Potable Water Supply (Groundwater)	90/0.2	120/0.27	5.2.1 and 5.2.2
Demin Water Supply (Lake Water)	550/1.23	720/1.60	6.2.1 and 6.2.2
Fire Protection Water Supply (Lake Water)	15/0.03	2500/5.57	7.1.1 and 7.1.2
Water Releases			
Evaporation Rate[c]			
Lake Anna[d]	12,600/28	--	See ER Section 5.2.2
UHS Tower	411/0.92	850/1.89	3.3.7
Blowdown[e] (UHS Tower)	144/0.32	850/1.89	3.3.4
Sanitary Waste Discharge	60/0.13	105/0.23	5.1.1
Rad Waste Discharge	100/0.22	--	10.2.1
Misc. Drains Discharge	100/0.22	150/0.33	8.1.1
Demin Water Discharge	110/0.25	150/0.33	6.1.1
Cooling Water Flows			
Circulating Water	1,140,000/2540	--	2.5.2
UHS Cooling Tower	26,125/58.2	52,250/116	3.3.12

a. Flow rates were converted from gpm to cfs.
b. Reference refers to the line entry on the PPE, Table 3.1-1.
c. The evaporation rate corresponds to the increased evaporation from Lake Anna (which includes the WHTF and the reservoir) based on the added heat load from Unit 3. The evaporation from the UHS cooling tower(s) is listed separately.
d. This is a site-specific value and is not based on the PPE Table.
e. This value includes blowdown from the UHS cooling tower(s) only.

Table 3.3-2 Unit 4 Water Consumption

Service	Normal (gpm/cfs)[a]	Maximum (gpm/cfs)[a]	Reference (PPE Section)[b]
Water Supplies			
Cooling Tower Makeup[c]			
UHS Towers	555/1.24	1700/3.79	3.3.9
CW Towers	19,600/43.7	31,418/70	See note [d]
Potable Water Supply (Raw Water)	90/0.2	120/0.27	5.2.1 and 5.2.2
Demin Water Supply (Raw Water)	550/1.23	720/1.60	6.2.1 and 6.2.2
Fire Protection Water Supply (Raw Water)	15/0.03	2500/5.57	7.1.1 and 7.1.2
Water Releases			
Evaporation Rate[e]			
UHS Tower	411/0.92	850/1.89	3.3.7
CW Towers[f]	15,650/34.9	—	See ER Section 5.2.1
Blowdown[g]			
UHS Tower	144/0.32	850/1.89	3.3.4
CW Towers[f]	3950/8.8	15,709/35	See ER Section 5.2.1
Sanitary Waste Discharge	60/0.13	105/0.23	5.1.1
Rad Waste Discharge	100/0.22		10.2.1
Misc. Drains Discharge	100/0.22	150/0.33	8.1.1
Demin Water Discharge	110/0.25	150/0.33	6.1.1
Cooling Water Flows			
Circulating Water	800,000/1782	—	2.3.12
UHS Cooling Tower	26,125/58.2	52,250/116	3.3.12

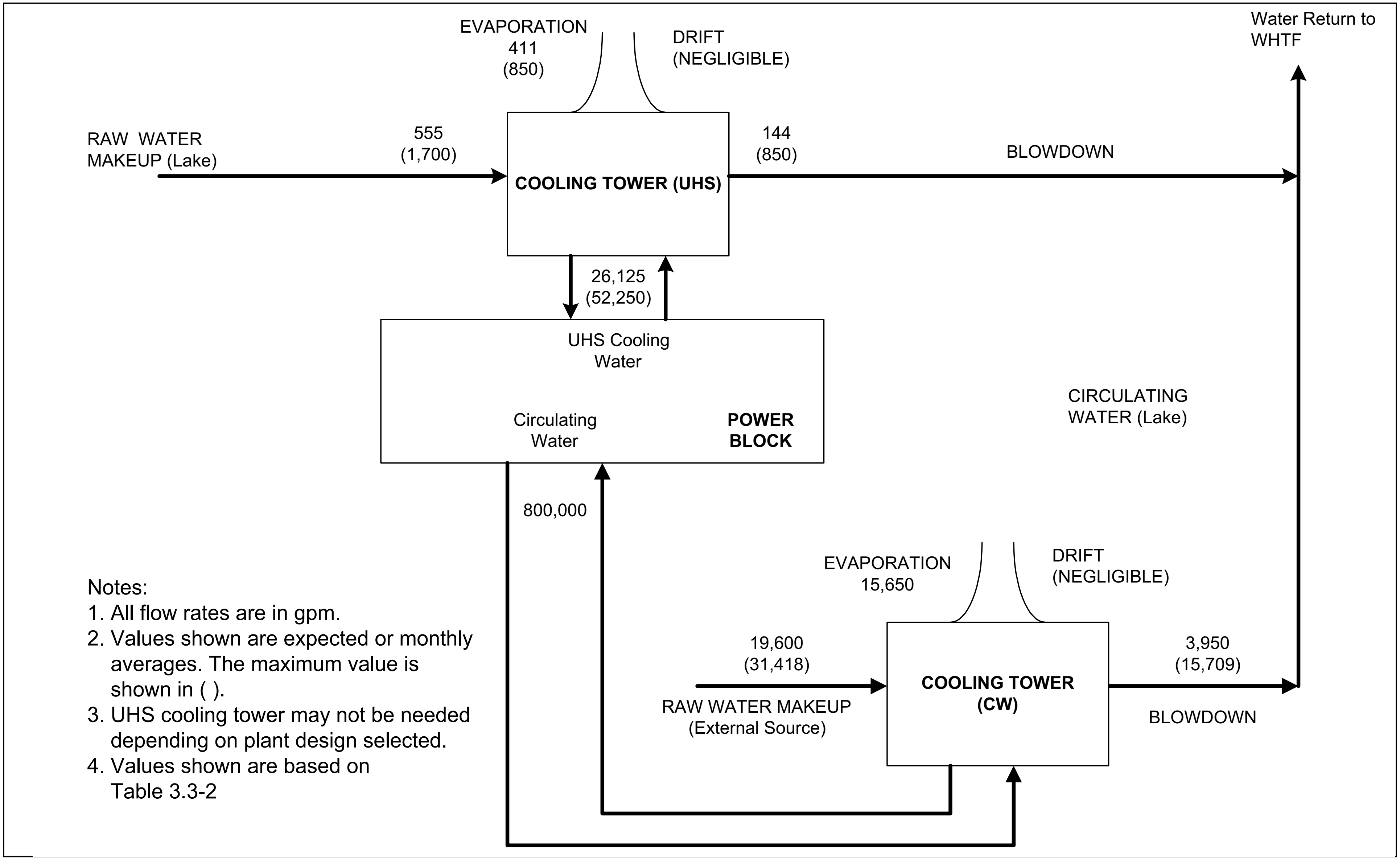
a. Flow rates were converted from gpm to cfs.
b. Reference refers to the line entry on the PPE, Table 3.1-1.
c. Makeup source to the CW cooling towers for Unit 4 would be from the North Anna Reservoir and supplemented, as necessary, from an external source. The UHS tower makeup would be from the North Anna Reservoir.
d. This value is the sum of the site-specific evaporation rate and blowdown rate for the CW Cooling Towers listed in this table.
e. This is the evaporation rate for the circulating water cooling tower(s) and the UHS cooling tower(s).
f. This is a site-specific value and is not based on the PPE table.
g. This value includes blowdown from the circulating water cooling towers and UHS cooling tower(s).



Notes:

1. All flow rates are in gpm.
2. Values shown are expected or monthly averages. The maximum value is shown in ( ).
3. UHS cooling tower may not be needed depending on plant design selected.
4. Values shown are based on Table 3.3-1

Figure 3.3-1 Unit 3 Cooling Water Use



Notes:
1. All flow rates are in gpm.
2. Values shown are expected or monthly averages. The maximum value is shown in ( ).
3. UHS cooling tower may not be needed depending on plant design selected.
4. Values shown are based on Table 3.3-2

Figure 3.3-2 Unit 4 Cooling Water Use

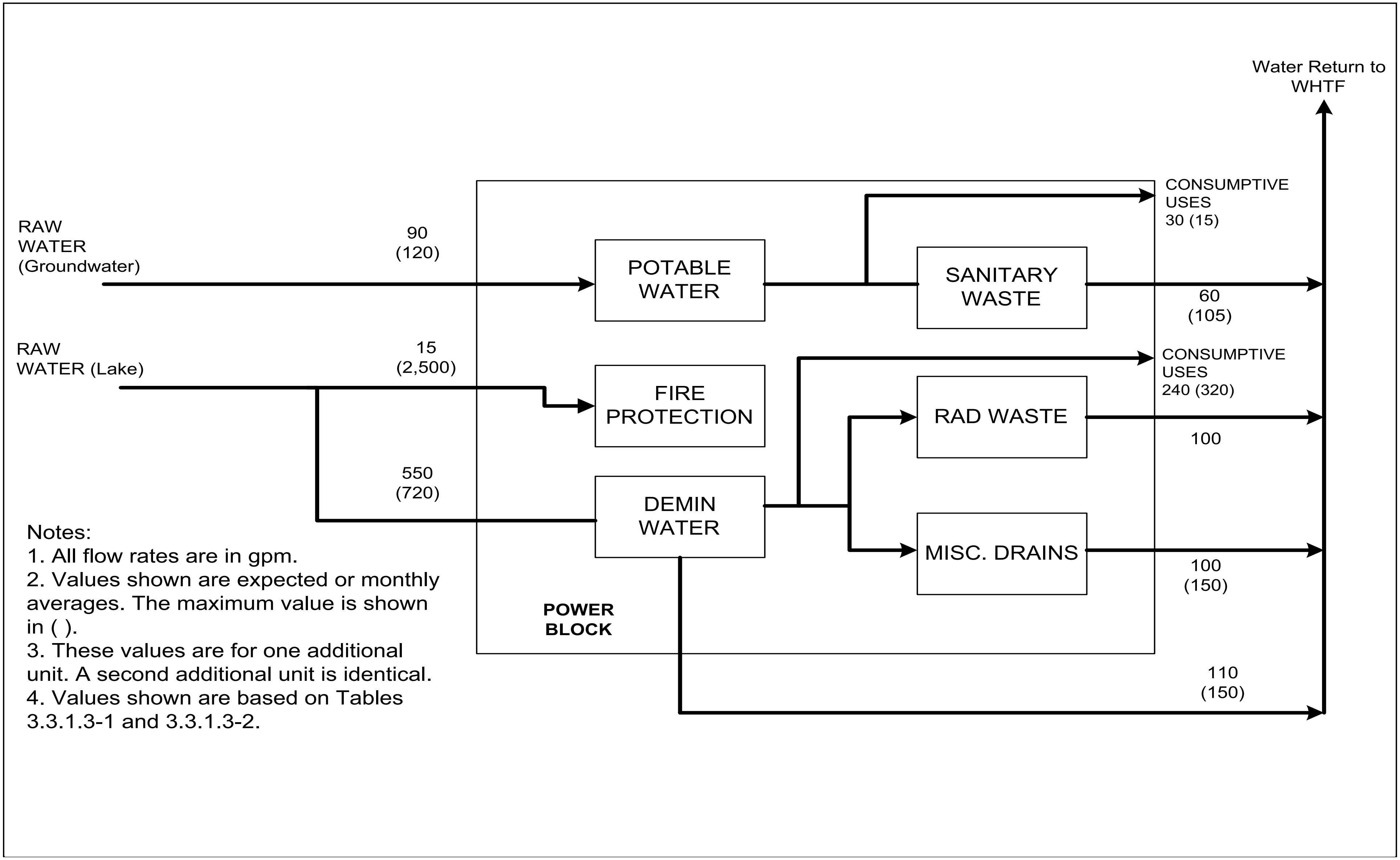


Figure 3.3-3 Power Block Water Use

3.4 Cooling System

The plant cooling system for new units and the anticipated modes of operation of the cooling system are described in Section 3.4.1. The design data of the cooling system components; specifically, the intake, the discharge, and the heat dissipation system, and their performance characteristics for the anticipated operational modes are presented in Section 3.4.2. The parameters provided are used to evaluate the physical, chemical, and biological impacts to the environment that would result from the operation of the cooling system.

3.4.1 Description and Operational Modes

The selection of the type of cooling system for new units requires consideration of the total amount of waste heat that would be generated as a byproduct of the proposed electricity generation, as well as the impacts of the waste heat to the environment. The amount of waste heat rejected from the steam-electric system varies, depending on the reactor type, because the core thermal output and the gross electrical output are different among the reactor types being evaluated. Unless site-specific data are available to generate a more realistic and appropriate estimate of the design parameters, bounding values from the PPE (described in Section 3.1.3) were used to provide the basis for evaluation and selection of the types of cooling system best suited for the ESP site. Dominion would apply for the required environmental permits to support the construction of the new cooling system(s), including permits for the discharge and intake structures under the EPA CWA 316(a) and 316(b) regulations after a decision is made to proceed with development of the new units.

3.4.1.1 Normal Plant Cooling

According to the PPE, each new unit would require a primary cooling system to dissipate up to 9.7×10^9 BTU/hr of waste heat rejected from the main condenser and the auxiliary heat exchangers during normal plant operation at full station load. A once-through cooling system that uses the North Anna Reservoir as the cooling water supply and the WHTF as the primary heat sink would be used for the normal plant cooling of the new Unit 3, a closed-cycle cooling system would be used for new Unit 4. The Unit 4 system would use mechanical or natural draft cooling towers for heat dissipation, and makeup water could potentially come from the North Anna Reservoir supplemented by an external source. As indicated by the water-use and lake level assessment (Section 5.2.1 and Section 5.2.2), which included the extended drought condition that occurred in 2002, the net inflows to the lake may not be able to sustain both the supply of makeup water to the Unit 4 cooling towers and the circulating water to the once-through units (Units 1, 2 and 3). If both the existing units and new units were to continue operation during the critical low flow periods, an external water source would be required to temporarily supplement the makeup water supply for Unit 4. The requirement of the external water supply and the environmental impact of bringing this water to Unit 4 would be assessed during detailed engineering and described in the COL application. A dry cooling system for Unit 4 would also be evaluated. Since there would be minimal

makeup water requirement and no blowdown discharge to the WHTF from a dry cooling system, impacts to Lake Anna would be minimal. Section 9.4.1 identifies the operating and environmental considerations of a dry cooling system on the ESP site.

In the once-through cooling system for new Unit 3, cooling water would be taken from the North Anna Reservoir by circulating water pumps, at a maximum rate of 1.14×10^6 gpm (2540 cfs). The intake pumps would be installed inside a new shoreline intake structure located in a cove west of the intake structure for the existing units. The cooling water would be circulated through the main condensers and auxiliary heat exchangers, and discharged to a new submerged outfall structure located at the head of the WHTF discharge canal at a temperature approximately 18°F above the intake temperature. Figure 3.4-1 shows the proposed location of the intake structure and discharge structures for the new units. Figure 3.4-2 shows the general layout of the WHTF and North Anna Reservoir. Within the discharge channel, cooling water discharge from Unit 3 would mix with the circulating water discharge from Units 1 and 2 and the blowdown discharge from the cooling towers of the new Unit 4. The combined effluent streams would travel through the main ponds, connecting canals and side arms of the WHTF, while dissipating the excess heat through surface heat exchange to the atmosphere. At the end of the WHTF, the combined flow, after losing a substantial amount of heat via heat exchange with the atmosphere, would return to the North Anna Reservoir through a 6-bay adjustable skimmer wall discharge structure at Dike 3 as described in Section 3.4.2. After entering the reservoir, most of the discharged cooling water would flow up-lake and would re-enter the intake structures after releasing more heat to the atmosphere.

The closed-cycle cooling tower system for new Unit 4 would consist of pumps that circulates water at a rate of 800,000 gpm (1782 cfs). The water would be pumped through the main condenser and auxiliary heat exchangers, and then to the cooling towers for heat dissipation. Figure 2.1-1 shows the location of the cooling towers on the ESP site. The cooling towers would be designed for a temperature range of 25°F to dissipate the heat load of 9.7×10^9 BTU/hr anticipated during full station load operation. During the heat transfer process, water would be lost to the atmosphere through evaporation. Based on the historical meteorological condition representative of the ESP site, an average rate of evaporative water loss of 35 cfs from the cooling towers is estimated (see Section 5.2.1 and Section 5.2.2), leading to a gradual buildup of the dissolved solids concentration in the circulating water. This estimated evaporation rate is less than the bounding value of 39 cfs in PPE. To maintain the concentration of dissolved solids acceptable to the system, a portion of the circulating water would be removed from the cycle in the form of cooling tower blowdown discharge. With the typical water quality condition at Lake Anna, the towers are expected to operate with 5 cycles of concentration or higher. This would result in an expected 9 cfs (during normal conditions) to a maximum of 35 cfs (during upset or abnormal conditions) of blowdown flow. The blowdown flow, which would have elevated dissolved solids concentration, would be released to the WHTF via the new discharge structure at the head of the discharge canal. Makeup water for the cooling towers at an average rate of 44 cfs to a maximum of 70 cfs, based on the predicted

evaporation rate of 35 cfs, would be required to replace the blowdown flow and the water lost to evaporation. Drift loss at the towers would be negligible and is not included in the water use evaluation. The makeup water, to be determined during detailed engineering, would be supplied from the North Anna Reservoir via a separate screen well and pump house next to the new intake structure for Unit 3, or from an external source. The blowdown water could reach 100°F in the extreme summer months, depending on the wet-bulb temperature. At the average blowdown flow rate of 9 cfs expected for the system during normal conditions, heat rejected to the WHTF would be on the order of 3×10^7 BTU/hr during the extreme summer months when the wet-bulb temperature is close to 80°F, and the average lake temperature is in the mid-80°F range. Comparing to the Unit 3 once-through cooling system discharge, which would have a maximum heat content of 9.7×10^9 BTU/hr; the heat load in the blowdown flow is very small, about 0.3 percent of the once-through system discharge, and would have little to no thermal impact on Lake Anna.

3.4.1.2 **Ultimate Heat Sink**

For safety-related cooling, the UHS would provide cooling water to the reactor cooling systems and safety-related components that are necessary for the safe shutdown and cool-down of the plant under normal operations, anticipated operational events, and DBAs. Some reactor designs use a passive system and stored water for safety-related cooling and do not require an external UHS system to reach safe shutdown. For other reactor designs, a dedicated closed-cycle system with mechanical draft towers is proposed for the UHS. The UHS for each new unit would dissipate the decay heat of up to 1.2×10^8 BTU/hr during normal conditions and 4.2×10^8 BTU/hr during shutdown or accident conditions, in accordance with the PPE. The UHS system would consist of a pump house that circulates cooling water to the safety-related cooling systems and components at a rate of 58 cfs during normal conditions or 116 cfs during shutdown or accident conditions. Then the cooling water would flow to the UHS cooling towers where the excess heat would be dissipated to the atmosphere by evaporation and conduction. The UHS cooling towers would be designed for a temperature range of 16°F. According to the PPE, the evaporation water loss of each new unit is expected to be about 0.9 cfs during normal conditions and 1.9 cfs during upset or abnormal conditions. The blowdown flow from the UHS towers would be discharged to the new outfall at the head of the discharge canal and would have a flow rate varying from 0.3 cfs per unit during normal conditions to 1.9 cfs per unit during upset or abnormal conditions. An underground basin beneath each UHS tower, with a potential storage of 3.06×10^7 gallons of water, equivalent to 4.1×10^6 ft^3, would provide the 30-day supply of makeup water flow at 1.2 cfs to 3.8 cfs, the bounding rates from the PPE. Water supply to the storage basin would be pumped directly from the service water pumps installed in the new intake structures.

3.4.1.3 Other Operational Modes

3.4.1.3.1 Station Load Factor

The new units are expected to operate with a maximum load factor of 96 percent (annualized) considering scheduled outages and other plant maintenance. On a long-term basis, an average heat load of 9.3×10^9 BTU/hr per new unit, that is 96 percent of the rated unit heat load of 9.7×10^9 BTU/hr, would be dissipated to the atmosphere via the WHTF for Unit 3 and the cooling towers for Unit 4.

3.4.1.3.2 Condenser Inlet and Lake Water Temperature

The new units' cooling systems would be designed for a maximum condenser inlet temperature limit of 95°F. When the condenser inlet temperature or the intake water temperature reaches 95°F, the control system would initiate the normal shutdown sequence. This temperature is consistent with the maximum allowable intake water temperature of 95°F, specified in the existing units' Technical Requirements Manual.

Since the existing units began operation, ice blockage has not been encountered that rendered the cooling system inoperable. Historical water temperatures in the lake show that the minimum temperature near the intake area has not gone below 37°F. De-icing operations are, therefore, not expected to be necessary at the intake structures of the new units.

3.4.1.3.3 Minimum Operating Lake Level

The water level in Lake Anna is currently regulated by the North Anna dam to maintain a normal lake level of 250 ft msl to support operation of the existing units. Fluctuations of the inflows to the lake cause the lake level to temporarily go above or below the normal design level of 250 ft msl. According to the existing units' Technical Requirements Manual, 244 ft msl is the minimum lake level for the Unit 1 and 2 circulating water systems to continue operation. With the additional water supply demand from the new units, the water budget analysis in Section 5.2.2 indicates that the lake level could drop below 244 ft msl during severe drought conditions. Specifically, with all four units operating, the water level could be below 244 ft msl about 3 percent of the time. If necessary to support the new units, Dominion would work with Virginia Power to change the minimum level requirement for the existing units to 242 feet. For the future concurrent operation, the normal lake level would be maintained at 250 ft msl.

3.4.1.3.4 Anti-Fouling Treatment

Bio-fouling control using thermal or chlorination treatment has not been used for the once-through cooling system (circulating water) of the existing units and is not expected to be necessary for the new once-through Unit 3 cooling system. Pre-treatment of the cooling tower makeup, however, would be required.

3.4.2 Component Descriptions

The design data of the cooling system components and their performance characteristics during the anticipated system operation modes are described in this section. Bounding values of the design parameters from the PPE, or site-specific estimates if available, are used as the basis for discussion.

3.4.2.1 Intake System

The intake structure for new units at the ESP site would meet Section 316(b) of the CWA and the implementing regulations, as applicable.

The new intake structure for the once-through Unit 3 system would withdraw cooling water from the North Anna Reservoir at an average rate of up to 2540 cfs. If the makeup water for Unit 4 is from the North Anna Reservoir, an additional 44 to 70 cfs of makeup water would be withdrawn for the closed-cycle cooling towers of Unit 4. This makeup flow would replenish the evaporation loss of 35 cfs, based on site-specific data, and an expected blowdown discharge of 9 cfs during normal conditions to a maximum of 35 cfs during upset or abnormal conditions (see Section 3.3.1). It should be noted that the makeup water demand (as shown in the PPE) ranges from 53 cfs to 98 cfs, which is slightly higher than the predicted range of 44 cfs to 70 cfs. From the water budget and lake level assessment study discussed in Section 5.2.1, it is estimated that during severe drought conditions, an external source of the makeup water may be required for Unit 4 to supplement the lake water. The design and impact of this makeup source would be evaluated during detailed engineering and described in the COL application.

The cooling water intake system (CWIS) of the new units would consist of a compartmented intake structure with a screenwell and pump bays dedicated to each unit, and a common dredged approach channel in a cove on the south shore of the North Anna Reservoir near Harris Creek and immediately west of the cove that houses the existing intake structure. The new intake structure would also house a number of smaller service water pumps with a total capacity of up to 11 cfs per unit to supply other plant water uses, including 1.2 to 3.8 cfs per unit on the makeup water of the UHS storage system, 1.2 cfs to 1.6 cfs of demineralized water, and a maximum of 5.6 cfs of fire protection water. The location of the new intake is shown in Figure 3.4-1. Figure 3.4-3 is a schematic drawing showing the approximate footprint and dimensions of the new intake structure and the intake channel.

As shown in Figure 3.4-3, the intake channel and combined intake structure are in the cove originally planned for the intake of the abandoned Units 3 and 4. In the early 1980s, a cofferdam was installed across the cove to facilitate the construction of the now-abandoned intake system. This cofferdam would be removed to allow dredging for the new approach channel. The new approach channel would have a typical side slope of 3:1 (horizontal to vertical) on both sides and a bottom width varying from about 300 feet at the lake end to 230 feet at the entrance to the screenwells and pump bays. The invert elevation of the channel would be approximately 220 ft msl

at the lake end to 213 ft msl near the intake structure. At the minimum lake operating level (242 ft msl) for the future combined operation of the new and existing units, the flow velocity along the new channel would about 0.3 to 0.4 ft/sec, based on the Unit 3 cooling water flow demand of 2540 cfs and the Unit 4 makeup water flow demand of 44 cfs.

At the end of the approach channel, lake water would flow into the screenwell and pump bays of either Unit 3 or Unit 4. A skimmer wall, extending to just below Elevation 242 ft msl, would be installed at the entrance of each of the screenwells to reduce the amount of floating debris carried into the intake. Each screenwell would also be equipped with automatically raking trash racks, traveling water screens, debris basin, and screen wash pumps. The traveling screens would be designed to have the capability to operate continuously. A fish return line, or an equivalent fish return system based on the latest technology available during detailed engineering, would be considered for implementation to return impinged fish back to the reservoir at a location away from the intake channel, as shown in Figure 3.4-3.

Debris collected by the trash racks and the traveling water screens would be collected in a debris basin for cleanout and disposal as solid waste. Downstream of the screenwells, multiple pump bays would house the circulating water pumps (for Unit 3) and the makeup water pumps (for Unit 4). Other smaller capacity service water pumps and firewater pumps would also share the space in some of the pump bays. To enhance the performance of the debris-filtering system and minimize fish mortality due to impingement and entrainment, the intake structure would be sized so that the designed approach velocity to the screenwell, trash racks, and traveling water screens would be less than 1 ft/sec at the minimum operating lake level of 242 ft msl. The total width of the intake structure would be about 230 feet wide, with 180 feet allocated for Unit 3 and 50 feet for Unit 4. A bottom sill would be installed at the entrance of each of the screenwells to reduce entrainment of bed sediment. Figure 3.4-4 is a schematic section view of the arrangement of the intake structure. Both side slopes of the approach channel and the channel bottom near the intake structure would be rip-rap protected against erosion. The intake systems for the new units would be located inside a restricted area marked by no-boat buoys to prohibit public access, as are the existing units.

3.4.2.2 **Discharge System**

In the Unit 3 once-through system, the circulating water would pass through the main turbine condenser and be released into the discharge channel of the WHTF via a new submerged outfall. The water would be released for heat dissipation at a temperature of about 18°F above the condenser inlet temperature. Figure 3.4-5 shows the location of the future outfall in relation to the existing outfall of Units 1 and 2. In accordance with the PPE, the maximum discharge flow rate of the once-through system would be 2540 cfs for Unit 3, the same as the intake cooling water flow rate. The cooling tower blowdown from the closed-cycle cooling system for Unit 4 would also be released to the new outfall in the discharge channel at a flow rate of 9 cfs (expected) to 35 cfs (maximum). The maximum temperature limit of the blowdown flow is 100°F according to the PPE.

With all four units operating, the 2540 cfs of circulating water effluent from Unit 3 would mix in the discharge channel with a maximum of 35 cfs of blowdown flow from Unit 4 and 4246 cfs of circulating water from Units 1 and 2. During the UHS cooling mode, a very small blowdown flow of about 0.3 to 1.9 cfs per new unit would be discharged to the outfall. Other plant discharges and miscellaneous drains from each new unit to the WHTF would total about 1.4 cfs to 1.9 cfs.

The discharge canal is 3850 feet long with a bottom width of 100 feet and side slopes of 2.5:1 (horizontal to vertical) as shown in Figure 3.4-6. The invert elevation of the canal is at Elevation 227 ft msl with an intermediate berm of 15 feet width at Elevation 255 ft. For the existing units, the water level in the WHTF is designed to be 1 to 1.5 feet above the water level in the North Anna Reservoir. At the normal pool level of 250 ft msl in the reservoir, the water level at the discharge canal would be about 251.5 ft msl with the new units on line.

The WHTF, which was formed by diking off a portion of Lake Anna, consists of three cooling ponds interconnected by canals with dimensions similar to the discharge canal. When filled to Elevation 251.5 ft, these ponds have a combined volume of about 2.66×10^9 ft^3, a total surface area of about 3400 acres, and an average depth of 18 ft (Reference 1). A major characteristic of the WHTF is the existence of the long narrow side arms that comprise about 1530 acres or 45 percent of the total WHTF area. The maximum depth is 50 feet in the vicinity of the dikes. The three dikes separating the WHTF from the North Anna Reservoir consist mostly of compacted earthen materials. Each has a crest width of 26 feet and a side slope of 2.5:1 (horizontal to vertical). Rip-rap protection against erosion is provided on both slopes from Elevation 242 ft msl to Elevation 250 ft msl.

As shown in Figure 3.4-2, Figure 3.4-7, and Figure 3.4-8, the plant discharge would flow through the various ponds and connecting canals of the WHTF and enters the North Anna Reservoir at Dike 3 through a 6-bay skimmer wall discharge structure. Each discharge bay is 16.7 feet wide and 15 feet high from Elevation 212 ft msl to Elevation 227 ft msl, as shown in Figure 3.4-9 and Figure 3.4-10. Stop-log gates adjust the effective area of the openings to achieve the design exit velocity of 7 to 8 fps for mixing the WHTF outflow with the North Anna Reservoir. To minimize localized erosion at the discharge, the discharge outlet is provided with a 12.5-foot-long concrete apron.

The bottom topography at the exit to the Dike 3 discharge is shown in Figure 3.4-8. A 700-foot-long section of Dike 3 is constructed to Elevation 253.5 ft msl; whereas, the crests of the other dikes are at Elevation 260 ft msl. The 700-foot long section of Dike 3 forms an emergency spillway between the WHTF and North Anna Reservoir during periods of high flood flow equal to the return period of 100 years or worse. (Reference 1)

After entering the North Anna Reservoir, most of the cooling water flows up-lake toward the intake for re-circulating back to the plant cooling system. A small portion of the discharge flow is released at the dam into the North Anna River downstream. As discussed in Section 5.3.1.1, the long-term

average flow released at the dam is estimated to be 275 cfs during the operation of the existing units. The lake receives inflow estimated to be about 370 cfs on a long-term average basis. At the normal pool level of 250 ft msl, the North Anna Reservoir has a surface area of 9600 acres, a volume of 1.06×10^{10} ft^3, and an average depth of 25 feet (Reference 1). The maximum depth is 70 feet near the dam

3.4.2.3 **Heat-Dissipation System**

The Lake Anna cooling system described in Section 3.4.2.2 would be the normal heat sink for the Unit 3 once-through cooling system to dissipate up to 9.7×10^9 BTU/hr of waste heat at full station load.

The cooling water would be circulated through the main condensers and auxiliary heat exchangers, and discharged to the WHTF at a temperature 18°F above the intake temperature. The surface area, water depth, and estimated volume under the normal pool level of 250 ft msl for the WHTF and the North Anna Reservoir are provided in Section 3.4.2.2. The flow-through time of cooling water discharge throughout the lake, for the existing and new units (calculated for 6786 cfs), from the discharge canal to the intake structure, and with lake level at 250 feet, is estimated to be about 2 to 3 weeks. The lake was designed to dissipate a heat load of up to 2.7×10^{10} BTU/hr from the four units originally planned. The ambient lake condition and the performance characteristics of the cooling lake system for the new units are evaluated in Section 5.3.2.2.

For the closed-cycle cooling system of Unit 4, cooling towers with plume abatement would be used as the normal heat sink. Since no reactor design has been selected at this stage, the PPE's bounding values for the performance characteristics of the cooling towers are used for discussion. To dissipate a maximum waste heat load of up to 9.7×10^9 BTU/hr, four mechanical draft towers with an initial estimated 11 cells each or two natural draft towers are predicted to be required. The towers would have a maximum design temperature range of 25°F, and a circulating water flow rate of 1782 cfs. The height of the mechanical towers would be about 60 feet; whereas, the natural draft towers would be about 550 feet. The location of the cooling towers is shown in Figure 2.1-1.

Section 3.4 References

1. Final Environmental Statement, related to the continuation of construction and the operation of Units 1 & 2 and the construction of Units 3 & 4, North Anna Power Station, Virginia Electric and Power Company, Docket Nos. 50-338 & 50-339 and Docket Nos. 50-404 & 50-405, United States Atomic Energy Commission, Directorate of Licensing, April 1973.

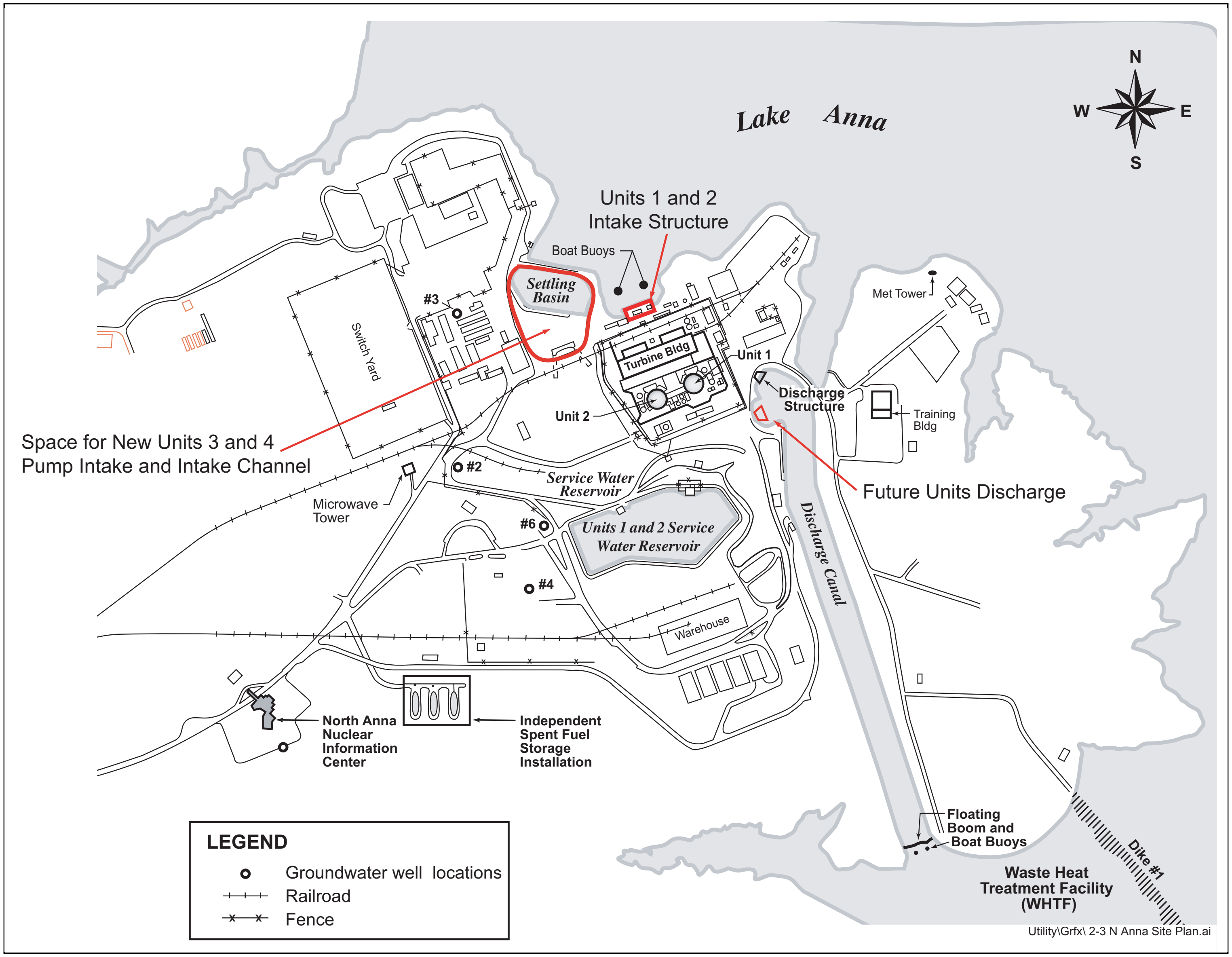


Figure 3.4-1 Proposed Location of the Intake Structure and Discharge Structures for the New Units 3 and 4

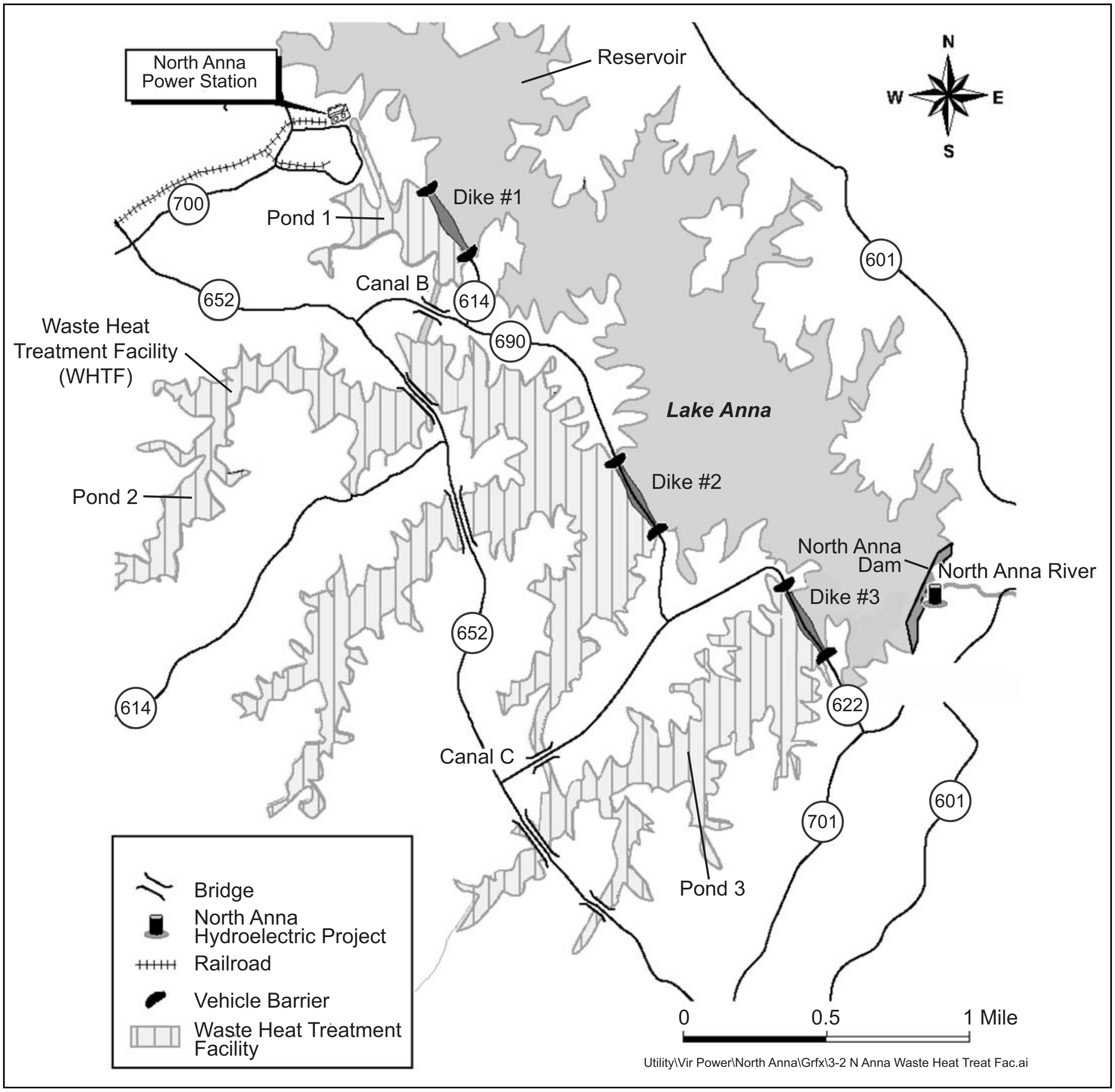


Figure 3.4-2 North Anna Plant - Reservoir and WHTF of Lake Anna

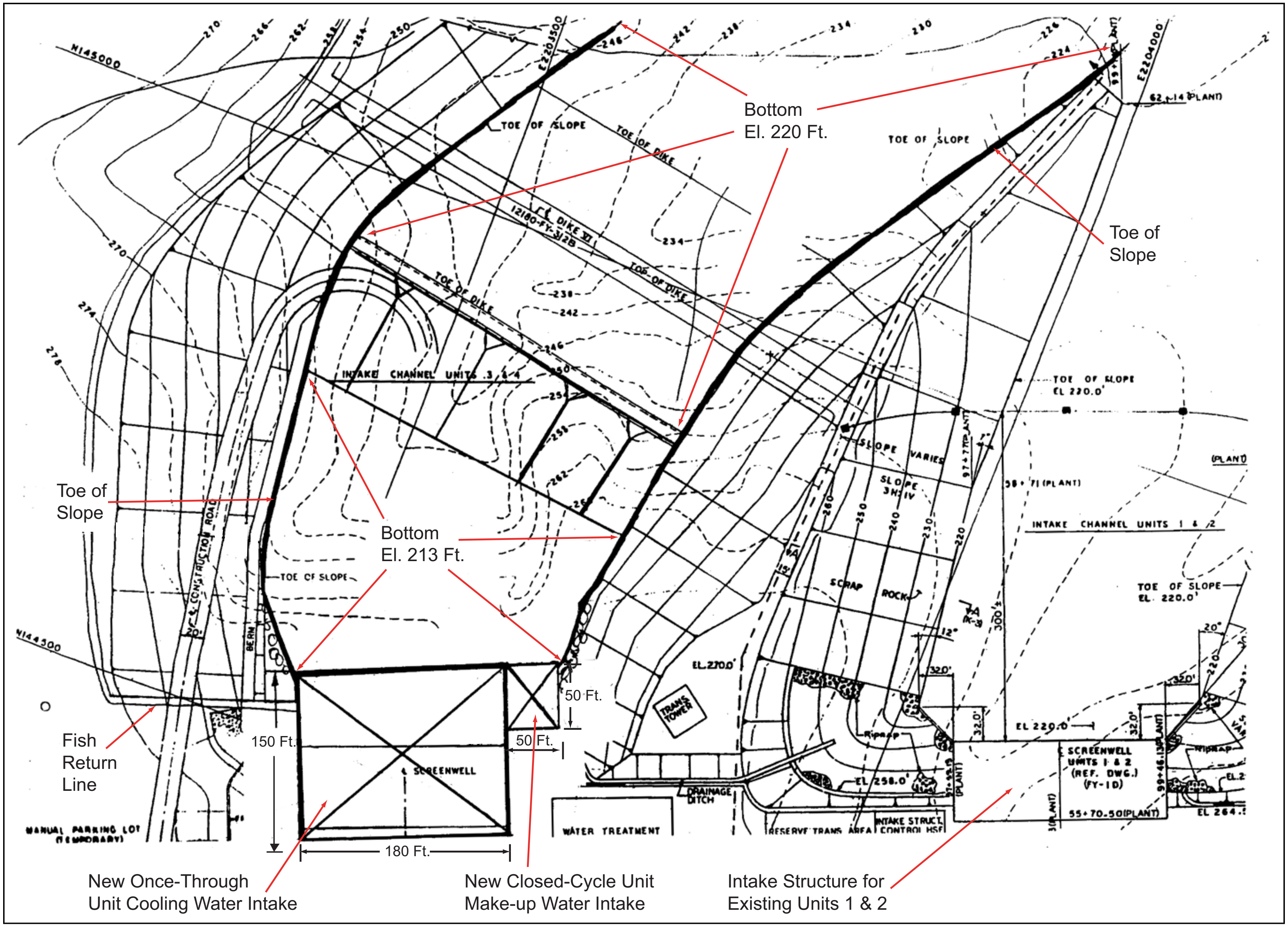


Figure 3.4-3 Layout of Screenwell/Pump Intake for New Units 3 and 4

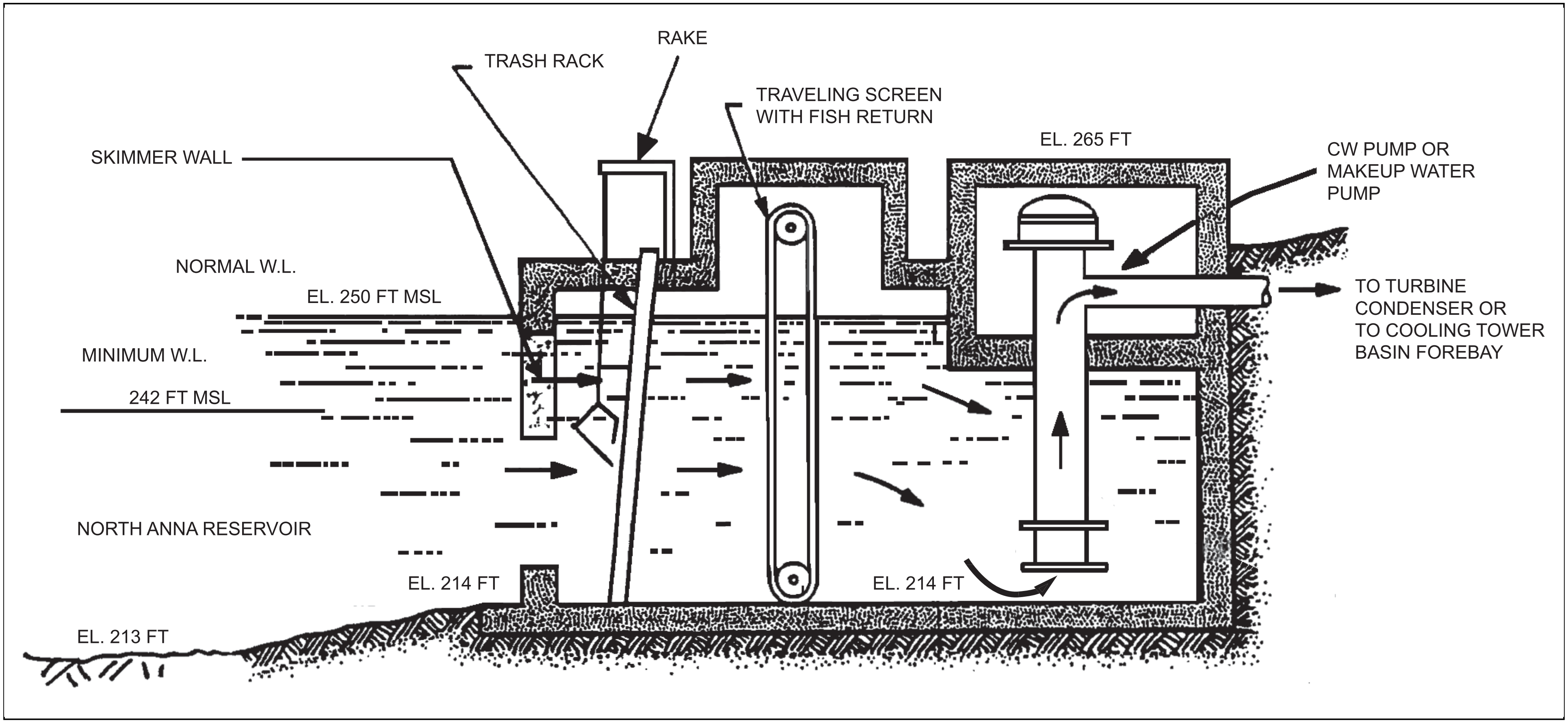


Figure 3.4-4 Schematic View of Pump Intake

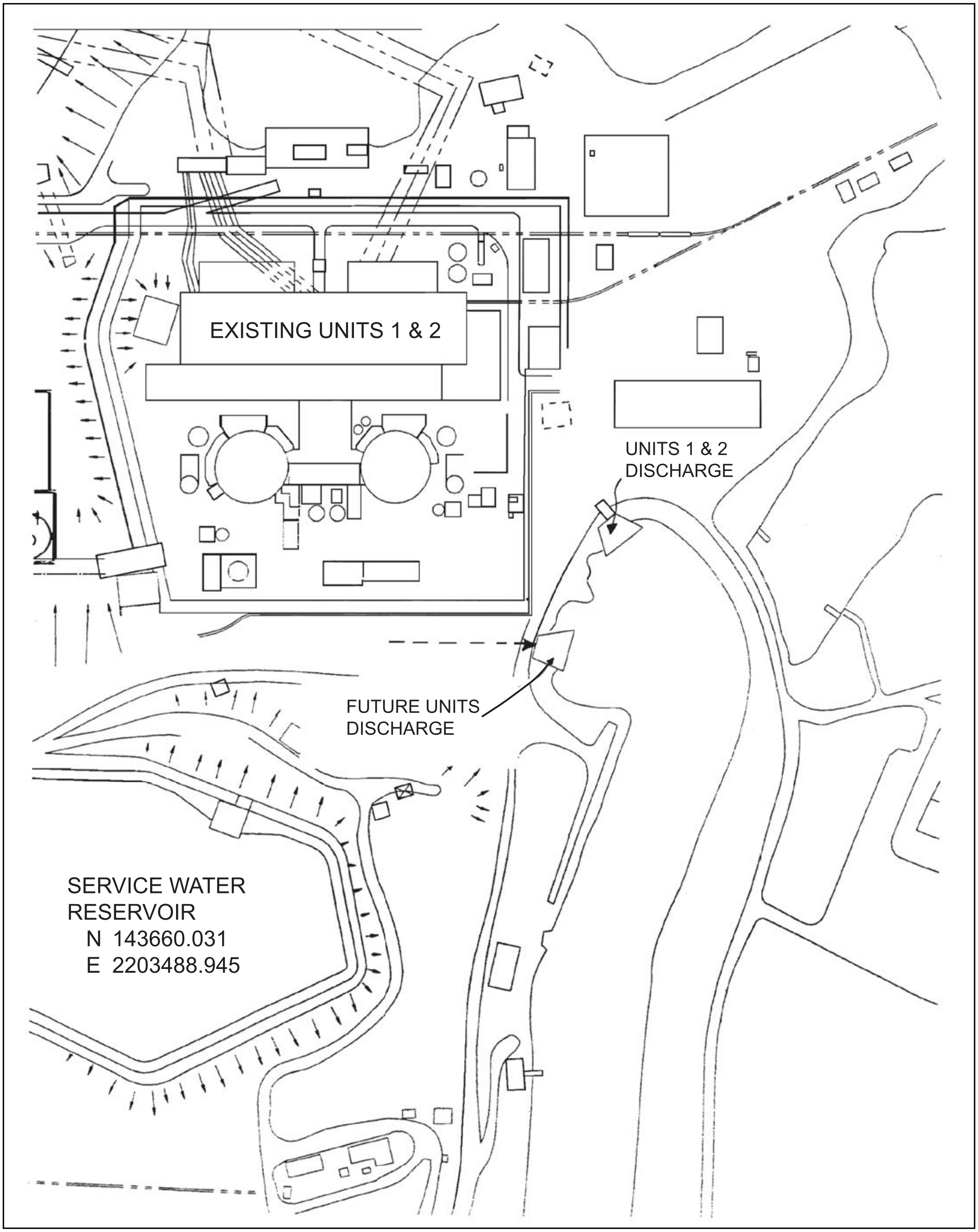


Figure 3.4-5 Discharge Outfall at Head of the Discharge Canal for New Units 3 and 4

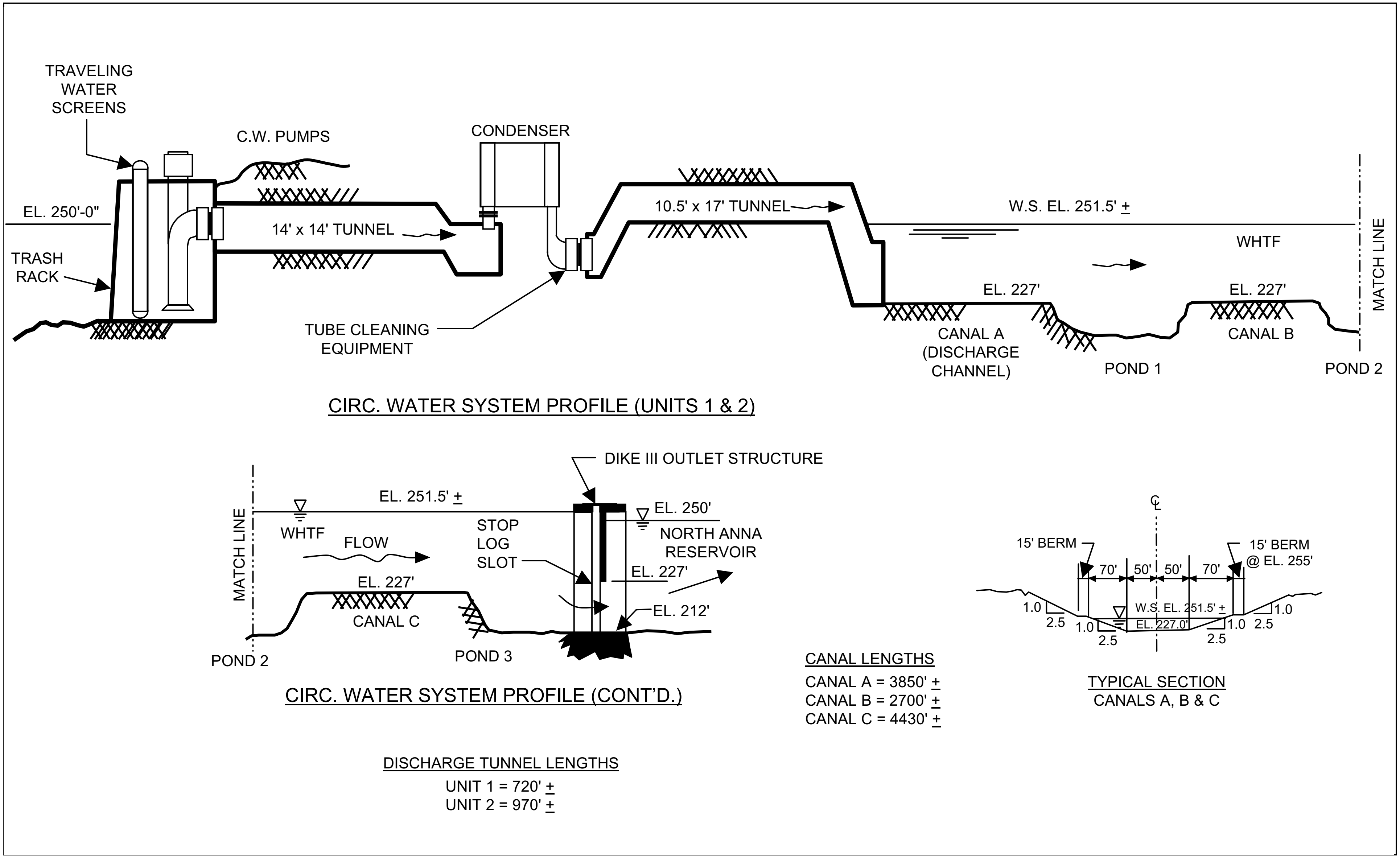


Figure 3.4-6 Discharge Channel and Dike 3 Outlet Structure

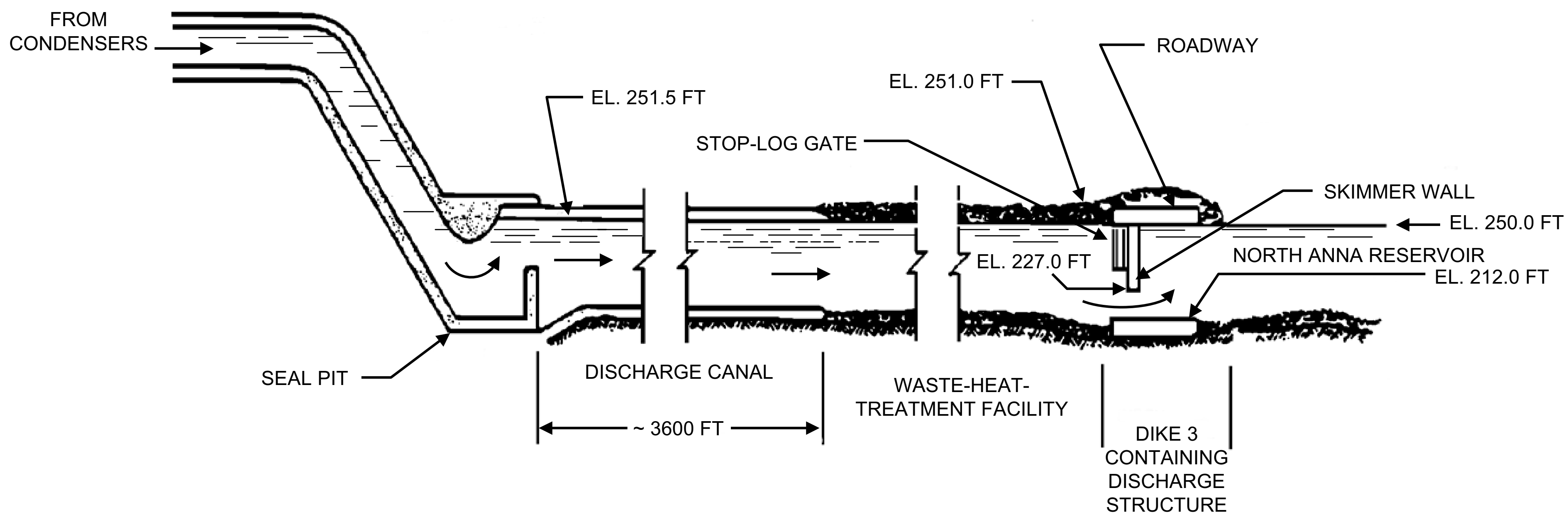


Figure 3.4-7 Schematic Diagram of the Discharge System

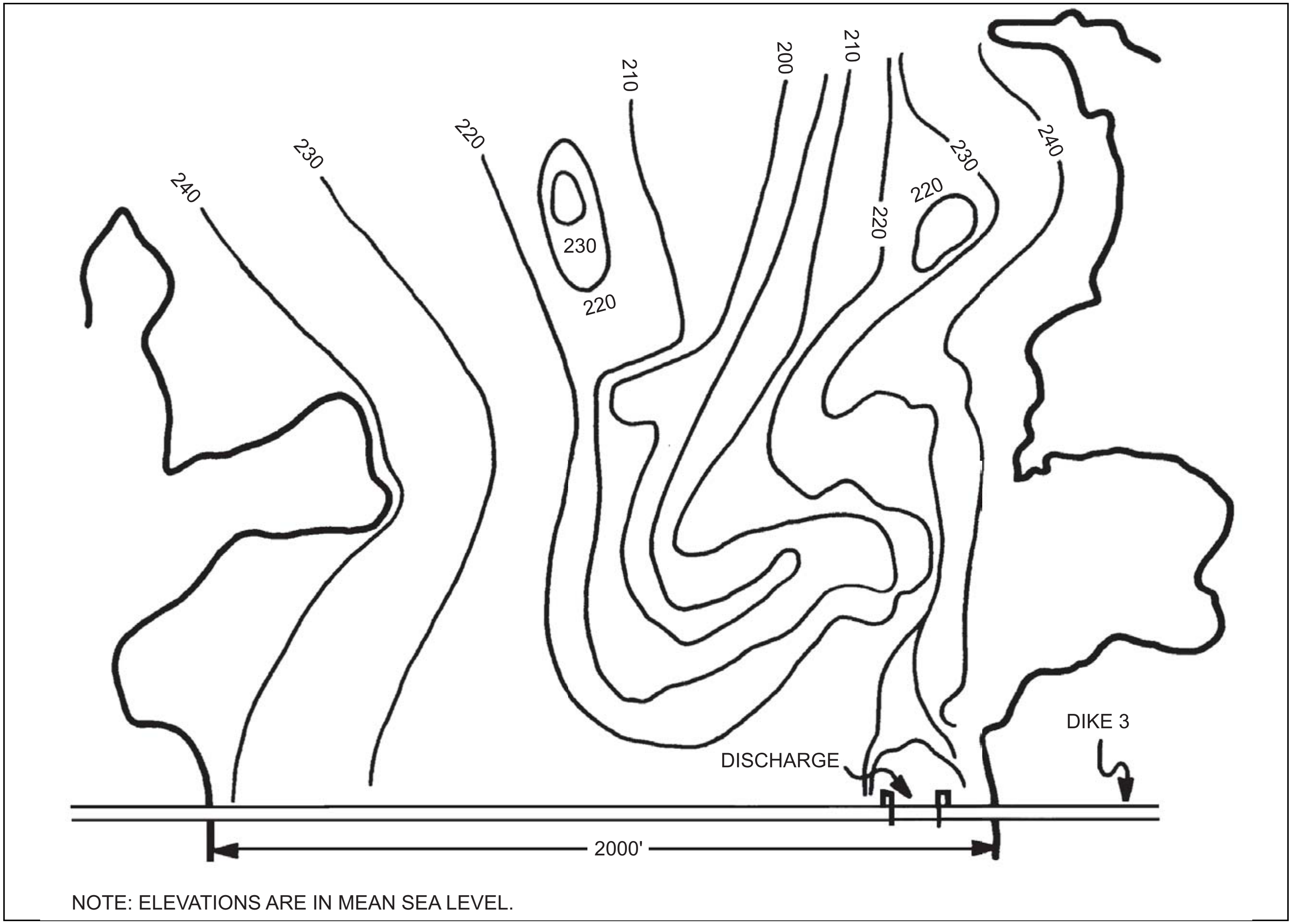


Figure 3.4-8 Location of Discharge Structure in Dike 3 and Bottom Topography of the North Anna Reservoir

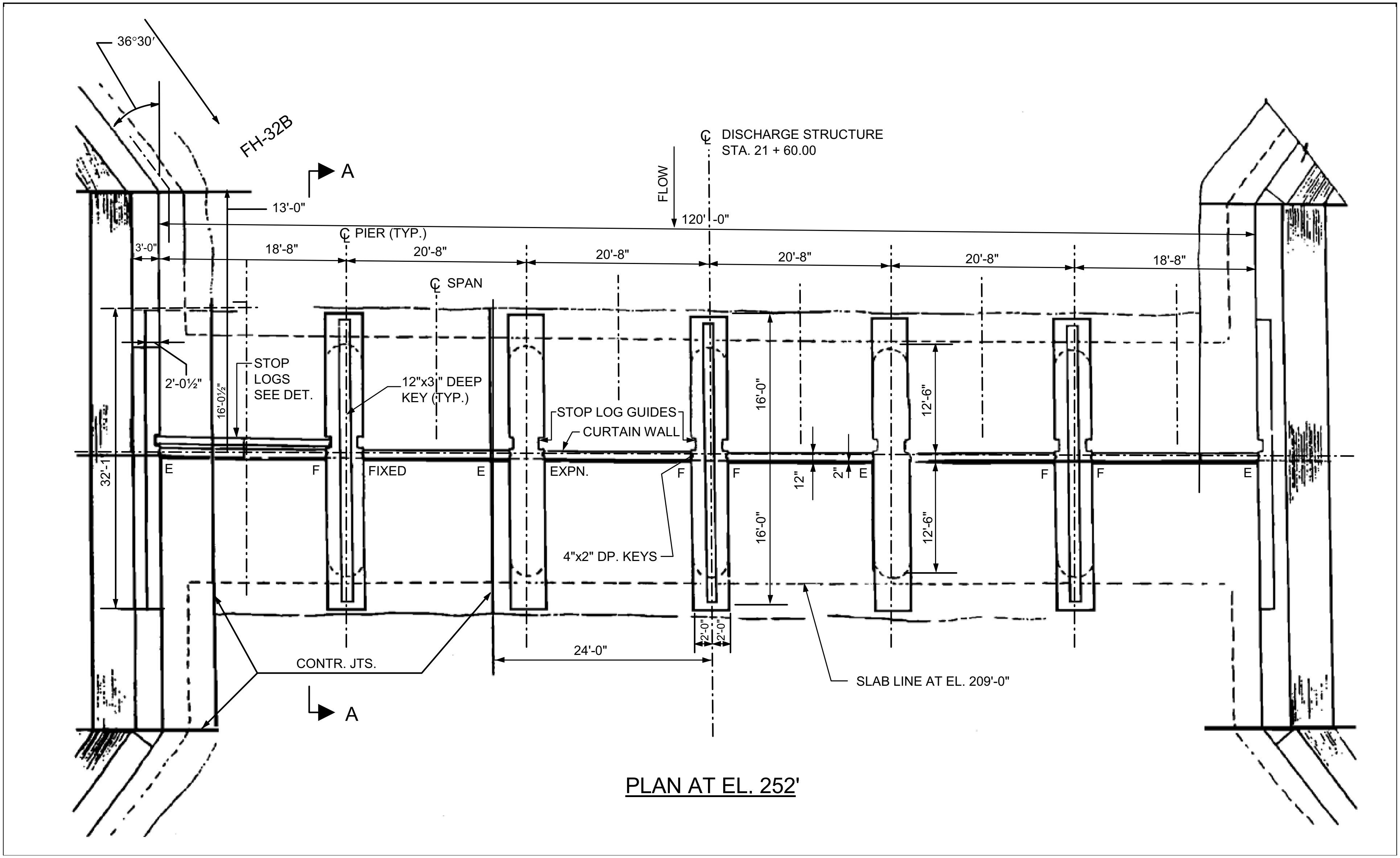


Figure 3.4-9 Water Discharge System from WHTF to North Anna Reservoir

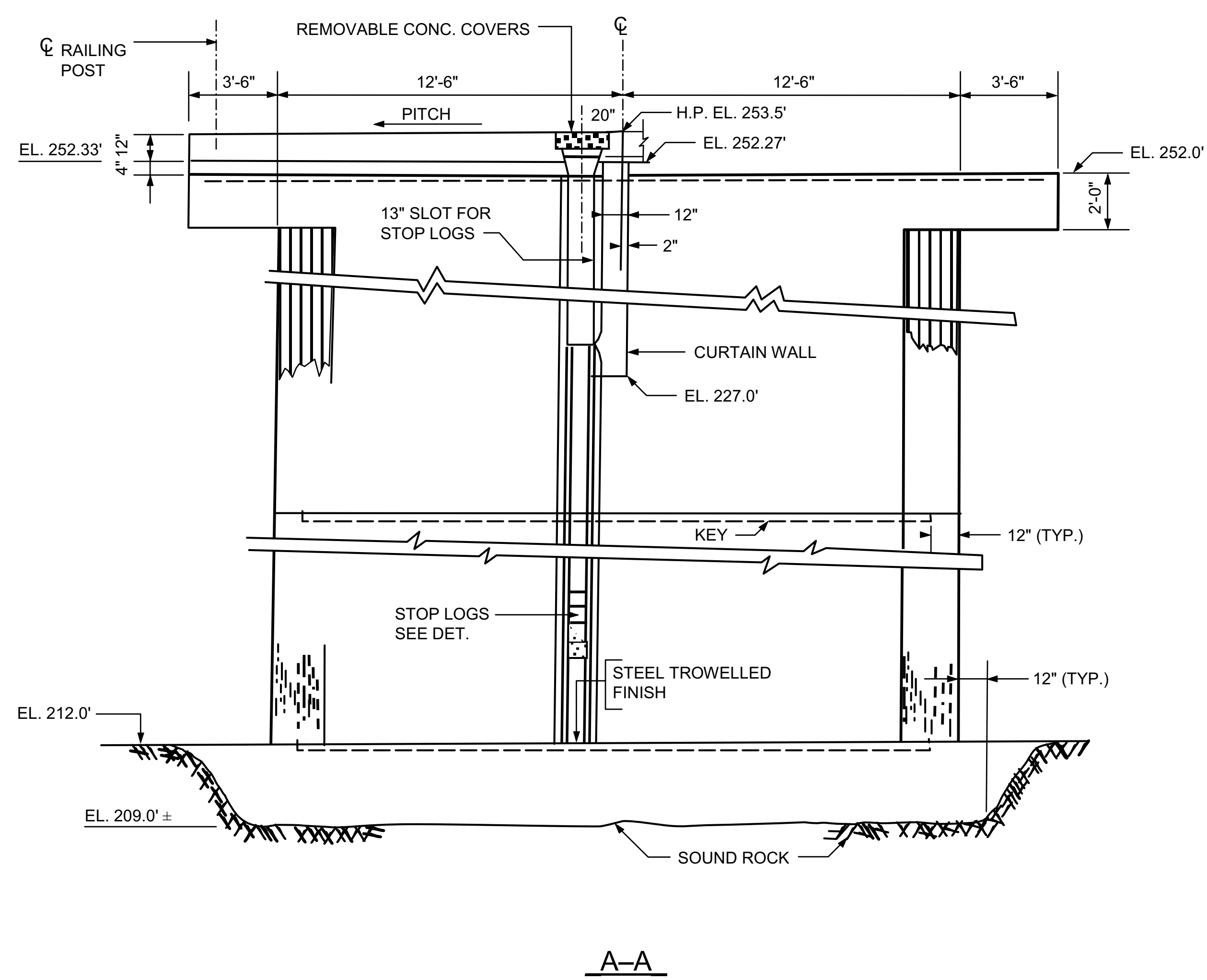


Figure 3.4-10 Water Discharge System from WHTF to North Anna Reservoir

3.5 Radioactive Waste Management System

Because a reactor design has not been chosen for the ESP site, a PPE was developed to characterize the bounding conditions for which the ESP site is suitable for development. The PPE is provided, beginning with Table 3.1-1.

The PPE provides a bounding quantity of radioactive wastes that are projected to be generated and processed and then stored or released annually as liquid or gaseous effluents or as solid waste. Radioactive waste management systems would be designed to minimize releases from reactor operations to values as low as reasonably achievable (ALARA). These systems would be designed and maintained to meet the requirements of 10 CFR 20 and 10 CFR 50, Appendix I. Based on the design of these systems, the plant effluents provided in the PPE have been used to determine the maximum individual and population doses for normal plant operations.

3.5.1 Liquid Radioactive Waste Management System

Radioisotopes are produced during the normal operation of nuclear reactors. The source of production varies by reactor type, but the primary liquid sources for light water reactors include activation of non-radioactive water-borne materials normally present as the water, used for cooling the reactor, circulates through the reactor core.

Because impurities in water are mostly removed prior to its introduction into a reactor, the activated materials in the water are corrosion products and other leached materials, such as iron, cobalt, and manganese. Additionally, small amounts of activated material may enter the coolant by diffusing through the fuel containment, leaching from the fuel itself, or by escaping through fuel cladding leaks, if they occur.

Commercial nuclear reactors have effective liquid waste management systems. These systems are designed to gather liquids that may leak from radioactive and potentially radioactive sources and to store those liquids for further processing. The sources of liquid waste in a water-cooled reactor include controlled and uncontrolled leakage from the reactor coolant systems, cleanup and purification systems, rod control systems in boiling water reactors (BWRs) and other similar sources. In addition, other related plant systems, such as cooling systems, can contain radioactive materials in the event of a minor component or system-based leak, such as a heat exchanger leak, or they can contain contaminants as part of their design, such as station laundry systems.

During the design phase of the new units, these sources and potential sources would be identified and collection systems designed such that any leakage would be contained and either returned to the system or transported to a liquid waste management system collection point for treatment or disposal. The system would be designed to store and process those wastes to maintain radiation exposure ALARA.

Following processing, the liquid waste systems may release small qualities of radioactive effluents to the environment at defined release points. These release points, typically in the cooling water discharge stream, would be monitored to measure the activity released.

The expected releases from water-cooled reactors are well known. Table 3.1-7 lists expected isotopic releases from a bounding single unit reactor design. Note that a single unit is defined in Section 3.1.2.2.

Gas-cooled reactors have fewer sources of liquid waste because no direct activation of impurities is likely. For this reason, Table 3.1-7 presents a bounding set of data for expected liquid releases.

3.5.2 **Gaseous Radioactive Waste Management System**

Gaseous radioisotopes are produced during the normal operation of nuclear reactors. The sources vary by reactor type and include fuel leakage, activation, and radioactive dissociation. These gases are typically retained in the plant systems and are removed in a controlled fashion through a gaseous waste collection system.

Gaseous waste collection systems collect waste from multiple sources, compress the gas to reduce its volume, and then store the gas for a predetermined time to allow short-lived isotopes to decay. The remaining activity is released in a controlled manner to the environment through a monitored release point.

The system would be designed to store and process those released wastes to maintain radiation exposure as low as reasonably achievable.

Some small gaseous fraction would leak from the plant systems into the plant atmosphere. Monitoring systems are designed to detect and quantify the leakage. In addition, plant design features route building ventilation flows through monitored release points, or in some cases, through filtration systems to remove particulates and selected isotopes. The release points for both the plant ventilation systems and the gaseous waste management systems are designed to dilute the waste stream and release the gas at an elevated location. The bounding plant's normal release point is a 95.5-foot horizontal stack (see Section 3.1, PPE Section 9.4.1 and Section 9.4.2).

Gaseous releases of water-cooled plants are well known, and studies of gas-cooled plant operation have indicated that their gaseous releases would be bounded by the water-cooled data. Table 3.1-8 lists expected gaseous isotopic releases from a bounding single unit reactor design. Note that a single unit is defined in Section 3.1.2.2.

3.5.3 **Solid Radioactive Waste Management System**

Solid radioactive wastes are produced by multiple methods in a nuclear power station. The waste can be either dry or wet solids, and depends on whether the source is from an operational activity, or based on maintenance or other function. The solid radioactive waste management system is

designed to receive, collect, and store solid radioactive wastes prior to their onsite storage or their shipment off site.

Since the NAPS site already has two existing units, low-level solid waste storage from the new units would be coordinated with that from the existing units. The system would be designed to store and process those wastes to maintain radiation exposure ALARA. Radiation monitors would be used to monitor the area as well as the waste to ensure that applicable requirements are met.

The system design would ensure that the solid radioactive wastes are collected, monitored, segregated, stored, and packaged for shipment (if required) in a manner that minimizes exposure to plant personnel and the public in accordance with 10 CFR 20 and 10 CFR 50, Appendix I.

The total yearly activity and yearly generated volume of solid radwaste is listed in the PPE, Table 3.1-1.

Section 3.5 References

None

3.6 Nonradioactive Waste Systems

The following sections provide descriptions and scopes of service for non-radioactive waste systems for the new units. Typical non-radioactive waste systems need to address: 1) waste streams with effluents containing chemicals or biocides, 2) sanitary effluents, and 3) miscellaneous or other effluents. Descriptions in this section are based on best available information from operating experience and regulatory guidance.

3.6.1 Effluents Containing Chemicals or Biocides

Proper water chemistry for plant operation incorporates the treatment of water used in various secondary systems. Consequently, effluents from these water systems in the new units would contain some chemicals and/or biocides, similar to effluents from the existing units. These effluents would be treated according to regulations, as current discharges. The following list identifies some typical possible effluents:

- Iron
- Chlorides
- Ammonia
- Hydrazine
- Sulfates
- Silica
- Sodium
- Microbiocides

Discharges would occur from domestic water treatment, circulation water treatment, and plant blowdown. Regardless of the water systems' sources or constituents, each constituent discharged to the environment would be limited (i.e., volume and concentration) by the VPDES permit (Reference 1).

3.6.2 Sanitary System Effluents

A sanitary waste system, with expected effluents in compliance with acceptable industry design standards, the CWA, and state regulatory authority (through the VPDES permit), would be maintained onsite during the new units' construction and operation. The waste treatment system would be a permanent, self-contained system: its wastes would not be addressed through a municipal system.

The waste treatment system would be monitored and controlled by trained operators. If there was a need during peak construction or outage support activities for additional provisions, approved supplemental means of handling sanitary wastes would be employed.

Approved technology for processing wastes would include laboratory testing of effluents to ensure proper treatment. Monitoring would be implemented to ensure compliance with regulatory limits.

3.6.3 Other Effluents

This section describes miscellaneous gaseous, liquids, or solid effluents not addressed in Section 3.6.1 and Section 3.6.2.

3.6.3.1 Gaseous Effluents

Non-radioactive gaseous effluents created during plant operation from back-up power plant supply sources, such as diesel generators, would be permitted by state and federal regulatory authorities. The permits would specify operation frequency parameters and allowable quantities.

There are no other planned sources of gaseous emissions from the new units.

3.6.3.2 Liquid Effluents

Non-radioactive liquid effluents that could potentially drain to Lake Anna would be limited under the VPDES permit. A list of permitted outfalls for the existing units would be expanded to include any additional locations, adjusted flowpaths, or volumes created by the construction and operation of the new units (Reference 2).

3.6.3.3 Solid Effluents

Non-radioactive solid wastes are addressed by local regulation under “truck and haul” permitting. These solid effluents include typical industrial wastes such as metal, wood, and paper, as well as process wastes such as non-radioactive resins and sludge. Hazardous wastes are handled by permitted contractors and are addressed on site in compliance with federal regulation. It is anticipated that there would be no change to the method for handling solid wastes created by the new units.

Section 3.6 References

1. VPDES Permit No. VA0052451, Authorization to Discharge Under the Virginia Pollutant Discharge Elimination System and the Virginia State Water Control Act, Commonwealth of Virginia, Department of Environmental Quality, permit’s effective date, January 11, 2001; expiration date, January 11, 2006.

2. VPDES Application (Part 1), VPDES Outfall Descriptions and Sampling Points, North Anna Power Station, Dominion, March 30, 2000.

3.7 Power Transmission System

3.7.1 Switchyard Interfaces

The 500 kV switchyard at the NAPS site is an air-insulated, breaker-and-a-half switchyard with two full bays and two half bays. One full bay is for an existing unit and a transmission line; the other full bay is for the other existing unit and a 500/230 kV transformer; and two half bays, are each for a transmission line and two breaker open positions.

New units would be connected to the existing 500 kV switchyard by overhead or underground conductor circuits in accordance with the final plant configuration. The need for breaker-and-a-half bays varies depending on the reactor design selected. The existing switchyard may require extension to the north and the possible construction of additional bays, depending on the reactor design selected. This extension could be accommodated within the existing space at the site. The interface with the transmission system would occur at the connections to the bay of the existing switchyard, which interconnects with the outgoing transmission lines.

Depending on the final configuration selected, some existing plant buildings in the vicinity of the switchyard would be relocated so that they would not interfere with the connections to the generator step-up transformers.

The existing high-voltage equipment in the bay is rated for 3000A and 40 kA, and the 5-inch tubular bus is rated for 3676A and a 2 fps wind. The addition of the new units would require the upgrading of both the existing equipment and the bus, due to an increased output of up to 3000 MWe. The specific upgrading would be determined based on detailed system studies and would be described in the COL application.

Each of the 500 kV switchyard buses is connected to a 500/36.5 kV, 60/80/100/112 MVA transformer to feed station service loads in a double-ended, single bus configuration. A voltage drop study would be performed to verify the acceptability of using these transformers.

Additional bays would require new control and relay protection systems in the control house, and the control house could require expansion, if room is not available for the new units. The existing relay protection system for the lines and buses may not be able to accommodate the scheme for the new units. Therefore, the existing relay system may need to be upgraded.

The addition of the new units would also require the modification and/or expansion of some service systems, such as grounding, raceway, lighting, AC/DC station service, and switchyard lightning protection.

3.7.2 Transmission System

The NAPS site is interconnected with the power grid system by three 500 kV transmission lines from the 500 kV switchyard and by one 230 kV transmission line from the 230 kV switchyard. These transmission interconnections are as follows:

- A 500 kV line to the east to a 500 kV switching station near Ladysmith, Virginia, provides a connection to the 500 kV system. This line normally delivers the power generated at the NAPS site to loads. This line can deliver power to the NAPS site, if desired.
- A 500 kV line to the north to a substation near Morrisville, Virginia, provides a second connection to the 500 kV system. This line can deliver power to the NAPS site, if desired.
- A 500 kV line to the south to a substation near Midlothian, Virginia, provides a third connection to the 500 kV system. This line can deliver power to the NAPS site, if desired.
- A 230 kV line to the west to the South Anna non-utility generator substation near Gordonsville, Virginia, provides power to the 230 kV substation, a non-utility generator.

Each transmission line, constructed between 1973 and 1984, occupies a separate right-of-way. The rights-of-way range in width from 37 to 84 meters (120 to 275 ft) and from 24 to 66 km (15 to 41 miles) in length, covering a total of approximately 1174 ha (2900 acres) (Reference 1). The capacity of the 500 kV transmission lines is such that the output of the existing units can be carried by any of the 500 kV lines. Units 1 and 2 were uprated in 1986 to a gross electrical output of 1964 MWe, with a net electrical output of approximately 1884 MWe (Reference 2). The gross electrical output of the new units would not exceed 3000 MWe. The existing 500 kV transmission line utilizes 2 x 2500 ACAR (aluminum conductor aluminum reinforced) 84/7 conductors per phase and is rated 2292 MWe with a 2 fps wind. The 230 kV line can carry approximately 571 MWe due to the size of the transformer.

Total maximum output of the existing units and the new units would be:

$$1884 \text{ MWe} + 3000 \text{ MWe} = 4884 \text{ MWe}$$

Capacity of any two 500 kV lines and a 230 kV line is:

$$(2 \times 2292 \text{ MWe}) + 571 \text{ MWe} = 5155 \text{ MWe}$$

Thus, based on this initial evaluation, any two 500 kV transmission lines and the 230 kV transmission line are expected to have sufficient capacity to carry the total output of the existing units and the new units. However, detailed system load studies for the new units cannot be performed until an in-service date for the new units is established.

Section 3.7 References

1. NUREG-1437, Supplement 7, Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding North Anna Power Station, Units 1 and 2, U.S. Nuclear Regulatory Commission.
2. North Anna Power Station Updated Final Safety Analysis Report, Revision 38.

3.8 Transportation of Radioactive Materials

This section addresses the transportation issues associated with siting and operating a new reactor and is divided into two main subsections. The first subsection addresses the light-water-cooled reactor (LWR) designs presently being considered. The second subsection addresses the gas-cooled reactor designs also being considered. This split addresses the regulatory distinction made in 10 CFR .52 for LWRs.

3.8.1 Light-Water-Cooled Reactors

As required by 10 CFR 51.52, every environmental report prepared for the construction permit stage of an LWR, and submitted on or after February 4, 1975, is to utilize Table S-4, “Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water-Cooled Nuclear Power Reactor,” and shall contain a statement concerning transportation of fuel and radioactive wastes to and from the reactor.

Table S-4 (as provided in 10 CFR 51.52(c) and repeated in Table 3.8-3) is a summary impact statement concerning transportation of fuel and radioactive wastes to and from a reactor. The table is divided into two categories of environmental considerations: 1) normal conditions of transport and 2) accidents in transport. The normal conditions of transport consideration are further divided into environmental impact, exposed population, and range of doses to exposed individuals per reactor reference year. The “accidents in transport” consideration is concerned with environmental risk. Under “normal conditions of transport,” the environmental impacts of the heat of the fuel cask in transit, weight, and traffic density are described. Also the number and range of radioactive doses to transportation workers and the general public are described. Under “accidents in transport,” the environmental risk from radiological effects and common non-radiological causes such as fatal and nonfatal injuries and property damage are described.

To indicate that Table S-4 adequately describes the environmental effects of the transportation of fuel and waste to and from the reactor, the reactor licensee must state that the reactor and this transportation either meet all of the conditions in paragraph (a) of 10 CFR 51.52 or all of the conditions in paragraph (b) of 10 CFR 51.52. Subparagraphs 10 CFR 51.52(a)(1) through (5) delineate specific conditions the reactor must meet to use Table S-4 as part of its environmental report. Subparagraph 10 CFR 51.52(a)(6) states, “The environmental impacts of transportation of fuel and waste to and from the reactor, with respect to normal conditions of transport and possible accidents in transport, are as set forth in Summary Table S-4 in paragraph (c) of this section; and the values in the table represent the contribution of the transportation to the environmental costs of licensing the reactor.” For reactors not meeting the conditions of 10 CFR 51.52(a) paragraph 10 CFR 51.52(b) requires a further analysis of the transportation effects. As accepted in other licensing proceedings, a sensitivity analysis may be used to show that the transportation effects for such reactors remain bounded by Table S-4.

The LWR technologies being considered have characteristics that fall within the conditions of 10 CFR 51.52, for use of Table S-4, with the minor exceptions of 1) rated core thermal power level for two of the reactors, and 2) average fuel irradiation. As discussed below, the rated core thermal power level for these reactors does not translate into a greater amount of fuel than that assumed in Table S-4, and because average fuel irradiation is within the bounds of sensitivity analyses performed by the NRC, the environmental impacts of transporting fuel and wastes for these five types of LWRs are all bounded by Table S-4.

The LWR technologies being considered are the ABWR, the ESBWR, the AP-1000 (Advanced Passive PWR), the IRIS, and the ACR-700 (Advanced CANDU Reactor). The standard configuration for each of these reactor technologies is as follows. The ABWR is a single unit, 4300 MWt, nominal 1500 MWe reactor. The ESBWR is a similar BWR: single unit, 4000 MWt, nominal 1390 MWe. The AP-1000 is a single unit, 3400 MWt, nominal 1117–1150 MWe PWR. The IRIS is a three module PWR configuration for a total of 3000 MWt and nominal 1005 MWe. And the ACR-700 is a twin unit, 3964 MWt, nominal 1462 MWe, LWR with a heavy water moderator.

These conditions establishing the applicability of Table S-4 are reactor core thermal power; fuel form; fuel enrichment; fuel encapsulation; average fuel irradiation; time after discharge of irradiated fuel before shipment; waste form and packaging; mode of transport for unirradiated fuel; mode of transport for irradiated fuel; and mode of transport for radioactive waste other than irradiated fuel. Table 3.8-1 was prepared to succinctly show the reference conditions along with the bounding values for the new reactor technologies. The information to complete the table was supplied by the reactor vendors.

10 CFR 51.52(a)(1) requires that the reactor have a core thermal power level not exceeding 3800 MW. Of the considered LWR technologies, only the two BWRs, the ABWR and the ESBWR, exceed this value. The ABWR has a core thermal power level of 4300 MW thermal (MWt) while the ESBWR reactor power level is 4000 MWt. The core power level was established as a condition because, for the LWRs being licensed when Table S-4 was promulgated, higher power levels typically indicated the need for more fuel and therefore more fuel shipments than was evaluated in Table S-4. This is not the case for the new LWR designs due to the higher unit capacity and higher burnup for these reactors. The annual fuel loading for the reference reactor was 35 MTU while the annual fuel loading for both the ABWR and ESBWR is only 32.8 MTU. In fact, the annual MTU of fuel normalized to equivalent electrical generation is just slightly more than half of the reference LWR, 18.4 versus 35. This reduced annual MTU of fuel would mean fewer shipments and less environmental impact. Also, WASH-1238 states: “The analysis is based on shipments of fresh fuel to and irradiated fuel and solid waste from a boiling water reactor or a pressurized water reactor with design ratings of 3,000 to 5,000 MW thermal (MWt) or 1,000 to 1,500 MW electrical (MWe).” Both the ABWR and the ESBWR fall within these bounds.

10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered uranium dioxide (UO_2) pellets. The LWR technologies being considered have a sintered UO_2 pellet fuel form.

10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 enrichment not exceeding 4 percent by weight. The NRC has subsequently concluded that enrichment up to 5 percent is also bounded by the environmental impacts considered in Table S-4. These evaluations are documented in the "NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation" as provided in 53 FR 30555 and 53 FR 32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The LWR technologies being considered meet this subsequent evaluation condition.

10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. 10 CFR 50.44 also allows use of ZIRLO™. License amendments approving use of ZIRLO™ rather than Zircaloy have not involved a significant increase in the amounts or significant change in the types of any effluents that may be released offsite, or significant increase in individual or cumulative occupational radiation exposure. Based on this assessment, the LWR technologies being considered meet this subsequent evaluation condition.

10 CFR 51.52(a)(3) requires that the average burnup is not to exceed 33,000 MWd/MTU. The NRC has subsequently concluded that average burnup up to 62,000 MWd/MTU for the peak rod is also bounded by the environmental impacts considered in Table S-4. These evaluations are also documented in the "NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation" as provided in 53 FR 30555 and 53 FR 32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The LWR technologies being considered meet this subsequent evaluation condition.

10 CFR 51.52(a)(3) requires that no irradiated fuel assemblies be shipped until at least 90 days after it is discharged from the reactor. Table S-4 assumes 150 days of decay time prior to shipment of any irradiated fuel assemblies. The sensitivity analysis performed by the NRC to extend Table S-4 to burnups of up to 62,000 MWD/MTU assumes a minimum of five years between removal from the reactor and shipment. For the LWR technologies being considered, five years is the minimum decay time expected before shipment of irradiated fuel assemblies. U.S. Department of Energy's (DOE's) contract for acceptance of spent fuel, as set forth in 10 CFR 961, Appendix E, requires a five year minimum cooling time. In addition, the NRC specifies five years as the minimum cooling period when they issue certificates of compliance for casks used for shipment of power reactor fuel (NUREG-1437, Addendum 1, pp 26). Further, all of the LWR technologies considered have a design storage capacity well exceeding that needed to accommodate five-year cooling.

10 CFR 51.52(a)(5) requires that unirradiated fuel be shipped to the reactor by truck. Unirradiated fuel is currently transported to the North Anna site by truck, and Dominion would do the same.

10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel. This condition would be met for all the LWR technologies being considered. Three of the reactor vendors identified rail as the shipment mode, two reactor vendors specified truck as the shipment mode, and the vendor for

the ABWR and the ESBWR stated either rail or truck. Of note, the DOE is responsible for transport from reactor sites to the repository and DOE would make the decision on transport mode.

10 CFR 51.52(a)(5) requires that the mode of transport of low-level radioactive waste is either truck or rail. Dominion would ship its radioactive waste by truck.

Finally, 10 CFR 51.52(a)(4) requires that with the exception of spent fuel, radioactive waste shipped from the reactor is to be packaged and in a solid form. The LWR technologies being considered would solidify and package their radioactive waste. Additionally, existing NRC (10 CFR 71) and DOT (49 CFR 173,178) packaging and transportation regulations specify requirements for the shipment of radioactive material. The LWR technologies being considered are also subject to these regulations.

In conclusion, since the LWR technologies being considered either satisfy the conditions for use of Table S-4 or have impacts shown by sensitivity analysis to be bounded by Table S-4, the environmental impacts of transportation of fuel and radioactive wastes are represented by the values given in 10 CFR 51.52(c), Table S-4. Thus, the radiological and non-radiological environmental impacts of transportation of fuel to and from, and waste from, an LWR are small.

3.8.2 Gas-Cooled Reactors

3.8.2.1 Introduction and Background

The following assessment of the environmental impacts of the transportation of fresh and spent fuel to and from, and low-level waste from, the reactor for gas-cooled reactor technologies is based on a comparison of the key parameters and conditions that were used to generate the impacts listed in 10 CFR 51.52(c), Table S-4. This comparison can then demonstrate that the environmental impacts of these gas-cooled reactor technologies are no greater than the impacts previously identified in Table S-4 for the LWR technologies. The premise is that if the values of the major contributors to the health and environmental impacts that were used for the reference LWR are greater than those comparable values for the gas-cooled reactor technologies, then the subsequent impacts would also be greater and therefore bounding. It is important to point out that even though the contributors are being examined individually, it is the overall cumulative impact that is of concern. That is, for purposes of comparing/evaluating cumulative impacts, there may be increases in select individual contributors if offset by decreases in other contributors.

The parameters that have been chosen for purposes of comparison include not only the major contributors to the health and environmental impacts but also the conditions listed in 10 CFR 51.52. The major contributor to transportation risk is the number of shipments. Basically, the more shipments, the more risk; if there are no shipments, there is no risk. The Table S-4 shipments include fresh fuel for both initial core loading and reloads, irradiated fuel, and low-level waste (LLW) from operations. The second main contributor to the transportation risk would be the mode of shipment. In this case, only trucks and trains are considered. The last important risk factor relates to

what kind of material is being shipped. In the category for irradiated fuel fission product inventory, krypton inventory, actinide inventory, total radioactivity, decay heat, and weight of shipment were compared. For radioactive waste, the volume was used to determine the number of shipments. Radioactivity was also estimated to verify that the assumption about the percentage of LLW that might require shielding was reasonable.

The 10 CFR 51.52 conditions are: reactor core thermal power; fuel form; fuel enrichment; fuel encapsulation; average fuel irradiation; time after discharge of irradiated fuel before shipment; mode of transport for unirradiated fuel; mode of transport for irradiated fuel; and mode of transport for radioactive waste other than irradiated fuel. In addition, there are two other conditions that require that all radioactive waste with the exception of irradiated fuel be packaged and in solid form. Since existing packaging and transportation regulations already address those items and these regulations would also apply to these new reactor technologies, no further discussion is needed for these two conditions.

Before proceeding with the evaluation, it is important to note that the NRC has an ongoing review of the safety of spent fuel transportation. One recent evaluation is NUREG/CR-6672, “Reexamination of Spent Fuel Shipment Risk Estimates,” published in March 2000. The NRC in their document “An Updated View of Spent Fuel Transportation Risk,” concluded that the NUREG/CR-6672 study confirmed that: 1) earlier risk estimates (NUREG-0170, “Final Environmental Statement on the Transport of Radioactive Materials by Air and Other Modes”) to the public remain conservative by factors of 2 to 10 or more; 2) existing regulations governing the shipment of spent fuel are adequate; and 3) no unreasonable risk is posed to the public by the continued shipment of spent fuel. The range of conservative risk factors covers differences in mode of transport (rail or truck) and either accident or accident-free scenarios.

These same NRC conclusions support the position that environmental assessments of the transport casks do not have to be done for the Part 71 cask certifications because they meet the categorical exclusion criteria in 10 CFR 51.22(c)(13) that package designs used for the transportation of licensed materials do not require an environmental review. As discussed in 10 CFR 51.22(a), the NRC has determined that certain categories of licensing and regulatory actions have already been determined individually or cumulatively to not have a significant effect on the human environment; thus, a separate environmental assessment is not required. As mentioned in the previous paragraph, a generic assessment of the environmental effects associated with transportation of all radioactive material, including spent fuel, has already been done as provided in NUREG-0170, “Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes,” dated December 1977. This environmental impact statement (EIS) provided the regulatory basis for continued issuance of general licenses for transportation of radioactive material under 10 CFR 71. In addition, the NRC has conducted a reexamination of the risks associated with spent fuel shipments as documented in NUREG/CR-6672. This reexamination concluded that the

estimated risks for future shipments are well below those in the 1977 study. Thus, NUREG-0170 remains valid as the baseline report on which NEPA analyses of transportation risk are based.

Table 3.8-2 captures the major features of the reference LWR that were used to develop Table S-4 and compares these same features with the gas-cooled reactor technologies being considered. The reference LWR pertains to the typical 1100 MWe LWR as described in WASH-1238. The information to construct the worksheet was taken from the “Normal Conditions of Transport” portion of the 10 CFR 51.52, Summary Table S-4 “Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor,” WASH-1238, *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants* and Supplement 1 to WASH-1238 (NUREG-75/038) for the reference LWR. The information for the reactor technologies was provided by the reactor vendors.

3.8.2.2 **Analysis**

This section provides a detailed description of the comparison of the individual characteristics supporting Table S-4 against the corresponding parameters for the gas-cooled reactor technologies. The value for the reference reactor is given along with the corresponding values or range of values for the gas-cooled reactor technologies. As appropriate, additional information and/or observations are provided. Table 3.8-2 provides additional details regarding the reactor technology specific values.

There are two gas-cooled reactor technologies presently being considered. These reactor technologies are the GT-MHR (Gas Turbine-Modular Helium Reactor), and the PBMR. The standard configuration for each of these reactor technologies is as follows. The GT-MHR is a four module, 2400 MWt, nominal 1140 MWe gas-cooled reactor. The PBMR is an eight module, 3200 MWt, nominal 1320 MWe gas-cooled reactor. The unit capacities for these reactors are as follows: 88 percent for the GT-MHR; 95 percent for the PBMR. These values are contrasted with the reference LWR, a single unit, 1100 MWe plant with a unit capacity factor of 80 percent.

It is important to note that the plants being considered are a different physical size, have a different electrical rating, and have a different capacity factor from the reference LWR. In order to make proper comparisons, we need to evaluate the characteristics based on equivalent criteria. In this case, electrical generation is the metric of choice. Electrical generation is why the plants are being built, and we want to know if these new reactor technologies, for the same electrical output, have a greater or lesser impact on the health and environment. The reference LWR is a nominal 1100 MWe plant with a capacity factor of 80 percent. Based on this, the reactor technologies should be normalized to 880 MWe using their plant specific electrical rating and capacity factor. For many of the characteristics being examined, this adjustment is not necessary. But in a few cases, specifically those dealing with the number of shipments of fuel and waste, an adjustment is appropriate. The amount of this adjustment ranges from minus 12 percent for the GT-MHR to minus 30 percent for the PBMR.

The risk to the environment associated with the transportation of fuel is a function of the number of shipments and the contents of the shipments. Thus, a detailed analysis of these risk contributors is provided in the following sections.

3.8.2.3 Risk Contributors – Shipments

This section discusses the type and number of shipments for the gas-cooled reactor technologies and the values used for the reference LWR.

The reference LWR assumed an initial core loading of 100 MTU for a PWR and 150 MTU for a BWR. These quantities resulted in 18 truck shipments. For the new gas-cooled reactor technologies, the numbers of shipments were 44 for the PBMR and 51 for the GT-MHR. If normalized to the equivalent electrical output, the number of shipments would be 31 and 45 respectively.

The reference LWR assumed an annual reload of 30 MTU. This quantity resulted in 6 truck shipments. For the new gas-cooled reactor technologies, the numbers of reload shipments ranged from 3 for the PBMR to 20 for the GT-MHR. The number of shipments normalized to the electrical generation changes slightly to 18 for the GT-MHR.

With respect to the number of spent fuel shipments by truck, the reference LWR assumed 60 shipments annually. For the two gas-cooled reactor technologies, the number of shipments is considerably less. The PBMR requires 16 annual shipments while the GT-MHR requires 38 truck shipments annually. Normalizing to the electrical generation lowers these numbers to 12 to 34, respectively.

The reference LWR assumed 10 rail shipments annually of spent fuel. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by rail, no comparison is needed. However, based on the comparison for truck shipments, fewer than 10 rail shipments annually would be expected if DOE decided to use larger and higher capacity rail transport casks for gas-reactor spent fuel.

The reference LWR also considered transporting spent fuel by barge and assumed 5 shipments annually. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by barge, no comparison is needed.

The reference LWR assumes 46 shipments annually of low-level radioactive waste. The gas-cooled reactor technologies would make far fewer shipments. The GT-MHR would need only six shipments while the PBMR would require nine shipments annually. These results assume that 90 percent of the LLW can be shipped at 1000 ft^3 per truck, and the remaining 10 percent can be shipped at 200 ft^3 per truck. If the numbers are normalized to electrical generation, the numbers of shipments range from six to seven.

The Table S-4 value, traffic density in trucks per day, for the reference LWR is given as less than one per day. Both the gas-cooled reactor technologies would also have less than one per day. In

fact, the new gas-cooled reactor technologies would have far fewer shipments per year. The reference LWR bounding annual value for truck shipments is 110 based on a 40-year period, while the normalized number of truck shipments for the gas-cooled reactor technologies would require as few as 18 for the PBMR and only 41 for the GT-MHR.

The rail density in cars per month for the reference LWR is given as less than three per month. Since the gas-cooled reactor technologies are not planning to make any shipments by rail, no comparison is needed. However, as noted above, if DOE decided to use rail transport for spent fuel instead of truck, fewer than three shipments per month would be expected based on the expected larger capacity of rail spent fuel casks compared to truck casks.

3.8.2.4 **Risk Contributors - Contents**

This section addresses the radioactive contents of the shipments and their thermal loading and compares them to the reference LWR. The radioactive and decay heat values are based on the earliest time of shipment. For the gas-cooled reactor technologies, the five-year time was selected because it is the current minimum allowed time before shipment per DOE contract. These values are compared with the reference LWR that used a 90-day decay time. Ninety days was the minimum allowed time before shipment for Table S-4. Since we are evaluating the transportation impacts, it is the inventory and associated decay heat at the time of shipment that is of interest, not the inventory and decay heat at any other particular time.

The fission product inventory at the time of shipment for the reference LWR was 6.19×10^6 curies (Ci) per MTU. The values for the fission product inventory at the time of shipment for the gas-cooled reactor technologies were both much lower, from 3.5 to 4 times lower.

The actinide inventory at the time of shipment in Ci per MTU for the reference LWR was 1.42×10^5. Because of the longer burnup times for the new gas-cooled new reactor technologies, both of these reactor technologies have values that exceed the reference LWR. The GT-MHR and the PBMR, exceed the reference LWR by $\approx$64 percent and $\approx$59 percent, respectively. This comparison changes significantly for the GT-MHR if one considers the Ci per shipment, which is really what is of concern. The reference LWR ships 0.5 MTU per truck cask while the GT-MHR ships about a third less 0.16044 MTU per truck cask. Based on this comparison, the actinide inventory per shipment is about half (53 percent) for the GT-MHR versus the reference LWR. Since the PBMR plans to ship 0.495 MTU per cask, there is essentially no difference from the comparison per MTU.

The total radioactive inventory in Ci per MTU at the time of shipment for the reference LWR was 6.33×10^6. The new gas-cooled reactor technologies have much lower total radioactivity at time of shipment. The differences are from three to almost four times lower.

The krypton-85 inventory in Ci per MTU at the time of shipment for the reference LWR was 1.13×10^4. Both the GT-MHR and the PBMR exceed the reference LWR by about a factor of 2.3. As before, if one considers the Ci per shipment, the Kr-85 inventory for the GT-MHR would be about

71 percent of the Kr-85 reference LWR inventory. The PBMR comparison remains essentially the same.

The kilowatts per MTU at the time of shipment for the reference LWR were 27.1. This value is considerably higher than for the gas-cooled reactor technologies. At the time of shipment, the decay heat for the gas-cooled reactor technologies being considered ranges from 6.36 kilowatts per MTU for the GT-MHR to 3.91 kilowatts per MTU for the PBMR.

The decay heat (per irradiated fuel truck cask in transit) in kilowatts for the reference LWR was 10. Both the gas-cooled reactor truck casks generate much less heat (5 to 10 times lower) per truck cask than the reference LWR.

The decay heat (per irradiated fuel rail cask in transit) in kilowatts for the reference LWR was 70. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by rail, no comparison is needed. However, should DOE elect to transport by rail, the expected decay heat would be less than 70 based on the comparison for truck shipment.

At the time of the reference LWR evaluation, the road limit was 73,000 lb. This has changed slightly through the years. 23 CFR 658.17 “Weight” states that for the interstate and defense highways the maximum gross vehicle weight shall be 80,000 pounds. In all cases for the gas-cooled reactor technologies, the road limit is governed by state and federal regulations.

3.8.2.5 **Discussion**

Of the close to 30 characteristics/conditions that were examined, there are only 8 that were exceeded by the gas-cooled reactor technologies being considered. Three of these characteristics have no direct transportation impact on the health and the environment: fuel form, U_{235} enrichment, and fuel rod cladding. There are operational issues and fuel cycle impact issues associated with these characteristics that are addressed as part of the operating license and as part of the evaluation of Table S-3 “Uranium fuel cycle data,” respectively. Two of these characteristics (number of shipments for initial core loading and number of reload shipments) are really a part of the overall truck transportation picture. When one considers the total number of truck shipments (fresh fuel, spent fuel, and radioactive waste), the new reactor technologies have many fewer total shipments. For example, on an average annual basis, the new reactor technologies require 69 to 105 fewer truck shipments. Comparing the total number of shipments is appropriate since the radiological impacts from fresh fuel are negligible. One characteristic, burnup, manifests its impact through other characteristics, fuel inventory and decay heat at time of shipment, which are addressed separately. In the case of decay heat, both of the gas-cooled reactor technologies would generate fewer watts per MTU at time of shipment, and fewer kW per truck cask at time of shipment. The fuel inventory would be discussed as part of the remaining two characteristics that were exceeded: actinide inventory and krypton-85 inventory.

That the actinide inventory per metric ton of spent fuel is greater for the majority of the new gas-cooled reactor technologies is not surprising, since actinide activity tends to increase with increasing burnup and both of the gas-cooled reactor technologies plan a higher burnup than the reference LWR. The increase in the actinide activity for the new reactor technologies ranges from 59 percent to 65 percent. And as discussed in the previous section, if one considers the actinide inventory per shipment, only the PBMR exceeds the reference LWR by 59 percent. From NUREG/CR-6703 "Environmental Effects of Extending Fuel Burnup Above 60 GWd/MTU," we learn that "none of the actinides contributes more than one percent of the external dose from an iron transportation cask, and as a group, the actinides do not contribute significantly to the dose from transportation accidents. In fact, increasing the activities of Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-242 and Cm-244 by more than a factor of 1000 only increased the cumulative dose for a transportation accident during shipment of 43 GWd/MTU spent fuel from the northeast to Clark County, NV from 0.0358 to 0.0359 person-mSv/shipment (3.58×10^{-3} to 3.59×10^{-3} person-rem/shipment)." There is one other area where the increased actinide activity needs to be considered and that is the corresponding increase in neutron source term. NUREG/CR-6703 states "because neutrons are effectively attenuated by low-density materials such as plastics and water, it is believed that minor modifications can be made to shipping casks to allow them to transport the higher burnup fuel at full load."

Based on the analysis performed and the conclusions drawn in NUREG/CR-6703 which show that actinides are not major contributors to the transportation risk, either incident free or accident, and with the actinide activity only 59 percent greater, the environmental impacts would still be bounded even for these higher burnups.

This leaves the Kr-85 inventory as the final characteristic to be addressed. The increase of Kr-85, a long-lived noble gas, would suggest an increase of the consequences associated with an accident that resulted in a breach of the fuel cask and fuel rods. The range of increase for the gas-cooled technologies being considered is from 121 percent to 133 percent. And as discussed in the previous section, if one considers the Kr-85 inventory per shipment, only the PBMR exceeds the reference LWR. These amounts are based on a 5-year cooling time. If this decay time were increased by about 11 years, slightly greater than the half-life of Kr-85 (10.6 years), not an unlikely scenario by the way, this increase would for the most part decay away. Another factor to consider is that transportation risk is a function of both consequences and likelihood. Because the new reactor technologies require fewer truck shipments, the likelihood would decrease approximately 37 percent for the reactor with the greatest Kr-85 inventory. Another factor to consider is that the accident rate for large trucks has steadily declined for more than the past 25 years and is less than half the rate in 1975. Thus, the likelihood has decreased to about 37 percent (0.63×0.5) of the 1975 likelihood. A final and major factor to consider is that the cask regulations are based on allowable releases independent of the inventory. Thus, regardless of the initial source term, if the cask releases more than a specific acceptable amount, it would not be licensed. Based on these

considerations, the 5-year Kr-85 quantities would still be bounded by the overall transportation risk profile provided by Table S-4.

3.8.2.6 **Conclusion**

In conclusion, this detailed comparison of the underpinnings of Table S-4 show that the existing environmental and health effects are also conservative for the gas-cooled reactor technologies being considered. Of close to 30 characteristics examined, only eight were exceeded by the new technologies. In these instances, either they are independent of any impact or there are mitigating factors and controls to demonstrate that these slight increases are bounded by the impacts specified in Table S-4. This conclusion is also borne out by the observation that these new reactor technologies would be using the same transportation modes and subject to the same NRC and DOT regulations for packaging and transportation as the original analysis that was used to develop Table S-4. Thus, the new reactor technologies under consideration and the transportation of radioactive material associated with them meet the conditions in 10 CFR 51.52(b).

3.8.3 **Methodology Assessment**

The selection of a reactor design to be used for the ESP Facility is still under consideration. Selection of a reactor to be used at the ESP site may not be limited to those considered above. However, the methodology utilized above is appropriate to evaluate the final selected reactor. Further, should the selected design be shown to be bounded by the above evaluation, then the selected design would be considered to be within the acceptable fuel cycle environmental impacts considered for this ESP.

Section 3.8 References

1. 10 CFR 50.44, Standards for combustible gas control system in light-water-cooled power reactors.
2. 10 CFR 51.22, Criterion for categorical exclusion; identification of licensing and regulatory actions eligible for categorical exclusion or otherwise not requiring environmental review.
3. 10 CFR 51.52, Table S-4 Environmental Impact of Transportation of Fuel and Waste.
4. 10 CFR 71, Packaging and Transportation of Radioactive Material.
5. 49 CFR 173, Shippers – General Requirements for Shipments and Packagings.
6. 49 CFR 178, Specifications for Packagings.
7. Docket No. 50-400, 53 FR 30355, *NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation*, August 11, 1988, and 53 FR 32322, August 24, 1988.

8. NUREG-0170, *Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes*, Vols. 1 and 2, December 1977.

9. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Volumes 1 & 2, May 1996.

10. NUREG-1555 *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*, October 1999.

11. NUREG/CR-6672, *Reexamination of Spent Fuel Shipment Risk Estimates*, March 2000.

12. NUREG/CR-6703 *Environmental Effects of Extending Fuel Burnup Above 60 Gwd/MTU*, January 2001.

13. WASH-1238, *Environmental Survey Of Transportation Of Radioactive Materials To And From Nuclear Power Plants*, December 1972.

14. Supplement 1 to WASH-1238 (NUREG-75/038), *Environmental Survey Of Transportation Of Radioactive Materials To And From Nuclear Power Plants*, April 1975.

Table 3.8-1 LWR-S4 Transportation Impact Evaluation

Reactor Technology	Table S-4 Condition	ESBWR (Single unit) (4000 MWt) (1390 MWe)	ABWR (Single unit) (4300 MWt) (1500 MWe)	AP-1000 (Single Unit) (3400 MWt) (1117–1150 MWe)	IRIS (3 Reactors) (3000 MWt total) (1005 MWe total)	ACR-700 (Twin Unit) (3964 MWt total) (1462 Mwe total)
Characteristic						
Reactor Power Level (MWt)	not exceeding 3800 per reactor	4000	4300	3400	3000 (1000 per reactor, 3 reactors per plant)	3964 (1982 per reactor, 2 reactors per plant)
Fuel Form	sintered UO_2 pellets	sintered UO_2 pellets	sintered UO_2 pellets	sintered UO_2 pellets	sintered UO_2 pellets	sintered UO_2 pellets
U235 Enrichment (%)	Not exceeding 4; NRC has also accepted 5 as bounded	Initial Core <3.5; Reload average <4.5	Initial Core <3.5; Reload average <4.5	Initial Core Load Region 1: 2.35 Region 2: 3.40 Region 3: 4.45 Reload Average 4.51	fuel cycle average ≈4.85; maximum assembly 4.95; reload 4.75–4.95	2
Fuel Rod Cladding	Zircaloy rods; NRC has also accepted ZIRLO per 10 CFR 50.44	Zircaloy	Zircaloy	Zircaloy or ZIRLO™	ZIRLO™	Zircaloy-4
Average burnup (MWd/MTU)	Not exceeding 33,000; NRC has also accepted 62,000 for peak rod as bounded	46,000	46,000	48,700	55,200	20,500

Table 3.8-1 LWR-S4 Transportation Impact Evaluation

Reactor Technology	Table S-4 Condition	ESBWR (Single unit) (4000 MWt) (1390 MWe)	ABWR (Single unit) (4300 MWt) (1500 MWe)	AP-1000 (Single Unit) (3400 MWt) (1117–1150 MWe)	IRIS (3 Reactors) (3000 MWt total) (1005 MWe total)	ACR-700 (Twin Unit) (3964 MWt total) (1462 Mwe total)
Characteristic						
Unirradiated fuel						
Transport mode	truck	truck	truck	truck	truck	truck
Irradiated fuel						
Transport mode	truck, rail or barge	truck, rail	truck, rail	rail	rail	rail
Decay time prior to shipment	Not less than 90 days is a condition for use of Table S-4; 5 years is per contract with DOE	five years	five years	ten years	five years	ten years
Radioactive waste						
Transport mode	truck or rail	truck	truck	truck	truck	truck
Waste form	solid	solid	solid	solid	solid	solid
Packaged	yes	yes	yes	yes	yes	yes
Yellow indicates a value larger than or different from Table S-4.						

Table 3.8-2 Gas-cooled Reactor Transportation Impact Evaluation

Reactor Technology	Reference LWR (Single unit) (1100 MWe)	GT-MHR (4 Modules) (2400 MWt total) (1140 MWe total)	PBMR (8 Modules) (3200 MWt total) (1320 MWe total)	Comments
Characteristic				
Capacity (%)	80	88	95	
Normalization factor	1	0.88	0.7	
Reactor Power Level (MWt)	≈3400	2400 (600 per module, 4 modules per plant)	3200 (400 per module, 8 modules per plant)	Not exceeding 3800 per reactor is a condition for use of Table S-4
Fuel Form	sintered UO_2 pellets	TRISO coated particle fuel with uranium oxycarbide (UCO) kernal	Sphere of TRISO Coated UO_2 fuel kernels	Sintered UO_2 pellets is a condition for use of Table S-4.
U235 Enrichment (%)	1–4	fissile particle 19.8; fertile particle natural uranium	initial 4.9; equilibrium 12.9	Not exceeding 4 is a condition for use of Table S-4; NUREG-1437 concludes that 5 is bounded.
Fuel Rod Cladding	zircaloy	Graphite	Graphite	Zircaloy rods are a condition for use of Table S-4; 10 CFR 50.44 allows use of ZIRLO).
Average burnup (MWd/MTU)	33,000	112,742	133,000	Not exceeding 33,000 is a condition for use of Table S-4; NUREG-1437 concludes 62,000 for peak rod is bounded.

Table 3.8-2 Gas-cooled Reactor Transportation Impact Evaluation

Reactor Technology	**Reference LWR** (Single unit) (1100 MWe)	**GT-MHR** (4 Modules) (2400 MWt total) (1140 MWe total)	**PBMR** (8 Modules) (3200 MWt total) (1320 MWe total)	**Comments**
Characteristic				
Unirradiated fuel				
Unirradiated fuel transport mode	truck	truck	truck	Shipment by truck is a condition for use of Table S-4
No. of shipments for initial core loading	18	51 shipments (1020 fuel elements per module × 4 modules; 80 elements per truck)	44 shipments (260,000 fuel spheres per module × 8 modules, 48,000 spheres per truck)	100 MTU for PWR; 150 MTU for BWR
No. of reload shipments/year	6	20 shipments (520 elements per reload per 1.32 years × 4 modules; 80 elements per truck)	3 shipments (18,000 fuel spheres per module × 8 modules, 48,000 spheres per truck)	30 MTU annual reload
Irradiated fuel				
Irradiated fuel transport mode	truck, rail or barge	truck	truck	Shipment by truck, rail or barge is a condition for use of Table S-4.
Decay time prior to shipment	150 days	five years	five years	Not less than 90 days is a condition for use of Table S-4; 5 years is per contract with DOE
Fission product inventory in Ci per MTU after 5-year decay	6.19×10^6	1.55×10^6	1.78×10^6	The value for the LWR is for a 90-day decay time.
Actinide inventory in Ci per MTU after 5-year decay	1.42×10^5	2.33×10^5	2.26×10^5	The value for the LWR is for a 90-day decay time.

Table 3.8-2 Gas-cooled Reactor Transportation Impact Evaluation

Reactor Technology	Reference LWR (Single unit) (1100 MWe)	GT-MHR (4 Modules) (2400 MWt total) (1140 MWe total)	PBMR (8 Modules) (3200 MWt total) (1320 MWe total)	Comments
Characteristic				
Irradiated fuel (continued)				
Total radioactivity inventory in Ci per MTU after 5 year decay	6.33×10^6	1.78×10^6	2.01×10^6	The value for the LWR is for a 90 day decay time.
Krypton-85 inventory in Ci per MTU after 5 year decay	1.13×10^4	2.50×10^4	2.63×10^4	The value for the LWR is for a 90 day decay time.
Watts per MTU after 5 year decay	2.71×10^4	6.36×10^3	3.91×10^3	The value for the LWR is for a 90 day decay time.
No. of spent fuel shipments by truck	60	38 shipments (520 elements per module × 4 modules per 1.32 years, 42 elements per truck)	16 shipments (12 shipments for 1000 Mwe)	0.5 MT of irradiated fuel per cask
Heat (per irradiated fuel truck cask in transit) (kW)	10	1.02 (6.356 kW/MTU x 0.16044 MTU/shipment)	1.9 (3.9 kw/MTU × 0.495 MTU/shipment)	
No. of spent fuel shipments by rail	10	0	0	Appendix B, Table 1 says 3.2 MT of irradiated fuel per cask, Appendix B, Table 3 says 3.5
Heat (per irradiated fuel rail cask in transit) (kW)	70	NA	NA	
No. of spent fuel shipments by barge	5	0	0	

Table 3.8-2 Gas-cooled Reactor Transportation Impact Evaluation

Reactor Technology	**Reference LWR** (Single unit) (1100 MWe)	**GT-MHR** (4 Modules) (2400 MWt total) (1140 MWe total)	**PBMR** (8 Modules) (3200 MWt total) (1320 MWe total)	**Comments**
Characteristic				
Radioactive Waste				
Radioactive waste transport mode	truck or rail	truck	truck	Shipment by truck or rail is a condition for use of Table S-4.
No. of radwaste shipments by truck	46	6 (1100 Ci/yr; 98 m^3/yr)	9 (800 drums)	Assumed 90% of the waste shipped at 1000 ft^3 per truck, 10% at 200 ft^3 per truck.
Weight per truck (lb.)	73,000	governed by state and federal regulations	governed by state and federal regulations	Current interstate gross vehicle limit is 80,000 lb. (23 CFR 658.17)
No. of radwaste shipments by rail	11	0	0	
Weight per cask per rail car tons	100	100	100	
Transport totals				
Traffic density, trucks per day	less than 1	less than 1	less than 1	
Rail density, cars per month	less than 3	0	0	

Yellow indicates a value larger than or different from the reference LWR.

Reference: 10 CFR 51.52, Table S-4 Environmental Impact of Transportation of Fuel and Waste.

Note: The results for the reactor technologies have not been adjusted for their larger electrical generation or increased capacity factor.

Table 3.8-3 Summary Table S-4: Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor[a]

Normal Conditions of Transport			
Condition	**Value**		
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr		
Weight (governed by Federal or State restrictions)	73,000 lb. Per truck; 100 tons per cask per rail car.		
Traffic density Truck Rail	 Less than 1 per day. Less than 3 per month.		
Exposed Population	**Estimated Number of Persons Exposed**	**Range of Doses to Exposed Individuals[b] (per reactor year)**	**Cumulative Dose to Exposed Population (per reactor year)[c]**
Transportation workers	200	0.01 to 300 millirem	4 man-rem
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem
Along Route	600,000	0.0001 to 0.06 millirem	
Accidents in Transport			
Types of Effects	**Environmental Risk**		
Radiological effects Common (non-radiological) causes	Small[d] 1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.		

a.Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. 1 NUREG-75/038 April 1975.

b.The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

c. Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case would be 1 man-rem.

d. Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multi-reactor site.

Chapter 4 Environmental Impacts of Construction

Chapter 4 presents the potential impacts of the construction of the new units. In accordance with 10 CFR 51, impacts are analyzed, and a single significance level of potential adverse impacts (i.e., small, moderate, or large) has been assigned to each analysis. This is noted in respective topic discussions. Mitigation of adverse impacts is also presented, where appropriate. Construction activities would take place within a clearly-defined and access-controlled area designated as the construction site. This chapter is divided into six subsections which address the following topics:

- Land use impacts
- Water-related impacts
- Ecological impacts
- Socioeconomic impacts
- Radiation exposure to construction workers
- Measures and controls to limit adverse impacts during construction

The environmental description, where referenced, includes the following definitions:

- NAPS site - the property within the NAPS site boundary, or fence line, including the EAB.
- ESP site - the property within the NAPS site intended for the construction and operation of new units.
- Vicinity - the area within a 6-mile radius of the ESP site.
- Region - the area within a 50-mile radius of the ESP site.

4.1 Land-Use Impacts

This section discusses the potential land use impacts associated with construction of the new units. Construction activities would not require any current, or planned, land uses to be changed or modified from the existing NAPS site or vicinity land uses, either temporarily or permanently. The land use areas considered include those that have the potential to be directly impacted by construction activities (e.g., the site, the vicinity, along transmission corridors, and offsite areas). Additionally, land use considerations include those historic properties identified in the NRHP, as well as those properties that have the potential to hold potential historically significant items such as artifacts and human remains. This section is divided into three subsections: 1) site and vicinity, 2) transmission corridors and offsite areas, and 3) historic properties.

4.1.1 **The Site and Vicinity**

This section describes the construction impacts on land use of the NAPS site and vicinity. The NAPS site is located in Louisa County, Virginia. The area identified as the NAPS site, which includes the EAB extending out 5000 feet from the reactors, creates an entire site area of

approximately 730 hectares (1803 acres). The ESP site is located entirely within the NAPS site. The ESP vicinity is defined as the area approximately within 6 miles of the existing units, making the entire vicinity area approximately 29,300 hectares (72,400 acres). The vicinity surrounding the ESP site contains parts of Louisa and Spotsylvania counties. Each county has different designations and definitions for land-use categories. Unless otherwise referenced, the information used in this section was taken from the Final Supplement 7 to the Generic Environmental Impact Statement (GEIS) Regarding License Renewal for the NAPS, Units 1 and 2 (Reference 1) as well as from contacts with applicable county-level agencies.

4.1.1.1 **Louisa County Land Use**

Louisa County lies on the southern shore of Lake Anna. During the 30 years since the existing units were constructed, Louisa County has experienced substantial growth in population but relatively little growth in industry. The predominant land use in the county remains forestry. Forestry activities are a major contributor to the county's economy through employment, the sale of timber and forest products, and the generation of forest-related support activities. Other land uses include: agricultural lands occupy 23.5 percent, developed land uses occupy 6 percent (i.e., residential development predominates with 5.5 percent of the county land area) and water resources about 3 percent. Residential land use has increased 3.7 percent since 1979.

Louisa County land-use changes have been generally consistent with changes in the region as a whole. The county's proximity to metropolitan areas (i.e., Richmond, Charlottesville, and Fredericksburg, Virginia), combined with regional population growth trending away from metropolitan areas toward less developed areas like Louisa County, are the predominant forces resulting in county land-use changes.

4.1.1.2 **Spotsylvania County Land Use**

Spotsylvania County lies on the northern shore of Lake Anna. Historically, agriculture and forestry have been important components of the county's economy. Currently, 11 percent of the total county land is in agriculture and 64 percent is in forest. Developed lands (e.g., residential, industrial, commercial, public lands) cover 25 percent of the county, with residential use representing 22 percent of the developed land.

4.1.1.3 **Vicinity Land Use Areas**

Land use maps of the NAPS site and the vicinity have been prepared by the County of Louisa, Department of Planning and Zoning, and the Spotsylvania Planning Department (Reference 2) (Reference 3). Within the vicinity of the ESP site, the predominant land use is forestry and agricultural, followed by residential. Table 4.1-1 identifies the land areas developed for major uses within the ESP site boundary and vicinity.

Table 4.1-1 Land Use within the ESP Site and Vicinity

Land Use	Area[a] (Hectares)
Forestry	15,000
Industrial	2,700
Agriculture	5,600
Residential	2,200
Recreational	3,200
Other	600
Total Area	29,300

a. Areas shown are approximated based on zoning maps provided by Louisa and Spotsylvania counties (Reference 2) (Reference 3).

4.1.1.4 NAPS Land Use

The entire NAPS site is zoned for industrial use by Louisa County. All construction activities for the new units, including ground-disturbing activities, would occur within the NAPS site boundary. The area that would be affected on a long-term basis as a result of permanent facilities is approximately 52 hectares. The additional areas that would be disturbed on a short-term basis (e.g., as a result of temporary facilities, lay down areas) is approximately 27.5 hectares. Table 4.1-2 lists the general construction zones and their expected areas within the NAPS site boundary.

Table 4.1-2 Construction Areas

Construction Zone	Area (Hectares)
Material Lay Down	10
Parking Lot	6
Temporary Offices and Warehouses	6
Spoil Stockpile and Overflow	4
Batch Plant	1.5
Total Area	27.5

A site redress plan has been developed (see Part 4: Chapter 1, Site Redress) that addresses the need to stabilize and/or restore lands disturbed by pre-construction activities. Locations that are permanently disturbed would be stabilized and contoured in accordance with design specifications to meet the surrounding areas. Re-vegetation of disturbed lands would be compliant with site maintenance and safety requirements. Methods used to stabilize and restore areas would be

compliant with applicable laws and regulations, permit requirements, good engineering and construction practices, and recognized environmental best management practices. Methods that may be used to restore and stabilize disturbed areas are as follows:

- Re-contour with heavy equipment
- Mulch, seed, and plant
- Re-vegetate
- Provide permanent stabilization (e.g., pavement, rock, and gravel)
- Install permanent and/or temporary storm water management and erosion and sediment controls

4.1.1.5 Highways, Railroads, and Rights-of-Way

Figure 4.1-1 illustrates the existing highways, railroads, and transmission rights-of-way that cross the NAPS site and vicinity. No new or modified (e.g., widened) highways or railroads are planned to support the new units. As described in Section 2.2.2 and Section 3.7, based on an initial evaluation, the existing transmission lines have sufficient capacity to carry the total output of the existing units and the new units. A system study (load flow) modeling these lines with the new units' power contribution would be performed, if and when Dominion decided to proceed with the development of new units at the ESP site to confirm this conclusion.

4.1.1.6 Other Land Uses Considered

4.1.1.6.1 Recreational Areas

Lake Anna extends along the northern border of the NAPS site. Recreational use of the North Anna Reservoir is controlled by VDCR and is open to the public. Construction of a new water intake system would generally be limited to activity along a small portion of the North Anna Reservoir shoreline. Any work conducted immediately adjacent to the lake would be performed in accordance with applicable federal, Virginia, and local laws and regulations, permits, and authorizations. Therefore, construction-related impacts would not affect the recreational uses of the lake. See Section 2.4.1 and Section 2.4.2 for potential ecological impacts and Section 4.4.1 for physical impacts associated with the new units.

Another recreational area within the vicinity of the ESP site is Lake Anna State Park. The park is across the lake from the ESP site and to the northeast in Spotsylvania County. No construction-related impacts would affect recreation at the park.

4.1.1.6.2 Water Courses and Wetlands

A few small wetland areas and two intermittent streams exist on the ESP site (refer to Section 2.4.1). Watercourses and wetlands would be avoided to the extent possible during any construction. Any work that has the potential to impact a wetland would be performed in

accordance with the applicable regulatory requirements. Therefore, no construction-related impacts on water courses or wetlands would result.

4.1.1.6.3 **Floodplains**

The floodplain along the Lake Anna shoreline has been determined using the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (Reference 4). Any flooding that might occur during construction of the new units would be limited to areas adjacent to the lake shoreline (i.e., below elevations of 255 feet above msl). Limited construction activity would occur within the lake floodplain for the construction and installation of a new water intake structure. Any construction work conducted within the floodplain would be performed in accordance with the applicable regulatory requirements. Therefore, no construction-related impacts are expected to affect current land uses within floodplains.

4.1.1.6.4 **Forested Areas**

Forested land does exist within the ESP site. Clearing and removal of trees within the ESP site would be required. The removal of the trees would not create land-use impacts on the existing (industrial) site or vicinity. Section 4.3.1 describes the removal of trees and ecological impacts resulting from such removal.

4.1.1.6.5 **Agriculture**

There are no agricultural lands within or adjacent to the ESP site. Therefore, no farmlands would be impacted by proposed construction activities.

4.1.1.7 **Significant Cumulative or Other Impacts**

Since construction activities would be limited to the ESP site, the new units would not impact federal, Virginia, regional, local, or Native American tribal land-use plans. Additionally, the new units would not significantly impact any future local or regional land-use plans (see Section 2.2.1 and Section 2.2.3). There are no known federally-sponsored actions that would have cumulatively significant impacts on construction activities, either at the ESP site or within the vicinity. Land or other similarly designated areas that may be considered for development (other than industrial) would be addressed through local county jurisdiction. All construction impacts on land use would be small and would not warrant mitigation.

4.1.2 **Transmission Corridors and Offsite Areas**

Based on an initial evaluation, the existing transmission lines have sufficient capacity to carry the total output of the existing units and the new units. A system study (load flow) modeling these lines with the new units’ power contribution would be performed, if and when Dominion decided to proceed with the development of new units at the ESP site, to confirm this conclusion. Additional transmission system information is provided in Section 3.7.

No new routes of access corridors would be necessary to serve operation of the new units. No offsite land uses would be affected by operation of the new units.

4.1.3 Historic Properties and Cultural Resources

This section provides information on potential impacts from new unit construction activities on historic properties in the NAPS site and vicinity, along transmission corridors, and offsite areas.

Historic properties listed in the NRHP that exist within the vicinity of the ESP site are identified in Section 2.5.3. There are no known historic properties listed in the NRHP that exist within the NAPS site boundary or within the existing transmission corridors. No offsite areas would be impacted by construction activities associated with the new units.

Virginia Power has maintained communications with the Virginia Division of Historic Resources (VDHR) regarding the management of the NAPS site and the potential ground-disturbing activities in areas that have the potential for containing historic and/or archaeological artifacts.

Prior to any activities that would disturb existing ground conditions, Dominion would assess the need, in coordination with VDHR, to undertake subsurface investigations for the identification of potentially significant historic or cultural resources in the area(s) to be disturbed. The investigations would be conducted in accordance with professional archeological practices and recommendations as developed in coordination with VDHR.

Additionally, Dominion would implement the necessary administrative steps to make proper notifications in the event of any unanticipated discovery (including human remains). These steps would include stop-work, assessment, and notification protocol.

The primary controls to be used to minimize impacts in the event of an unanticipated discovery would include: ongoing coordination with VDHR with regards to the potential presence of historic and cultural resources within planned disturbed areas, adherence to Dominion administrative procedures regarding activities to be implemented in the event of an unanticipated discovery, and adherence to specific permit requirements through their integration into construction scheduling and work practices.

Section 4.1 References

1. Final Supplement 7 to the Generic Environmental Impact Statement (GEIS) Regarding License Renewal for the North Anna Power Station, Units 1 and 2, November 2002.

2. *Land Use Classifications for Louisa County, Virginia (Site and Vicinity),* Louisa County Department of Planning/Zoning, Louisa County (Virginia), 2002.

3. *Land Use Classifications for Spotsylvania County, Virginia (Site and Vicinity),* Spotsylvania County Planning Department, Spotsylvania County (Virginia), 2002.

4. *Flood Insurance Rate Map, Louisa County, VA and Incorporated Areas*, Federal Emergency Management Agency (FEMA), U.S. Department of Interior, November 1997.

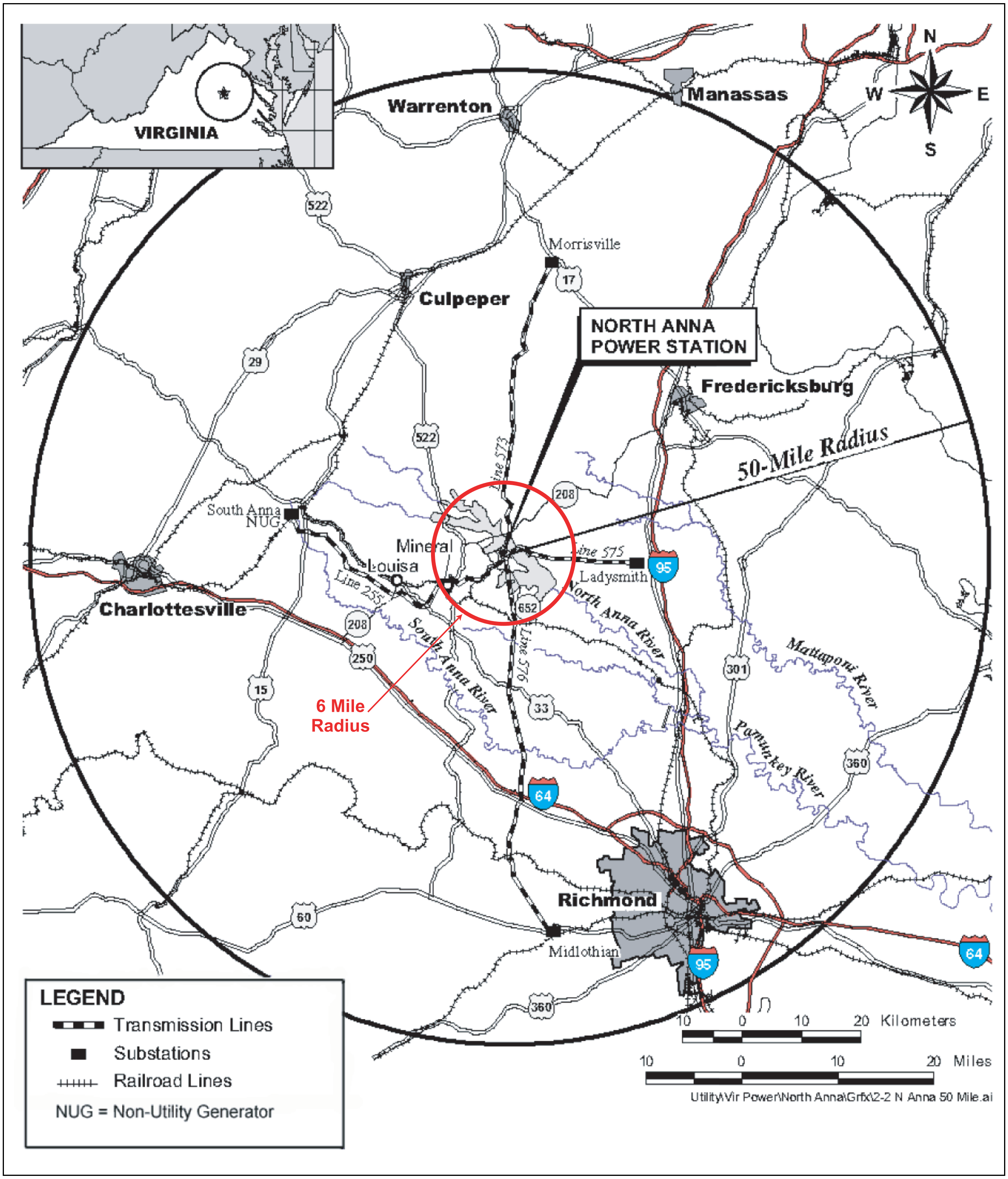


Figure 4.1-1 Vicinity Highways, Railroads, and Utility Rights-of-Way

Source: Reference 1, Figure 2-5

4.2 Water-Related Impacts

This section addresses hydrologic alterations and water-use impacts that would result from new unit construction activities at the ESP site. The discussion includes mitigation measures that would be incorporated to reduce adverse impacts from hydrologic alterations and water-use. Compliance with applicable regulatory requirements is also addressed.

4.2.1 Hydrologic Alterations

During construction of new units at the ESP site, hydrologic alterations would occur to two small ephemeral streams, the North Anna Reservoir, and groundwater. Mitigation measures would be implemented to reduce adverse impacts. This section addresses each of the alterations and the mitigation measures that would be used to reduce the adverse impacts.

4.2.1.1 Surface Water

Currently, the ESP site area slopes gently north toward the North Anna Reservoir. Runoff from the majority of the site reaches the North Anna Reservoir as sheet flow or shallow concentrated overland flow. In the cooling tower area that is west of the power block area, two small ephemeral streams discharge to the North Anna Reservoir. These streams are designated Stream A and Stream B on Figure 4.2-1. The drainage areas for Streams A and B are about 74 and 56 acres, respectively (Reference 1). Should cooling towers be constructed, portions of these ephemeral steams would be filled to level the site. Approximately 1500 feet of stream channel would require filling.

The ESP site drainage system design would incorporate measures to convey streamflows to Lake Anna. Construction activities would comply with the applicable regulatory requirements governing the filling of these ephemeral streams. All required permits would be obtained prior to the commencement of construction.

During construction of the new units, the potential would exist for sediment from the construction site to be eroded and conveyed to Lake Anna by storm water runoff until the ESP site drainage system is installed and construction is completed. Best management practices (BMPs) described in the Virginia Erosion and Sediment Control Handbook (Reference 2) would be used to control erosion and minimize the sediment load to Lake Anna in accordance with an approved erosion and sediment control plan. Best management practices may include sediment basins, sediment barriers, vegetative stabilization and filter strips, rip rap, rock filter berms, mulching, etc. Other than the two ephemeral streams, there are no other existing defined drainage channels or streams in the proposed area of construction.

Once construction is completed and the ESP site has been stabilized, the risk of increased sediment loading to the lake would be minimal. Given the volume of Lake Anna and the use of state-approved BMPs, the adverse impacts from sediment loading to Lake Anna would be small.

The small amount of sediment that could reach Lake Anna during construction would settle out in the vicinity of the ESP site.

The circulating water intake for the new units would be located along the shoreline of the North Anna Reservoir west of the intakes for the existing units. A cofferdam installed in the early 1980s for the construction of the intake for the abandoned Units 3 and 4 exists at this location. Construction of the intake for the new units would require dewatering. Because of the cofferdam, the intake location is not in contact with the North Anna Reservoir. Therefore, construction of the shoreline intake could proceed without any hydrologic impacts to the North Anna Reservoir. State-approved BMPs would be implemented prior to construction of the intake to reduce the impacts of erosion and sedimentation.

After construction of the intake, the cofferdam would be removed. Removal of the cofferdam would temporarily create the potential for increased sediment loading to the North Anna Reservoir in the vicinity of the new intake. The increased sediment loading would be mitigated by the installation of approved mitigation measures, such as silt curtains or similar methods, and BMPs. Federal, state, and local permits associated with the removal of material from the cofferdam area and/or lake would be obtained prior to construction of the new units. By implementing the mitigation measures, any adverse impacts to the reservoir would be small, and limited to the duration of the cofferdam removal. Removing the cofferdam would also permanently increase the North Anna Reservoir surface area and shoreline as the lake fills in the void behind the cofferdam and reaches the original shoreline.

4.2.1.2 **Groundwater**

Depending on the reactor type selected, excavations for foundations could reach depths of up to 140 feet below the final grade elevation. The final grade elevation is anticipated to be at or near the grade at the existing units at Elevation 271.0 ft. Therefore, the foundation excavations could reach approximately Elevation 130 ft msl. Based on measurements in observation wells at the site, groundwater is present at depths as shallow as about 5 feet below existing grade (Section 2.3.1.2). Dewatering would be required to a greater or lesser extent in excavations extending below the water table to permit construction of foundations. Dewatering for individual excavations would continue until construction is raised to a point above the water table and backfill is placed in the excavation.

The dewatering process would draw down the water table in the excavated area and the area surrounding the excavation. Subsurface investigations indicate that the subsurface materials underlying the ESP site consist of residual soils and metamorphic bedrock. Based on the experience gained from the construction of the existing units and abandoned Units 3 and 4, the drawdown created by dewatering would be localized to the area of the ESP site.

Impacts of the dewatering drawdown would be temporary and small.

Groundwater extracted from the excavations would be monitored and, if necessary, treated to remove sediment before discharging it to the North Anna Reservoir. The additional flow to the North Anna Reservoir resulting from dewatering activities would be temporary and small. Groundwater at the ESP site is generally of good quality, as discussed in Section 2.3.3.2, and its discharge to the North Anna Reservoir would not have an adverse affect on the quality of the water in the lake.

4.2.2 Water-Use Impacts

This section identifies construction activities or construction-related alterations that could impact water use. Proposed practices to minimize adverse impacts are also discussed.

Construction activities for the new units would be limited to the ESP site adjacent to Lake Anna.

In addition to the existing units, there are three known industrial water users (Bear Island Paper Co., St. Laurent Paper Products, and the Doswell Water Treatment Plant) that take water from the affected hydrologic system. The existing units use lake water for their circulating water systems. The general public uses the lake for recreational boating and fishing. Impacts of construction activities to the lake and the North Anna River would be temporary and limited to the area near the construction site. The only impact would be a small increase in sediment loading in the lake near the new units. Other than increased sediment loading near the site, no other water quality impacts to surface waters are anticipated.

In addition to the Erosion and Sediment Control Plan, an approved construction storm water pollution prevention plan (SWPPP) would be implemented for the duration of construction activities at the ESP site. The SWPPP would provide approved measures to prevent fuel, oil, and other chemicals associated with construction from contaminating the surface water or the groundwater. Applicable federal, state, and local permits would be obtained prior to the commencement of construction. Because any impacts would be limited to the area adjacent to the lake, no impacts to the recreational water use of Lake Anna are anticipated. Additionally, there would be no water quality impacts to the North Anna River upstream or downstream of the ESP site.

The private groundwater user nearest to the ESP site is about one mile south-southeast. Because the impacts of dewatering would be confined to the area around the ESP site, private groundwater uses would not be affected. There are also existing potable water wells at the NAPS site. Some of the existing potable water supply wells at the site could be affected by the resulting drawdown.

The combined production capacity of the water supply wells of the existing units is greater than the water use requirements (Section 2.3.2.2.2). Because not all of the water supply wells would be affected by construction dewatering, the excess capacity of the unaffected wells would be sufficient to supply the needs for the existing units. However, if additional water is needed, a temporary supply of potable water could be obtained from an offsite source.

Section 4.2 References

1. 38077-A7-TF-024, *Lake Anna West, VA*, 7.5 Minute Series Topographic Map, U.S. Department of Interior, U.S. Geological Survey, Photorevised 1983.

2. *Virginia Erosion and Sediment Control Handbook,* 3rd Edition, Virginia Department of Conservation, Division of Soil and Water Conservation, 1992.

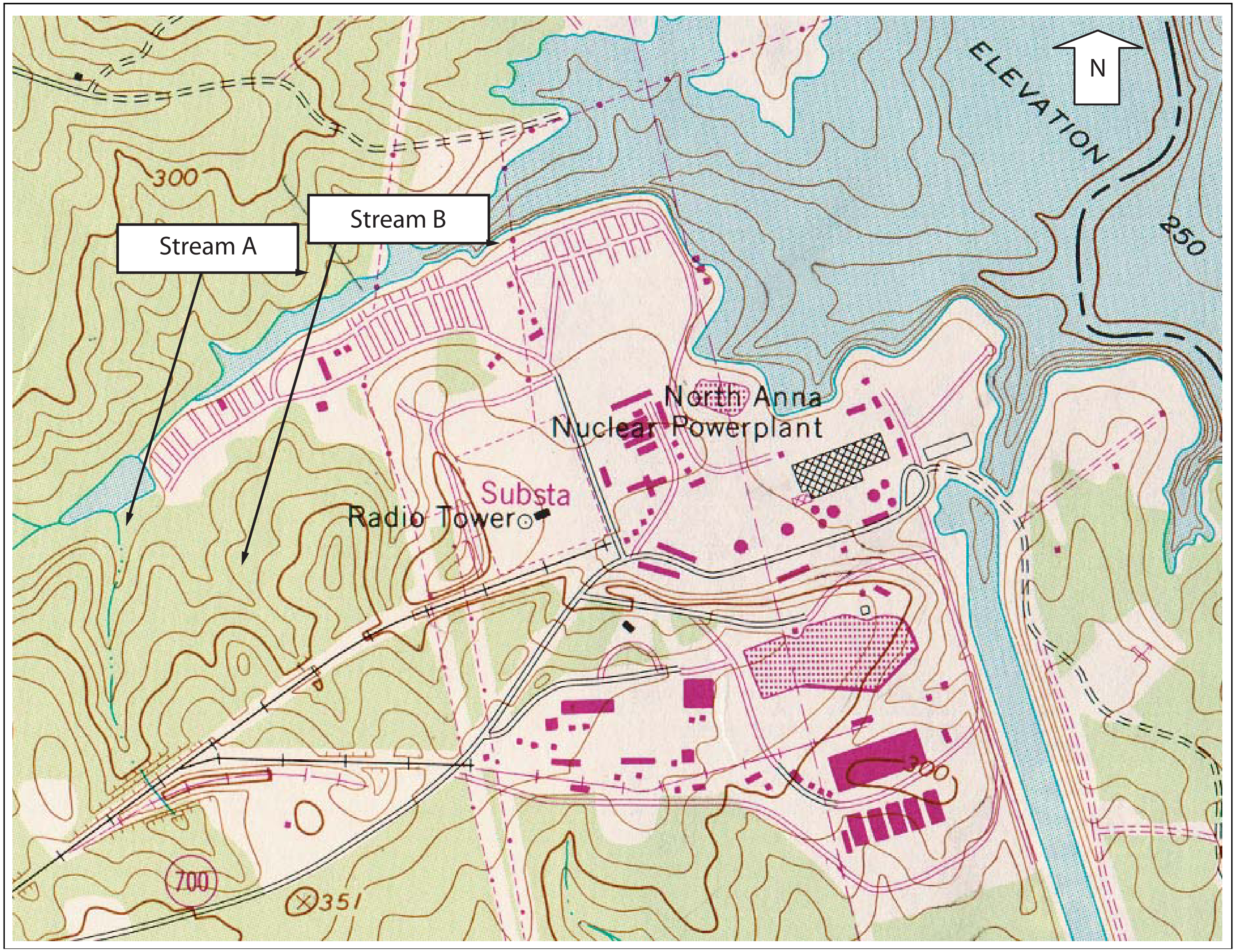


Figure 4.2-1 Ephemeral Steam Locations

4.3 Ecological Impacts

This section describes the potential impacts to the ecological resources that could result from construction activities. This section is divided into two subsections: 1) Terrestrial ecosystems, and 2) Aquatic ecosystems. Each subsection provides sufficient detail to assess the nature and magnitude of potential impacts on the identified resources.

4.3.1 **Terrestrial Ecosystems**

4.3.1.1 **Transmission Corridors**

Section 3.7 discusses assessment of the power transmission system. No impacts on transmission corridors, transmission towers, transmission-tower configurations, or transmission tower access roads are anticipated.

4.3.1.2 **ESP Site**

Section 2.4.1 discusses terrestrial ecological habitats at the ESP site. The approximate area of the ESP site is 200 acres. Natural habitats are absent from the industrial/developed portions (approximately 120 acres) of the ESP site (Figure 2.1-1). As a result, construction activity would have no impact on ecological resources within these portions of the ESP site.

Construction of the new units would result in the removal of essentially all forested habitat (approximately 80 acres) within the ESP site (Figure 2.1-1). The ESP site does not contain any old growth timber, unique or sensitive plants, or unique or sensitive plant communities. Therefore, construction activities would not noticeably reduce the local or regional diversity of plants or plant communities. There are no “important” species or habitats on the ESP site. No areas designated by the USFWS as “critical habitat” for endangered species exist at or near the ESP site, nor are threatened or endangered plants or animals known to exist there. Therefore, construction would have no impact on any threatened or endangered species, or other “important” species or habitats. Section 2.4.1 discusses the results of consultation with agencies regarding protected species.

A few small wetland areas and two intermittent streams exist on the ESP site (refer to Section 2.4.1). Watercourses and wetlands would be avoided to the extent possible during any construction. Any work that has the potential to impact a wetland would be executed in accordance with the applicable laws, regulations, permits, and authorizations. Therefore, construction-related impacts would be small.

Land clearing associated with construction would be conducted according to federal and state regulations, permit conditions, existing procedures, good construction practices, and established best management practices (e.g., directed drainage ditches, silt fencing). Fugitive dust would be minimized by watering the access roads and construction site as necessary. Thus, impacts from dust would be small and mitigation would be unwarranted. Emissions from heavy construction equipment would be minimized through scheduled equipment maintenance procedures.

Section 4.1.1 describes the physical impacts of construction at the site. To minimize construction-related impacts, Dominion would adhere to permit conditions that may restrict the timing of certain construction activities. As the site undergoes clearing and grading, disturbance and forested habitat loss would displace mobile animals such as birds and larger mammals. Species that can adapt to disturbed or developed areas (e.g., raccoon, opossum, mockingbird, Northern cardinal) may recolonize portions of the site where grasses and other vegetation are undisturbed or are replanted following construction activities. Species more dependent on forested habitat may be permanently displaced. Clearing and grading activities may directly result in the loss of some individuals, particularly the less mobile animals such as toads, lizards, snakes, moles, and mice.

Construction activities would involve movement of workers and construction equipment, and would be associated with noisy activities from construction equipment (e.g., earth-moving equipment, portable generators, pile drivers, pneumatic equipment, and hand tools). Although short-term noise levels from construction activities could be as high as approximately 110 dBA, (e.g., impulse noise during pile driving activities), these noise levels would not extend far beyond the boundaries of the ESP site. Table 4.3-1 illustrates the rapid attenuation of construction noise over relatively short distances.

Construction noises would range from approximately 60 to 80 dBA 120 meters (400 feet) from the construction site. These noise levels are below the 80 to 85 dBA threshold at which birds and small mammals are startled or frightened (Reference 1). Thus, noise from construction activities would not disturb wildlife beyond 120 meters from the construction site. After initial land clearing, wildlife such as mammals and songbirds that are associated with uplands would be impacted only by the construction noise in the area to the west of the ESP site. In addition, only a narrow lake inlet immediately north of the laydown area and a small wet area near the existing units comprise portions of Lake Anna that are within 120 meters of the ESP site. Furthermore, it is noted that construction would occur adjacent to the existing units, where wildlife have presumably become accustomed to typical existing operating facility noise levels of approximately 50 to 60 dBA at the security fence.

Avian collisions with man-made structures are a result of numerous factors related to species' characteristics such as flight behavior, age, habitat use, seasonal habits, and diurnal habitats; and to environmental characteristics such as weather, topography, land use, and orientation of the structures. Most authors on the subject of avian collisions with utility structures agree that collisions are not a biologically significant source of mortality for thriving populations of birds with good reproductive potential (Reference 2). The number of construction-related bird collisions with structures has not been quantitatively assessed; however, because no avian collisions with existing structures at the NAPS site have been noted, such collisions during the construction phase would also be negligible.

Table 4.3-1 Peak and Attenuated Noise (in dba) Levels Expected from Operations of Construction Equipment[a]

Source	Nose Level (peak in dBA)	Distance from Source			
		50 feet[b]	100 feet	200 feet	400 feet
Heavy trucks	95	84-89	78-83	72-77	66-71
Dump trucks	108	88	82	76	70
Concrete mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Generator	96	76	70	64	58
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Dragline	105	85	79	73	67
File driver	105	95	89	83	77
Fork lift	100	95	89	83	77

a. Source: (Reference 1)

b. To convert feet to meters, multiply by 0.3048.

In summary, while the construction-related impacts of forested habitat loss to local wildlife populations cannot be quantitatively assessed because population data for species on and adjacent to the NAPS site are not available, relatively large tracts of forest to the north, west, and south of the NAPS site are available to displaced animals. Given the fact that approximately 80 acres of forested habitat at the site represents a small portion of the available undeveloped land in the vicinity, the construction-related mortality and temporary displacement of wildlife would be minimal, relative to wildlife populations in the region. In addition, construction activities would not reduce the local or regional diversity of plants or plant communities, and would not impact endangered or threatened species. Noise-related impacts and bird collisions during construction would be negligible.

4.3.2 **Aquatic Ecosystems**

Construction of the new intake structure and intake channel would be the primary source of construction impacts on the aquatic environment. Construction would involve major modifications to

an existing intake structure and deepening and enlarging the existing intake canal. Section 3.4.2 provides a description of the proposed construction activities.

The intake structure would be approximately 150 feet long and 300 feet wide and would house the trash racks, traveling screens, and intake pumps (Figure 3.4-3 and Figure 3.4-4). The new intake channel would extend from the intake structure toward the west slope of the intake cove. Construction would result in the removal or reshaping of the shoreline to accommodate the intake structure and to meet the intake approach velocity requirements.

As part of the intake structure and channel modification, the existing cofferdam would be removed. Approximately 84,000 cubic yards of material would be moved from the cofferdam. All of the dredged material would be properly disposed of in accordance with regulatory requirements and permit conditions.

In anticipation of construction, topsoil would be removed from the construction footprint, stored, rolled, and seeded as necessary, to minimize erosion. Some disturbed areas may be graveled, paved, or compacted to prevent erosion. These soil preparation procedures and others would minimize impacts to the aquatic environment from earth-moving activities. Following the cessation of construction activities, areas that are disturbed temporarily would be graded and contoured, covered with topsoil, and seeded with native vegetation.

Degraded water quality (e.g., increased turbidity and siltation) as a result of shoreline contouring and dredging would pose the greatest potential for impacts on the North Anna Reservoir ecosystem in the immediate vicinity of the construction activities. This shoreline contouring would result in the temporary loss of benthic habitat and the displacement or loss of benthic organisms, which provide food for other animals such as fish and shorebirds. After construction, the intake channel cove and the shoreline substrate near the new intake structure would be re-colonized by benthic organisms available to predators. To minimize impacts to benthic populations in the reservoir, intake construction and protection activities would be conducted in accordance with state regulations and permit requirements. The benthic habitat lost would be temporary and a small percentage of the available benthic habitat. The loss of this habitat would not have a long-term impact on the aquatic ecosystem.

Some fishery habitat may be changed as well. Fish inhabiting the intake channel and the lake near the intake channel would likely leave the area temporarily during construction activities. After construction is completed, fish would re-populate those areas. Temporary habitat loss would be a small percentage of the total fishery habitat available in the North Anna Reservoir. To minimize impacts to fish populations in the reservoir, intake construction and protection activities would be conducted in accordance with state regulations and permit requirements. Construction impacts on the reservoir’s fishery would be small and temporary.

Dredging of the new intake channel could re-suspend heavy metals from the Contrary Creek area (see Section 2.4.2) that may be in the bottom sediments of the old North Anna River channel in the

lake. Should heavy metals be present in the re-suspended sediments they could result in impacts to aquatic biota. Any environmental concerns would be addressed through the permitting process for the new units.

Increased turbidity also could result in a temporary reduction in primary productivity due to reduced light penetration and smothering of periphyton and aquatic macrophytes in the intake channel. After construction, primary productivity would be expected to increase to previous levels and macrophyte re-colonization would occur. A barrier (e.g., turbidity curtain, sheet piling) may be installed between the ESP site and the lake to reduce the potential for silt and soil entrainment through the existing units to the WHTF, where it could adversely affect primary production.

The potential for fuel or other fluid spills exists throughout the construction phase. To prevent contaminants from entering the aquatic system any spills would be handled according to an approved Spill Prevention Control and Countermeasure (SPCC) Plan.

As stated in Section 2.4.2, Virginia Power has monitored fish populations in Lake Anna and the North Anna River since the early 1970s, to evaluate the response of these populations to the operations of the existing units. No federal or state-listed protected fish species has been collected in any of these monitoring studies, nor has any listed species been observed in creel surveys or special studies conducted by Virginia Power biologists and affiliated researchers. Refer also to the discussion in Section 2.4.2 for other field and database searches regarding threatened, endangered, or state-listed aquatic species. Based on the absence of federal and state-listed protected fish species, construction impacts to threatened, endangered, or important aquatic species in Lake Anna, its tributary streams or the North Anna River would be unlikely.

Construction of cooling towers for Unit 4 could be near an intermittent stream (Figure 3.4-3). See Section 4.3.1 for additional discussion. Construction of these towers could result in soil erosion and silt entry into the stream.

Refurbishment of an existing rail spur or construction of a new one also could occur near the stream. Intermittent streams in this area are not known to provide key fishery habitat for any important species. However, sedimentation and erosion control BMPs and/or effective stormwater management would be used to protect aquatic resources in the construction area.

In summary, construction activities would affect the North Anna Reservoir and its aquatic communities in the vicinity of the intake channel. These impacts would be small and temporary and would be mitigated through adherence to applicable laws, regulations, and permit conditions, and the use of good construction and BMPs to minimize impacts on aquatic resources. No critical habitats or protected aquatic species exist in the area, so none would be adversely affected by construction activities.

4.3.2.1 **Construction Implications of Options to Mitigate Increased Lake Temperature**

Construction activities from a number of options considered to mitigate the projected increases in water temperature could affect the aquatic ecosystem. Options currently under consideration include the following: 1) a submerged intake structure (i.e., curtain wall), 2) helper towers, and 3) spray cooling systems. See Section 9.4.1.1.3.

Submerged intake: Submerged intakes or skimmer walls have been used for the past 50 years to ensure a cooler water supply for power plants. In general, this intake system maximizes the use of cooler water available from the deeper layers of a reservoir. Traditionally skimmer walls were constructed of steel or concrete and extended from just above the water surface to within 5–15 feet of the reservoir bottom. In recent years flexible floating curtains have been employed in a variety of intake systems to control the discharge of warmer water or to ensure a supply of cooler water for intake systems.

Construction Impacts – Construction of a curtain/wall in the North Anna Reservoir would result in some short-term environmental impacts, similar to those identified with the construction of a new intake structure. Impacts would depend on the specific location, solid or flexible curtain, size of lay-down areas, and other normal construction related activities. Soil and erosion from runoff could impact the aquatic ecosystem and result in reduced productivity in the immediate vicinity. In addition, accidental spills of fuel or other chemicals associated with the construction activities could impact the aquatic ecosystem. Use of a barge, dragline or other equipment during installation of the curtain and the associated anchoring system could impact the bottom ecosystem and result in temporary loss of habitat and reduced productivity. However, as previously mentioned BMPs would be employed and all permit conditions would be followed. For these reasons, There would not be any long-term ecological impacts to the aquatic ecosystem.

Spray Cooling Systems: Floating spray modules to dissipate waste heat from power plants have been used in a variety of types and configurations. For the new units, the modules would be moored in the discharge canal and as the circulating water is passed through the canal it would be picked up by the pump and sprayed into the air where it is cooled. Approximately 100 spray modules would be used.

Construction Impacts – Construction impacts would be similar to impacts described previously for construction of the new intake structure. One option for the spray modules is that they would be removed and re-installed on an annual basis. This could result in periodic short-term impacts from soil and erosion runoff and the potential for fuel or other fluids spills. Installation and removal could also cause temporary impacts to the shoreline and bottom areas of the discharge canal, resulting in temporary loss of habitat and reduced productivity. Impacts to the fish community would be short-term. All impacts would be ameliorated by use of BMPs and implementation of an approved SPCC Plan. Thus, impacts on the aquatic ecosystem would be small.

Helper Towers: Helper towers are generally mechanical draft cooling towers. Helper towers would only operate during certain times of the year based upon higher temperatures at the intake structure (generally >87°F). To achieve the necessary cooling, it is estimated that 30 to 40 towers would be needed and the maximum intake flow rate would be 470,000 gpm.

Construction Impacts – Construction impacts to the aquatic ecosystem would be similar to those described for the new intake structure, a new skimmer wall, or spray modules. Depending on the size, number, and location of towers to be permanently installed the impacts could affect the aquatic ecosystem in the form of siltation and runoff during construction, dredging in the discharge canal, and operation and maintenance of the cooling towers after installation. BMPs would ameliorate any impacts. These impacts would be short-term, temporary, and small.

Section 4.3 References

1. Golden, J., Ouellette, R. P., Saari, S, and Cheremisinoff, P. N.; *Environmental Impact Data Book* (Second Printing), Chapter 8, “Noise.” Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 1980.

2. Brown, W. M., *Proceedings: Avian Interactions with Utility Structures International Workshop*, Miami, Florida, September 13-16, 1992, “Avian Collisions with Utility Structures: Biological Prospectives.” Prepared by Electric Power Research Institute, Palo Alto, California, December 1993.

4.4 Socioeconomic Impacts

This section discusses the socioeconomic impacts of construction activities, including those impacts that could result from the construction-related activities at the ESP site, and from the activities and demands of the workforce on the surrounding region. Evaluated socioeconomic impacts include potential effects on individual communities, the surrounding region, and minority and low-income populations.

This section has three subsections:

- Physical impacts,
- Social and economic impacts,
- Environmental justice impacts.

4.4.1 **Physical Impacts**

Construction activities can cause temporary and localized physical impacts such as noise, odor, vehicle exhaust, and dust. Vibration and shock impacts are not expected, due to the strict restriction or control of such activities onsite. This section addresses those potential impacts that may affect people, buildings, roads, and recreational facilities (e.g., Lake Anna). The physical impacts would be small and, therefore, are discussed qualitatively.

The NAPS site is located in an area zoned for industrial use. The site is bounded by light industrial and commercial zones to the north and west, a recreational area (Lake Anna) to the east, and residential housing to the south. All construction activities would occur within the NAPS site boundary. Offsite areas that would support construction activities (e.g., borrow pits, quarries, disposal sites) would already be permitted and operational. Therefore, impacts on those facilities from constructing new units would be small incremental impacts associated with their normal operation. The use of public roadways and railways would be necessary to transport construction materials and equipment. The roadways could require some minor repairs or upgrading, such as patching and filling potholes, to allow safe equipment access. However, no extensive work is planned to the existing roads or railways and no new routes would be required.

4.4.1.1 **Groups Vulnerable to Physical Impacts**

4.4.1.1.1 **People**

The area within 10 miles of the ESP site is estimated to be populated by approximately 15,500 people (See Section 2.5). This area is predominately rural and characterized by farmland and wooded tracts (Reference 1). No significant industrial or commercial facilities exist or are planned for this area. Population distribution details are given in Section 2.5.1.1.

People who could be vulnerable to noise, fugitive dust, and gaseous emissions resulting from construction activities are listed below in order of most vulnerable to least vulnerable:

- Construction workers and personnel working onsite
- People working or living immediately adjacent to the site
- Transient populations (i.e., temporary employees, recreational visitors, tourists)

Construction workers would have adequate training and personal protective equipment to minimize the risk of potentially harmful exposures. Services would be provided for emergency first-aid care, and regular health and safety monitoring would be conducted during construction.

People working onsite or living near the ESP site would not experience any physical impacts greater than those that would be considered an annoyance or nuisance. In the event that atypical or noisy construction activities would be necessary (e.g., pile driving), public announcements and/or notifications would be provided. These activities would be performed in compliance with local, state, and federal regulations, and site-specific permit conditions.

Fugitive dust and odors could be generated as a result of normal construction activities. Mitigation measures (e.g., paving disturbed areas, water suppression, reduced material handling) would be in place to prevent or reduce such occurrences Additional mitigation control measures would address any nuisance issues on a case-by-case basis.

Noise and exhaust emissions from construction equipment would have no discernible impact on the local noise level and air quality. All equipment would be operated in accordance with local, state, and federal emission requirements (see Section 4.4.1.2).

Reasonable efforts would be made to ensure that transient populations are aware of the potential impacts of construction activities. Signs would be posted at or near construction site entrances and exits to make the public aware of potentially high construction traffic areas.

4.4.1.1.2 **Buildings**

Construction activities would not impact any offsite buildings. In the event that pile driving would be necessary, the building(s) most vulnerable to shock and vibration would be those within the NAPS site boundary. Onsite buildings have been constructed to safely withstand any possible impacts, including shock and vibration, from construction activities associated with the proposed activity. (No historically significant buildings (see Section 2.5.3) exist near the ESP site.

4.4.1.1.3 **Roads**

The transportation network in Louisa County and at the ESP site already a well-developed system, would not be significantly impacted as a result of construction activities. Material transportation routes (haul routes) would be selected based on equipment accessibility, existing traffic patterns, and noise restrictions, logistics, distance, costs, and safety. Methods to mitigate potential impacts include: 1) avoiding routes that could adversely affect sensitive areas (e.g., housing, hospitals,

schools, retirement communities, businesses) to the extent possible and 2) restricting activities during daylight hours and delivery times.

No new public roads would be required as a result of construction activities. No public roads would be altered (e.g., widened) as a result of construction activities. Some minor road repairs and improvements (e.g., patching cracks and potholes, adding turn lanes, re-enforcing soft shoulders) would be necessary to enable equipment accessibility and reduce safety risks.

Construction site exits onto public roads would be marked clearly with signs and maintained such that they are clear of debris and markings are visible. Any damage to public roads, markings, or signs caused by construction activities would be repaired to pre-existing conditions or better.

A new access road on the NAPS site would support construction activities. The new road would be private and fully contained within the existing NAPS site boundary. The road would be maintained by Virginia Power personnel as needed.

4.4.1.1.4 **Recreational Facilities**

Lake Anna was created in 1971 on the main stem of the North Anna River to supply cooling water for the power station. The lake has public access, and its resource use includes recreational boating, fishing, camping and picnicking. People live along its shoreline. Virginia Power and ODEC own, and Virginia Power controls, the land that forms Lake Anna, both above and beneath water surfaces, up to the expected high-water marks (i.e., Elevation 255 ft msl). The aquatic resources of Lake Anna are managed cooperatively by Virginia Power and state natural resource agencies, including the VDGIF and the VDCR.

Construction activities would include limited in-water activity to construct the intake structure, remove a portion of the existing cofferdam and local dredging. The work would be executed in accordance with applicable regulations such as the CWA and permit conditions such as CWA Section 404 administered by the U.S. Army Corps of Engineers. Fugitive dust would be generated during site construction activities; however, quantities would not have any discernible impact on Lake Anna or adjacent environs. Water turbidity could be temporarily degraded in the immediate construction area during cofferdam removal and localized dredging. Measures to control turbidity include permit conditions, use of best management practices and, if necessary, installing a barrier (e.g. silt curtain) to prevent the migration of a turbid water plume into the lake.

4.4.1.2 **Applicable Standards**

Applicable local, state, and federal standards for noise, fugitive dust, and equipment emissions are described in these subsections.

4.4.1.2.1 **Noise**

The Commonwealth of Virginia has no state regulations nor guidelines for noise limits and provides no model noise ordinance for municipalities. Additionally, the state does not provide guidelines or limitations for impulse noise like a sharp sound pressure peak occurring in a short interval of time.

Within the County of Louisa, “it shall be unlawful to create any unreasonable loud, disturbing and unnecessary noise in the county, and noise of such character, intensity and duration as to be detrimental to the life or health of any person or to unreasonably disturb or annoy the quiet comfort or repose of any person is hereby prohibited. This prohibition shall not be construed to apply to any livestock, domesticated animal, fowl, or agricultural operation.” (Reference 2) No guidelines or ordinances have been identified that are written specifically to address construction activities.

Within the County of Spotsylvania, “The creation of any unreasonably loud, disturbing, and unnecessary noise in the county is prohibited. Noise of such character, intensity, and duration as to be detrimental to the life or health of any individual is prohibited.” (Reference 3) Construction activities are exempt from this ordinance between the hours of 6:00 a.m. and 10:00 p.m.

The Noise Control Act of 1972 gives authority to the EPA to determine the limits of noise and to set noise emission standards for major sources of noise in the environment, including construction equipment. Federal regulations exist for noise emitted from construction (40 CFR 204, Noise Emission Standards for Construction Equipment).

4.4.1.2.2 **Fugitive Dust**

Virginia Administrative Code (VAC) 9 VAC 5-50 establishes standards for visible emissions and fugitive/dust emissions. 9 VAC 5-50 defines “fugitive dust” as particulate matter composed of soil or other materials of natural origin, or both. Fugitive dust may include emissions from haul roads, wind erosion of exposed surfaces and storage piles, and other activities in which the material (dust) is removed, stored, transported, or redistributed.

4.4.1.2.3 **Gaseous Pollutants**

Virginia Administrative Code 9 VAC 5-40-5680 establishes emission standards for mobile sources.

4.4.1.3 **Predicted Noise Levels**

The impacts from noise would be small; therefore, no modeling was undertaken for of this analysis. As discussed previously, Louisa and the surrounding counties are predominantly farmland and wooded tracts. Areas that are subject to farming are prone to seasonal noise-related events such as planting and harvesting. Wooded areas provide natural noise abatement control to reduce noise propagation. Table 4.4-1 identifies expected noise levels in the immediate vicinity (less than 10 feet) of operating pieces of construction equipment. (Reference 4)

Table 4.4-1 Equipment and Approximate Noise Level

Equipment	Noise Level (dB)
Pneumatic chip hammer	103-113
Earth Tamper	90-96
Jackhammer	102-111
Crane	90-96
Concrete joint cutter	99-102
Hammer	87-95
Skilsaw	88-102
Gradeall	87-94
Front-end loader	86-94
Bulldozer	93-96
Backhoe	84-93

Noise level attenuates with distance. The noise from a gradeall earth mover can be as high as 94 decibels (dB) from 10 feet away, and from 70 feet away can be 82 dB. A 10-dB decrease is perceived as roughly halving loudness; a 10-dB increase doubles the loudness. A crane lifting a load can make 96 dB of noise; at rest, it may make less than 80 dB. Moderate auto traffic at a distance of 100 feet (30 m) rates about 50 dB. To a driver with a car window open or a pedestrian on the sidewalk, the same traffic rates about 70 dB; that is, it sounds four times louder. The level of normal conversation is about 50 to 60 dB.

The EAB extends 5000 feet from the center line of the abandoned Unit 3 containment building. No major roads, public buildings or residences are located within the exclusion area. Distances from the construction site to the EAB are shown in Table 4.4-2 (See Section 4.1.1.4). As discussed in Section 4.1.1, the land adjacent to the ESP site along the western boundary is zoned light industrial.

Table 4.4-2 Distances from Construction Site to EAB

Direction	Approximate Distance (feet)
North	2650
South	4450
East	4680
West	70

In addition to the local ordinances and permitted noise restrictions that would be adhered to by construction activities to reduce potential noise impacts, the following controls could also be incorporated into activity planning:

- Regular inspection and maintenance of equipment to include noise aspects
- Restrict noise-related activities (e.g., pile driving) to daylight hours
- Restrict delivery times

4.4.1.4 **Predicted Air Pollutant Levels**

Physical impacts from air pollutants such as engine exhaust and fugitive dust would be small; therefore, no modeling was undertaken for this analysis. Temporary and minor impacts to local ambient air quality occur as a result of normal construction activities. Fugitive dust and fine particulate matter emissions – including those less than 10 microns (PM10) in size, are generated during earth-moving and material-handling activities. Construction equipment and offsite vehicles used for hauling debris, equipment, and supplies also produce emissions during construction. The pollutants of primary concern include PM10 fugitive dust, reactive organic gases, oxides of nitrogen, carbon monoxide, and, to a lesser extent, sulfur dioxides. Because the variables affecting construction, emissions (e.g. type of construction vehicles, timing and phasing of construction activities, and haul routes) cannot be determined until the project is ready for construction; no reasonable estimate of construction emissions can be undertaken. However, construction would be conducted in accordance with all federal, state and local regulations that govern construction activities and emissions from construction vehicles.

Specific mitigation measures to control fugitive dust would be identified in a dust control plan, or similar document, prepared prior to project construction. These mitigation measures would include any or all of the following:

- Stabilize construction roads and spoil piles
- Limit speeds on unpaved construction roads
- Perform housekeeping (e.g., remove dirt spilled onto paved roads daily)
- Cover haul trucks when loaded or unloaded
- Minimize material handling (e.g., drop heights, double-handling)
- Cease grading and excavation activities during high wind speeds and during extreme air pollution episodes
- Phase grading to minimize the area of disturbed soils
- Phase construction to minimize daily emissions
- Perform proper maintenance of construction vehicles to maximize efficiency and minimize emissions

- Re-vegetate road medians and slopes in accordance with the site redress plan (see, Part 4: Chapter 1, Site Redress)

While emissions from construction activities and equipment would be unavoidable, a mitigation plan would minimize impacts to local ambient air quality and the nuisance impacts to the public in proximity to the project. Other mitigation measures would include temporary storm water management and erosion and sediment control strategies.

4.4.2 Social and Economic Impacts

The social and economic impacts on the immediate vicinity and surrounding region during construction of new units at the ESP site are evaluated in this section. This evaluation assesses both the potential impacts that could result from the construction-related activities at the ESP site and the activities and demands of the workforce on the surrounding region.

Construction of a new unit is estimated to occur over a 5-year period. Construction of the second unit may lag the first by a year or more. Because a specific reactor design has not been selected, the peak workforce estimate does not include consideration of reactor-specific approaches which could reduce the types and lengths of activities onsite.

The peak workforce is estimated to be about 5,000 people, which would be maintained for a large part of the construction period(s). If such a large workforce were introduced into the region, it could affect traffic, taxes, housing, and public services. Most of the workforce would probably come from the 50-mile region. This peak workforce estimate and the assumption that most of the workforce would be local are consistent with experience during prior construction projects at NAPS.

The magnitude of impacts is dependent on two considerations:

- The percentage of the workforce that would come from the region and, therefore, be expected to commute
- Where those who have to relocate to the region would reside

4.4.2.1 Economic Impacts

The impacts of construction of the new units on the local and regional economy of the ESP region are based on the region’s current and projected economy and population. The projected economy is based on information developed internally by Virginia Power and from Comprehensive Land Use plans for applicable localities. Because the ESP would be in effect for 20 years after approval, construction could start anytime within that 20-year timeframe, once a COL authorizing construction has been issued. The issuance of an ESP allows, under certain regulatory conditions, the start of limited early construction activities (see Part 4). Therefore, the positive economic benefits of construction could begin some time before the start of major construction.

4.4.2.1.1 Potential Non-Income Taxes Related to Construction of New Units

The actual monetary value of the revenues generated because of the construction of the new units cannot be estimated with precision because the type of reactor has not been selected. This decision would affect the size of the work force and the percentage of the work force that could come from outside the region. Therefore, at this time it is not possible to estimate the value of taxes that could be paid to the regional governments nor expenditures that the regional governments would have to incur to accommodate the workforce.

a. **Sales and Use Taxes**

The Commonwealth of Virginia and counties surrounding the ESP site would experience an increase in the amount of sales and use taxes collected from construction materials and supplies purchased for the project. Additional sales and use taxes would be generated by retail expenditures (restaurants, hotels, merchant sales) of construction workers. It is estimated that about half of the day-to-day expenditures during construction would occur in the region.

The current combined sales and use tax rate for Louisa County is 4.5 percent; 3.5 percent would be paid to the Commonwealth of Virginia and 1 percent to the locality, Louisa County.

b. **Property Taxes**

Louisa County would benefit from additional property tax revenue from two sources. The first source would be tangible personal property taxes paid by contractors during construction of the additional units. The tax would be based on the value of property owned by the contractors that acquire taxable status in Louisa County during the construction period. Currently, the county calculates the assessed value of the property at ten percent of the original cost, which is then taxed at the rate of $1.90 per $100 of value.

The second source would be the property taxes levied for the incremental increase in value to the entire site from the additional units. During the construction phase, tax would be levied only on the value of the tangible personal property to become part of the additional units. Currently, the Virginia State Corporation Commission is responsible for the valuation of the property both during construction and following completion of the additional units. The current tax rate for this property is $0.67 per $100 of value.

4.4.2.1.2 Housing

If the entire construction workforce came from within a 50-mile radius of the ESP site, there would be no impact on housing. However, based on prior experience on projects of similar size, up to 20 percent of the workforce could come from beyond the 50-mile region. Most, if not all, of these workers from outside the region would be expected to relocate to the region at least during the workweek.

If up to 1000 workers were to come from outside the region, there would be a demand for up to that many housing units, mainly apartments, although, some single-family residences might be required if construction workers decide to relocate with their families. A review of the vacant housing available in the year 2000, shows that there were sufficient numbers of rentals (5,884 units) and permanent housing units (2,656 units) in the region to accommodate the expected workforce. Most of these were in the City of Richmond and Henrico County. Very few rental properties were available in Louisa, Hanover, Spotsylvania, or Orange Counties.

There is also the possibility that some relocated construction workers would bring trailers for the duration of their employment. For purposes of this ER, it is assumed that the number of such workers who bring trailers would be low. If this is not the case, an influx of construction workers into the local area could compete with recreational users for spaces at existing trailer/RV parks.

Alternatively, if the incoming construction force were to generate demand for additional private trailer parks, this demand could lead to an increase in spaces being made available. However, there are no public water or sewer systems in the vicinity of the ESP site except for those of the incorporated towns. It is not likely that new trailer/RV parks would be constructed within the boundaries of these towns. New trailer/RV parks would most likely be located in Henrico County, nearer to the City of Richmond where public water and sewer systems are in place and where expansion of infrastructure is currently planned.

Neither Henrico County nor the City of Richmond would benefit directly from property taxes paid by Dominion. However, both should benefit from increased sales taxes and rents for housing units.

It is assumed that the number of housing units for rent or sale in the nearby counties would remain at or near the Year 2000 levels in future years. Under this assumption, an in-migration of up to 1000 construction workers should be able to find housing without creating issues for the region regardless of when construction is initiated.

4.4.2.2 **Social Impacts**

Under the assumption that the construction workforce would come from the region, the main social impact of the proposed construction would be most related to the transportation network in the vicinity of the ESP site. It is assumed that workers who relocate would settle in the City of Richmond, or, Henrico County. The relative social impact of such an in-migration to these two areas should be small, given the population of the areas. Impacts on the fire, police, school systems, recreational facilities, medical facilities, and the sewer and water systems would be small.

The installation of the new units would not displace families, because housing is not allowed on the NAPS site and construction activities would be entirely on site.

Most of the larger pieces of equipment or structures would probably be brought in to the site by rail. However, the transport of such large pieces of equipment would be an infrequent occurrence.

4.4.2.2.1 **Transportation-Related Impacts**

Impacts of construction of new units at the ESP site could be associated with transportation-related activities offsite, such as the delivery of major pieces of equipment.

Construction-related impacts on the transportation network in the region would arise from an additional 5,000 people commuting to the NAPS site.

a. **Federal Highways**

Construction workers traveling south on Interstate 95 (I-95) (Figure 2.1-3) from Spotsylvania or further north would take the Virginia Route 606 west exit, or the Spotsylvania Turnpike exit to the Route 208 Bypass (under construction in 2003), and then south on Route 208 (Courthouse Road) to reach the site.

The Route 606 - Interstate 95 interchange is congested, generally at a level of service D (LOS D) or better (Table 4.4-3). A VDOT I-95 interchange study has determined that this interchange would become more congested with time (Reference 5). The addition of commuting construction workers would increase this congestion.

The VDOT I-95 study includes an analysis of traffic patterns for the Route 606 – I-95 interchanges out to the Year 2025. The study identifies an existing congestion issue and relates it to the ongoing rapid growth in western Spotsylvania County. Upgrading the access to I-95 has been delayed due to funding. This study also identifies the need for widening the western section of Route 606 to alleviate the existing congestion that affects traffic trying to access I-95 north and south.

I-95 north from Richmond would not be adversely impacted by commuting construction workers coming from the Greater Richmond area, because the more likely commuting routes would be Virginia Route 33 through Hanover County or I-64 through northwest Henrico County and along the southern boundary of Louisa County.

I-64 west from Richmond has a LOS no worse than B. Commuting construction workers from the Greater Richmond Area to Virginia Route 208 or Route 522 would not cause congestion problems.

b. **Virginia Roadway System**

The Louisa-Orange-Spotsylvania Advisory's 3-county planning group, the Lake Anna Advisory Committee (LAAC), has recommended that planners in each of the three counties upgrade their local roads around Lake Anna. This recommended upgrade would provide a circumferential roadway system around the lake with adequate lanes for towed boats and bicycles (Reference 6). Such upgrades would alleviate congestion on local roads due to the influx of construction workers.

The Louisa County draft Comprehensive Plan of 2001 recognizes the need to improve roadways around Lake Anna. The draft Comprehensive Plan of 2001 recommends

improvement of the roads within Louisa County, but provides no information on funding or the timing of the road improvements. (Reference 7)

Spotsylvania County plans to widen Route 606 west of I-95 to four lanes and has included this project in their Comprehensive Plan (Reference 8). This project should be completed in the near-term and should reduce additional impacts of large number of construction workers commuting on Route 606 to the site. Additionally, the Route 208 Bypass around the historic Courthouse District is currently under construction and should be completed in the near-term. When completed, the 208 Bypass would connect the Spotsylvania Parkway (Route 208 north), with Courthouse Road (Route 208) south of its intersection with Route 606. Route 208 south is a minor road with a bridge over the North Anna Reservoir west of the ESP site. Spotsylvania County plans to upgrade the 2-lane roads around Lake Anna by widening them to include shoulders to accommodate larger vehicles such as motor homes. This upgrade is in line with the 3-county planning group's plans for the Lake Anna area.

In Hanover County, U.S. Route 33 links Richmond with Louisa and points north and west. This 2-lane road in the northern part of the County is subject to congestion and needs to be widened according to the Hanover Comprehensive Plan of 1998. No time frame has been set because the source of funding has not been identified. If the widening does not occur before the start of construction of the new units, U.S. Route 33 congestion could increase from construction workers commuting from Richmond. The magnitude of the impact would depend to some extent on the shift schedule for the construction of the new units relative to the normal commuting schedule of other road users. Traffic congestion would be considered in developing a traffic management plan as a mitigation measures. (Reference 9)

c. **Local Roads**

According to the North Anna License Renewal Environmental Report, the major commuting routes in the immediate vicinity of the ESP site are local roads Routes 700, 652, 208, 522, and 618 (Figure 2.1-2). These roads carry a LOS designation of B. (Reference 4)

Table 4.4-3 Level-of-Service Designation Characteristics

Level of Service	Conditions
A	Free flow of the traffic stream; users are unaffected by the presence of others.
B	Stable flow in which the freedom to select speed is unaffected, but the freedom to maneuver is slightly diminished.
C	Stable flow that marks the beginning of the range of flow in which the operation of individual users is significantly affected by interactions with the traffic stream.

Table 4.4-3 Level-of-Service Designation Characteristics

Level of Service	Conditions
D	High-density stable flow, in which the freedom to maneuver are severely restricted; small increases in traffic will generally cause operational problems.
E	Operating conditions at or near capacity level, causing low but uniform speeds and extremely difficult maneuvering that is accomplished by forcing another vehicle to give way; small increases in flow or minor perturbation will cause breakdowns.
F	Defines forced or breakdown flow that occurs whenever the amount of traffic approaching a point exceeds the amount that can traverse the point. This situation causes the formation of queues characterized by stop-and-go waves and extreme instability.

Source: Environmental Report (Reference 4), Appendix E of the North Anna Power Station Unit 1 and 2 Applications for Renewed Operating Licenses, Page 2-39, May 2001.

d. **Route 700 East of Route 652**

Route 700 is the only road that leads directly into the ESP site, and the traffic east of the intersection with Route 652 is normally related only to the power station site. This would be true during the construction of the new units.

Construction worker access to the ESP site would be via a construction access road that would be built on the north side of Route 700 on Virginia Power property and would intersect with Route 700 several hundred yards west of the access road to the existing units. Therefore, the potential exists for congestion to develop on site access roads and on Route 700, if the construction shifts and the plant shifts are not synchronized. To avoid congestion, a traffic management plan would be developed in cooperation with VDOT as a construction mitigation measure.

Beginning at the intersection of Route 700 with Route 652, the increased construction traffic would start to disperse onto local roads. However, congestion could develop at the 700/652 intersection during construction shift changes even if the shift changes for construction and operation are synchronized.

Currently, about 850 employees commute to NAPS. These workers are spread over three 8-hour shifts. Planned outages of 4 to 6 weeks occur at each existing unit on a staggered basis. The workforce onsite doubles during these outages (Reference 4). Outage workers are also spread over three 8-hour shifts. Route 700 has historically been able to handle the peak demands of around 2,000 workers without creating a major traffic problem on the local road system. Assuming an average of 1.8 workers per vehicle, this represents about 1100 cars per day traveling this road into and out of the site.

The construction of the new units would add a maximum of approximately 5,000 workers over two 10-hour shifts. These workers would travel the section of Route 700 between Route 652 and the access road to the ESP site on a daily basis. Assuming the same average of 1.8 workers per vehicle, this would represent 2800 additional vehicles, for a total of about 3300 vehicles per day. This would be a major increase in Route 700 traffic. Implementation of a traffic management plan for construction would alleviate the traffic increase to some extent.

At least four outages at the existing units would occur during the 5-year period when the peak construction workforce of 5,000 workers would be onsite. This would create short-term periods when the total onsite workforce (for construction of the new units and work at the existing units) would be about 7,000. Of these, 5,000 would be working two 10-hour shifts and 2,000 would be spread over three 8-hour shifts. During outages, the number of vehicles could rise to 3900 per day unless the use of multi-person vans is strongly encouraged by both the construction and the outage workforces.

e. **Proposed Mitigation Measures**

Currently, Route 700 into the NAPS site has a LOS B. The objective of any traffic mitigation measures would be to maintain LOS on Route 700 at D or better.

To avoid congestion on Route 700 that could congest the Route 700-652 intersection and the construction access road-Route 700 intersection, a construction management traffic plan would be developed prior to the start of construction. This plan would include approaches to increase the number of workers per vehicle above the average of 1.8. The traffic management plan would include methods for enhancing the use of multi-person vans by the construction workforce. Typically, such a plan involves providing offsite parking areas from which workers can be bused to the site and ways to encourage the use of vanpools and carpools.

Concurrently, Dominion would implement measures that enhance the use of vanpools for use by the outage workforce. Additionally, schedules for shift changes for operating personnel, outage workers, and construction workforce would be coordinated to reduce the number of vehicles on the road at any one time. The need to hand-off work from the outgoing to the incoming shift workers may complicate this scheduling effort for the construction workforce and, possibly, for the outage workforce.

Currently, traffic control at the intersection of the Routes 700 and 652 consists of a blinking red light for traffic exiting the NAPS site. Upgrades to Route 700 may be necessary to reduce congestion during shift changes that could develop at the intersection of Routes 652 and 700 due to construction traffic. Upgrades may include construction of turning lanes, and, possibly traffic lights, including green arrows for left-turning vehicles. These options would be assessed after the type of reactor is selected and a better definition of the size of the required workforce can be determined.

4.4.2.2.2 **Impacts on Lake Anna Recreational Area**

Lake Anna is a recreational area that attracts visitors during the summer and early fall months, as well as year-round residents. Therefore, any construction impacts that would substantially reduce the number of visitors could have adverse socioeconomic impacts on the local area. Most impacts that would affect local residents would be related to traffic, and would be confined to discrete times of day when worker shifts were changing.

4.4.2.2.3 **Conclusion**

Analyses of potential impacts of construction activities on the surrounding vicinity and region, presented in Section 4.1, Section 4.2, Section 4.3, and Section 4.4.1, concluded that most impacts would be small. Impacts from traffic would be moderate and would be mitigated with a construction management traffic plan.

4.4.3 **Environmental Justice Impacts**

This section addresses the potential for disproportionately high and adverse human health or environmental impacts on minority and low-income populations that reside within an 80-km (50-mile) radius of the NAPS site during construction of the new units at the ESP site.

The potential for environmental impacts associated with the installation of new units at the ESP are based on the following findings:

- Construction impact analyses presented in Section 4.4.1 and Section 4.4.2 conclude that the physical and socioeconomic impacts would be small to moderate.
- The ESP site is located in an area that does not raise environmental justice concerns. There are relatively few minority and low-income populations in the environmental impact area. The nearest minority or low-income populations are 20 km (about 12 miles) from the ESP site and most types of impacts associated with construction of the new units decrease rapidly with distance from the construction site.
- As described in Section 4.4.2, the only potential moderate impact from construction of the new units would be associated with traffic congestion created by the large workforce. However, these traffic issues would affect all drivers in the impacted areas equally. That is, there would not be a disproportionately high and adverse impact on minorities and low-income populations within the 80-km (50-mile) radius of the ESP site.

Based on the above, it can be concluded that there would be no disproportionately high and adverse human health or environmental impacts on minority and low-income populations due to construction of new units. There are potential beneficial impacts for these populations related to increased direct employment.

Section 4.4 References

1. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Supplement 7, Regarding North Anna Power Station, Units 1 and 2, U.S. Nuclear Regulatory Commission (SEIS), November 2002.
2. Louisa County Ordinance, Section 51-3, Unnecessary and disturbing noise prohibited.
3. Spotsylvania County Ordinance, Section 14-14, Unreasonably loud, disturbing, and unnecessary noise.
4. *Environmental Report* (ER) as Appendix E of the North Anna Power Station, Units 1 and 2 Application for Renewed Operating Licenses, Dominion Energy, May 2001.
5. *I-95 Collector-Distribution Access Feasibility Study Final Report*, prepared by BMI et al. for Virginia Department of Transportation, March 2002.
6. *Lake Anna Special Area Plan* by the Lake Anna Special Area Plan Committee appointed by the Boards of Supervisors of Louisa, Orange and Spotsylvania Counties, March 2000.
7. *The County of Louisa Tomorrow – The Plan*, The County of Louisa, Virginia, Comprehensive Plan, Chapter V, September 4, 2001.
8. *Spotsylvania County Approved 2002 Comprehensive Plan*, Transportation Plan, February 12, 2002.
9. *Hanover County Comprehensive Plan – Vision 2017*, Transportation Plan, adopted September 1998.

4.5 Radiation Exposure to Construction Workers

4.5.1 Site Layout

The physical location of the new units relative to the existing units at the NAPS site is presented on Figure 2.1-1. As shown, the new units would be located west of the protected area for the existing units. Hence, construction activity would take place outside the protected area for the existing units, but inside the restricted area boundary.

4.5.2 Radiation Sources

During the construction of the new units, the construction workers may be exposed to radiation sources from the routine operation of the existing units as described in the following paragraphs.

4.5.2.1 Direct Radiation

The boron recovery tanks and the low-level contaminated storage area are among the existing units' principal sources contributing to direct radiation exposure at the construction site. The design basis radiation source term for the boron recovery tank is listed in the North Anna UFSAR, Table 11.2-4. The UFSAR also estimates that the low-level contaminated storage area contains the equivalent of less than 1 Ci of Co-60 (Reference 1).

Another source of direct radiation is the ISFSI, which is located south of the construction site. The source terms for the ISFSI are provided in the ISFSI Safety Analysis Report (SAR), Tables 7-1 to 7-4 (Reference 2).

4.5.2.2 Gaseous Effluents

Sources of gaseous releases include the waste decay tanks, boron recovery and high-level waste tanks, containment purge system, auxiliary building vent, main condenser air ejector vents, auxiliary steam drain receiver, turbine building ventilation exhaust, and gland seal ejector vent. The annual releases for 2001 have been reported as 270 Ci of fission and activation gases, 2.1E-3 Ci of I-131, 4.0E-5 Ci of particulates with half-lives greater than eight days, and 82 Ci of tritium (Reference 3). The annual releases for 2001 are typical for the existing units.

4.5.2.3 Liquid Effluents

Effluents from the liquid waste disposal system produce small amounts of radioactivity in the North Anna Reservoir and the WHTF. The annual liquid radioactivity releases for 2001 have been reported as 0.49 Ci of fission and activation products, 810 Ci of tritium, and 1.2E-2 Ci of dissolved and entrained gases (Reference 3). The annual releases for 2001 are typical for the existing units.

4.5.3 Measured and Calculated Dose Rates

The measured or calculated dose rates used to estimate worker dose are presented below.

4.5.3.1 Direct Radiation

Table 4.5-1 provides thermo-luminescent dosimeter (TLD) measurements at the west protected area fence of the existing units from 1996 to 2002. The average annual dose for this period is 56 mrem with a maximum annual dose of 74 mrem. It should be noted that the TLD measurements include background radiation. A radiological survey taken at the same location in April 2003 shows a dose rate of 0.02 mrem/hr.

4.5.3.2 Gaseous Effluents

The Annual Radioactive Effluent Release Report for 2001 (Reference 3) reports a whole body dose of 1.35E-2 mrem and a critical organ dose of 0.103 mrem to the maximally exposed member of the public due to the release of gaseous effluents from the existing units, calculated in accordance with the existing units' Offsite Dose Calculation Manual (Reference 4).

4.5.3.3 Liquid Effluents

The Annual Radioactive Effluent Release Report for 2001 (Reference 3) reports a whole body dose of 0.308 mrem and a critical organ dose of 0.352 mrem to the maximally exposed member of the public due to the release of liquid effluents from the existing units, calculated in accordance with the existing units' Offsite Dose Calculation Manual (Reference 4).

4.5.4 Construction Worker Doses

Construction worker doses were conservatively estimated using the following information (see Section 4.4.2):

- The estimated maximum dose rate for each pathway
- An exposure time of 2080 hours per year
- A peak loading of 5000 construction workers per year

The estimated maximum annual dose for each pathway as well as the total dose are shown below.

4.5.4.1 Direct Radiation

Section 4.5.3 indicates a maximum annual dose of 74 mrem based on TLD measurements and a dose rate of 0.02 mrem/hr based on a radiological survey. The latter reading reflects the sensitivity of the instrument in measuring such low instantaneous dose rates. TLD measurements, however, are more accurate as they reflect continuous exposures for long periods of time. The maximum measured dose rate over a seven-year period of 74 mrem/yr is based on continuous exposure at the protected area fence between the existing and new units. Since the construction workers would spend most of their time west of this fence, further away from the existing units, using this dose rate for the workers is conservative. Adjusting for an exposure time of 2080 hr/yr yields an annual worker whole body or total effective dose equivalent (TEDE) dose of 18 mrem.

4.5.4.2 **Gaseous Effluents**

The annual gaseous effluent doses to the maximally exposed member of the public (Section 4.5.3) are based on continuous occupancy. Adjusted for an exposure time of 2080 hr/yr and multiplying by a factor of 10 to cover uncertainty regarding the location of the worker compared to the maximally exposed member of the public, the estimated worker doses are 3.2E-2 mrem for the whole body and 2.4E-1 mrem for the critical organ. Applying a weighting factor of 0.3 to the organ dose (Reference 5) and adding to the whole body dose, a TEDE of 1.1E-1 mrem is estimated.

4.5.4.3 **Liquid Effluents**

As the annual liquid effluent doses to the maximally exposed member of the public in Section 4.5.3 are based on continuous occupancy, they are adjusted for an exposure time of 2080 hr/yr. Although the liquid effluent dose rates to which the workers would be exposed are expected to be no higher than those to the maximally exposed member of the public, the doses are multiplied by a factor of 10 for conservatism and consistency with the gaseous dose factor above. The resulting doses are 7.3E-1 mrem for the whole body and 8.4E-1 mrem for the critical organ. Applying a weighting factor of 0.3 to the organ dose and adding to the whole body dose, a TEDE of 9.8E-1 mrem is estimated.

4.5.4.4 **Total Doses**

The annual doses from all three pathways are summarized in Table 4.5-2 and compared to the public dose criteria in 10 CFR 20.1301 (Reference 6) and 40 CFR 190 (Reference 7) in Table 4.5-3 and Table 4.5-4, respectively. The unrestricted area dose rate in Table 4.5-3 was estimated by rounding up the 0.02 mrem/hr reading (Section 4.5.3) to 0.1 mrem/hr. Since the calculated doses meet the public dose criteria of 10 CFR 20.1301 and 40 CFR 190, the workers would not need to be classified as radiation workers. Table 4.5-5 shows that the doses also meet the design objectives of 10 CFR 50, Appendix I, for gaseous and liquid effluents (Reference 8).

The maximum annual collective dose to the construction work force (5000 workers) is estimated to be 93 person-rem.

The calculated doses are based on available dose rate measurements and calculations. It is possible that these dose rates would increase in the future as site conditions change. However, the ESP site would be continually monitored during the construction period and appropriate actions would be taken as necessary to ensure that the construction workers are protected from radiation.

Section 4.5 References

1. *Updated Final Safety Analysis Report,* North Anna Power Station, Revision 38.

2. *Independent Spent Fuel Storage Installation Safety Analysis Report,* North Anna Power Station, Revision 3.

3. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2001 to December 31, 2001),* Virginia Electric and Power Company, 2002.

4. Procedure No. VPAP-2103N, *Offsite Dose Calculation Manual,* Revision 2, Administrative Procedure, Dominion.

5. ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers*, Part 1, Published for the International Commission on Radiological Protection by Pergamon Press, 1979.

6. 10 CFR 20.1301, *Code of Federal Regulations*, “Dose Limits for Individual Members of the Public.”

7. 40 CFR 190, *Code of Federal Regulations*, “Environmental Radiation Protection Standards for Nuclear Power Operations.”

8. 10 CFR 50, Appendix I, *Code of Federal Regulations*, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low As is Reasonably Achievable’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents.”

Table 4.5-1 TLD Dose Measurements at West Protected Area Fence of Existing Units

	Dose (mrem)				
Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
1996	25	0	16	18	59
1997	13	9	12	14	48
1998	14	13	12	13	52
1999	1	9	8	15	32
2000	16	22	0	17	55
2001	16	19	13	21	69
2002	18	15	15	26	74
Average					56

Table 4.5-2 Annual Construction Worker Doses

	Annual Dose (mrem)		
	Whole Body	Critical Organ	TEDE
Direct radiation	1.8E+01	-	1.8E+01
Gaseous effluents	3.2E-02	2.4E-01	1.1E-01
Liquid effluents	7.3E-01	8.4E-01	9.8E-01
Total	1.8E+01	1.1E+00	1.9E+01

Table 4.5-3 Comparison with 10 CFR 20.1301 Criteria for Doses to Members of the Public

Criteria	Dose Limit	Estimated Dose
Annual TEDE (mrem)	100	19
Unrestricted area dose rate (mrem/hr)	2	0.1

Table 4.5-4 Comparison with 40 CFR 190 Criteria for Doses to Members of the Public

	Annual Dose (mrem)	
Organ	**Limit**	**Estimated**
Whole body	25	18
Thyroid	75	1.1
Other organ	25	1.1

Note: The estimated whole body dose conservatively includes background radiation whereas the dose limit applies to exposures from plant operation only.

Table 4.5-5 Comparison with 10 CFR 50, Appendix I Criteria for Effluent Doses

	Annual Dose (mrem)	
	Limit	**Estimated**
Whole body dose from liquid effluents	3	0.73
Organ dose from liquid effluents	10	0.84
Whole body dose from gaseous effluents	5	0.03
Skin dose from gaseous effluents	15	0.24
Organ dose from all effluents	15	1.1

Note: The estimated dose of 0.24 mrem shown for the skin is actually for the critical organ, which has a higher dose than the skin.

4.6 Measures and Controls to Limit Adverse Impacts During Construction

The following measures and controls would limit adverse environmental impacts:

- Compliance with applicable federal, Virginia, and local laws, ordinances, and regulations intended to prevent or minimize adverse environmental impacts (e.g., solid waste management, erosion and sediment control, air emissions, noise control, storm water management, spill response and cleanup, hazardous material management).
- Compliance with applicable requirements of existing permits and licenses (e.g., VPDES Permit, Operating License) for the existing units and other permits or licenses required for construction of the new units (e.g., U.S. Army Corps of Engineers Section 404 Permit, VDEQ wetlands permit).
- Compliance with existing Virginia Power processes and/or procedures applicable to construction environmental compliance activities for the NAPS site (e.g., solid waste management, hazardous waste management, spill prevention and response).
- Incorporation of environmental requirements into construction contracts.
- Identification of environmental resources and potential impacts during the development of this Environmental Report and the Early Site Permitting process.

The Potential Impact Significance columns in Table 4.6-1 list the elements identified in NUREG-1555, Section 4.6, (Reference 1) that relate to the construction issues. The significance levels – (S)mall, (M)oderate, or (L)arge – provided for each element in the table are determined by evaluating the potential impacts after any controls or mitigation measures are implemented.

Section 4.6 References

1. NUREG-1555, *Standard Review Plans for Environmental Reviews of Nuclear Power Plants,* Section 4.6, “Measures and Controls to Limit Adverse Impacts During Construction,” Office of Reactor Regulation, U.S. Nuclear Regulatory Commission (USNRC), October 1999.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Specific Measures and Controls**
4.1 Land-Use Impacts																
4.1.1 The Site and Vicinity		S				S				S	S				• Ground disturbing activities including grading and re-contouring • Removal of existing trees and vegetation. Potential impacts to wetlands and intermittent streams. • Stockpiling of soils onsite. • Construction of new buildings and impervious surfaces (e.g., parking lots).	• Conduct ground disturbing activities in accordance with regulatory and permit requirements. Use adequate erosion controls and stabilization measures to minimize impacts. • Limit tree and vegetation removal to the existing NAPS site, which is zoned “industrial.” • Minimize potential impacts to wetlands and intermittent streams through avoidance and compliance with applicable permitting requirements. • Restrict soil stockpiling and re-use to the NAPS site. • Restrict construction activities to the NAPS site.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Specific Measures and Controls**
4.1.2 Transmission Corridors and Offsite Areas															Based on an initial evaluation, the existing transmission lines have sufficient capacity to carry the total output of the existing units and the new units. A system study modeling these lines with the new units' power contribution would be performed to confirm this conclusion. This evaluation would be conducted at a suitable time after a decision is made by Dominion to proceed with the new capacity.	None
4.1.3 Historic Properties and Cultural Resources														S	• Ground disturbing activities including grading, excavation, and re-contouring.	• Conduct sub-surface testing prior to initiating ground disturbing activities to identify buried historic or archeological resources. • Take appropriate actions (e.g., stop work) following discovery of potential historic or archeological resources. • Use existing Virginia Power procedures that require contacting the appropriate regulatory agencies following a discovery of potential historic or archeological resources.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Specific Measures and Controls
	Potential Impact Significance [a, b]															
4.2 Water-Related Impacts																
4.2.1 Hydrologic Alterations		S				S	S		S		S	S			• Removal of existing cofferdam for the construction of new water intake on Lake Anna. • Impact to intermittent streams. • Erosion, sediment, and storm water runoff from construction site to Lake Anna prior to permanent stabilization, and installation of storm water drainage system • Potential impact to some potable water wells at the NAPS site from construction dewatering activities.	• Design and install appropriate barrier (e.g., turbidity curtain in Lake Anna near cofferdam work location) to prevent turbid water from migrating into the Lake. • Adhere to applicable regulations and permit requirements with regard to seasonal restrictions for in-water work, installation of appropriate erosion control measures, drainage controls to convey stream flow, and construction storm water management. • Use Best Management Practices (BMP) described in the Virginia Erosion and Sediment Control Handbook to control erosion and minimize the sediment load from the construction zone. • Use wells unaffected by dewatering activities to maintain needed capacity for the NAPS site. Not all wells are expected to be affected by dewatering activities.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

Section Reference	Potential Impact Significance [a, b]														Impact Description or Activity	Specific Measures and Controls
	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)		
4.2.2 Water-Use Impacts		S			S	S	S		S		S	S			• Potential impacts from releases of fuel, oils, or other chemicals associated with construction to surface or ground water. • Potential impacts from increased sediment loading in storm water runoff to North Anna Reservoir. • Potential impact to the local water table due to construction dewatering activities.	• Develop and implement a construction Storm Water Pollution Prevention Plan (SWPPP) and spill response plan during construction at the NAPS site. • Implement an Erosion and Sediment Control Plan that describes use of approved/recognized Best Management Practices (BMP). • Limit dewatering activities to only those necessary for construction. • Use offsite sources of potable water, if necessary, to temporarily supplement onsite water resources.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Specific Measures and Controls
	Potential Impact Significance [a, b]															
4.3 Ecological Impacts (i.e., impacts on the physical environment)																
4.3.1 Terrestrial Ecosystems	S		S					S		S					• Clearing and grading activities and habitat loss would displace existing mobile animals such as birds and larger mammals from construction zone. • Wildlife (e.g., birds and small mammals) may be startled or frightened away by noisy construction activities. • Potential impacts from avian collisions with man-made structures (e.g., cranes, buildings) during construction.	• No measures and controls are necessary because impacts would be small.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

Section Reference	Potential Impact Significance [a, b] Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Specific Measures and Controls
4.3.2 Aquatic Ecosystems		S	S			S			S		S				• Potential impacts on surface water from releases of fuel, oils, or other chemicals associated with construction to surface water. • Potential impacts on the North Anna Reservoir from increased sediment loading in storm water runoff to the North Anna Reservoir. • Temporarily degraded water quality due to in-water and shoreline work near the cofferdam. • Temporary loss of benthic habitat and organisms near cofferdam. • Potential impact from re-entrainment of contaminated sediments into the water column.	• Develop and implement a construction Storm Water Pollution Prevention Plan (SWPPP) and spill response plan during construction at the site. • Implement an Erosion and Sediment Control Plan that describes use of approved/recognized BMPs. • Design and install appropriate barrier (e.g., turbidity curtain in the North Anna Reservoir near cofferdam work location) to prevent turbid water from migrating into the lake. • Adhere to seasonal restrictions on in-water construction activities. Following temporary construction disturbance, intake channel cove would likely be re-colonized by benthic organisms and fish.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Specific Measures and Controls
4.4 Socioeconomic Impacts (i.e., Impacts on the Human Community)																
4.4.1 Physical Impacts	S		S	S		S			S		S	S			• Potential temporary and limited impact to sensitive populations due to noise, fugitive dust, and gaseous emissions resulting from construction activities. • Potential for traffic accidents with increased construction traffic near the NAPS site. • Limited in-water construction activity to remove the existing cofferdam.	• Train and appropriately protect NAPS site and temporary construction personnel (i.e., those most directly and frequently affected by construction noise, dust and gaseous emissions) to reduce the risk of potential harmful exposures from noise, dust, and gaseous emissions. • Provide onsite services for emergency first aid care and conduct regular health and safety monitoring for affected personnel on site. • In the event of atypical or noisy construction activities are necessary (e.g., pile driving), make public announcements and/or notifications prior to undertaking such activities. • Use normal dust control measures (e.g., watering, stabilizing disturbed areas, covering truck loads). • Manage concerns from adjacent residents, business owners, or landowners, on a case-by-case basis through a Dominion prepared concern resolution process. • Post signs at or near construction site entrances and exits to make the public aware of potentially high construction traffic areas. • Design and install appropriate barrier (e.g., turbidity curtain in the North Anna Reservoir near cofferdam work location) to prevent turbid water from migrating into the lake.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Specific Measures and Controls**
4.4.2 Social and Economic Impacts				M								S			• Potential impact on existing transportation network in the vicinity of the ESP site due to increased construction workforce traffic. • General increase in construction equipment and material deliveries affecting local and regional roadways.	• Develop a construction traffic management plan prior to construction to address potential impacts on local roadways. • Encourage the use of shared (e.g., carpooling) and multi-person transport (e.g., buses) of construction personnel to the ESP site. • Coordinate schedules during work force shift changes to limit impacts on local roads. • Schedule delivery of larger pieces of equipment or structures on off-peak traffic hours (e.g., at night) or through other transportation modes (e.g., rail). • If necessary, consider/coordinate with local planning authorities the upgrading of local roads, intersections, and signals to handle increased traffic loads.
4.4.3 Environmental Justice Impacts															No impacts identified	No mitigation measure or controls proposed
4.5 Radiation Exposure to Construction Workers															No impacts identified	No mitigation measure or controls proposed

a. The assigned significance levels [(S)mall, (M)oderate, or (L)arge are based on the assumption that for each impact, the associated proposed mitigation measures and controls (or equivalents) would be implemented.

b. A blank in the elements column denotes “no impact” on that specific element due to the assessed impacts.

Chapter 5 Environmental Impacts of Station Operation

This chapter presents the potential environmental impacts from the operations of new units on the ESP site. In accordance with 10 CFR 51, impacts are analyzed, and a single significance level of potential adverse impacts (i.e., small, moderate, or large) has been assigned to each analysis. This is noted in respective topic discussions. Mitigation of adverse impacts is also presented, where appropriate. This chapter is divided into ten subsections:

- Land use impacts
- Water-related impacts
- Cooling system impacts
- Radiological impacts of normal operation
- Environmental impacts of waste
- Transmission system impacts
- Uranium fuel cycle impacts
- Socioeconomic impacts
- Decommissioning
- Measures and controls to limit adverse impacts during operation

These subsections also present potential ways to avoid, minimize, or mitigate environmental impacts to the extent possible, including complying with the applicable sections of the following laws, regulations, guidelines, or procedures:

- Federal, Virginia, and local laws and regulations that minimize or prevent adverse environmental impacts (e.g., waste management, air emissions, noise control, storm water management, spill response and cleanup, hazardous material management).
- Recognized industry-standard codes and practices.
- Site permits and licenses (e.g., VPDES Permit, Operating License) and other permits that would be required if/when operation and maintenance activities commence.
- Existing Virginia Power policies and/or procedures that address environmental compliance requirements.

The environmental description, where referenced, includes the following definitions:

- NAPS site - the property within the NAPS site boundary, or fence line, including the EAB.
- ESP site - the property within the NAPS site intended for the construction and operation of new units.
- Vicinity - the area within a 6-mile radius of the ESP site.
- Region - the area within a 50-mile radius of the ESP site.

5.1 Land-Use Impacts

This section discusses the potential land-use impacts associated with operations of the new units. The operational activities of the new units would not require any current or planned land-uses to be changed or modified either temporarily or permanently. The land use areas considered include those that have the potential to be impacted by operational activities (e.g., the site, the vicinity, the area along transmission corridors, and offsite areas). Additionally, land-use considerations include those historic properties that have been identified in the NRHP, as well as those properties that have the potential to hold historic significance, such as artifacts and human remains. The section is further segregated into the following subsections:

- Site and vicinity
- Transmission corridors and offsite areas
- Historic properties

5.1.1 The Site and Vicinity

Section 2.2.1 describes the NAPS site and vicinity. The NAPS site (including the EAB) has been zoned by Louisa County for industrial use. Land-use impacts to the ESP site as a result of operating the new units would not be significant to the region. Potential land-use impacts to the vicinity from the new units may occur as a result of the following:

- Additional discharges through the WHTF
- Fogging, icing, and salt deposition from the operation of cooling towers
- Increased traffic loads on the existing local transportation network

5.1.1.1 Waste Heat Treatment Facility Discharges

A detailed description of the WHTF is provided in Section 3.3. The WHTF discharges to the North Anna Reservoir through the Virginia Power owned and operated Dike #3. The North Anna Reservoir has public access and is used for recreational boating, swimming, fishing, camping, and picnicking, and has residential (vacation and year-round) housing along its shores.

All discharges to the WHTF due to operations would continue to be in accordance with federal, state, and local laws and regulations and applicable permit requirements (e.g., VPDES Permit). State agencies (e.g., VDEQ) conduct regular inspections and advise Virginia Power of any concerns or problems that require resolution. Dominion does not know of any current activities of the existing units that adversely impact recreational uses. The expected increase in discharge water volume and the small increase in temperature at the discharge point of the WHTF due to operation of the new units would not significantly impact the current or future recreational uses of the lake.

Section 5.3.2.2, provides an assessment of the potential operational impacts to aquatic ecosystems in Lake Anna due to anticipated increases in discharge volume and temperature resulting from the new units.

5.1.1.2 Cooling Tower Fogging, Icing, and Salt Deposition

Potential impacts on land use would be related primarily to fogging, icing, and drift and salt deposition from plumes associated with new cooling towers for Unit 4.

An analysis of the potential for fogging and icing is presented in Section 5.3.3.2. The analysis concludes that any impacts would be small and limited mainly to areas on or very near the ESP site.

Section 5.3.3.2 indicates that any offsite salt drift deposition rate would be well below the threshold value potentially adverse to plants and crops. Therefore, any impacts to offsite areas would be small. Impacts on offsite land use from cooling towers fogging, icing, or salt deposition would be small.

5.1.1.3 Increased Use of the Existing Local Transportation Network

The impact on the transportation network accessing the ESP site would be small as a result of operational activities associated with the new units. During the operation of the new units there could be minor increases in traffic on existing public roads leading to and from the NAPS site due to an increase in operations personnel. However, any increases would be small.

5.1.2 Transmission Corridors and Offsite Areas

Based on an initial evaluation, the existing transmission lines have sufficient capacity to carry the total output of the existing units and the new units. If Dominion decides to proceed with development of new units at the ESP site, a system study (load flow) modeling these lines with the new units' power contribution would be performed at that time, to confirm this conclusion. Additional information regarding the existing transmission system is provided in Section 3.7.

No new routes of access corridors would be necessary to serve operation of the new units. No offsite land uses would be affected by operation of the new units.

5.1.3 Historic Properties

Impacts of operations on historic properties or cultural resources would be small. (See Section 4.1.3)

Section 5.1 References

None

5.2 Water-Related Impacts

This section describes the hydrological alterations, plant water supply, and water-use impacts associated with the operation of new units at the ESP site. The following topics are covered.

- Hydrologic alterations resulting from station operations and the effects of these alterations on other water users
- Adequacy of water supplies to meet plant water needs
- Water quality changes and possible effects on water use
- Practices that would minimize or avoid hydrologic alterations having adverse impacts
- Identification and compliance with federal, state, regional, and local regulations applicable to water use and water quality

The evaluation of hydrologic alterations and water quality changes considers both surface water and groundwater uses, including domestic, municipal, industrial, mining, recreation, navigation, and hydroelectric power uses.

5.2.1 Hydrologic Alterations and Plant Water Supply

This section describes the hydrological alterations resulting from plant operation and the adequacy of the water sources to supply water needs to the new units. The following topics are covered.

- Identification and description of proposed operational activities that could result in hydrologic alterations
- Identification, description, and analysis of the resulting hydrologic alterations and the effects of these alterations on other water users
- Analysis of proposed practices to minimize hydrologic alterations having adverse impacts.
- Analysis and comparison of plant water needs and the availability of water supplies to meet the plant water needs
- Conclusions with respect to the adequacy of water supplies to meet plant water needs

As described in Section 3.3.1, the North Anna Reservoir would supply most water needs during operation of the new units, which include plant cooling, the initial fill and make-up water for the UHS cooling tower, water supply to the demineralized water system, and fire protection water. Most of the water needs would be for plant cooling. Unit 3 would use a once-through system for plant cooling, wherein water would be withdrawn from the North Anna Reservoir, circulated through condensers, and returned to the North Anna Reservoir via the WHTF. Unit 4 would use a closed-cycle system for plant cooling and mechanical or natural draft cooling towers for heat dissipation. Cooling tower make-up water necessary to replace the water lost to evaporation from the Unit 4 cooling towers would be obtained from the North Anna Reservoir and supplemented, as necessary, from an outside source to maintain acceptable lake levels. Blowdown from the Unit 4

cooling towers would be discharged to the WHTF. Water needs other than for plant cooling would be required on an intermittent, short-term basis and would be small relative to the long-term plant water use for normal cooling.

5.2.1.1 Operational Activities That Could Result in Hydrologic Alterations

The operational activity that could result in the most significant hydrologic alterations is the use of water from the North Anna Reservoir for plant cooling. The associated hydrologic alterations are described below.

The operation of Unit 3 would increase the quantity of water withdrawn from the North Anna Reservoir and increase the quantity of heated water discharged to the WHTF for return to the North Anna Reservoir. Unit 3 would require up to 2540 cfs of water for normal plant cooling. This withdrawal is in addition to the 4246 cfs of cooling water withdrawn currently by the existing units (Reference 1). The additional waste heat from Unit 3 would increase water temperatures in the WHTF and the North Anna Reservoir above present lake temperatures (temperature impacts are quantified in Section 5.3). With the increase in water temperatures, additional water would be lost from Lake Anna due to evaporation. The rate of this additional evaporative loss from Unit 3 is estimated to be 29 cfs during normal plant operation.

The operation of Unit 4 would also increase the quantity of water withdrawn from the North Anna Reservoir and increase the quantity of water discharged to the WHTF for return to the North Anna Reservoir. During normal plant operation, Unit 4 would require cooling tower make-up water at a rate of 44 cfs, based on an evaporation rate of 35 cfs. Therefore, the normal operation of Unit 4 would increase reservoir withdrawals by 44 cfs in addition to the 2540 cfs withdrawn for Unit 3 and the 4246 cfs withdrawn by the existing units. The cooling tower blowdown, which would have total dissolved solids concentrations elevated above ambient levels would be discharged to the WHTF at a rate of 9 cfs. This rate assumes 5 cycles of concentration during normal cooling tower operation. (The discharge of blowdown would have a small heat content and would have minimal impact on Lake Anna water temperatures. See Section 5.3.2.1 for additional discussion.) The difference between the make-up water withdrawal and blowdown discharge rates represents evaporation by Unit 4, which would be 35 cfs during normal operation. This 35 cfs of evaporative water loss by Unit 4 would be in addition to the 29 cfs of evaporative water loss by Unit 3.

5.2.1.2 Hydrologic Alterations and Effects on Other Water Users

The additional water use would reduce the volume of water available for release from the North Anna Dam. The operation of Unit 3 would decrease the water available to be released by 29 cfs. The operation of Unit 4 would decrease the water available to be released by an additional 35 cfs. These flow rates represent average annual values, which assume that the new units would operate at a 100 percent plant capacity factor. No reductions in the minimum releases specified in the Lake Level Contingency Plan (Reference 2) would occur.

Additional effects of the hydrologic alterations would be reductions in the Lake Anna water levels during periods of extended drought, due to the additional evaporative losses associated with the operation of the new units. The impacts on lake level from the operation of Units 3 and 4 are discussed in Section 5.2.2.

No hydrologic alterations in addition to those identified and analyzed above are anticipated.

5.2.1.3 **Proposed Practices to Minimize Hydrologic Alterations Having Adverse Impacts**

Practices to minimize hydrologic alterations could be implemented. In the COL application, options to mitigate water use and lake level impacts would be further evaluated. These options include:

- the use of an external source of water to supply make-up water for the Unit 4 cooling towers,
- the use of an external source of water to supplement the make-up water supplied from the reservoir during critical low flow periods such that acceptable lake levels are maintained, and
- depending on the type of plant selected for Unit 4, the use of a dry cooling tower with minimal make-up water requirements.

The hydrologic impacts of any chosen option(s) would be evaluated in the COL application.

5.2.1.4 **Comparison of Plant Water Needs to the Availability of Water Supplies**

The available water supplies are compared to plant water needs on a time-averaged basis in Table 5.2-1. The available water supply is estimated from the water balance equation:

Available Water Supply = Net Inflow – Evaporation – Minimum Release (Equation 5.2-1)

where:

Net Inflow = average net inflow to Lake Anna from tributary inflow, groundwater discharge, and direct precipitation;

Evaporation = average pre-operational evaporation not considering the new units, including natural evaporation and forced evaporation from the existing units; and

Minimum Release = minimum amount of flow that must be released from the North Anna Dam.

Table 5.2-1 summarizes the results for the following two cases:

1. The existing units plus new Unit 3 using a once-through cooling system.
2. The existing units plus new Unit 3 using a once-through cooling system, and new Unit 4 using a closed-cycle cooling system with cooling tower make-up water supplied from the North Anna Reservoir.

The water lost by forced evaporation defines a plant's water needs on a long-term operating basis. The evaporative loss values in Table 5.2-1 are slightly lower than the evaporation values cited in Section 5.2.1.2 to reflect a 96 percent plant capacity factor which is a more realistic long-term capacity factor. Available water supply exceeds the plant water needs for both cases.

Table 5.2-1 Available Water Supply Versus Plant Water Needs

	Flow Rate (ft^3/s)	
Quantity	**Existing Units Plus Unit 3**	**Existing Units Plus Units 3 & 4**
Average Net Inflow[a]	370	370
Pre-operational Evaporation[b]	93	93
Minimum Release[c]	40	40
Available Water Supply[d]	237	237
Plant Water Needs	28[e]	61[f]

a. Derived from water balance model described in Section 5.2.2.

b. Natural evaporation from Lake Anna plus forced evaporation from the existing units; derived from the thermal model described in Section 5.3. Forced evaporation is based on a 93% plant capacity factor.

c. Minimum release for Lake Anna water levels in excess of 248 ft above mean sea level (Reference 2).

d. Equation 5.2-1

e. Additional lake evaporation associated with Unit 3 based on a 96% plant capacity factor.

f. Additional lake evaporation associated with Unit 3 plus evaporative losses from Unit 4 cooling towers based on a 96% plant capacity factor.

5.2.1.5 **Adequacy of Water Supplies to Meet Plant Water Needs**

The analysis presented in Section 5.2.1.4 demonstrates that the available water supply from the Lake Anna watershed is adequate to meet plant water needs for the existing units plus Unit 3 alone, or the existing units plus new Units 3 and 4, on a long-term average basis. On a short-term basis during droughts, there may be periods when an additional source of water might be required for Unit 4 makeup (see Section 5.2.2.1.3).

5.2.2 Water-Use Impacts

This section analyzes and assesses the impacts of plant operation on water use. The following topics are covered in the section:

- Analysis of hydrologic alterations that could have impacts on water use, including water availability
- Analysis of water-quality changes that could affect water use
- Analysis and evaluation of impacts resulting from hydrologic alterations and changes
- Analysis and evaluation of proposed practices to minimize or avoid water-use impacts
- Evaluation of compliance with federal, state, regional, local, and affected Native American tribal regulations applicable to water use and water quality

As described in Section 5.2.1, the primary hydrologic alterations resulting from the operation of new units at the ESP site include:

- reductions in the volume of water available for release from the North Anna Dam, and
- reductions in Lake Anna water levels during periods of drought.

A water balance model for Lake Anna was developed to quantitatively assess the impacts of adding new Unit 3. The model formulation, input data, and results, in terms of lake outflow and lake level, are described below. Analysis and evaluation of impacts are described subsequently. The impacts of adding new Unit 4 would depend of the specific heat dissipation system selected and would be evaluated in the COL application.

5.2.2.1 Water Balance Model

5.2.2.1.1 Model Formulation

Figure 5.2-1 illustrates the conceptual model used to represent the Lake Anna water balance. The continuity equation for this control volume may be expressed as (Reference 3):

$$\frac{dS}{dt} = I - O, \quad S(0) = S_0 \qquad \text{(Equation 5.2-2)}$$

where:

S is the storage
t is time
I is the inflow rate
O is the outflow rate
S_0 is the initial storage

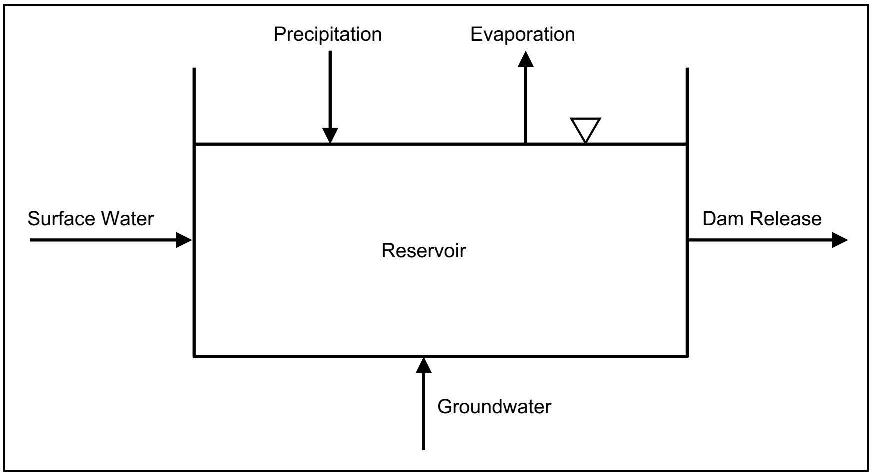


Figure 5.2-1 Lake Anna Water Balance Model

In this analysis, *S* includes the combined storage of the North Anna Reservoir and the WHTF. The inflow rate to Lake Anna, *I*, is defined as:

$$I \equiv I_{SW} + I_{GW} + I_P \qquad \text{(Equation 5.2-3)}$$

where:

I_{SW} is the surface water inflow to the lake from contributing tributaries
I_{GW} is the groundwater inflow to lake
I_P is the inflow from precipitation falling directly on the lake

Because data are not available to characterize I_{SW} and I_{GW} adequately, the total inflow rate to Lake Anna, *I*, is unknown. The basis for estimating this time series will be described subsequently.

The outflow rate from Lake Anna, *O*, is defined as

$$O \equiv O_{Preop\text{-}Evap} + O_{Unit3\text{-}Evap} + O_R \qquad \text{(Equation 5.2-4)}$$

where:

$O_{Preop\text{-}Evap}$ is the pre-operational outflow due to evaporation
$O_{Unit3\text{-}Evap}$ is the evaporative loss associated with the addition of the Unit 3 once-through cooling system
O_R is the outflow from dam releases

Note that $O_{Preop\text{-}Evap}$ includes the natural evaporation from the lake plus the forced evaporation from operating the once-through cooling systems of the existing units.

The initial value problem defined by Equation 5.2-2 is solved by the finite-difference method. Using subscript *n* and *n+1* to represent the beginning and end of any given time period, Equation 5.2-2 can be written:

$$\frac{S_{n+1} - S_n}{\Delta t} = I_n - O_n \qquad \text{(Equation 5.2-5)}$$

and rearranged to yield:

$$S_{n+1} = (I_n - O_n)\Delta t + S_n \qquad \text{(Equation 5.2-6)}$$

Note that S_{n+1} is a function of reservoir elevation, *h*, which can be obtained from the reservoir's elevation-storage relationship. Equation 5.2-6 is solved first for S_1 given the initial conditions at $t = 0$. The computation is then repeated for succeeding time steps.

5.2.2.1.2 **Model Input Data**

Required model input includes the relationship between water surface elevation and lake storage, the relationship between water surface elevation and lake outflow, the inflow time history to Lake Anna, and the time histories of evaporative losses from the lake. The bases for assigning these input data are described below.

The relationship between water surface elevation and storage is derived from the elevation-volume curves for the North Anna Reservoir and the WHTF, which are included in the UFSAR for the existing units (Reference 1, Appendix 2A). These curves have been added to yield a single elevation-storage curve for the entire Lake Anna for the purpose of this water balance study. Table 5.2-2 summarizes these data.

Table 5.2-2 Data Input for Water Balance Model

	Storage (acre-feet)		
Elevation (ft msl)	**North Anna Reservoir**	**WHTF**	**Total Lake Anna**
240	161,550	32,950	194,500
250	244,550	60,450	305,000
260	353,550	104,950	458,500

The operating rule curve implemented in the model, which relates water surface elevation to dam releases, has been developed as follows. For lake levels less than or equal to the normal pool elevation of 250 ft above msl, the Lake Level Contingency Plan is followed (Reference 2). This plan requires a minimum instantaneous release from the Lake Anna impoundment of 40 cfs. When lake

level drops to or below 248 ft msl, releases can be incrementally reduced to a 20 cfs minimum. For lake levels greater than or equal to 250.1 ft msl, it is assumed that any inflow in excess of the evaporative losses is released, provided the minimum release requirements are met.

The inflow time history to Lake Anna has been calculated by a reverse routing procedure using observed Lake Anna releases and water levels and estimated pre-operational evaporation. This procedure has been adopted because only a small fraction of the Lake Anna watershed is gauged, as is described in Section 2.3.1. The inflow to Lake Anna is calculated by solving Equation 5.2-5 for I_n, or:

$$I_n = \frac{S_{n+1} - S_n}{\Delta t} + O_n \qquad \text{(Equation 5.2-7)}$$

This calculation requires the time histories for storage, *S*, and outflow, *O*. The storage time history has been determined using the available period of record for lake level observation, which extends from October 1, 1978, through April 10, 2003. Lake levels, *h*, have been related to *S* through linear interpolation of the values summarized in Table 5.2-2. According to Equation 5.2-4, *O* includes the historical releases from the North Anna Dam, and the historical rate of Lake Anna evaporation associated with operation of the existing units. Historical releases from the dam from October 1, 1978, through October 9, 1995, have been derived from the Partlow stream gauging station, which is located approximately one-half mile downstream of the dam. Stream gauging at this station was discontinued on October 10, 1995. Releases from October 10, 1995, through April 10, 2003 have, therefore, been estimated from the historical gate openings and associated rating curves for the North Anna Dam. The determination of historical lake evaporation is described below.

Evaporation from Lake Anna has been estimated using the thermal model described in Section 5.3.2.1. This model calculates, as part of the heat balance, the heat lost to the atmosphere due to evaporation and the associated evaporation rate on a daily basis for the control volumes used to represent the main ponds in the WHTF and the North Anna Reservoir. The thermal model also includes a number of side arms for which the model does not provide the evaporation rates directly. To determine these evaporation rates, an exponentially decreasing function is used to represent the temperature distribution in the surface layer of each side arm based on the entrance and return flow temperatures predicted by the thermal model. Using the mean value of this function to assign a characteristic temperature for the entire side arm, side arm evaporation is calculated using the Ryan-Harleman function. The pre-operational evaporative loss, $O_{Preop\text{-}Evap}$, is then determined as the sum of the values calculated directly by the thermal model for the ponds and those calculated for the side arms. Note that this time series has been estimated using the historical waste heat load from the existing units.

For predictive purposes, the evaporative losses associated with the existing units and Unit 3, all of which using once-through cooling systems, have been determined using the thermal model

following the methodology described above. The calculated evaporation rates have been corrected to reflect a 93 percent plant capacity factor for the existing units and a 96 percent plant capacity factor for Unit 3. The corresponding waste heats loads are 1.26×10^{10} BTUs per hour for the existing units combined and 9.86×10^{9} BTUs per hour for Unit 3, which is based on a circulating water flow rate of 2540 cfs and an 18°F temperature rise across the condenser.

5.2.2.1.3 Model Results

The water balance model described above has been used to predict releases from the North Anna Dam and water levels in Lake Anna on a weekly basis for the 24-year period extending from October 1, 1979, through April 10, 2003 considering the addition of Unit 3 as described above. For comparative purposes, the existing units running at a plant capacity factor of 93 percent, which exceeds their historical operating experience, have been simulated as well. An assumption inherent to this analysis is that the climatic conditions and variations during this historical period would be representative of future conditions. Figure 5.2-2 and Table 5.2-3 summarize the results for water releases from the North Anna Dam. Figure 5.2-3 and Table 5.2-4 summarize the results for Lake Anna water levels. A discussion of these results is provided below.

Table 5.2-3 Lake Anna Low Outflow Frequency

	Percent of Time Outflow is Less Than or Equal to Indicated Values	
Outflow (ft^3/s)	Exiting Units	Existing Units plus Unit 3
100	50.7%	57.6%
80	48.0%	55.4%
60	46.4%	53.6%
40	43.9%	52.4%
20	5.3%	11.8%

Figure 5.2-2 illustrates the variation in the flow released from the North Anna Dam as a function of time for the 24-year period as simulated by the water balance model for the existing units, and the existing units with the addition of Unit 3. These results indicate that outflows from the dam vary seasonally and annually. Typically, flow rates are relatively high in the wetter fall and winter months due to the need to release water in order to maintain the normal pool elevation of 250 ft msl. Releases in the drier summer months are typically limited to the minimum releases required by the Lake Level Contingency Plan. With the onset of wetter conditions in the fall months, inflows to the lake increase, and releases typically increase above the minimum values. Exceptions to this pattern

would have occurred during the droughts of 1980–1981 and 2001–2002 during which the minimum release was maintained over the winter months due to diminished lake inflow.

Table 5.2-3 summarizes the outflow duration-frequency for the low flows of interest. Results for the existing units indicate that water would have been released from the dam at a rate of 40 cfs or less for 43.9 percent of the time and at a rate of 20 cfs for 5.3 percent of the time. These durations increase with the increasing plant water needs associated with the addition of Unit 3.

Figure 5.2-3 illustrates the variation in Lake Anna water level as a function of time, as simulated by the water balance model for the two cases under consideration. These results indicate that the water level in Lake Anna varies seasonally and annually in response to climatic conditions. The typical seasonal pattern is as follows. Water levels are normally at their minimum values in October, the beginning of the water year. In response to runoff from fall and winter precipitation, water levels then normally increase to the normal operating pool level of 250 ft msl. This normal pool level is usually maintained over the winter months. With the reduction in precipitation beginning in April, decreased tributary inflows, and increased lake evaporation, water levels in the lake are typically drawn down during the summer months such that the maximum annual drawdown occurs near the end of the water year in September. The magnitude of the lake drawdown varies year to year in response to annual variations in surface water and groundwater inflow, which are caused by annual variations in climate conditions. In particular, the maximum annual drawdown during drought years, such as 1980–1981 and 2001–2002, is substantially greater than in other years.

Table 5.2-4 provides the water level duration-frequency for the low water levels of interest to Lake Anna users and the minimum water level for the 24-year simulation period. These results demonstrate that the percent of time that the water level is less than or equal to a given elevation increases with the increasing plant water needs associated with the addition of Unit 3. The results also indicate that the minimum water level for the simulation period decreases with increasing plant water needs of Unit 3. Note that this simulation models the existing units as continuing to operate even when the North Anna Reservoir level drops below the minimum elevation of 244 ft msl specified in their Technical Requirements Manual. Dominion would work with Virginia Power to change the minimum operating level of the existing units to 242 ft msl.

Table 5.2-4 Lake Anna Low Water Level Frequency

	Percent of Time Water Level is Less Than or Equal to Indicated Values	
Elevation (ft msl)	Existing Units	Existing Units plus Unit 3
248	5.2%	11.6%
246	1.1%	3.0%
244	0%	1.1%
242	0%	0%
Minimum Water Level	245.1 feet	242.6 feet

5.2.2.2 Analysis and Evaluations of Impacts on Water Use

The results described in Section 5.2.2.1 indicate there would be water-use impacts associated with the operation of Unit 3. These impacts include reductions in the volume of water available for release from the North Anna Dam, which would decrease the volume of water available for downstream users. Impacts also include increases in lake drawdown during the summer months, which could impact other lake users. These impacts are analyzed and evaluated below.

Results included in Figure 5.2-2 and Table 5.2-3 quantify the impact of the releases from the North Anna Dam that would occur with the addition of Unit 3. Given that the minimum releases would comply with the current Lake Level Contingency Plan (Reference 2), there would be no impact on downstream water users in terms of the minimum flow rate in the North Anna River. However, the duration of the minimum flow release rates would increase with the addition of Unit 3. For the existing units, the durations for which the minimum releases are less than or equal to 40 and 20 cfs are 43.9 and 5.3 percent of the time, respectively. Comparable durations are 52.4 and 11.8 percent of the time with the addition of Unit 3. Potential impacts would be greatest in the reach of the North Anna River extending from below the North Anna Dam to its confluence with the South Anna River.

Results presented in Figure 5.2-3 and Table 5.2-4 quantify the impact on lake levels that would occur with the addition of Unit 3. In this case, the maximum annual drawdown in most years would not differ greatly from the current operation of the existing units alone. Drawdown during the drought years of 1981 and 2002 would have been 1.5 to 2.5 feet greater, respectively, with the addition of Unit 3, as illustrated in Figure 5.2-3. The additional drawdown that occurs during drought years with an added Unit 3 could adversely affect the recreational use in the North Anna Reservoir, which is described in Section 2.3.2. Lake drawdown to Elevation 244 ft msl and below would impact the existing units. The Technical Requirements Manual for the existing units currently requires plant shutdown when the lake level drops below Elevation 244 ft msl. Results included in Table 5.2-4

indicate that lake levels would fall to or below Elevation 244 ft msl 1.1 percent of the time when Unit 3 is added. Dominion would work with Virginia Power to change the minimum operating level of the existing units to 242 ft msl.

No other water-use impacts on surface water or groundwater users due to the normal operation of a new unit or units at the ESP site are anticipated other than those described above.

5.2.2.3 **Analysis of Water-Quality Changes**

The primary impact of operating new units at the ESP site on water quality would be an increase in the water temperature in the WHTF and, to a lesser extent, the North Anna Reservoir. This impact would result from adding waste heat via the once-through cooling system for Unit 3. Section 5.3.2.1 details and quantifies the thermal impacts.

As discussed in Section 5.2.1, the blowdown from the Unit 4 mechanical or natural draft cooling towers would be discharged to the WHTF via the discharge canal. The total dissolved solids in the water discharged would be elevated above ambient levels due to cooling tower evaporation and the concentration of dissolved solids. The cooling tower blowdown would discharge at a rate of about 9 cfs and would be mixed with and diluted in the circulating water discharge from the existing units and Unit 3, which totals about 6786 cfs. Because of the high dilution factor, water-quality impacts of blowdown concentration would be small.

Other than the water-quality changes identified above, no other water-quality impacts on either surface-water or groundwater users would result from the normal operation of new units at the ESP site.

5.2.2.4 **Proposed Practices to Minimize or Avoid Impacts**

Practices to minimize or avoid the water-use impacts could be implemented. In the COL application, options to mitigate water-use impacts would be further analyzed and evaluated. These options are described in Section 5.2.1.3.

5.2.2.5 **Compliance With Regulations Applicable to Water Use and Water Quality**

The new units at the ESP site would comply with all regulations applicable to water use and water quality. Compliance would be demonstrated in the COL application. Modification of the existing units' VPDES permit (Reference 2) to include discharges from the new units would be required. The discharge of heated water to the North Anna Reservoir via the WHTF would be subject to CWA Section 316(a) regulations which require that the thermal discharges assure the maintenance of a balanced, indigenous population of shellfish, fish, and wildlife in and on the receiving body of water. The withdrawal of cooling water from the North Anna Reservoir would meet Section 316(b) of the CWA and the implementing regulations, as applicable.

Section 5.2 References

1. *Updated Final Safety Analysis Report,* North Anna Power Station, Revision 38.

2. Commonwealth of Virginia, Department of Environmental Quality, Authorization to Discharge Under the Virginia Pollutant Discharge Elimination System and the Virginia State Water Control Law, Virginia Electric & Power Company, North Anna Nuclear Power Station, Permit No. VA0052451, January 2001.

3. Linsley, Jr., R. K., M. A. Kohler, and J. L. H. Paulhus. *Hydrology for Engineers,* 2nd Edition, McGraw-Hill, 1975.

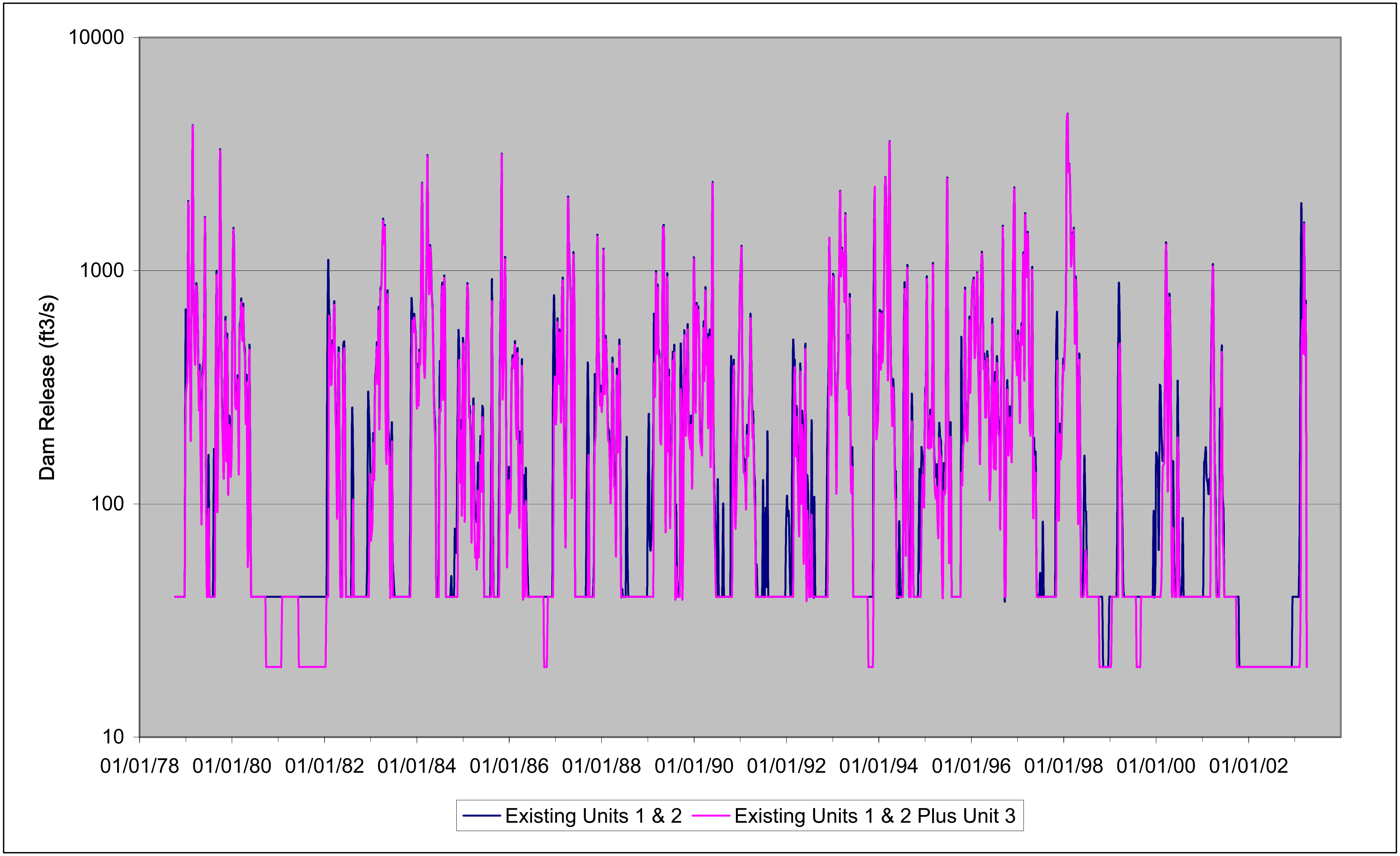


Figure 5.2-2 Lake Anna Outflow Hydrographs

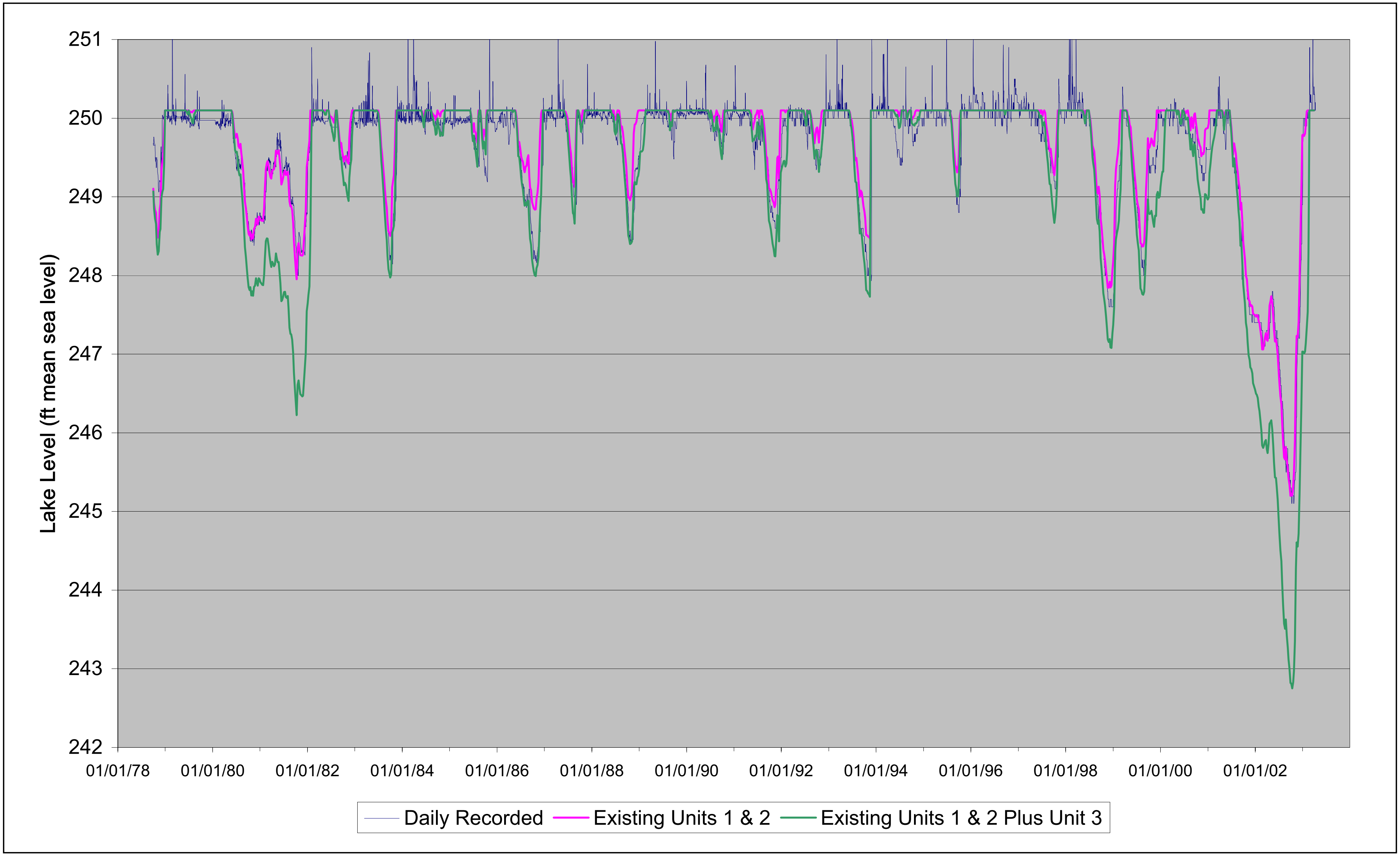


Figure 5.2-3   Lake Anna Water Level Hydrographs

5.3 Cooling System Impacts

This section discusses the impacts on Lake Anna of the cooling systems associated with operation of new units at the ESP site. As described in Section 3.3, and Section 3.4, the lake would be the main source of cooling water for the new units.

Unit 3 would use a once-through system with cooling water supply from the lake. Unit 4 would use a closed-cycle system with mechanical or natural draft cooling towers. Cooling tower make-up water necessary to replace the water lost to evaporation from the Unit 4 cooling towers would be obtained from the North Anna Reservoir and supplemented, as necessary, from an outside source to maintain acceptable lake levels. Depending on the design selected, Unit 4 could use dry cooling towers with minimal makeup from the lake. For those reactor designs that require an UHS, safety-related cooling would be provided by mechanical draft cooling towers. Those cooling towers would have a separate basin to provide a minimum 30-day water supply. The lake would provide makeup to this 30-day basin as necessary. Cooling water would be withdrawn from the North Anna Reservoir through a new intake structure located in a cove adjacent to the intake structure for the existing units. All cooling system discharges, including tower blowdown, would be sent to the WHTF via a new outfall at the head of the existing discharge canal.

The different aspects of cooling system impacts are addressed separately in the following sections:

- Intake system
- Discharge system
- Heat-discharge system
- Impacts to members of the public

5.3.1 **Intake System**

This section describes the impacts of the intake system for the new units, including the physical impacts of the projected hydrodynamic condition induced by the new intake flow and the potential impacts on the aquatic community of Lake Anna.

As described in Section 3.4.2, the CWIS would consist of an intake structure and a dredged channel located in a cove on the south shore of the North Anna Reservoir near Harris Creek. The area that would be occupied by this intake system, originally planned for the intake of the abandoned Units 3 and 4, is adjacent to the cove that houses the intake structure for the existing units.

During normal plant operation, the new intake would supply lake water at a maximum flow rate of 1.14 million gpm (2540 cfs) for the once-through cooling system of Unit 3, and up to 19,600 gpm (44 cfs) of makeup water for the closed cycle cooling system of Unit 4. The new intake structure would also supply lake water as makeup water to the underground storage basins of the UHS cooling towers.

Other water for the new units, including demineralized water and fire protection water, would also be supplied through the new intake structure. According to Section 3.3.1, the total of the incidental plant water usage would be an additional 4920 gpm (11 cfs) of intermittent intake flow per each new unit.

5.3.1.1 **Hydrodynamic Descriptions and Physical Impacts**

The intake hydrodynamics and the potential alteration of the ambient flow field induced by the intake system operation are discussed in this section. The physical hydrological impacts to the lake during operation of the new units, including shoreline erosion, bottom scouring, induced turbidity and silt buildup, have been assessed. Unless site-specific data are available, bounding parameters from the PPE are used to characterize the cooling water flow and other plant water uses for the new units. As demonstrated in the following analysis, adverse impacts would be small. This section also identifies and evaluates design considerations, engineering practices, and operating procedures that would increase stability of the shore and lakebed.

Currently, the North Anna Reservoir is the principal water source for the existing units, providing circulating water for the once-through cooling system and other plant water needs during normal plant operation. Up to 4310 cfs of lake water is withdrawn from an existing intake structure located on the south shore of the North Anna Reservoir in a cove about 5 miles upstream of the dam (Reference 1). Of the 4310 cfs withdrawn, a maximum flow of 4246 cfs is used for the normal plant cooling of the existing units and is discharged at an elevated temperature to the WHTF via a common outfall at the head of the discharge canal. The remaining 64 cfs is for incidental plant use.

As described in Section 3.3 and Section 3.4, the North Anna Reservoir would also be a main source of cooling water for Unit 3 during normal station operation. Unit 4 plant cooling would be provided either by dry cooling towers or wet cooling towers. If wet cooling towers are selected, cooling tower make-up water would be taken from the North Anna Reservoir and supplemented by offsite sources, as necessary, to maintain acceptable lake levels. The following analysis assumes that the makeup water supply for Unit 4 wet-evaporative cooling towers would come from the lake as this represents the bounding scenario for the evaluation of the physical impacts to the lake hydrodynamic system due to the higher induced velocity from the combined flow.

The lake would also provide makeup water to maintain the separate 30-day supply of emergency cooling water needed for the UHS for both new units, as discussed in Section 3.4.2. However, during any shutdown requiring the UHS, no cooling or makeup water from the lake would be needed for any of the affected reactors to reach safe shutdown.

The new intake system would consist of a compartmented intake structure with a screenwell and pump bays dedicated to each unit, and an approach channel, dredged in the cove adjacent to the intake for the existing units. During normal plant operation, the new intake system would supply up to 2540 cfs of cooling water for the once-through system of Unit 3 and 44 cfs (during normal conditions) to 70 cfs (during upset or abnormal conditions) of makeup water for the closed-cycle

cooling system of Unit 4. During an extended drought condition, however, consideration would be given to using an external makeup water source to reduce the water demand on Lake Anna. Impact analysis of this external water source for Unit 4 would be performed during detailed engineering and described in the COL application. Additional plant water needs of up to 2.5 cfs (during normal conditions), 11 cfs (during upset or abnormal conditions) for each new unit, including water to supply the demineralized water system, fire protection water, and the makeup water for the 30-day storage of UHS cooling tower, would also be withdrawn from the lake through the new intake structure. These incidental plant water needs would be intermittent and small compared to the once-through cooling water flow. They would have no adverse physical impact to the lake.

At the downstream end of the plant cooling system, a new combined outfall would discharge up to 2540 cfs of cooling water effluent from the once-through system of Unit 3, and an expected 9 cfs to 35 cfs of cooling tower blowdown from the closed-cycle cooling system of Unit 4. Other permitted plant discharges such as demineralized and sanitary drains would be released to the new outfall, but their volume would be small and would have no physical impact on the lake. The new outfall structure would be next to the existing units outfall at the head of the discharge canal in the WHTF. From the discharge canal, the cooling water effluent from both the new units and the existing units would flow through the WHTF's various canals, ponds, and side-arms to dissipate heat, and would eventually re-enter the North Anna Reservoir at Dike 3 via six adjustable submerged skimmerwall gates. The physical impacts of the operation of the discharge system are discussed in Section 5.3.2.1.

5.3.1.1.1 **Lake Hydrologic Characteristics**

Section 2.3.1 describes the hydrologic characteristics of the Lake Anna watershed and the impoundment that was created by the construction of the North Anna Dam. Figure 5.3-1 is a map of Lake Anna showing the upper lake, mid-lake and lower lake reaches of the North Anna Reservoir, the WHTF, the relative location of the existing station intake, the new intake, and the discharge canal.

Lake Anna is about 17 miles long with a shoreline length of approximately 272 miles. At the normal operating lake level of 250 ft msl, the reservoir and the WHTF have a combined volume of 305,000 acre-feet and a surface area of approximately 13,000 acres. The watershed area above the dam draining into Lake Anna is 343 square miles. Based on the water budget analysis described in Section 5.2.1, the long-term average inflow to the lake including surface water runoff, direct precipitation, and ground water flow is estimated to be about 370 cfs. The average outflow at the dam varies, depending on various water use on the lake, including water loss due to evaporation. The outflow is estimated to be about 275 cfs during the operation of the existing units.

The hydrologic characteristics of the North Anna Reservoir gradually change from riverine upstream to lacustrine downstream. The upper lake is primarily riverine, shallow (average depth of 4 m (13 ft)) and slightly stratified in summer. The mid-lake is more lacustrine and stratified. The

lower lake is deeper (average depth of 11 m (36 ft)) and displays lacustrine characteristics (e.g., more vertical gradients of light, temperature, and decomposition). Both the lower lake and mid-lake reaches tend to be stratified in summer and mixed in winter. (Reference 2)

Because the additional waste heat from the new units would be discharged through the WHTF to the North Anna Reservoir, the lower lake reach near Dike 3 and the North Anna Dam would be strongly stratified in summer and mixed or weakly stratified in winter. The hydrothermal impact on the lake is discussed in detail in Section 5.3.2.1.

According to the Lake Anna Special Area Plan (Reference 3), the primary cause of lakeshore erosion is wave action induced by wind and wakes from boats. The operation of additional units would have a small impact on lakeshore erosion.

5.3.1.1.2 **Intake Hydrodynamics and Physical Impacts**

The hydrodynamics of the North Anna Reservoir are different from those of most other lakes and reservoirs, in that during station operation, the mid-lake and lower lake reaches, where the intakes and the Dike 3 skimmer gates are located, have a circulation pattern induced by the plant circulating water flow. Most of the cooling water from the existing plant, which discharges at a rate of up to 4246 cfs into the reservoir via Dike 3, is drawn uplake by the cooling water and service water pumps in the existing intake structure. Since the circulating water flow is very large compared to the average inflows to the lake and the average release flow at the dam, the plant's cooling system flow dominates the circulation in the lake except during periods of high inflows from the tributaries upstream.

As shown in Figure 5.3-1, the width of the reservoir perpendicular to the main flow direction varies from less than 1600 feet near Dike 1 to over 7000 feet near Dike 2 in the lower lake reach. With a typical epilimnion thickness of 26 feet to 33 feet in the lower lake region during the operation of the existing units (Reference 2), the induced surface current is estimated to be flowing in a general uplake direction at 0.1 ft/sec or less on the average during the normal lake level of 250 ft msl. The colder return flow from the upper lake toward the dam occurs in the lower part of the water column (the hypolimnion) and is predicted to have a lower velocity. A conservative estimate has been made based on the assumption that the return flow would be the same as the total inflows to the lake. In the lower lake reach upstream of the Dike 3 discharge, the velocity of the bottom current is predicted to be less than 0.1 ft/sec on a long-term average basis. The flow near Dike 3 is more complicated and is dominated by the mixing process at the skimmer gates. The outfall hydrodynamics and the physical impacts to the lake are discussed in Section 5.3.2.1. With operation of the new units, additional cooling water discharge of 2540 cfs from Unit 3, and Unit 4 cooling tower blowdown of 9 cfs (during normal conditions) to 35 cfs (during upset or abnormal conditions) through Dike 3 to the reservoir, would induce a stronger surface current in the uplake direction of 0.2 ft/sec or less on the average across the reservoir. The bottom returning flow would increase because of the reduction of the hypolimnion as a result of the additional heat load from the

new units. The slightly stronger induced current due to the operation of the new intake system would not be sufficient to cause scouring of the lakebed or erosion of the shoreline.

Water quality parameters in the lake and the WHTF were measured as part of the 316(a) demonstration study for the existing units (Reference 2). Measured turbidity levels were reported as generally low, except during periods of heavy inflows from the tributary streams. According to the 316(a) demonstration study, the mean annual turbidities from 1981 to 1986 ranged from 6 to 10 NTUs in the upper lake, and 2 to 5 NTUs in the lower lake reaches. Most of the turbidity measurements greater than 15 NTUs were taken in February, March, and April, months with higher runoff. The combined operations of the existing and new units would not increase turbidity in the lake.

The intake channel for the existing units has a bottom width of approximately 320 feet at the mouth of the cove opening to the North Anna Reservoir, and narrows down to 185 feet wide just in front of the screen well. The channel banks have a typical side slope of 3:1 (horizontal to vertical) and the bottom of the channel has been dredged to Elevation 220 ft msl. At a proposed minimum operating lake level of Elevation 242 ft msl and the existing intake flow rate of up to 4310 cfs, the flow velocity in the channel is estimated to be about 0.5 ft/sec at the mouth to less than 1 ft/sec at the approach to the screen well. At the normal lake level of 250 ft msl, the velocity in the existing channel is slightly lower, in the range of 0.3 ft/sec to 0.8 ft/sec. The approach channel of the new intake would have a bottom width that varies from approximately 300 feet near the mouth to 230 feet upstream of the screen well and pump house. The channel bottom would be dredged to Elevation 220 ft msl at the lake end and Elevation 213 ft msl at the screen well and pump house. The channel banks would have a side slope of about 3:1 (horizontal to vertical). At the proposed minimum lake operating level of Elevation 242 ft msl, the flow velocity along the channel would vary from 0.3 ft/sec to 0.4 ft/sec, based on the maximum combined intake flow of 2630 cfs (which includes 2540 cfs of cooling water from Unit 3, 70 cfs of makeup for Unit 4 and 11 cfs of miscellaneous plant water uses for each new unit during upset or abnormal conditions) for the new units. At the normal operating lake level of 250 ft msl, the velocity in the new intake channel would be reduced to about 0.2 ft/sec to 0.3 ft/sec. Because there is no indication of scour or erosion at the existing intake, and because the new units would have lower approach velocities than the existing units; neither intake channel is expected to have any scouring and erosion effect on the lake bottom or shoreline.

Siltation in the channel would not be a problem during normal lake conditions as the coarse and medium sediment would settle out in the reservoir where the current velocity is lower. Any suspended sediment entrained by the intake flow would remain in suspension as the flow velocity increased downstream of the screen well and pump house, and would be carried through the plant cooling system and discharged to the WHTF.

The banks of the channel to the screen well and pump house would be stabilized with riprap to protect against erosion due to wind waves, as along the existing intake channel. The design approach velocity to the traveling water screens and trash racks would be less than 1.0 ft/sec at the

lowest estimated operating lake level of 242 ft msl, and would enhance the performance of the debris filtering system, and create a non-eroding environment. The intake structure would have a sill at the entrance to avoid the entrainment of bed sediment into the screen well and pump house. Maintenance dredging during operation of the new units would not be necessary.

A fish return system based on the latest technology available during detailed engineering, would be considered for incorporation into the new intake system to return impinged fish back to the lake, away from the approach channel, to reduce the impact on the fish population.

Section 5.3.1.2 discusses in further detail the impact of the operation of the intake system on the aquatic ecosystem of the lake.

5.3.1.2 **Aquatic Ecosystems**

CWISs can potentially impact aquatic communities by either impingement or entrainment. The first mechanism by which a CWIS may adversely impact aquatic organisms is through impingement. Traveling screens in the front of the cooling water pumps filter the water and provide protection to the cooling water pumps from damage and clogging. Impingement occurs when swimming organisms are not strong enough to escape the cooling water intake flow and are driven into the screens (i.e., impinged). Impinged organisms are generally fish, but can include other semi-aquatic animals such as amphibians (e.g., frogs and salamanders), waterfowl (e.g., ducks and coots), or mammals (e.g., muskrats). The screens are periodically cleaned using a spray wash system from which the impinged organisms are collected and disposed.

The second mechanism that may cause adverse impact is entrainment (i.e., the intake of organisms into the cooling water system). Entrained organisms are generally small in size and include phytoplankton, zooplankton, and fish eggs and larvae. As these entrained organisms pass through the cooling water system, they are subjected to stresses that may result in mortality. Impacts to the entrained organisms include physical damage from contact with pumps, pipes, and condensers; pressure damage from passage through pumps; shear damage from complex water flows; thermal damage from elevated temperatures in the condenser passage; and toxicity damage from the addition of chemicals to the cooling water system.

In May 1985, Virginia Power published *Impingement and Entrainment Studies for North Anna Power Station, 1978-1983* (Reference 4). This study was conducted in accordance with Section 316(b) and in compliance with the NAPS Environmental Technical Specifications and the existing VPDES Permit under Special Conditions: Environmental Studies. The objective of the study was to examine the effects of impingement and entrainment at the CWIS and determine if they adversely affect the fish populations in Lake Anna.

When the existing units are operating, there is a maximum total withdrawal capacity of 1,934,300 gpm, or about 2.8 percent of the total Lake Anna volume per day (305,000 acre-feet at 250 ft msl). In addition, the existing units operate in a once-through mode and all water withdrawn is

returned to the lake, but at a higher temperature. Each unit uses four circulating water pumps to withdraw condenser cooling water from Lake Anna. The cooling water is withdrawn through two screenwells (one for each unit) located in a cove north of the station (see Figure 5.3-1). Each screenwell contains four individual bays and each bay is equipped with a trash rack, a traveling screen, and a vertical, motor-driven, circulating water pump. The trash racks consist of 1.3 centimeters (cm) wide by 8.9 cm thick vertical bars spaced 10.2 cm on center. The flow through the trash racks is about 0.2 meters per second (0.69 fps) (Reference 4). The traveling screens, constructed of 14-gauge wire with 9.5 mm square openings, are designed to rotate once every 24 hours or whenever a predetermined pressure differential exists across the screens. Debris collected at the trash racks is removed by mechanical rakes and collected in hoppers that discharge the debris into wire baskets. Debris and fish collected in the wire baskets are disposed of as solid waste (Reference 4). The existing units also withdraw a small volume of water for a variety of other uses (e.g., backup service water, bearing cooling; Section 3.3.1). These additional uses contribute less than 3 percent of the total water withdrawal and are included in the total withdrawal capacity presented earlier.

5.3.1.2.1 **Impingement**

Impingement studies were conducted at NAPS from April 1978 through December 1983 in compliance with Section 316(b) of the CWA (Reference 4). An average of just over 47,400 fish representing 34 species was collected annually during each full year of the study. 1978 was not included because sampling was not conducted for the entire year (Reference 4).

For each sample collection the screens were washed to ensure that all fish were removed. The fish were washed into a catch basket at the end of a sluiceway and were removed and transported to the laboratory. Decayed fish that obviously had been dead for longer than 24 hours were excluded from the impingement sample. In the laboratory, up to 50 individuals of each species were measured and weighed. Those species numbering over 50 were counted and weighed in bulk (Reference 4).

To determine the total estimated number of fish impinged over a given time period, daily impingement values (number per gallon withdrawn) were multiplied by the average volume of intake cooling water withdrawn on that sample day, which provides the number of fish impinged per day per gallon of water withdrawn. Period estimates were computed using daily estimates and the number of days in each period. Totaling period estimates by species results in estimates of total fish impinged by month; yearly estimates are the sum of the months.

Six species accounted for 99 percent of all fish impinged during the study. The most commonly impinged fish were gizzard shad (61 percent), followed by black crappie (16 percent), yellow perch (16 percent), bluegill (4 percent), white perch (1 percent), and striped bass (1 percent). No other species comprised more than 1.0 percent of the total number impinged (Reference 4). Based on the estimation process outlined above, an average of 182,000 fish was impinged each year from

1979 through 1983 (Table 5.3-1), 114,000 of which were gizzard shad. These impingement estimates represent a maximum number based on the withdrawal capacity for the existing units on the specific sample collection date. A comparison of impingement numbers to standing crop estimates based on cove rotenone data from Lake Anna indicates that the percentage of the fish population affected by impingement is very low. Gizzard shad impingement losses represent 0.38 percent by number and 0.32 percent by weight of the total standing crop for Lake Anna. For black crappie, the percentages were 3.1 percent by number and 3.8 percent by weight. Values for all other species were 1.4 percent or less (Reference 4).

Table 5.3-1 Mean Number of Representative Important Fish Species Estimated Impinged per Month at the Existing Units from 1979–1983

Month	Striped Bass	Black Crappie	Bluegill	Gizzard Shad	White Perch	Yellow Perch	Total All Species
January	213	929	134	14,600	92	44	16,012
February	265	2,360	235	26,459	162	1,392	30,873
March	381	9,734	465	58,314	625	24,436	93,955
April	87	4,347	636	8,407	471	1,754	15,702
May	10	1,643	630	1,607	390	84	4,364
June	0	480	839	57	135	49	1,560
July	0	372	392	67	164	39	1,034
August	3	426	985	84	159	23	1,680
September	12	845	644	485	161	19	2,166
October	30	3,449	574	236	160	5	4,454
November	357	2,143	1,944	714	176	26	5,360
December	682	1,211	293	2,827	231	36	5,280
Yearly Totals	2,040	27,939	7,771	113,857	2,926	27,907	182,440

Source: Reference 4.

During the study period, total impingement rates declined; the decline appeared to be associated with the reduction in gizzard shad impingement after 1979. On a yearly basis, the majority of the fish impinged were gizzard shad during 1979, 1981, and 1983. However, black crappie were impinged most often in 1980 and 1982 (Reference 4). Most fish were impinged during the winter (75 percent, January–March), followed by spring (13 percent, April-June), fall (9 percent, October–December), and summer (3 percent, July–September). Lower water temperatures during the winter months tend to make fishes lethargic and thus more susceptible to impingement. During

1979, gizzard shad accounted for over 78 percent of the impingement total: 64 percent of these shad (290,000) were impinged between February 20 and March 20. This large gizzard shad impingement occurred when water temperature (1.18°C, February 20, 1979) was the lowest recorded during the study period (Reference 4). Winter kills are common for gizzard shad when water temperatures fall below 3.3°C (Reference 5). This suggests that impingement rates may have been inflated by winter-killed or cold-stunned shad that float into the intake area and are "impinged." In subsequent years of the study impingement levels for gizzard shad never reached the levels of 1979.

a. **Impingement Estimate for Unit 3 Once-Through Cooling**

In order to estimate the impacts of the addition of a new once-through CWIS with a maximum intake flow of 1,202,565 gpm on the impingement of fish in the North Anna Reservoir, data from the 1978–1983 sampling study (Reference 4) were used. The following assumptions were used to extrapolate fish impingement rates for a new once-through cooling system:

- Fish distribution and composition has remained generally the same as in the 1978–1983 study,
- A new once-through CWIS would operate at 100 percent pumping capacity, and
- The intake screen mesh size and approach flow velocity of the new units would be the same as that of the existing units.

Based on the impingement rate for the six representative important fish species from the 1978–1983 study and the maximum flow rate for a new once-through cooling system, an estimate of the total number of fish that could be impinged was calculated. Mean monthly impingement estimates for the six representative important fish species were calculated for the same five full years of operation (Table 5.3-2). It was determined that using the mean of the five representative years would give the most accurate estimate for annual fish impingement. As expected, gizzard shad dominated the impingement estimates for the new system with an estimated annual impingement of approximately 152,000 fish. This estimate is about 30 percent greater than the yearly estimate for the existing units (Table 5.3-1), and is primarily due to assuming that the new once-through cooling system would be operating at 100 percent pumping capacity and withdraw 1,202,565 gpm. In reality, the new CWIS would operate at less than 100 percent capacity, but the maximum withdrawal capacity was used in calculating a "worst case" estimate. In addition, these estimates for gizzard shad may be unusually high due to increased impingement during the winter of 1979 as discussed earlier.

Table 5.3-2 Mean Number of Representative Important Fish Species Estimated Impinged per Month at NAPS With New Unit 3 Using a Once-Through Cooling System

Month	Striped Bass	Black Crappie	Bluegill	Gizzard Shad	White Perch	Yellow Perch	Total All Species
January	269	919	152	12,201	91	43	13,675
February	361	2,514	267	30,634	155	1,754	35,685
March	504	13,386	611	93,500	781	34,701	143,483
April	123	6,622	730	10,250	650	2,741	21,116
May	8	1,724	663	2,022	605	112	5,134
June	0	543	795	70	144	70	1,622
July	0	309	322	68	137	40	876
August	2	323	816	64	128	20	1,353
September	7	648	487	311	148	31	1,632
October	32	3,462	569	197	194	10	4,464
November	367	2,575	1,721	620	121	39	5,443
December	681	1,511	270	2,409	203	30	5,104
Yearly Totals	2,354	34,536	7,403	152,346	3,357	39,591	239,587

Estimated impingement for the other representative important species would be proportional to those of the existing units. In addition, seasonal impingement would be highest during the winter and lowest during the summer; all reflective of the 1985 study (Table 5.3-2).

Cumulatively, based on the “worst case” estimate, impingement would approximately double with the addition of a new unit with a once-through cooling system. Total estimated impingement for the six representative important species would be approximately 422,000 fish annually. Approximately 94 percent of the annual impingement would be gizzard shad (63 percent), yellow perch (16 percent), and black crappie (15 percent) (Table 5.3-3).

Table 5.3-3 Mean Number of Representative Important Fish Species Estimated Impinged per Month with Existing Units and a New Unit 3 Using a Once-Through Cooling System.

Month	Striped Bass	Black Crappie	Bluegill	Gizzard Shad	White Perch	Yellow Perch	Total All Species
January	482	1,848	286	26,801	183	87	29,687
February	626	4,874	502	57,093	317	3,146	66,558
March	885	23,120	1,076	151,814	1,406	59,137	237,438
April	210	10,969	1,366	18,657	1,121	4,495	36,818
May	18	3,367	1,293	3,629	995	196	9,498
June	-	1,023	1,634	127	279	119	3,182
July	-	681	714	135	301	79	1,910
August	5	749	1,801	148	287	43	3,033
September	19	1,493	1,131	796	309	50	3,798
October	62	6,911	1,143	433	354	15	8,918
November	724	4,718	3,665	1,334	297	65	10,803
December	1,363	2,722	563	5,236	434	66	10,384
Yearly Totals	4,394	62,475	15,174	266,203	6,283	67,498	422,027

b. **Impingement Estimates for Unit 3 Once-Through Cooling, Plus Unit 4 with Cooling Towers**

In order to estimate the impacts of both an additional once-through unit (with maximum intake flow of 1,202,565 gpm), plus an additional new unit with cooling towers (using 24,365 gpm of Lake Anna water for cooling), on the impingement of fish in the North Anna Reservoir, data from the 1978–1983 sampling study (Reference 4) were used. The following assumptions were used to extrapolate fish impingement rates for a new once-through unit (Unit 3) plus a new unit (Unit 4) with cooling towers using Lake Anna for makeup water:

- Fish distribution and composition has remained generally the same as in the 1978–1983 study,
- A new once-through CWIS would operate at 100 percent pumping capacity,
- The intake screen mesh size and approach flow velocity of the new units would remain the same as that of the existing units (it is understood that the Unit 4 intake design would differ from the Unit 3 intake design, and this assumption, therefore, is worst case), and
- The makeup water for the new cooling towers would come from the North Anna Reservoir.

The addition of a new unit with cooling towers would increase impingement of the six representative important fish species by approximately 4900 fish annually (Table 5.3-4). Impingement of the six representative important species and their seasonal impingement levels would be proportional to those of the existing units in the 1985 study (Reference 4). To obtain the cumulative total impingement values, the estimates for the existing units (Table 5.3-1), the new once-through unit (Table 5.3-2), and for the new unit with cooling towers (Table 5.3-4), were added. Cumulative total yearly impingement would increase approximately 3 percent above the impingement rates for the existing units, and approximately 1 percent above the impingement estimates for the existing units plus the new unit with a once-through cooling system.

Table 5.3-4 Mean Number of Representative Important Fish Species Estimated Impinged per Month With the Operation of a New Unit 4 with Cooling Towers Using Makeup Water from North Anna Reservoir

Month	Striped Bass	Black Crappie	Bluegill	Gizzard Shad	White Perch	Yellow Perch	Total All Species
January	5	19	3	247	2	1	277
February	7	51	5	621	3	36	723
March	10	276	12	1,894	16	703	2,911
April	3	134	15	208	13	56	429
May	-	35	13	41	12	2	103
June	-	11	16	1	3	1	32
July	-	6	7	1	3	1	18
August	-	7	17	1	3	-	28
September	-	13	10	6	3	1	33
October	1	70	12	4	5	-	92
November	7	52	35	13	2	1	110
December	14	31	5	49	4	1	104
Yearly Totals	47	705	150	3,086	69	803	4,860

5.3.1.2.2 Impingement Discussion

Gizzard shad are the major forage fish in Lake Anna (Section 2.4.2). Threadfin shad, which were introduced by VDGIF in 1983, were collected in impingement samples only in late summer and fall of 1983, and were not included in the impingement estimates due to lack of data. Threadfin shad

contribute to the forage base, but the population is cyclic and subject to die-offs during cold winters (Section 2.4.2).

The percentage of the total reservoir population that is impinged is very low. Based on cove rotenone sampling in Lake Anna, the average annual standing crop of gizzard shad over a five year period (1979–1983) was 121 kg per hectare and the average annual impingement weight of gizzard shad was 2200 kg (Reference 4). Therefore, the average percentage of gizzard shad standing crop in the North Anna Reservoir that was removed annually by impingement was 0.32 percent by weight. Similarly, values for black crappie were 3.8 percent, yellow perch 1.4 percent, bluegill 0.02 percent, and white perch 0.1 percent (Reference 4). Using the worst case scenario and the assumptions presented earlier, the addition of a new once-through cooling system would nearly double the number of fish impinged. Therefore, a new once-through cooling system in combination with the current once-through system would remove approximately 0.7 percent by weight of gizzard shad annually, 8 percent of black crappie, 3 percent of yellow perch, 0.04 percent of bluegill, and 0.2 percent of white perch. Adding a new cooling tower with makeup water taken from the North Anna Reservoir would not increase these numbers appreciably.

Gizzard shad have a high reproductive potential because they grow rapidly, mature quickly, and produce a large number of eggs per female. As reported in Carlander (Reference 6), gizzard shad can reproduce at 2 years of age and each age-2 female can produce from 211,000 to 543,000 eggs. The average yearly combined impingement estimates for the existing units, a new once-through cooling system, and new cooling towers using makeup water from Lake Anna, is approximately 270,000 gizzard shad, considerably less than the maximum egg production of one average size age-2 female gizzard shad. Likewise, black crappie become sexually mature at age-2 or age-3 and a mature female can produce from 11,000 to 188,000 eggs annually (Reference 7). The average yearly impingement estimates for black crappie from all existing and new units combined would be approximately 63,000 fish; well below the maximum egg production of one mature female. These trends hold true for the other representative important species.

There are a number of factors that directly influence recruitment in fish populations. Growth rates, survival rates, and age at maturity are critical elements in determining recruitment success in fish populations. Fish that grow and mature quickly are more likely to be added to the population than those that grow and mature slowly. Growth, survival, and age at maturity are in turn influenced by an array of interrelated factors that include water quality, disease, competition, predator-prey relationships, and genetics. Generally speaking, high mortality rates are associated with low rates of recruitment. Fish can be preyed on by larger fish, by wading birds, and by fishermen. Power plants can function as predators, and like predators, tend to be more “successful” as prey populations expand and densities increase. The theory of natural compensation relies on the principle that fish populations would grow when the population density (standing crop) is low and would likewise decline when the density is high. In other words, compensation is the capacity of a population to offset, to some extent, reductions in numbers caused by some disturbance. This is a

natural compensation process that works to ensure that population size remains relatively stable over time. The assessment presented in Section 2.4.2 concludes that the Lake Anna fish population is balanced and has remained balanced is an indication that natural compensation is occurring. Therefore, natural compensation would offset fishery losses from impingement in Lake Anna.

Generally, new reservoirs exhibit high initial productivity followed by a decline in productivity, and finally a period of stability, but at a productivity level below the initial level. The initial surge in productivity is primarily due to high nutrient levels from freshly inundated vegetation and soil and thus cannot be maintained (Reference 8) (Reference 9). Environmental conditions tend to stabilize 5–10 years after impoundment, and fish biomass stabilization follows. Lake Anna exhibited high initial fish abundance during 1973 and 1974 followed by a decline in succeeding years. Since 1978, the mean standing crop of fishes has remained relatively stable, with the exception of 1985 when the standing crop increased significantly due to the introduction of threadfin shad in 1983 and concurrently an excellent year-class for gizzard shad. Lake Anna appears to support a standing crop of fish higher than most reservoirs in the United States, with thriving populations of several forage and gamefish species (see Section 2.4.2).

The 1985 Section 316(b) study showed no significant impacts due to impingement, a conclusion validated by 20-plus years of monitoring in Lake Anna. In addition, the Section 316(a) demonstration (Reference 2) and more recent monitoring data and annual reports (Reference 10) indicate that Lake Anna fish populations are healthy and diverse. The operation of new Unit 3 using a once-through cooling system and new Unit 4 with cooling towers using makeup water from Lake Anna would not change this conclusion. This conclusion is supported because the fish impinged most frequently are prolific, exhibit a high reproductive potential, and compensatory responses of the fish population would occur to offset losses due to impingement, and therefore would not require mitigation.

5.3.1.2.3 **Entrainment**

During the 1978–1983 study referenced earlier, entrainment samples were collected once a week in front of the intake forebays from March through July of each year, which represents the spawning period of Lake Anna fish (Reference 4). During this six-year study, an average of 1318 fish larvae were collected annually in the entrainment samples. No fish eggs were collected. Most of the fish species in Lake Anna produce demersal (sinking), adhesive eggs, which reduces their potential for entrainment. For purposes of the study and as a conservative estimate, 100 percent entrainment and 100 percent mortality were assumed for all larval fish collected (Reference 4).

During the study, five larval fish taxa dominated the collections; with gizzard shad (65.7 percent) being the most commonly entrained larvae followed by white perch (15 percent), sunfishes (*Lepomis* sp.) (13.3 percent), yellow perch (4.9 percent), and black crappie (1.0 percent). All of the larvae collected were representatives of common, widely distributed species found across Virginia

and the southeast (Reference 11) (Reference 12). As noted in Section 2.4.2, no threatened or endangered fish species have been recorded from Lake Anna. Seasonal differences in the sample collections of the various species reflected the spawning characteristics of the individual species (Reference 4).

More sunfish (*Lepomis* sp.) and yellow perch larvae were collected in the first year of the study (1978) than in subsequent years. Gizzard shad were collected in relatively greater numbers in 1979 and 1981. White perch exhibited a general increase in samples over the study period. Collections of black crappie were considered too low to make any meaningful comparison between years. With the exception of 1978, when sunfish and yellow perch dominated the collections, trends in total numbers of larvae entrained from year to year were generally reflected in the number of gizzard shad, sunfishes, and white perch collected. The percentage of the total larvae collected represented by gizzard shad remained high (between 43 and 88 percent) and stable each year of the study, whereas the percentage of white perch increased each year from 0.3 percent in 1978 to 31 percent in 1983 (Reference 4).

Seasonally, yellow perch larvae were the first to appear each year in collections, generally in early April, when water temperatures approached 12°C. White perch appeared in April when temperatures approached 14°C, peaked in numbers in mid-May, and were collected into July. Gizzard shad larvae generally were first collected in late April to early May at water temperatures between 14°C and 18°C and peaked in numbers in mid-May to early June. Sunfishes were the last group to appear in samples (May-June) and were first collected when water temperatures rose to 19°C. Both gizzard shad and sunfish larvae were collected in relatively fewer numbers in July (Reference 4).

To determine the total estimated number of larvae entrained over a time period, daily entrainment values (number per gallon withdrawn) were multiplied by the average volume of intake cooling water withdrawn on that sample day. Period estimates were computed using daily estimates and the number of days in each period. Totaling period estimates by species results in estimates of total numbers of larvae entrained by month; yearly estimates are the sum of the months (Reference 4).

Based on the estimation method outlined above, an average of 149,400,000 fish larvae was entrained each year from 1978 through 1983 (Table 5.3-5). During this period, gizzard shad had an average yearly entrainment of approximately 95,500,000 or about 63 percent of the total entrainment, while white perch represented 15.4 percent; sunfish 14.9 percent; yellow perch 4.6 percent and black crappie 1.2 percent.

On a seasonal basis, highest estimated larval fish entrainment occurred in May (47.6 percent) when all representative important species were present (Table 5.3-5). June estimates were the second highest with collections dropping dramatically in July.

Table 5.3-5 Mean Number of Representative Important Fish Species Estimated Entrained per Month From 1979-1983 With Existing Units Operating

Taxa	March	April	May	June	July	Yearly Totals
Black Crappie	-	-	1,144,967	598,711	-	1,743,678
Lepomis sp.	-	-	892,255	12,326,144	9,031,991	22,250,390
Gizzard Shad	-	367,705	51,580,191	41,131,018	2,396,247	95,475,161
White Perch	-	3,923,856	17,157,903	1,818,796	92,820	22,993,375
Yellow Perch	223,513	6,309,313	384,800	10,400	-	6,928,026
Monthly Totals	223,513	10,600,874	71,160,116	55,885,069	11,521,058	149,390,630

Source: Reference 4.

a. **Entrainment Estimates for Unit 3 Once-Through Cooling**

In order to estimate the impacts of the addition of a new once-through CWIS with a maximum intake flow of 1,202,565 gpm on the entrainment of fish from the North Anna Reservoir, data from the 1978–1983 sampling study (Reference 4) were used. The following assumptions were used to extrapolate fish entrainment rates for a proposed new once-through cooling system:

- Fish distribution and composition has remained generally the same as in the 1978–1983 study,
- A new once-through CWIS would operate at 100 percent pumping capacity, and
- The intake screen mesh size and approach flow velocity of the new unit would remain the same as that of the existing units.

Based on the entrainment rate (number per gallon) for the five representative important fish species from the 1978–1983 study and the maximum flow rates for the new once-through cooling system, an estimate of the total number of these species' larvae entrained was calculated. As noted earlier in this section, the maximum cooling water withdrawal rate from the North Anna Reservoir for a new unit with once-through cooling would be 1,202,565 gpm. Combined with current usage of 1,934,300 gpm for the existing units, this would result in 5.7 percent of Lake Anna's volume being used each day. Entrainment rates were calculated for the following representative important species: gizzard shad, sunfishes, white perch, yellow perch, and black crappie.

Mean monthly and yearly entrainment estimates for the new unit were calculated for the five representative important fish species for each of the six years of the study (Table 5.3-6). Because the sampling period was similar in all six years, all data were used and an average

yearly estimate was calculated. As expected, the entrainment estimates for the new unit follow those of the existing units very closely.

Entrainment estimates for the new unit averaged approximately 147,700,000 larvae annually, with gizzard shad dominating the estimates. Estimated entrainment for the other representative important species also would be proportional to those of the existing units on an annual and monthly basis.

Table 5.3-6 Mean Number of Representative Important Fish Species Estimated Entrained per Month With New Unit 3 Using a Once-Through Cooling System

Taxa	March	April	May	June	July	Yearly Totals
Black Crappie	-	-	1,301,138	510,611	-	1,811,749
Lepomis sp.	-	-	1,372,567	11,304,534	7,868,851	20,545,952
Gizzard Shad	-	299,825	50,802,477	39,808,477	2,196,895	93,107,674
White Perch	-	4,439,294	18,444,442	1,399,913	71,976	24,355,625
Yellow Perch	231,241	7,165,176	478,451	8,751	-	7,883,619
Monthly Totals	231,241	11,904,295	72,399,075	53,032,286	10,137,722	147,704,619

Cumulatively, entrainment would approximately double (Table 5.3-7) with the addition of a new once-through cooling system. As noted earlier, this is based on a “worst case” estimate and is subject to the assumptions presented earlier in this section. Total estimated entrainment with the old and new units operating for the five representative important species would be approximately 297,000,000 fish larvae annually. Once again, gizzard shad would account for approximately 63 percent of all larvae entrained (Table 5.3-7).

Table 5.3-7 Mean Number of Representative Important Fish Species Estimated Entrained per Month With Existing Units And a New Unit 3 Using a Once-Through Cooling System

Taxa	March	April	May	June	July	Yearly Totals
Black Crappie	-	-	2,446,105	1,109,322	-	3,555,427
Lepomis sp.	-	-	2,264,822	23,630,678	16,900,842	42,796,342
Gizzard Shad	-	667,530	102,382,668	80,939,495	4,593,142	188,582,835
White Perch	-	8,363,150	35,602,345	3,218,709	164,796	47,349,000
Yellow Perch	454,754	13,474,489	863,251	19,151	-	14,811,645
Monthly Totals	454,754	22,505,169	143,559,191	108,917,355	21,658,780	297,095,249

b. **Entrainment Estimate for Unit 3 Once-Through Cooling Plus Unit 4 with Cooling Towers Using Lake Anna for Makeup Water**

In order to estimate the impacts of both an additional once-through unit (Unit 3) (with maximum intake flow of 1,202,565 gpm), plus an new Unit 4 with cooling towers (utilizing 24,365 gpm of Lake Anna water for cooling), on the entrainment of larval fish in Lake Anna, data from the 1978–1983 sampling study (Reference 4) were used. The following assumptions were used to extrapolate fish entrainment rates for a proposed new once-through unit plus a new unit with cooling towers utilizing Lake Anna for makeup water:

- Fish distribution and composition has remained generally the same as in the 1978–1983 study,
- A new once-through CWIS would operate at 100 percent pumping capacity,
- The intake screen mesh size and approach flow velocity of the new units would remain the same as that of the existing units (it is understood that the Unit 4 intake design would differ from the Unit 3 intake design, and this assumption, therefore, is worst case), and
- The makeup water for the new cooling towers would come from the North Anna Reservoir.

The addition of a new unit with cooling towers with a maximum withdrawal rate of 24,365 gpm for makeup would increase entrainment of the five representative important species by approximately 3,000,000 larvae annually (Table 5.3-8). As expected, entrainment of the five representative important species and their annual and seasonal entrainment levels would be proportional to those entrainment values estimated for the existing units during the six-year study this analysis is based upon. To obtain the cumulative total entrainment values, the estimates for the existing units (Table 5.3-8, the new once-through unit (Table 5.3-6), and the estimates for the new unit with cooling towers (Table 5.3-8), would be added. Entrainment would cumulatively increase approximately 2 percent above the entrainment estimates for the existing units, and approximately 1 percent above the combined entrainment estimates for the existing units plus the new unit with a once-through cooling system.

Table 5.3-8 Mean Number of Representative Important Fish Species Estimated Entrained per Month with the Operation of a New Unit 4 with Cooling Towers Using Makeup Water from North Anna Reservoir

Taxa	March	April	May	June	July	Yearly Totals
Black Crappie			26,362	10,345		36,707
Lepomis sp.			27,809	229,043	159,430	416,282
Gizzard Shad		6,075	1,029,302	806,559	44,511	1,886,447
White Perch		89,944	373,700	27,965	1,458	493,067
Yellow Perch	4,685	145,173	9,694	177		159,729
Monthly Totals	4,685	241,192	1,466,867	1,074,089	205,399	2,992,232

5.3.1.2.4 Entrainment Discussion

Reproductive strategies vary among fish species. In general, the strategy is to produce large numbers of eggs but provide little protection thereafter. Therefore, mortality rates are extremely high, with generally less than 1 percent of the larvae surviving to one year of age (Reference 13). Survival rates are higher in species (e.g., sunfish, salmonids) that build nests and provide protection until the larvae swim away from the nest, but are still generally 10 percent or less (Reference 13). To assess the impact of the loss of fish larvae due to entrainment on the fisheries of Lake Anna, the adult equivalent model of Goodyear (Reference 14) was used (Reference 4). Assumptions used included:

- There is 100 percent mortality of entrained larvae,
- The stock populations are at equilibrium and the total lifetime fecundity produces two adults,
- No compensatory mechanisms are operating, and
- 75 percent of the eggs produced by the entrained species survive to the larval stage.

This model estimates the number of adult fish that would have resulted from the entrained larvae had they not been lost to entrainment. It also provides an estimate of the potential percent reduction in the adult fish population as a consequence of entrainment. Values ranged from 0.01 percent for black crappie in 1978 and 1979 and sunfishes in 1982, to 4.13 percent for gizzard shad in 1980. Percent reductions of this magnitude would not have a significant adverse effect on the Lake Anna fishery, especially when viewed in concert with other population mechanisms such as compensation (see Section 5.3.1.2.2) (Reference 4).

The analysis from the adult equivalent model provided a conservative estimate of entrainment impact, primarily as a result of assumptions used in the analysis (Reference 4). Applying the adult equivalent model analysis to a new once-through cooling system and associated entrainment

estimates would result in a doubling of the losses estimated for the existing units (Reference 4). Losses of this magnitude would not impact the Lake Anna fishery. Likewise, the addition of a new unit using a cooling tower with makeup water from the North Anna Reservoir in addition to a new unit using a once-through cooling system would not have a significant adverse effect on Lake Anna's fishery.

The information summarized in Section 2.4.2 and in the *Environmental Study of Lake Anna and the Lower North Anna River Annual Report for 2000 including summary for 1998–2000* (Reference 10) indicates that the fish population in Lake Anna represents a balanced community. Over the years, the fishery of Lake Anna has matured and changed to meet the demands for public fishing through species additions (threadfin shad) and annual stockings of striped bass. Overall, the abundance and quality of the fishery has remained healthy and balanced despite increased fishing pressure and shoreline development. Therefore, based on the information presented in Section 2.4.2 that summarizes the Lake Anna fish community and its thriving populations of gamefish and the forage species that support them, the additional entrainment resulting from the operation of a new once-through unit would have a small impact on the fishery community and would not require mitigation.

5.3.1.2.5 Impingement and Entrainment Implications of Options to Mitigate Increased Lake Temperature

The options that would be considered in the COL application to mitigate the projected increases in water temperature in Lake Anna could affect impingement and entrainment rates. These options include a submerged intake structure (i.e., curtain wall), helper towers, and spray cooling systems (see Section 9.4.1.1.3).

Submerged intake: Submerged intakes or skimmer walls have been used for the past 50 years to ensure a cooler water supply for power plants. In general, this intake system maximizes the use of cooler water available from the deeper layers of a reservoir. Traditionally, skimmer walls were constructed of steel or concrete and extended from just above the water surface to within 5-15 feet of the reservoir bottom. In recent years, flexible floating curtains have been employed in a variety of intake systems to control the discharge of warmer water or to ensure a supply of cooler water for intake systems. Either a solid skimmer wall or a flexible floating curtain in the North Anna Reservoir could reduce impingement and entrainment.

Depending on the intake velocities and intake configuration, impingement levels could be significantly reduced with a curtain/wall. If the intake velocities are reduced to 0.25 to 0.5 fps (current projections) then the impingement rates likely would be dramatically reduced.

Entrainment rates of larval fish and fish eggs could also be reduced because the configuration of the wall/curtain would allow for the withdrawal of water with relatively few larval fish or fish eggs. Most larval fish are found near-shore or in the upper strata of a lake. They have phototactic behaviors that result in diel distribution through the water column, with greater larval densities

higher in the water column at night, at dawn, and at dusk, than in the middle of the day. Therefore, larval fish would be less likely to be found in the cooler hypolimnetic water being withdrawn for cooling and thus less susceptible to entrainment. However, depending on the location of the curtain/wall, there would be the potential for nursery areas between the curtain/wall and the actual intake structure and for larval fish or fish eggs from this area to be withdrawn into the intake system. Generally with the use of a curtain/wall the intake velocities are reduced (i.e., <0.5 fps) and this could significantly reduce the entrainment of larval fish and fish eggs.

Spray Cooling Systems: Floating spray modules to dissipate waste heat from power plants have been used in a variety of types and configurations. For the new units, the modules would be moored in the discharge canal and as the circulating water is passed through the canal it would be picked up by pumps and sprayed into the air where it is cooled. Approximately 100 spray modules would be used.

A spray cooling system would have only marginal impacts on impingement because the system would be located in the discharge canal and would be operated only during limited periods of time when water temperatures were highest. Because the system would be active only when water temperatures are highest, and fish generally avoid water temperatures that would trigger operation of the spray system, it is unlikely fish would be impinged.

A spray cooling system in the discharge canal would entrain none or very few larval fish or fish eggs. Larvae and/or eggs drift in the current, so only ichthyoplankton from upstream of the spray system, which would be the head of the discharge canal, essentially the reactor outfall, would be available for entrainment.

Helper Towers: Helper towers are generally mechanical draft cooling towers. Helper towers would only operate during certain times of the year based upon higher temperatures at the intake structure (generally >87°F). To achieve the necessary cooling, it is estimated that 30 to 40 towers would be needed and the maximum intake flow rate would be 470,000 gpm.

Helper towers would be installed adjacent to the discharge canal and would withdraw water from the canal, cool it, and then return the cooler water to the discharge canal. The discharge canal would have low numbers of fish during the time of year helper towers would be required because fish avoid elevated water temperatures, impingement, therefore, would be low.

Helper tower intakes should entrain no or very few larval fish or fish eggs because larvae and eggs would not be present in the discharge canal during the period when the helper towers would be operating.

5.3.2 **Discharge System**

This section describes the impacts on Lake Anna of the discharge system during operation of the units at the ESP site. The temporal and spatial temperature distributions in Lake Anna and the potential physical impacts resulting from the new units' thermal discharges are described in

Section 5.3.2.1. Potential thermal, physical, and chemical stresses to aquatic organisms that may occur as a result of plant cooling system discharges to Lake Anna are described, quantified, and assessed in Section 5.3.2.2.

5.3.2.1 Thermal Description and Physical Impacts

This section discusses the thermal distribution in Lake Anna and potential physical impacts, including increased turbidity, scouring, erosion, and sedimentation in the lake resulting from the new units' cooling system discharges. The next section, Section 5.3.2.2, evaluates the aquatic impact on the lake's ecosystem. Section 5.2.1 and Section 5.2.2 describe the water use impacts of the new cooling systems. Unless site-specific data were available, the bounding design parameter values from the PPE were used as the basis for the analysis and evaluation of the new units' discharge system. Section 3.4.2 describes the physical attributes of the new discharge system.

According to the PPE, each new unit would generate, during normal full load operation, up to 9.7×10^9 Btu/hr of waste heat that needs to be dissipated. This heat load is in addition to the 1.35×10^{10} Btu/hr of waste heat currently permitted for discharge to the WHTF from the existing units (Reference 15). Three alternative systems are identified as technically viable options for normal plant cooling of the new units:

- A once-through system using Lake Anna as the heat sink
- A closed-cycle system with wet evaporative-type cooling towers
- A closed-cycle system with air-cooled condensers

As noted in Section 5.4, Unit 3 would use a once-through system and Unit 4 would use cooling towers or air-cooled condensers. Both units would discharge to the WHTF. The impacts of each of these systems have been evaluated. No cooling system or combination of cooling systems would cause significant adverse impact to Lake Anna physical, chemical, biological or ecological parameters.

The Unit 3 once-through cooling system using Lake Anna as the normal heat sink would have the greatest thermal impact. The once-through system would release the entire heat load of 9.7×10^9 Btu/hr from the new unit into the WHTF for heat dissipation.

The Unit 4 closed-cycle system would not have a detectable thermal impact on the lake, because the only heat load released to the WHTF would be the blowdown discharge, which would carry a relatively small heat content of 3.0×10^7 Btu/hr or less. The heat content of closed-cycle cooling system releases would be only 0.3 percent of the once-through system's discharge heat load.

Dry evaporative cooling by air-cooled condensers would have the least thermal and water loss impacts on the lake, because there would be a negligible makeup water requirement and no blowdown discharge to be released. In spite of these benefits, a dry cooling system has other operating and environmental issues that could be considered as part of the selection criteria; such

as, additional power consumption, space requirement, and noise impact, as illustrated in Section 9.4.1.

The UHS for each unit would dissipate decay heat of up to 1.2×10^8 Btu/hr during normal conditions, and 4.2×10^8 Btu/hr during shutdown or accident conditions. A blowdown flow of 0.3 cfs (normal) to 1.9 cfs (maximum) per unit would be discharged to the WHTF if a plant was in UHS mode, but the heat load associated with this discharge would be very small, and its impact is bounded by the normal plant cooling discharge. No thermal analysis was conducted specifically for the UHS discharge. The following discussion pertains to the thermal impacts on the lake due to normal plant cooling only.

5.3.2.1.1 Existing Hydrothermal Condition

The existing units each have a reactor core power level of 2893 MWt (uprated in 1986) and an expected gross electrical output of about 982 MWe (Reference 1), rejecting a waste heat load of about 1911 MW (6.5×10^9 Btu/hr) per unit to the condenser cooling system for dissipation. The total heat load to the existing heat dissipation system is, therefore, below the current VPDES permit limit of 13.54×10^9 Btu/hr (Reference 15),on which the thermal impact analysis is conservatively based. The existing units use a once-through cooling system to dissipate the waste heat from the turbine condensers and from the auxiliary cooling systems. When both units are operating, eight circulating water pumps draw water to the plant from the North Anna Reservoir at a design rate of 4246 cfs (2123 cfs per unit). The cooling water, at a design temperature rise of about 14°F above the water temperature at the intake, is discharged through rectangular tunnels to an outfall structure at the head of the WHTF discharge channel. The actual temperature rise across the condensers may be greater or less than 14°F, depending on the power station load and the number of circulating water pumps operating. For instance, at lower condenser flow rates with three circulating water pumps running per unit rather than four, the temperature increase across the condenser averages approximately 18.3°F. A minimum of three circulating water pumps is required for each operating unit in the summer months when the intake temperature exceeds 75°F. (Reference 16)

In the WHTF, the heated effluent flows through a series of ponds and connecting canals, and returns to the North Anna Reservoir via a 6-bay skimmer wall submerged structure at Dike 3. Each discharge bay can be adjusted to maintain the discharge velocity at about 7 fps to promote mixing with the receiving water. Although the discharge is submerged, the slope of the reservoir bottom immediately adjacent to the Dike 3 discharge structure directs the discharge to the surface. (Reference 16)

Circulation in Lake Anna results from four mechanisms:

- Station pumping, which produces a forced horizontal surface flow through the WHTF and the North Anna Reservoir
- Wind stresses, which produce currents in the direction of the wind

- Water temperature differences, which produce natural convective flows into the sidearms of the WHTF and the main reservoir
- Inflows and outflows to and from the reservoir

Station pumping normally dominates the flow pattern and forces the majority of the cooling water flow to circulate back to the intake, because the cooling water flow rate is much higher than the average inflow to the lake and outflow at the dam. The average inflow to the lake including surface runoff, direct precipitation, and groundwater flow is estimated to be about 370 cfs (Section 5.2.1). The average outflow at the dam varies and is estimated to be about 275 cfs when the existing units are in operation (see Section 5.3.1.1). Waste heat is transferred to the atmosphere mostly by evaporation, conduction, and back radiation. Only a small percentage of waste heat is released downstream via the North Anna Dam. It is estimated that, with the existing units operating, the cooling water's residence time in the WHTF is approximately 7 days, where about half of the waste heat is dissipated. The remaining waste heat is dissipated to the atmosphere from the North Anna Reservoir surface.

As discussed in Section 5.3.1.1, the natural hydrologic characteristics of Lake Anna gradually change from riverine upstream to lacustrine downstream. Figure 5.3-1 shows the three different reaches of the lake: the upper, middle, and lower. The upper lake is primarily riverine, shallow (average depth of 4 m (13 ft)) and slightly stratified in summer. The mid-lake is more lacustrine and stratified. The lower lake is deeper (average depth of 11 m (36 ft)) and displays lacustrine characteristics (e.g., more vertical gradients of light, temperature, and decomposition). It is stratified in summer and mixed in winter.

Table 5.3-10 identifies physical attributes of the North Anna Reservoir and WHTF.

With the additional waste heat from the new units discharged to Lake Anna, the lower North Anna Reservoir reach near Dike 3 and the North Anna Dam would be strongly stratified in summer and mixed or weakly stratified in winter. As in a typical cooling lake, one of the defining features is the temperature differential that exists between the discharge and the intake. If transient fluctuations are averaged, this differential is equal to the condenser temperature rise. As density changes are associated with temperature changes, buoyancy forces arise, which tend to cause the spreading of lighter (warmer) water over heavier (cooler) water. The discharge of heated effluent into the lower lake at Dike 3 causes the surface water to become warmer and lighter than the bottom water. Thus, the lower lake tends to be more stratified. Turnover of the hypolimnion (deeper, colder water) of the lower lake occurs through vertical entrainment of the hypolimnion by the horizontally circulating warmer cooling water. Fresh water from the upper lake, which is cooler and more dense than the heated surface water, tends to sink to the bottom of the lake, or to some intermediate depth, and thus reinforces stratification in the reservoir, especially in the lower lake. (Reference 17) This stratification pattern would persist with the addition of new units. The thermal plume would likely be larger, and the hypolimnion reduced as a consequence of the additional heat load.

Temperature data collected prior to the operation of the existing units indicated that the more shallow upper lake warmed more quickly than the lower lake water in the spring. The water in the upper lake reach was also warmer into the early summer, and it reached a higher maximum temperature than the water in the lower lake reach. The large volume of the water in the lower lake retained heat longer, as the natural heat inputs decreased in the fall. In 1976, the lower lake temperature changes lagged about 2-3 weeks behind the temperature changes in the upper lake from February through July, and surface temperatures were warmer in the lower lake from mid-July through December. In 1983, a year when the existing units were operating at close to full load capacity, the surface temperature in the lower lake exceeded the upper lake temperature, except during the spring and early summer. Hence, station operation apparently causes the following lake temperature changes:

- The lower lake is more closely aligned with the upper lake temperature in spring.
- Peak summer temperatures of both lake reaches are similar (whereas the lower lake was cooler pre-operation).
- Heat retention of the lower lake is prolonged. (Reference 2)

Quarterly field temperature surveys have been conducted since 1983 to characterize the thermal plume entering the reservoir via the discharge structure at Dike 3. The data show that in the hottest months of the year (July and August), near-maximum operating conditions have not produced a distinct thermal plume in the lower lake reach. In fact, results show nearly uniform temperatures across the reservoir. There is also no clearly defined thermal plume in the lower lake in the fall, winter, or spring. The results of recent quarterly plume studies (1994 to 1998) are similar. Typically, no thermal plume is evident in spring and summer surveys. In cooler months, differences between upper lake, mid-lake, and lower lake temperatures have been noticeable, both at the surface and at depth. However, seasonal cooling and warming trends of surface waters in the shallow upper lake and in the deeper lower lake have made it difficult to identify or precisely define a thermal plume. (Reference 16) (Reference 2)

Table 5.3-11 shows the observed maximum, average, and minimum daily temperature at four monitoring stations: NALDISC1 near the end of the discharge channel in the WHTF; NALST10 near Dike 3 in the WHTF side; NALBRPT near Burrus Point, which is about one-third of the way up the North Anna Reservoir from the dam; and NALINT, near the intake. In this context, daily temperature refers to the 24-hour average temperature. The temperature summary is based on the continuous surface temperature measurements at the monitoring stations since 1978. Surface temperatures are taken in the top 1 m of the water column. Figure 6.1-1 shows the relative locations of the continuous temperature monitoring stations. Table 5.3-12 summarizes the time exceedence of the measured surface temperatures at the same four locations. Table 5.3-13 shows the seasonal trend of the monthly maximum and average surface temperature observed near the intake (monitoring station NALINT), and near Burrus Point (monitoring station NALBRPT). The temperature at the

intake monitoring station is considered to be representative of the mid-lake condition, whereas the temperature of the Burrus Point monitoring station is representative of the lower lake condition. During the spring months, the monthly maximum temperature near the intake is warmer than the temperature at the Burrus Point. This temperature difference is due to the effect of the warmer inflows from the shallower upper lake reach and the potentially more pronounced natural stratification near the sheltered area around the intake monitoring station. During the summer months, the monthly maximum temperatures at the two locations are more similar due to the effect of the station heat load, as stated previously.

Figure 5.3-3 and Figure 5.3-4 show the observed seasonal average vertical temperature profiles near the dam (monitoring station A) and near the intake (monitoring station I). These profiles have been generated from plume survey data measured quarterly since 1983. The location of the plume survey monitoring stations is illustrated in Figure 6.1-2. The seasonal warming and cooling trend in the lower lake and mid-lake reaches can easily be identified in the observed temperature profiles.

5.3.2.1.2 **Hydrothermal Analysis and Thermal Prediction**

A hydrothermal analysis was conducted using a numerical model called the Lake Anna Cooling Pond Model (see Section 5.3.2.1.4). This analysis characterizes the temporal and spatial temperature distribution in Lake Anna and predicts changes in the thermal structure of the lake due to the thermal discharges from the new units during normal plant operation.

The numerical model was first developed by the Massachusetts Institute of Technology (MIT) in 1977 to simulate temperature changes in Lake Anna due to the plant's waste heat discharge from Units 1 and 2 and the abandoned Units 3 and 4. The numerical model mathematically simulates the heat and mass transfer processes in the WHTF and the North Anna Reservoir. These processes occur due to both natural and waste heat inputs and the forced circulation induced by the intake and discharge systems. Inflows to the lake and releases from the dam, are not simulated due to their small quantity, relative to the circulating water flow.

The physical characteristics of the lake, as shown in Table 5.3-3 are approximated in the model. Thus the model can reasonably predict the time variation of the water temperature in the cooling lake system in response to a given set of transient meteorological conditions and the cooling water intake and discharge operating parameters.

The original 1977 model used synthetic meteorological data from 1957 to 1966, generated with a statistical technique called regionalization using one year of meteorological conditions collected at NAPS and historical meteorological data from Charlottesville, Richmond, and Quantico. The cooling lake model was later calibrated, verified and recalibrated using 1977 to 1981 measured lake temperature data and meteorological data directly from the NAPS site. The final calibration was completed in 1984 with two more years of field data (to 1983).

The ESP thermal analysis is based primarily on the 1984 version of the cooling lake model, with minor modifications to more accurately represent the effective cooling area, especially in the reach

of the reservoir upstream from the plant's intake. The model was recalibrated for the period of 1986 to 2001, using the existing units' historical operating data, meteorological data from the Richmond International Airport, and continuous temperature monitoring data collected from four stations in the WHTF and the North Anna Reservoir. The Richmond Airport meteorological record was used for the current modeling because of its longer, more complete record, as compared to the NAPS site's meteorological data. Validation of the calibrated cooling lake model was performed with historical plant data, Richmond meteorological data, and lake temperature data for the period of 1978 to 1983, the same time period used in the 1984 model calibration. The purpose of the validation was to baseline the performance of the model as a prediction tool.

Thermal impact and performance of the cooling lake system under different heat load conditions were predicted using 42 years of historical meteorological data. Statistically, the historical meteorological condition can be assumed to reasonably represent the future condition. Section 5.3.2.1.4 provides a summary of the model formulation, calibration, and validation.

To assess the thermal impact caused by the addition of waste heat from the new units to the cooling lake system, the calibrated model was used to predict the water temperature in the lake for a period of 42 years, from January 1961 to May 2003, for three operating scenarios:

Scenario 1 – Current operation of the existing Units 1 and 2 once-through cooling system.

Scenario 2 – Future combined operation of the once-through cooling system for the existing Units 1 and 2, a once-through cooling system for the first new unit (Unit 3), and a closed-cycle cooling system for the second new unit (Unit 4).

Scenario 3 – Future combined operation of the existing units once-through cooling systems, a once-through cooling system for the first new unit (Unit 3) and a once-through cooling system for the second new unit (Unit 4).

In the three operating scenarios, the units were assumed to be operating continuously at full station load. PPE bounding values characterize the waste heat discharge of the new units. In particular, new Unit 3 using a once-through cooling system would discharge cooling water at a flow rate of 2540 cfs with a condenser temperature rise of 18°F. The heat content associated with this discharge flow is calculated to be 1.03×10^{10} Btu/hr, about 6 percent higher than the 9.7×10^{9} Btu/hr heat load value provided in the PPE. The thermal analysis was based on the 1.03×10^{10} Btu/hr heat load, thus providing a conservative estimate of the thermal impacts. Blowdown discharge from a new Unit 4 closed-cycle cooling system or from the UHS was not included due to the small heat content as explained previously. The rated cooling water flow of 4246 cfs at a temperature rise of 14.1°F, equivalent to 1.35×10^{10} Btu/hr of heat content, represents the existing units' cooling water discharge.

Table 5.3-14 provides predictions of the maximum and minimum daily surface temperatures at different locations in the WHTF and the North Anna Reservoir based on 42 years of model simulation for the three scenarios. The locations shown in the table follow the general flow direction

in the cooling lake system, starting from the discharge channel through the WHTF to Dike 3 for release to the North Anna Reservoir in the vicinity of the dam, and moving up reservoir to the intake area.

Table 5.3-15 presents the predicted mean surface temperature and the mean temperature during July and August, the two summer months with the warmest temperatures. Figure 5.3-5 and Figure 5.3-6 show the predicted long-term monthly average and monthly maximum surface temperature variation near the North Anna Dam, Burrus Point, and the intake for Scenarios 1 and 2. Table 5.3-16 summarizes the exceedence frequency of five predicted daily surface temperatures at six locations in the WHTF and the North Anna Reservoir. Table 5.3-17 tabulates the maximum daily surface temperature increases in the WHTF and the North Anna Reservoir, due to the additional waste heat discharges for each new unit. The predicted vertical temperature profiles near the intake and the dam, averaged over each season, are shown in Figure 5.3-7 and Figure 5.3-8 for Scenario 1 and in Figure 5.3-9 and Figure 5.3-10 for Scenario 2. The average temperature profiles reflect the seasonal warming and cooling trend in the lake.

The model results can be summarized as follows:

- With one new unit on once-through cooling using Lake Anna (WHTF and North Anna Reservoir) as the heat sink, and the second unit on the closed-cycle cooling system (Scenario 2), the maximum daily intake temperature is not predicted to be above 95°F over the 42 years of the simulation period. The maximum daily surface temperature at the dam is predicted to be above 90°F for 13 percent of the time, compared to 1 percent of the time predicted when only the existing units are operating (Scenario 1), as shown in Table 5.3-16. The maximum daily surface temperature would increase over the existing 2-unit operating temperature by 3.6°F near the dam and 2.8°F near the intake (Table 5.3-17).
- With both new units on once-through cooling using Lake Anna as the heat sink (Scenario 3), the maximum daily intake temperature is predicted to be about 96.7°F over the 42 years of the simulation period (Table 5.3-14). The maximum daily intake temperature is predicted to be above 95°F for about 0.1 percent of the time, as shown in Table 5.3-16. The maximum daily surface temperature at the dam is predicted to reach 100.5°F (Table 5.3-14) and to be above 90°F for 27 percent of the time (Table 5.3-16). The maximum daily surface temperature is expected to increase over the existing 2-unit operating condition by 7.2°F near the dam and 5.5°F near the intake (Table 5.3-17). This scenario was not further evaluated.

The impact of the additional heat load on the temperature field of the upper lake area would be none too small. Section 5.3.2.2 presents the potential impact on the aquatic ecological system of the North Anna Reservoir based on the predicted lake temperature changes induced by the additional heat load from the new units.

5.3.2.1.3 **Other Physical Impacts**

Section 5.3.1.1 discusses the hydrodynamics and the flow distribution induced in the North Anna Reservoir with the addition of new units. The conclusion is that with the low flow velocity in the North Anna Reservoir, the impacts, such as increased shoreline erosion, lakebed scouring, and turbidity levels, due to the operation of the new intake system would be small.

The flow velocity in the discharge channel, the connecting canals, and the main ponds of the WHTF would be slightly higher than in the North Anna Reservoir due to their smaller dimensions. It is assumed that Unit 3 would use a once-through cooling system with a circulating flow rate of up to 2540 cfs, and that Unit 4 would use a closed-cycled system with cooling towers that would discharge approximately 9 cfs of blowdown to the WHTF. Including the cooling water discharge of 4246 cfs from the existing units, the total maximum discharge flow to the WHTF would be 6795 cfs. At maximum discharge rate and a water level in the WHTF of 251.5 ft msl, corresponding to the design lake level of 250 ft msl, the flow velocity in the discharge channel and the connecting canals would be approximately 1.7 fps.

During severe drought conditions when the lake level could lower to 242 ft msl, which would be the proposed minimum operating lake level, the flow velocity in the channel and canals would be 2.9 fps. With only the existing units are in operation, the channel velocity is estimated to be about 1.1 fps to 1.8 fps at water level of 251.5 ft msl and 243.5 ft msl, respectively. The velocity in the WHTF system for the flow from the existing units and future units would be higher than the velocity projected at the intake channel area, but would be low enough not to cause scouring or erosion problems.

Banks of the connecting canals are currently protected by rip-rap from 242 ft msl to 250 ft msl to protect against erosion. The flow velocity slows substantially in the main ponds of the WHTF beyond the entrance-mixing zone near the end of the connecting canals. At the Dike 3 discharge to the reservoir, the exit velocity is designed to be about 7 fps. The bottom of the discharge structure is protected by a concrete apron to minimize local erosion at the discharge, as shown in Figure 3.4-9. No adverse impact due to scouring from the existing plant discharge has occurred, and none would occur as a result of the future combined operation of four units.

There is limited record of turbidity level measurements in the WHTF, but based on the projected discharge flow velocity, the range of the turbidity level in the WHTF would be approximately the same as current turbidity.

Siltation would be minimal, because the medium to coarse sediment would settle before reaching the intake approach channel. A small amount of fine, suspended sediment could be entrained into the CWIS and discharged to the WHTF where the majority of entrained sediment would stay in suspension. The sediment laden cooling water would return to the North Anna Reservoir via Dike 3.

5.3.2.1.4 **Lake Anna Cooling Pond Model**

As discussed in Section 3.4.2 and Section 5.3.1.1.1, Lake Anna has a complicated hydrodynamic structure with an irregular shoreline and many coves, referred to as sidearms. To analyze the heat dissipation of this complex cooling lake system, a segmented model was developed that links different mathematical models applicable for each of the components of the WHTF and the North Anna Reservoir. Figure 5.3-11 is a schematization of the segmented model used to represent the North Anna cooling lake system. There are three main model segments:

- Three ponds of the WHTF, which are shallow.
- Long, dead-end, sidearms of the WHTF and the North Anna Reservoir.
- The deeper main reservoir.

Based on the typical dimensions of the WHTF ponds, the ponds are postulated to be stratified due to the low flow velocity. A 2-layer model was therefore used to represent the ponds of the WHTF with each layer having a uniform temperature in the vertical direction and no heat or mass flux across the interface. Inflows into and return flows from the side-arms are included in the pond model. The interconnecting canals, on the other hand, are modeled as fully mixed segments because the flow velocity is higher, due to the canals' smaller cross-sectional area. The entrance mixing, when flow enters from a canal to the downstream pond, is represented by a dilution ratio that is a function of the discharge flow rate, depth of the canal, half-width of the canal, water depth in the pond, and the densimetric Froude number in the interconnecting canal.

The convective circulation in the dead-end side arms is driven by the spreading of the warm surface water from the main ponds into the side arms, while dissipating heat to the atmosphere. The gradual cooling of the surface flow as it spreads further into the sidearm reduces the density difference between the surface layer and the bottom layer, eventually causing the in-flowing water to sink and be replaced by new warm water.

Figure 5.3-12 is a schematic model of the side-arm circulation flow and heat exchange. MIT performed an experimental and analytical study of the buoyant convection due to the surface cooling in the long side-arms to assist the formulation of the side-arm model, to determine the flow rate and the return flow temperature. The study considered salient features such as the length and depth of the side-arm, the thickness and temperature of the stratified layer at the entrance to the side-arm, and the rate of surface cooling. In addition, the effects of the bottom slopes and the lateral constriction within the side-arm were investigated. Basically, the side-arm flow takes place as the result of a hydrostatic pressure gradient buildup caused by the elevated temperature at the entrance to the sidearm. This hydrostatic motive force is resisted by the fluid inertia and by the bottom and interfacial friction. The equation derived for the side-arm flow is, therefore, a function of the initial upper layer depth, initial temperature at side-arm entrance, equilibrium temperature, surface heat exchange coefficient, coefficient of the thermal expansion of water, and the ratio of the interfacial friction factor to bottom friction factor, which is assumed to be 0.5. The temperature of the

return flow is determined by the classical exponential decay profile, based on the concept of temperature excess from the equilibrium temperature, the buoyancy-driven flow rate, the surface heat transfer rate, and the length of the side-arm. The effective length of the side-arms in the North Anna model is reduced by 20 percent to take into account the area of the down-welling.

The WHTF model as a whole is formulated in steady state. To predict the transient temperature changes in the WHTF, a residence time is computed dynamically for each pond and is used to delay the temperature at the end of each pond to simulate the transient response.

The Dike 3 discharge structure is designed to promote mixing when the cooling water enters the North Anna Reservoir. A simple jet mixing model based on the densimetric Froude number and water depth is used to described the entrance mixing and dilution ratio.

The North Anna Reservoir, between the dam and the plant intake, is likely to be stratified due to its larger depth. The model for the North Anna Reservoir consists of three components:

- A vertically well-mixed surface layer of constant thickness of 28 feet along the entire reservoir with a longitudinally varying temperature distribution.
- A vertically stratified subsurface pool of uniform horizontal temperature.
- A side-arm, attached to the end of the main reservoir, that has a return flow into the subsurface pool.

The transient one-dimensional model used to represent the temperature distribution of the main reservoir is solved with the finite difference method. The 28-foot surface layer is divided into 40 areal increments and seven vertical sublayers. The deeper water between Elevation 222 ft msl and Elevation 190 ft msl is represented in the subsurface model by eight horizontally uniform elements, with a constant thickness of 4 feet each. The subsurface segment includes an additional boundary layer of 4 feet in thickness between Elevation 226 ft msl and Elevation 222 ft msl. The side-arm of the main reservoir is modeled similar to those of the WHTF. In the previous versions of the cooling lake model, the main pond segment of the reservoir has an area of 5000 acres at 250 ft msl, extending from the North Anna dam to the crossing of Highway 208 bridge, about 2 miles up-lake of the plant's intake.

The main reservoir side-arm was initially represented in the model with an area of 4231 acres, representing the surface area at 250 ft msl from the Highway 208 bridge to the far upstream end of the reservoir. A recent review of the Lake Anna system indicates that the constrictions at the bridge crossings – Highway 612 (Stubbs Bridge Road) and Highway 719 (Days Bridge Road) can essentially block the surface's convective flow from spreading further upstream, thus limiting the effective cooling area of the main reservoir side-arm. Therefore, the side-arm area has been reduced to 872 acres in the current model to more accurately model cooling in the area up-lake of Highway 208 bridge crossing. The 20 percent reduction in the effective side-arm length is also applied as in the WHTF. The sidearm areas in the WHTF are also reduced to include only the

deeper areas where buoyancy driven currents are effective. Table 5.3-18 compares the area of the model segments used in the current model and in the 1984 version.

Surface heat transfer is an essential component in the model, and the various heat transfer components are determined from the predicted surface temperature and meteorological forcing condition.

The following list identifies other cooling lake model assumptions:

- Constant lake level of 250 ft msl
- Zero model inflows and outflows, except for the cooling water flow
- Intake flow withdrawn equally over the upper 30 ft of the water column in the last segment of the main reservoir model
- A time-varying diffusion coefficient that depends on wind speed, intake flow rate, and vertical density gradient
- An exponential filter on both the equilibrium temperature and surface heat transfer coefficient to better represent transients in the WHTF
- The side-arm flow rates in the WHTF adjusted for constrictions from bridge piers

Model input includes daily meteorological data and daily plant operation data. Meteorological inputs are air temperature, relative humidity, wind speed, cloud cover, and solar radiation. Plant data inputs are circulating water flow rate and condenser temperature rise. A model time step of one day is used for all simulations.

The modified model was re-calibrated using historical plant operation data and historical meteorological Richmond International Airport station data for Years 1996 to 2001. The reason for choosing the period of 1996 to 2001 is two-fold: a) availability of suitable plant operation data from this period, b) both existing units have been in operation at their uprated power levels since 1986. The calibration target was to minimize the mean error between the predicted surface temperature and observed surface temperature at four representative diagnostic control points in the WHTF and in the main reservoir: the discharge channel, Dike 3 on the WHTF side, Burrus Point, and the intake. The surface temperature measured at the continuous monitoring stations, as described in Section 6.1, was used as the observed data. The calibration parameter is the wind adjustment factor α in the evaporative flux formula by Ryan and Harleman (Reference 18):

$$E = \alpha[22.4(T_{sv} - T_{av})^{1/3} + 14W_2](e_s - e_a) \quad \text{(Equation 5.3-1)}$$

where:

E = evaporative flux in Btu/ft^2/day

T_{sv} = virtual temperature of thin vapor layer in contact with water surface (°F)

T_{av} = virtual air temperature (°F)

e_s = saturated vapor pressure at surface temperature T_s (mm Hg)

e_a = vapor pressure at 6.6 ft (2 m) above water surface (mm Hg)

W_2 = wind speed at 6.6 ft (2 m) above the water surface (MPH)

The sum of the surface temperature errors, defined as predicted value minus the corresponding observed value, at the four diagnostic points was minimized by varying α within a reasonable range. The final calibrated value of α is 0.75 for the WHTF and 0.85 for the North Anna Reservoir, similar to the α values used in the 1984 calibrated model. The mean error for the calibration run varies from -0.4°F at Burrus Point to 1.1°F at the discharge channel. The standard deviation is in the range of 1.5°F to 2.0°F.

Figure 5.3-13 and Figure 5.3-14 show the calibration comparison of the predicted surface temperature versus observed temperature at Burrus Point and at the discharge channel. The model accurately captures the seasonal variation of surface temperature at both locations and predicts the peak surface temperature with excellent overall accuracy. In conclusion, the calibrated model can be used to reliably predict the thermal impact of the new units.

To increase the confidence of the model performance, the calibrated model was validated for another time period by applying the Richmond International Airport's meteorological conditions and the plant's operating conditions from 1978 to 1983, and comparing the predicted surface temperature with observations at the same four diagnostic control points. This is the same simulation period as used by MIT in the 1984 model calibration. The model performs reasonably well with a mean error of 0.8°F at Burrus Point to 1.7°F at the discharge canal. The standard deviation is in the range of 1.3°F to 2.4°F. Figure 5.3-15 and Figure 5.3-16 show the comparison of the predicted temperature versus the measured temperature at Burrus Point and the discharge canal.

Thermal impact predictions were made for three operating scenarios with 2 units, 3 units, and 4 units using once-through systems, as discussed in Section 5.3.2.1.2. Long-term simulations were performed using: a) Richmond International Airport meteorological data from January 1961 to May 2003, b) plant design parameters from the PPE, and c) current design data for the existing units. The calibrated model was also used to estimate the evaporative loss in the lake due to the addition of new units, as described in Section 5.2.2.

5.3.2.2 **Aquatic Ecosystems**

5.3.2.2.1 **Overview**

Nuclear power plant heat dissipation systems can affect aquatic communities in receiving waters in a number of ways. High flows associated with circulating water systems have the potential for scouring discharge substrates and transporting sediment to downstream locations, potentially harming benthic organisms and damaging fish spawning habitats. Chemicals used in circulating

water systems to control biofouling and corrosion can be harmful to aquatic organisms. Heated effluent from once-through cooling systems can affect the distribution and abundance of aquatic organisms in receiving waters. For example, fish may avoid a heated discharge area in summer and be attracted to the same area in winter and spring.

5.3.2.2.2 Aquatic Ecosystem Impacts: Unit 3 Using a Once-through Cooling System

a. **Physical effects**

The NRC has queried utilities and regulatory agencies and reviewed operational monitoring reports of more than 100 nuclear power plants in the course of preparing the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS). With regard to physical effects (scouring, sediment transport, and siltation), the NRC has observed in the GEIS that sediment scouring has caused “minor localized effects” at three operating plants, but has not been a problem at most plants. (Reference 19)

An additional once-through unit would increase circulating water flows by approximately 60 percent, with a corresponding increase in current velocity at the Dike 3 discharge (if no modifications are made to the existing structure). As a result, there could be some additional bottom scouring and some additional sediment transport, depending on the configuration of the discharge structure at Dike 3. However, the existing Dike 3 structure could be modified (i.e., baffles removed) to accommodate increased flows and maintain the velocity at current rates. Any changes to the substrate in the vicinity of Dike 3 from the additional flow associated with a new unit would be small and localized. Mitigation would not be warranted.

b. **Chemical effects**

As noted, an additional once-through unit would increase circulating water flows by approximately 60 percent, with an attendant increase in the use of water treatment chemicals. Nuclear power plants use a variety of chemicals, including biocides, corrosion inhibitors, and dispersants to control biofouling, corrosion, and scale formation in circulating and service water systems. For North Anna, the use of these chemicals is regulated and monitored under the VPDES permit, which prescribes their use (i.e., frequency, concentrations, and limits) and their monitoring frequency (i.e., continuous, daily, or monthly monitoring). Because of continuing efforts of utilities to reduce the use of these chemicals and required NPDES monitoring and reporting, water quality degradation from cooling water system chemicals used in once-through cooling systems at nuclear power plants has not been a major regulatory concern. The GEIS notes that “…water quality effects of [the] discharge of chlorine and other biocides are considered to be of small significance for all plants” (Reference 19). NAPS submits monthly discharge monitoring reports to the VDEQ, which administers the Commonwealth’s VPDES program. In addition, on a 5-year cycle, VDEQ conducts an extensive review of the effectiveness of existing VPDES programs, ensuring that water treatment systems in place adequately protect aquatic communities.

The GEIS notes (p 4-11) that discharges of sanitary wastes are regulated by NPDES permit, and discharges that do not violate the permit limits “are of small significance.” Similarly, the GEIS notes (p 4-11) that water quality impacts of minor chemical discharges and spills do not have a significant impact on aquatic biota for all plants and have been mitigated as needed. NAPS has not had a pattern of permit exceedances or violations, and there is no basis for predicting that operation of an additional once-through unit would increase the frequency or severity of VPDES permit exceedances.

Sewage treatment capacity may increase to accommodate additional personnel. Any modification or expansion of existing sewage treatment facilities would be made in consultation with VDEQ, and any discharges from new or expanded facilities would comply with VPDES permit limits.

Metals such as copper and zinc, leached from condenser tubing and other heat exchangers, have accumulated in some water bodies receiving discharges from nuclear plants (Reference 19). Concentrations of metals in the discharges of once-through nuclear power plants are normally within NPDES permit limits, because the metals are quickly flushed from the area by the large volumes of cooling water or diluted by the receiving water (Reference 19). Concentrations of metals in the NAPS discharge are regulated by VPDES permit. There has been no pattern of exceedances or permit violations at NAPS.

Notwithstanding the fact that mining operations discharging to the Contrary Creek drainage have resulted in elevated concentrations of metals in some Lake Anna surface water and sediment samples in the past, there is no evidence of adverse impacts to aquatic communities. An additional once-through unit would not result in additional impacts because discharges would continue to be regulated by the VPDES permit and thus be protective of aquatic biota. The impacts of chemicals associated with the operation of an additional once-through unit on aquatic resources of Lake Anna would be small, regulated by VPDES permit, and would not warrant mitigation.

c. **Thermal effects**

1. **Thermal effects on important species**

   Cold shock occurs when aquatic organisms that have been acclimated to warm water, such as fish in a power plant’s discharge canal, are exposed to a sudden temperature decrease. This sometimes occurs when single-unit power plants shut down suddenly in winter. It is less likely to occur at a multiple-unit plant, because a sudden temperature decrease is moderated by the heated discharge from the unit or units that continue to operate. Cold shock mortalities at U.S. nuclear power plants are “relatively rare” and typically involve small numbers of fish (Reference 19).

   There have been “winter kills” of fish in Lake Anna associated with cold weather and unusually cold water temperatures, but plant operations were not a factor. In February and

March 1979, large numbers of gizzard shad were killed or stunned when Lake Anna water temperatures fell below 36°F (Reference 4). These fish drifted into the existing units' intake, and were observed in impingement samples. Limited threadfin shad kills have occurred during severe winters. The susceptibility of gizzard shad and threadfin shad to winter kills is well known.

As noted above, incidents of cold shock in receiving waters of nuclear power plants are rare, and rarer still at multiple unit sites. The operation of an additional once-through unit would, therefore, reduce the likelihood of a cold shock incident. In any case, impacts would be small and would not warrant mitigation.

The thermal analysis described in Section 5.3.2.1.2 predicts surface and sub-surface temperatures for three locations. Surface and sub-surface temperatures were predicted for Burrus Point, Thurman Island, and the existing intake area based on historical meteorological data (1961–2003), thermal capacities of the WHTF and the North Anna Reservoir, and heat rejection rates for 2- and 3-unit operations. Temperatures predicted under historical 2-unit operation were compared to field measurements and found to closely approximate actual temperatures.

With 3-unit operation, there would be a measurable increase in Lake Anna surface temperatures. Based on the modeled results, 3-unit operation would increase average daily surface temperatures in the Burrus Point area by approximately 5°F and would increase average daily surface temperatures in the Thurman Island and Intake areas by approximately 5°F and 4°F, respectively. (See Table 5.3-15; Scenario 1 and Scenario 2.)

Maximum daily surface temperatures predicted for the Burrus Point, Thurman Island, and the existing intake locations over approximately 42 years of 3-unit operation were 96.0°F, 95.1°F, and 94.0°F, respectively (Table 5.3-14). The model predicts that 95°F would be exceeded at a surface depth in the Burrus Point area only 1 year out of 42, and in only 6 days of that year (Table 5.3-16). This translates into less than 0.04 percent of the 42-year period (more than 15,000 days) evaluated. At the Thurman Island location, 90°F would be exceeded at a surface depth on an average of 20 days per year, during the June-September period. At the Intake location, 90ºF would be exceeded at a surface depth on an average of 8 days per year during the July-September period. Average annual surface temperatures at these locations would be substantially lower, ranging from 70.5°F to 73.1°F (see Table 5.3-15).

As discussed in Section 5.3.2.1, the thermal modeling assumes that temperatures at a given location would be uniform from the surface to a depth of 28 feet. This upper layer of warm, well-mixed water corresponds with the area of the epilimnion in a thermally-stratified body of water. The thermocline, a transitional zone where temperature drops rapidly with increasing depth, lies between the epiliminion and the hypolimnion.

Under the thermocline in the hypoliminion, temperatures are markedly cooler, even at the hottest times of year. Table 5.3-19, Table 5.3-20, and Table 5.3-21 show average daily temperatures (over a 42-year period) predicted for surface and subsurface depths at Burrus Point, Thurman Island and Intake locations during the summer months.

Table 5.3-22 summarizes preferred temperatures, upper avoidance temperatures, and reported lethal temperatures for several important Lake Anna species. While study objectives, methods, and definitions varied among the studies cited, patterns of temperature preference and temperature tolerance are generally evident for a given species. Critical thermal maxima and chronic lethal maxima values are arrived at experimentally, and are based on different endpoints and acclimation schemes.

The analysis indicates that average daily Lake Anna water temperatures at the surface would be high enough in late summer with three units operating to produce an avoidance response in some resident fish species. Fish could respond by moving up-lake, into tributary streams, or into deeper, cooler water. Temperatures below the warm, well-mixed epilimnion (at the thermocline and below, until dissolved oxygen becomes limiting) would be somewhat lower and acceptable to most Lake Anna fish species. Many non-pelagic fish species in temperate-zone lakes and reservoirs move seasonally in response to changes in temperatures, oxygen levels, and availability of food, even when the lake or reservoir is unaffected by the operation of a power plant (Reference 20).

The striped bass is one of the most thermally-sensitive fish species in Lake Anna, and perhaps the species most vulnerable to thermal stress. The Lake Anna striped bass population is sustained by annual stockings and provides a “put-grow-and-take” fishery. Striped bass in reservoirs across the southeast show a preference for deeper, cooler water in late summer and are often found concentrated in the area of the thermocline at these times. If conditions in the area of the thermocline become inhospitable (i.e., too warm or too low in dissolved oxygen), striped bass in some southeastern reservoirs disperse to thermal refuges, areas within the reservoir that are slightly cooler because they are deeper, or cooled by underwater seeps or springs, or influenced by cooler inflowing streams.

Coutant and Carroll (Reference 21) found that sub-adult striped bass preferred temperatures of 68°F to 75°F in summer, but frequently made brief “excursions” to warmer and cooler water. Cheek et al. discovered that striped bass were restricted in summer to riverine areas of Watts Bar Reservoir (Reference 22) where temperatures were less than 75°F and dissolved oxygen concentrations exceeded 4.0 milligrams per liter. Other researchers have noted a tendency of striped bass to move to deep, downlake areas near dams in late summer in search of cooler water (Reference 23).

Coutant theorized that striped bass populations are limited by available summer habitat, which he defined as 64°F to 77°F temperatures and 2.0 to 3.0 milligrams per liter dissolved oxygen concentrations (Reference 24). Mathews et al. (Reference 25) found that in late summer, large adult striped bass moved downlake to deeper, cooler water “just above the anoxic hypolimnion,” and that these adults were able to tolerate temperatures somewhat higher than 77°F. Moss (Reference 26) observed that striped bass in two Alabama reservoirs sought out cool-water refuges in summer when water temperatures approached 81°F. Several researchers, including Coutant and Carroll (Reference 21) and Dudley et al. (Reference 27) have suggested 79°F to 81°F as upper avoidance temperatures for striped bass.

Experience has shown that unusually high air temperatures and low rainfall in summer (e.g., the drought conditions seen over the 1998–2002 period) can reduce striped bass habitat in some portions of the North Anna Reservoir’s lower lake area (see Section 2.4.2 for description of Lake Anna’s three ecological areas). This situation could be exacerbated by adding an additional unit with its additional heat load. Experience has also shown that even extreme circumstances (e.g., an extended drought) do not eliminate striped bass habitat in the upper lake and mid-lake areas. No striped bass die-offs have been observed in any portion of the North Anna Reservoir.

Striped bass restricted to a narrow layer of water around the thermocline or to thermal refuges may not be able to move freely and feed normally, thus they may be forced to live on stored energy reserves. As a consequence, they may lose weight or show a decline in condition. This phenomenon has been observed at a number of southeastern reservoirs where striped bass experience a late-summer habitat “squeeze.” When surface waters cool in September and October, striped bass are able to move freely in the water column again and resume normal feeding. Weight gain and an improvement in their condition generally follow.

Based on its thermal preferences and tolerances, the striped bass would be classified as a cool-water species. The term “cool-water species” is not rigorously defined, but it refers generally to fish species that are distributed by temperature preference between the coldwater salmonid communities of the northern U.S. and the more diverse centrarchid-dominated warm water assemblages of the southern U.S. (Reference 28).

Striped bass were, until the 1940s, found only in estuaries along the Atlantic Coast from Nova Scotia to South Carolina and, during their annual spawning runs, in large freshwater rivers that flow into these estuaries. The striped bass's ability to physiologically adapt to freshwater led fisheries managers to stock them in many inland reservoirs, including a number in Virginia (Reference 29).

As noted previously in this section, a number of southeastern reservoir populations experience a summer habitat “squeeze,” trapped between a too-warm upper layer and an oxygen-deficient lower layer. Some reservoir populations experience summer die-offs.

Because the Lake Anna striped bass population does not reproduce naturally, the striped bass fishery is dependent on annual stockings. The section of the river above the Lake Anna Dam lacks the required flow, depth, and length to support striped bass spawning (see Section 2.4.2). Thus, reproduction would not be affected by the addition of a new unit.

The warm water fish species of Lake Anna – those with less stringent temperature requirements that are native to inland waters in the southeast – should not be adversely affected by the operation of a new unit with a once-through cooling system. These include most of the species sought by anglers: largemouth bass, black crappie, bluegill, channel catfish, and white catfish. The two most important forage species, gizzard shad and threadfin shad, also should not be adversely affected. The threadfin shad is native to the Gulf slope of the U.S., peninsular Florida, and Central America, and was introduced to a number of Virginia impoundments in the 1950s, 1960s, and 1970s as a forage fish (Reference 29). Because this species is subject to cold kills when water temperatures drop below 48°F, it is able to overwinter in northern latitude impoundments only when waters are heated by power plant effluents (Reference 30).

Mount Storm Lake, a 1200-acre impoundment in Grant County, West Virginia, was built to provide condenser cooling water for Dominion Energy’s Mount Storm Power Station, a large 1600 MW, coal-fired generating station. Maximum (monthly mean) temperatures (one meter depth) in the impoundment ranged from 92.5°F to 96.3°F over the 1998–2001 period at a location in the vicinity of the station’s discharge (Reference 31). Annual maxima ranged from 97.9°F to 99.5°F over the same period at the same location. Despite water temperatures that would appear certain to induce thermal stress in fish, Mount Storm Lake supports a recreational fishery dominated by largemouth bass, smallmouth bass, and channel catfish, temperate-zone species that are found in streams, lakes, and impoundments across Virginia and West Virginia. Mount Storm Lake had the third highest “success rate” (i.e., number of fish caught per hour) of 17 West Virginia lakes and impoundments where sanctioned (West Virginia Bass Federation) bass fishing tournaments were held in 2002 (Reference 32). In addition to these species, the impoundment contains hybrid striped bass, walleye, and sunfish (bluegill and green sunfish), with spotfin shiner, emerald shiner, and threadfin shad providing the forage base.

Based on the available information, waste heat input to the North Anna Reservoir from a new unit with a once-through cooling system could affect striped bass in the reservoir by forcing them up-lake into areas that provide suitable habitat, but effects would be limited to a three-to-four month period in summer and early fall. There could be some energetic

costs associated with the up-lake movement and there could be a period of “lost” growth, if fish are restricted to relatively small areas with an inadequate supply of forage. When confined in late summer to areas that provide only marginal habitat, striped bass sometimes cease feeding (Reference 33).

Thermal impacts on the native warm water species in Lake Anna would be small and would not warrant mitigation. Thermal impacts on striped bass would be moderate and could warrant mitigation.

2. **Thermal effects on nuisance species**

Densities of the introduced Asiatic clam (*Corbicula fluminea*) in Lake Anna increased from 1979 (when first discovered) to the late 1980s, and declined in the 1990s (see Section 2.4.2). Increased water temperatures associated with an additional once-through unit could reduce *Corbicula* numbers further by reducing the available habitat for this species.

At present, maximum mean monthly Lake Anna surface temperatures approach 90°F in July and August (Reference 34). With an additional unit operating, maximum surface temperatures could be as high as 94°F to 97°F in some parts of the reservoir (see Table 5.3-14). Temperatures below the warm epilimnion would be somewhat lower, less than 88°F in all cases. *Corbicula* are able to tolerate temperatures as high as 93°F when properly acclimated (Reference 35), but metabolic and reproductive processes may be hindered by temperatures no higher than 86°F (Reference 36).

A new unit with once-through cooling would increase surface temperatures, but temperatures at the thermocline and below would support *Corbicula* when sufficient dissolved oxygen was present. There could be some reduction in the amount of available *Corbicula* habitat, but any change would be small. *Corbicula* would remain an important component of the benthos, and the most common mollusk in Lake Anna. Impacts would be small but positive, limited to a possible reduction in densities of a nuisance organism. No mitigation would be necessary.

5.3.2.2.3 Aquatic Ecosystem Impacts: Unit 3 Using Once-through Cooling and Unit 4 Using a Cooling Tower

a. **Physical effects**

The addition of a new Unit 4 using recirculating cooling towers to the two existing units and a new once-through unit (Unit 3) would contribute very little to circulating water discharge flows (less than 0.0001 percent, when discharging blowdown), and would have no effect on substrate in the area of the Dike 3 discharge beyond those described in Section 5.3.2.2.2.a. Physical impacts to aquatic communities would be small, and would not warrant mitigation.

b. **Chemical effects**

Adding a new unit with recirculating cooling towers to the two existing units and a new once-through unit would result in the discharge of cooling tower blowdown with concentrations of chemical constituents and solids that are approximately four times higher than those in water withdrawn from Lake Anna for makeup. However, this blowdown would mix with circulating water flow in the WHTF and be diluted.

Based on four cycles of concentration in cooling towers and the design blowdown flow, Dominion estimated that concentrations of chemicals and solids would approach equilibrium (i.e., concentration in circulating water) at the point at which the discharge canal enters the first pond of the WHTF. Concentrations of chemicals and solids would be below applicable VPDES permit limits at the point of compliance, the Dike 3 discharge. Impacts of chemicals in cooling tower blowdown on Lake Anna's aquatic communities would be small and would not warrant mitigation.

c. **Thermal effects**

The temperature of cooling tower blowdown would be lower than the temperature of the circulating water entering the WHTF in most circumstances. As noted previously, a new unit equipped with recirculating cooling towers would contribute very little to total discharge flows (less than 0.0001 percent, when discharging blowdown), and thus would have no effect on discharge temperatures. As noted previously, in Section 5.3.2.2.2.c, a new once-through unit would have small-to-moderate thermal impacts, depending on the species affected. Adding a new unit with a cooling tower to the two existing units and a new once-through unit would have no incremental thermal impacts. Impacts would be essentially the same as those described for a single new once-through unit in Section 5.3.2.2.2.c.

5.3.2.2.4 Implications of Mitigation Options

Although not warranted for the evaluated impacts a number of options have been initially evaluated to potentially reduce thermal impacts to Lake Anna's aquatic communities (see Section 9.4.1). Three of the eight mitigation options appear to be especially promising: a submerged intake (skimmer wall), helper cooling towers, and a discharge canal spray system. The submerged intake option would involve the installation of flexible floating curtains offshore of the intake structure cove area to selectively withdraw deeper, cooler water for condenser cooling and direct warmer water in surface layers into the upstream portion of the reservoir. This would increase the cooling efficiency of upstream "sidearms," and potentially increase oxygenation in the major coves and arms of the reservoir up-lake of the ESP site that are associated with inflowing tributary streams. Studies have shown that these floating curtains could reduce temperatures across the reservoir by approximately 2°F. The second mitigation option explored is an array of floating spray modules in the discharge canal area and the first pond of the WHTF. If employed, this system would be used in late summer and early fall when water temperatures reached some pre-determined level, such as 90°F at the

dam or 87°F at the intake. A spray module system could reduce temperatures at the end of the discharge canal by 2.5°F (relative to temperatures that would be expected with no mitigation) and could reduce intake temperatures by 0.5°F. A third option investigated was the use of mechanical-draft “helper” cooling towers. This option, like the spray module system, would be used only when water temperatures reached some threshold level. Depending on the configuration of the helper towers, such a system could reduce Intake temperatures by 0.6°F to 1.2°F.

5.3.3 Heat-Discharge System

This section describes the impacts of the heat-discharge system during operation of the new units, including the impacts of heat dissipation on the atmosphere and on terrestrial ecosystems. Impacts of the heat-discharge system have been assessed assuming that Unit 3 would use a once-through cooling water system with the existing WHTF and the North Anna Reservoir for heat dissipation, while Unit 4 would use a closed-cooling water system with cooling towers for heat dissipation. Consideration is given to vapor plumes from heat-dissipation systems that may have physical or aesthetic impacts due to the moisture and chemical content of the plume, the nature and extent of these increases, and the significance of their potential environmental impacts on terrestrial ecosystems and human activities in the ESP site vicinity.

5.3.3.1 Heat Dissipation to the Atmosphere

The cooling system options that have been evaluated for the new units would transfer waste heat from the plant components to the atmosphere and to surface water. Lake cooling is the primary cooling process evaluated for Unit 3. Unit 4 cooling would be provided a wet evaporative cooling system that would use either mechanical or natural draft cooling towers to transfer heat to the atmosphere. This section focuses on the effects of heat dissipation to the atmosphere from the wet evaporative cooling systems.

The vapor plumes associated with wet cooling processes have the potential to produce some physical and/or aesthetic impacts.

The following potential impacts have been assessed:

- Visible plume length and frequency downwind of the cooling towers
- Ground level fogging and icing frequencies
- Salt deposition impact near the site
- Plume shadowing effect and additional precipitation associated with visible plumes downwind of the cooling towers
- Interaction of the cooling tower plume with existing pollution sources located near the ESP site
- Increase in relative humidity at ground level in the immediate vicinity of the ESP site

When air is induced into a mechanical-draft cooling tower, it takes up both heat and moisture from the hot water. When this warm moist air mixes with the cooler ambient air, condensation occurs and small droplets (usually less than 10 μ in diameter) form, and the plume become visible, like fog (Reference 37). As the visible plume travels downwind, it is dispersed until eventually it becomes invisible due to evaporation of the water-droplets.

Visible plume length depends on local meteorological factors, tower duty, and topography. Visible plumes are aesthetically undesirable (e.g., blockage of scenic vistas). They also can limit visibility at airports and along highways. Additionally, they can be responsible for icing conditions near the towers during severe winter weather, creating slippery conditions on roads and icing transmission lines in the switchyard.

Abated mechanical draft towers would be used to minimize these aesthetic and safety concerns. The primary advantage of abated towers is the reduction of local fogging and icing. In this type of tower, a dry section is positioned downstream of the wet section for the purpose of drying the supersaturated air exiting from the wet section. The size of any visible plume would depend on the proportional mix of wet and dry cooling media and the local meteorological conditions. Depending on the tower design, vapor plumes exiting from an abated tower would either be invisible or only become visible downstream of the tower. Under unusual weather conditions, initially invisible plumes could become visible some distance downwind as a detached plume. However, these conditions are not common. Use of a plume-abated mechanical tower would minimize plume impacts on highways and airports.

The winter design conditions for the plume-abated towers would be 90 percent relative humidity and 35°F ambient temperature. If the relative humidity was greater than 90 percent and the ambient temperature was lower than 35°F, then fogging would be likely to occur near the tower. If the relative humidity was greater than 90 percent and the ambient temperature was lower than 32°F, then icing in the vicinity of the tower would be possible.

To estimate the frequencies of fogging and icing for the ESP site near the abated towers, 5 years (1996–2000) of the hourly meteorological data from Richmond, Virginia, have been screened to identify the number of hours that were colder and moister than these winter design conditions. This 5-year cooling tower impact screening analysis predicts 44 hours of cooling-tower-induced fogging per year. These induced fogging conditions would be expected to occur on the ESP site near the location of the plume-abated towers. Therefore, the impact of induced fogging would be small.

The operation of the plume-abated cooling towers would increase the relative humidity in the immediate area of the towers. However, because no sensitive vegetation grows near the ESP site (Reference 38, Section 2.2.6), the impact on local vegetation due to any increase in humidity would be small.

The roadway closest to the ESP site that is commonly used by the general public is State Route 652, less than a mile southwest of the ESP site. The closest airport is the Lake Anna Airport,

which is about 7 miles from the ESP site. The transportation impacts attributable to flume-abated cooling tower operation at the ESP site would be small.

The screening analysis also indicates that based on the 5 years of meteorological data analyzed, no cooling-tower-induced icing would occur. Therefore, while infrequent icing could potentially occur, the plume-abated cooling tower icing impact at the ESP site would be small.

Salt deposition is another potential impact issue associated with the operation of cooling towers. The EPRI-sponsored SACTI model (Reference 39) was used to estimate seasonal and annual salt deposition rates that could occur around the cooling towers at the ESP site. The modeling results show that the salt deposition rates would never exceed 1 kg/ha/month beyond the ESP site boundary. This evaluation is based on salt deposition at ground levels on a seasonal basis, as described in Section 5.3.3.2 of NUREG-1555 (Reference 40). Since the majority of the salt deposition would fall near the tower, and no important species/vegetation exists within the ESP site boundary (Reference 38, Section 2.2.6), the salt deposition impact due to the operation of the proposed plume-abated towers would be small. Section 5.3.3.2 addresses terrestrial ecosystem impacts from salt deposition.

Natural draft cooling towers have also been evaluated for the new units at the ESP site. Natural draft towers have a greater potential aesthetic impact because the top of these towers are usually from 500 to 550 feet above grade. These towers would generate visible plumes at relatively high elevations because of the combined effect of the tower height and the thermal buoyancy of the plume. As a result, their plumes seldom reach the ground level, and related ground level fogging and icing problems would be rare. Natural draft towers also tend not to have salt deposition impacts because of the relatively high plume exit and subsequent plume rise allow for more significant plume dispersion than mechanical draft towers.

Generally, natural draft towers are not equipped with plume-abating equipment. Therefore, visible plumes are common. There are no elevated highways near the ESP site and the closest airport (Lake Anna Airport) is at least seven miles away. According to the UFSAR, Section 2.2 (Reference 1), Lake Anna Airport has only limited facilities and aviation traffic is very light, consisting primarily of practice landings. Therefore, transportation impact from natural draft tower would also be small.

The shadowing effect induced by the visible plume is a potential issue associated with the natural draft towers. However, the shadow impact at the ESP site would be small because the shadows would be localized to the site, and the ESP site does not contain sensitive agriculture or public lands (Reference 38, Sections 2.2.4 and 2.2.6). Offsite, the visible vapor plumes would undergo dispersion and dissipation, thus eliminating any related shadowing effect.

New Unit 3 would use a once-though cooling system, using the existing North Anna Reservoir as the cooling water supply and the WHTF as the primary heat sink. A cooling system analysis was performed as described in Section 3.4. The WHTF dissipates the rejected heat from the plant by

heat transfer to the atmosphere and through internal mixing within the water body itself. Under extreme humidity conditions during fall, winter, and spring; cool moist air above the WHTF could turn to fog (i.e., steam fog) and drift to adjacent areas. Any steam fog impact would be small because this type of atmospheric phenomena tends to impact ground level visibility in a very localized area. Additionally, the results of the 5-year cooling tower impact screening analysis have shown that steam-fog-induced icing conditions are very infrequent at the site. Therefore, ice buildup on transmission lines, switchyard, insulators and structures due to steam fog would not be anticipated.

Air-cooled condensers could be used for new Unit 4 to dissipate heat. Because air-cooled condensers are designed for heat rejection based on dry-bulb temperature, evaporation is not a factor. Because air-cooled condensers are not as efficient as mechanical or natural draft cooling towers, they would occupy more land area and would consume more energy. The operation of air-cooled condensers would not produce visible plume because no evaporation is involved.

The new units would include additional standby diesel generators and auxiliary power systems for emergency power and auxiliary steam purposes. However, these systems would operate on an infrequent and temporary basis and any interaction of the heat-dissipation system induced plumes with these fossil fuel emission source effluents would be limited. As stated in the UFSAR, Section 2.2, there are no significant industrial activities within five miles of the ESP site. Also, there are no near term plans for such development in this area. Thus, the impact of interaction of the cooling tower vapor plumes at the ESP site with fossil emissions would be small.

5.3.3.2 **Terrestial Ecosystems**

Heat dissipation systems associated with nuclear power plants have the potential to impact terrestrial ecosystem resources through salt drift, vapor plumes, icing, noise, or avian collisions with surface structures (e.g., cooling towers). Each of these topics is discussed below.

5.3.3.2.1 **Salt Drift**

Salt deposition potentially can cause vegetation stress, either directly by deposition of salts onto foliage or indirectly from accumulation of salts in the soil. An order-of-magnitude (OOM) approach is typically used to evaluate salt deposition on plants, because plant species sensitivities vary, and tolerance levels are not well documented. In this approach, deposition of sodium chloride at rates up to 1 to 2 kg/ha/mo is considered not damaging to plants, while deposition rates approaching or exceeding 10 kg/ha/mo during the growing season could cause leaf damage in many species (Reference 40).

Expected salt deposition rates at the ESP site were calculated using SACTI modeling. Vegetation within approximately 300 feet of the cooling towers may be subjected to salt deposition. All of the predicted deposition rates are less than 10 kg/ha/mo. Seasonal impact variations were evaluated, and modeling indicates that sodium chloride concentrations would not exceed 1 kg/ha/mo at

distances greater than 300 feet. This distance from the towers is within the NAPS site boundary and would likely be mowed lawn and old field vegetation maintained by Dominion or Virginia Power.

No important terrestrial species or habitats exist within the vicinity of the cooling towers. Important species are defined below:

- State- or federally-listed (or proposed for listing) threatened or endangered species
- Commercially or recreationally valuable species
- Species that are essential to the maintenance and survival of species that are rare and commercially or recreationally valuable
- Species that are critical to the structure and function of the local terrestrial ecosystem
- Species that may serve as biological indicators to monitor the effects of the facilities on the terrestrial environment

Important habitats include any wildlife sanctuaries, refuges, preserves, or habitats identified by state or federal agencies as unique, rare, or of priority for protection; wetlands and floodplains; and land areas identified as critical habitat for species listed by the USFWS (Reference 40) as threatened or endangered.

Salt deposition impacts would be small and mitigation would not be warranted because deposition rates would be less than 1 kg/ha/mo at distances greater than 300 feet; and there are no important terrestrial species or habitats in the area of maximum expected salt deposition (i.e. within 300 feet of the cooling towers). The GEIS conclusion that this issue is of small impact and not warranting mitigation (Reference 19) is valid for the new units at the ESP site.

5.3.3.2.2 **Vapor Plumes and Icing**

Based on hourly temperature and relative humidity data recorded from 1996 to 2000 in Richmond, Virginia; the systems discussed in Section 3.4.2 would result in 44 hours of vapor plumes per year and no additional icing. Therefore, vapor plumes (i.e., fog) produced by the cooling system would have a small impact on flying birds’ vision. Similarly, the effects of icing would be small. The GEIS conclusion that this issue is of small impact and not warranting mitigation (Reference 19) is valid for the new units at the ESP site.

5.3.3.2.3 **Noise**

Noise from the operation of the heat dissipation systems would be similar to current noise levels to which local species are adapted. Current noise levels at NAPS are occasionally as high as 100 dBA (measured at the security fence during outages), but they are typically less than 80 to 85 dBA, which is the threshold at which birds and small mammals are startled or frightened (Reference 41). As discussed in Section 5.3.4, noise levels from cooling tower operation would be less than 60 dBA. Furthermore, there are no important terrestrial species or important habitats in the vicinity of the heat dissipation systems. Thus, noise impacts would be small.

5.3.3.2.4 **Avian Collisions**

Mechanical or natural draft cooling towers would be used as part of the Unit 4 heat dissipation system. See Section 3.4 for a description of the cooling towers. No avian collisions with existing NAPS structures have been noted, and it is likely that bird collisions with the new towers would be extremely rare. Therefore, the cooling towers would not adversely affect birds. Once-through cooling systems integrate no elevated structures that could pose a risk of avian collisions. Impacts to birds from collisions with heat dissipation structures would be small and would not warrant mitigation. The GEIS conclusion that impacts from bird collisions would be minimal (Reference 19) is valid for new units at the ESP site.

5.3.3.2.5 **Aesthetics**

Aesthetic impacts are addressed in Section 5.8.1.

5.3.3.2.6 **Conclusions**

Heat dissipation systems associated with new units at the ESP site would have small impacts on terrestrial ecosystem resources and mitigation would not be warranted.

5.3.4 **Impacts to Members of the Public**

This section describes the potential health impacts associated with the cooling system for the new units. Specifically, impacts to human health from thermophilic micro-organisms and from noise resulting from operation of the cooling system are addressed. (Reference 40) (Reference 19)

The existing units use an open-cycle cooling system which withdraws cooling water from the North Anna Reservoir and returns heated effluent to the WHTF. The WHTF discharges to the North Anna Reservoir through Dike 3 (Reference 38). The WHTF is considered by the VDEQ to be a mixing zone for the purpose of complying with the state water quality standards under the VPDES program. Virginia Power considers the WHTF to be an integral part of the power station, and as such it has never been operated as an extension of the North Anna Reservoir for the purposes of public recreational use. However, with Virginia Power’s permission, homeowners on the shoreline of the WHTF have access to it for recreational use (boating, fishing, swimming). This limited access and use would remain unchanged following the addition of the cooling systems for the new units. The WHTF would be the area most likely affected by the heated water and the noise from the new cooling systems.

Although the WHTF is an “industrial facility” rather than a multi-use impoundment that is subject to state water quality standards, a review of historical impacts and current modeling results for the WHTF are presented in this section.

Public usage of the lake is transient and therefore less sensitive to noise impacts. Typically, noise limits apply at permanent residences or similar sensitive locations, as opposed to open ground

where the public may have transient access. The noise impacts in this assessment were evaluated at the EAB, which is 5000 feet from the existing units.

As described in Section 3.4, the cooling needs of the new units would be provided by an open-cycle cooling system and a closed-cycle system. The Unit 3 open-cycle cooling system would generate the greater thermal impact. The Unit 4 closed-cycle cooling towers would generate more noise. The evaluations of thermophilic organisms and noise on the public are based on the composite cooling system (i.e., an open-cycle system operating in tandem with cooling towers).

5.3.4.1 **Thermophilic Micro-Organism Impacts**

NUREG-1555 and NUREG-1437 state that consideration of the impacts of thermophilic micro-organisms on public health are important for facilities using cooling ponds, lakes, canals, or small rivers, because use of such water bodies may significantly increase the presence and numbers of thermophilic micro-organisms. These micro-organisms could be causative agents of potentially serious human infections.

Thermophilic micro-organisms (e.g., *Naegleria fowleri*) generally exist in water bodies with ambient temperatures between 77°F to 176°F. However, maximum growth of such organisms generally occurs when ambient temperatures are maintained between 122°F and 140°F (Reference 16, Section 4.12). Since 1975, Virginia Power has monitored water temperatures at various locations in the North Anna Reservoir, the WHTF, and the discharge canal. The highest temperatures recorded are summarized in Table 5.3-9:

While ambient summer water temperatures in the sampled locations were found to be within the range of those known to permit the reproduction and growth of pathogenic micro-organisms, the temperatures measured were below those considered optimal for the growth of thermophilic forms. Temperatures in the WHTF immediately downstream of the discharge structure were several degrees cooler than those in the immediate area of the discharge outfall and under normal circumstances would not support the reproduction and growth of pathogenic micro-organisms.

Because the existing units currently discharge heated cooling water into the WHTF, and then into the North Anna Reservoir and the North Anna River, the potential impacts of thermophilic organisms have been investigated since the 1970s (Reference 16). Findings are summarized in a recent letter from Virginia Power to the VDH (Reference 16, Section 4.12 & Appendix F). An excerpt from this letter is provided below:

In the late 1970s, a Medical College of Virginia researcher isolated Naegleria fowleri from a number of central-Virginia lakes, including the WHTF at the North Anna Power Plant. As a result of this discovery, Virginia Power environmental protection staff met with Dr. Grayson Miller, State Epidemiologist, to determine if Naelgeria in the WHTF or Lake Anna represented a public health risk. Dr. Miller in turn consulted with other state and federal agencies, including the Florida Department of Health, Centers of Disease Control, and EPA. Officials determined the risk of

Table 5.3-9 Lake Anna Reservoir Temperature Measurements

Date	Monitoring Station	Temperature
	Pre-Operation Period (Units 1 & 2)	
July 1977	North Anna Reservoir – Pamunkey Arm	92.7°F (hourly average)
August 1980	North Anna Reservoir – Lower Lake Station	91.6°F (hourly average)
	Operational Period (Units 1 & 2)	
Summer 1983	North Anna Reservoir	92.3°F (hourly average)
June 1984	North Anna Reservoir – Upper Lake Station	91.8°F (hourly average)
Summer Seasons 1983-1985	Dike 3 – Discharge of WHTF to North Anna Reservoir	88.2°F (monthly mean)
July 1993	Dike 3 – Discharge of WHTF to North Anna Reservoir	95.0°F (hourly average)
July 1993	Lake Anna – inlet structure	90.1°F (hourly average)
Summer Season 1997	North Anna Reservoir	86.4°F (max. recorded)
Summer Season 1997	Discharge Canal	97.7°F (max. recorded)
Summer Season 1997	WHTF	94.3°F (max. recorded)
August 2002	Discharge Canal	102.4°F (hourly average)

Data Source: Reference 15 and Reference 16, Section 4.12

contracting primary amoebic encephalitis (PAM) from Naegleria in the WHTF and Lake Anna to be too low to justify any necessary actions by Virginia Power or state agencies. No cases of PAM have been documented among station workers or area residents in nearly 20 years since the initial discovery report.

The addition of new units and the attendant thermal effluent discharge would not increase the historic temperature enough to create an environment conducive to the optimal growth of thermophilic organisms. The temperatures in the North Anna Reservoir would be too low to support thermophilic micro-organisms and the downstream North Anna River temperatures would be unaffected by the predicted increase in thermal discharge. The maximum hourly average discharge canal and WHTF water temperatures would remain below the optimal range for thermophilic micro-organism growth (see Section 5.3.2).

Another component of the risk evaluation is the source of pathogenic materials; that is, the seeds or inoculants for such organisms. Wastewater (e.g., domestic sewage from the existing units case) represents the primary potential source of water-borne pathogens. Virginia Power recently upgraded the onsite sewage treatment plant to include disinfection processes that reduce coliform bacteria and other micro-organisms to levels that meet state water quality standards (see

Section 3.6.2). The addition of personnel to support operation of the new units would not adversely impact the performance of this upgraded treatment facility.

In summary, the thermal and wastewater discharges from the addition of new units at the ESP site would result in the following:

- No significant alteration of the existing ambient temperature regime of the North Anna Reservoir.
- No significant seeds or inoculants of pathogenic organisms would be present.
- No significant increases to the population of naturally occurring micro-organisms.
- No change to the Virginia State Epidemiologist's NAPS licensing renewal recommendation that no further action regarding thermophilic micro-organism impacts is warranted. (Reference 16, Appendix F)

5.3.4.2 **Noise Impacts**

NUREG-1555, Section 5.3.4, mandates that the day-night average level of noise at the site boundary (dB[A-scale]) from the operation of the cooling system comply with applicable state limits. Because neither the Commonwealth of Virginia nor the counties surrounding the ESP site prescribe specific noise limitations, the noise evaluation compared potential offsite noise impacts with noise levels that the NRC considers to be at the threshold of significance: 60 to 65 dB(A) (Reference 40) (Reference 42) (Reference 43).

Using the Raytracing Program, a noise model based on ISO 9613, Part 1 & 2, Noise Propagation Outside, predicted peak noise levels along the EAB from operation of the new composite cooling system would be below the applicable NRC-defined significance levels. Thus, the new units' cooling system would not produce adverse noise impacts to the public, and consequently, no noise mitigation measures would be required.

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Table 5.3-10 Physical Attributes of North Anna Reservoir and WHTF

North Anna Reservoir	
Surface Area[a]	9600 acres
Downstream from NAPS[b]	4998 acres
Upstream from NAPS	4602 acres
Volume	10.6×10^9 ft^3
Mean Depth	25 ft
Downstream from NAPS	36 ft
Upstream from NAPS	13 ft
Maximum Depth	80 ft
Downstream from NAPS	46 ft
Upstream from NAPS	46 ft
Length	17 miles
Shoreline Length	272 miles
Waste Heat Treatment Facility	
Surface Area[c]	3400 acres
Volume	2.66×10^9 ft^3
Mean Depth	18 ft
Maximum Depth	50 ft
Side-Arm Areas	1530 acres

a. Reservoir area at the design pool level of 250 ft msl

b. From NAPS to the North Anna Dam

c. WHTF area at design water level of 251.5 ft msl

Table 5.3-11 Maximum, Minimum, and Average Daily Observed Surface Temperatures at Four Monitoring Stations in WHTF and North Anna Reservoir from 7/26/1978 to 4/10/2003

Discharge[a]	Dike 3[a]	Burrus Point[a]	Intake[a]
Maximum Daily Temperature[b] (°F)			
102.4	95.0	89.4	90.1
Average Daily Temperature[b] (°F)			
77.1	69.6	65.5	63.8
Average July-August Daily Temperature[b] (°F)			
95.0	88.9	84.3	83.8
Minimum Daily Temperature[b] (°F)			
39.4	36.1	34.7	34.2

a. Refer to Section 6.1 and Figure 6.1-1 for the location of the monitoring stations.

b. Daily temperature refers to the 24-hour average temperature.

Table 5.3-12 Exceedence Frequency of Observed Daily Surface Temperatures at Four Monitoring Stations in WHTF and North Anna Reservoir from 7/26/1978 to 4/10/2003

Daily Temperature[a]	Number of Days Equal to Or Exceeding (% of Total[b])			
	Discharge	Dike 3	Burrus Point	Intake
100°F	129 (1.5%)	0 (0%)	0 (0%)	0 (0%)
95.0°F	1186 (14%)	2 (0.02%)	0 (0%)	0 (0%)
90.0°F	2085 (24%)	527 (6.0%)	0 (0%)	1 (0.01%)
87.0°F	2588 (30%)	1346 (15%)	197 (2.4%)	109 (1.3%)

a. Daily temperature refers to the 24-hour average temperature.

b. Total number of days with observations: 8251 days for Burrus Point, 8449 days for Intake, 8766 days for Dike 3 and 8640 days for Discharge.

Table 5.3-13 Monthly Maximum and Average Observed Surface Temperature Near Intake from 7/26/1978 to 4/10/2003

	Monthly Maximum Temperature (°F)		Monthly Average Temperature (°F)	
Month	Burrus Point	Intake	Burrus Point	Intake
January	56.3	52.7	47.0	43.6
February	54.5	52.5	46.4	42.8
March	59.7	60.6[a]	51.0	48.5
April	71.4	72.1[a]	59.6	58.4
May	82.8	84.2[a]	69.8	69.5
June	86.5	86.9[a]	78.7	78.8[a]
July	89.2	90.1[a]	84.2	84.0
August	89.4	89.4	84.3	83.6
September	87.4	86.5	79.9	78.7
October	79.7	78.8	70.6	68.7
November	69.8	68.5	61.5	58.8
December	64.0	62.2	53.2	50.2

a. Higher temperature at intake during spring months due to effects of in-flows from the shallower upper reach and potentially more pronounced natural stratification in the sheltered area of the intake monitoring station.

Table 5.3-14 Maximum and Minimum Daily Surface Temperature at Six Locations in the WHTF and the Reservoir Based on 42-years of Model Prediction from January 1961 to May 2003

	Scenario 1		Scenario 2		Scenario 3	
Location	**Max (°F)**	**Min (°F)**	**Max (°F)**	**Min (°F)**	**Max (°F)**	**Min (°F)**
End of Discharge Canal	104.7	54.2	109.3	57.5	112.7	58.3
Dike 3	97.1	47.6	101.9	52.9	105.4	54.8
North Anna Dam	93.3	44.5	97.0	48.3	100.5	50.0
Burrus Point	92.2	42.6	96.0	42.8	99.5	42.8
Thurman Island	91.7	41.1	95.1	42.3	98.3	42.6
Intake	91.2	40.1	94.0	41.9	96.7	42.1

Scenario 1 – Operation of the once-through cooling system of the existing units.
Scenario 2 – Future combined operation of the once-through cooling system of the existing units, a once-through cooling system for Unit 3 and a closed-cycle cooling system for Unit 4.
Scenario 3 – Future combined operation of the once-through cooling system of the existing units, a once-through cooling system for Unit 3, and a once-through cooling system for Unit 4.

Table 5.3-15 Mean Surface Temperature and Mean Surface Temperature During July and August at Six Locations in the WHTF and the North Anna Reservoir Based on 42-years of Model Prediction from January 1961 to May 2003

	Scenario 1		Scenario 2		Scenario 3	
Location	**Long-Term Mean (°F)**	**Mean of July-August (°F)**	**Long-Term Mean (°F)**	**Mean of July-August (°F)**	**Long-Term Mean (°F)**	**Mean of July-August (°F)**
End of Discharge Canal	79.9	98.4	85.9	103.3	90.7	106.9
Dike 3	72.5	90.6	78.5	95.4	83.4	99.3
Dam	68.6	86.9	74.0	90.8	78.8	94.6
Burrus Point	67.9	86.3	73.1	90.1	77.8	93.6
Thurman Island	67.0	85.6	72.0	89.1	76.4	92.5
Intake	66.0	84.6	70.5	87.9	74.6	90.8

Scenario 1 – Operation of the once-through cooling system of the existing units.
Scenario 2 – Future combined operation of the once-through cooling system of the existing units, a once-through cooling system for Unit 3 and a closed-cycle cooling system for Unit 4.
Scenario 3 – Future combined operation of the once-through cooling system of the existing units, a once-through cooling system for Unit 3, and a once-through cooling system for Unit 4.

Table 5.3-16 Exceedence Frequency of Daily Surface Temperatures at Six Locations in the WHTF and the North Anna Reservoir Based on 42-years of Model Prediction from January 1961 to May 2003

		Number of Days Equal or Exceeding (% of Total[a])					
Temp	Scenario	Discharge Canal	Dike 3	Dam	Burrus Point	Thurman Island	Intake
105ºF	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	2	458 (3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	3	2719 (18%)	3 (0.02%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
100ºF	1	529 (3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	2	3432 (22%)	14 (0.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	3	4917 (32%)	978 (6%)	3 (0.02%)	0 (0%)	0 (0%)	0 (0%)
95.0ºF	1	3388 (22%)	33 (0.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	2	5174 (33%)	1731 (11%)	11 (0.1%)	6 (0.04%)	2 (0.01%)	0 (0%)
	3	6415 (41%)	4035 (26%)	1181 (8%)	596 (4%)	223 (1%)	10 (0.1%)
90.0ºF	1	5104 (33%)	1829 (12%)	155 (1%)	42 (0.3%)	11 (0.1%)	6 (0.04%)
	2	6627 (43%)	4389 (28%)	2037 (13%)	1475(10%)	857 (6%)	340 (2%)
	3	7918 (51%)	5667 (37%)	4173 (27%)	3721 (24%)	3065 (20%)	2050 (13%)
87.0ºF	1	5915 (38%)	3480 (23%)	1412 (9%)	976 (6%)	622 (4%)	294 (2%)
	2	7454 (48%)	5254 (34%)	3707 (24%)	3334 (22%)	2806 (18%)	2044(13%)
	3	8798 (57%)	6632 (43%)	5163 (33%)	4862 (31%)	4488 (29%)	3767(24%)

Scenario 1 – Operation of the once-through cooling system of the existing units.
Scenario 2 – Future combined operation of the once-through cooling system of the existing units, a once-through cooling system for Unit 3 and a closed-cycle cooling system for Unit 4.
Scenario 3 – Future combined operation of the once-through cooling system of the existing units, a once-through cooling system for Unit 3, and a once-through cooling system for Unit 4.

a. Total number of simulation days = 15,463

Table 5.3-17 Predicted Maximum Daily Surface Temperature Increase Due to One and Two New Once-through Cooling System Units On the Lake

Location	1 New Once-Through Unit on the Lake	2 New Once-Through Units on the Lake
Discharge	4.6°F	8.0 F
Dike 3	4.7°F	8.3°F
Dam	3.6°F	7.2°F
Burrus Point	3.8°F	7.3°F
Thurman Island	3.4°F	6.6°F
Intake	2.8°F	5.5°F

Table 5.3-18 North Anna Cooling Pond Model Areas

Model Segment	Area (acres) in 1984 Model Version	Area (acres) in Current Model Version
Discharge Channel	12.1	12.1
WHTF Pond 1	212.12	212.12
WHTF Pond 2	993.94	993.94
Sidearm 1 of WHTF Pond 2[a]	704.04	325.07*
Sidearm 2 of WHTF Pond 2[b]	665.65	261.94*
WHTF Pond 3	662.63	662.63
Sidearm 1 of WHTF Pond 3[c]	87.88	57.39*
Sidearm 2 of WHTF Pond 3[d]	76.77	34.44*
Main Reservoir	5000	5000
Sidearm of Main Reservoir[e]	4231	872*
Total	12,646.13	8431.63

* A 0.8 factor is applied to the side-arm in the evaporation loss calculation to reflect the reduction of the effective length due to down-welling.

a. Model width = 800 ft; length = 17,700 ft

b. Model width = 700 ft; length = 16,300 ft

c. Model width = 500 ft; length = 5000 ft

d. Model width = 500 ft; length = 3000 ft

e. Model width = 2000 ft; length = 19,000 ft

Table 5.3-19 Average Daily Water Temperatures at Burrus Point with 3-Unit Operation

	Temperature °F			
Depth[a]	**June**	**July**	**August**	**September**
Surface (Elev. 250)	85.42	89.96	90.13	86.13
222	82.76	87.46	87.73	83.67
218	82.21	87.14	87.58	83.57
214	81.67	86.85	87.45	83.49
210	81.20	86.60	87.35	83.43
206	80.79	86.38	87.27	83.39
202	80.46	86.20	87.21	83.35
198	80.19	86.05	87.16	83.33
194	80.02	85.96	87.13	83.31
190	79.96	85.93	87.11	83.30

a. Depth is presented as elevation above msl.

Table 5.3-20 Average Daily Water Temperatures at Thurman Island with 3-Unit Operation

	Temperature °F			
Depth[a]	**June**	**July**	**August**	**September**
Surface (Elev. 250)	84.57	89.07	89.16	84.98
222	82.76	87.46	87.73	83.67
218	82.21	87.14	87.58	83.57
214	81.67	86.85	87.45	83.49
210	81.20	86.60	87.35	83.43
206	80.79	86.38	87.27	83.39
202	80.46	86.20	87.21	83.35
198	80.19	86.05	87.16	83.33
194	80.02	85.96	87.13	83.31
190	79.96	85.93	87.11	83.30

a. Depth is presented as elevation above msl.

Table 5.3-21 Average Daily Water Temperatures in Intake Area with 3-Unit Operation

	Temperature °F			
Depth[a]	June	July	August	September
Surface (Elev. 250)	83.30	87.81	87.91	83.80
222	82.76	87.46	87.73	83.67
218	82.21	87.14	87.58	83.57
214	81.67	86.85	87.45	83.49
210	81.20	86.60	87.35	83.43
206	80.79	86.38	87.27	83.39
202	80.46	86.20	87.21	83.35
198	80.19	86.05	87.16	83.33
194	80.02	85.96	87.13	83.31
190	79.96	85.93	87.11	83.30

a. Depth is presented as elevation above msl.

Table 5.3-22 Temperature (°F) Requirements of Important Fish Species of Lake Anna

Species	Preferred	Upper Avoidance	Lethal (Undefined Experimental method)	Critical Thermal Maximum (Lethal)	Chronic Lethal Maximum (Lethal)	Reference
Gizzard shad	69–73	86	[a]			Reference 44
			98			Reference 45
Channel catfish	77–87	90–95				Reference 44
			92–95			Reference 45
				95.9–107.8[b]		Reference 46
Striped bass	65–70	77–81				Reference 27 Reference 21 Reference 26
				88.9		Reference 46
Bluegill	82–91					Reference 47
	81–90	90–95				Reference 44
				97–106.5[c]	95.9	Reference 46
Large-mouth bass	81–90	84–93				Reference 44
	81–90	88–91				Reference 47
				97.3–104.4[d]		Reference 46

a. Blank entries indicate no data was found.

b. Acclimation temperatures >68°F.

c. Acclimation temperatures >82°F.

d. Acclimation temperatures >68°F.

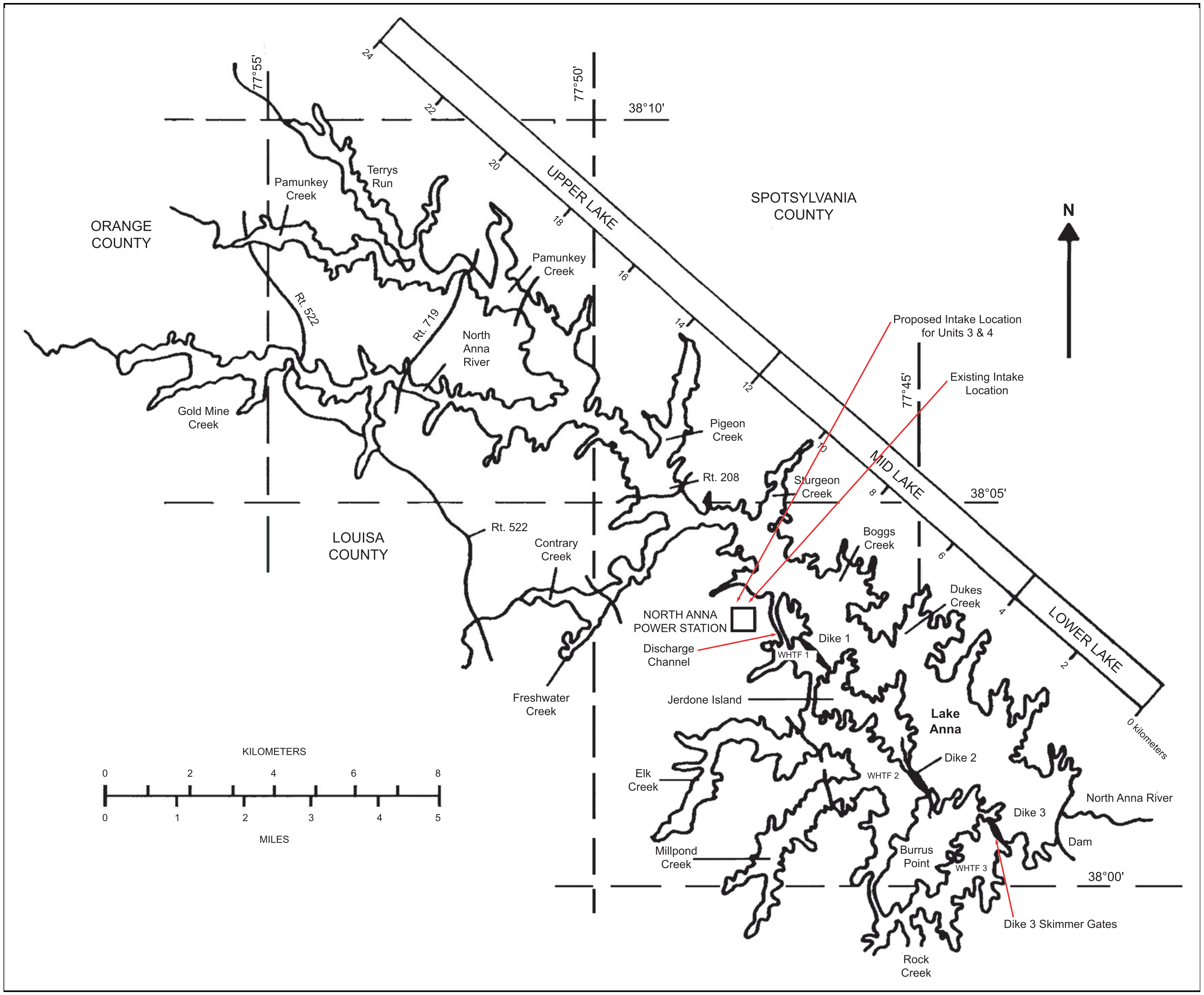

Figure 5.3-1 Generalized Map of North Anna Power Station Environs

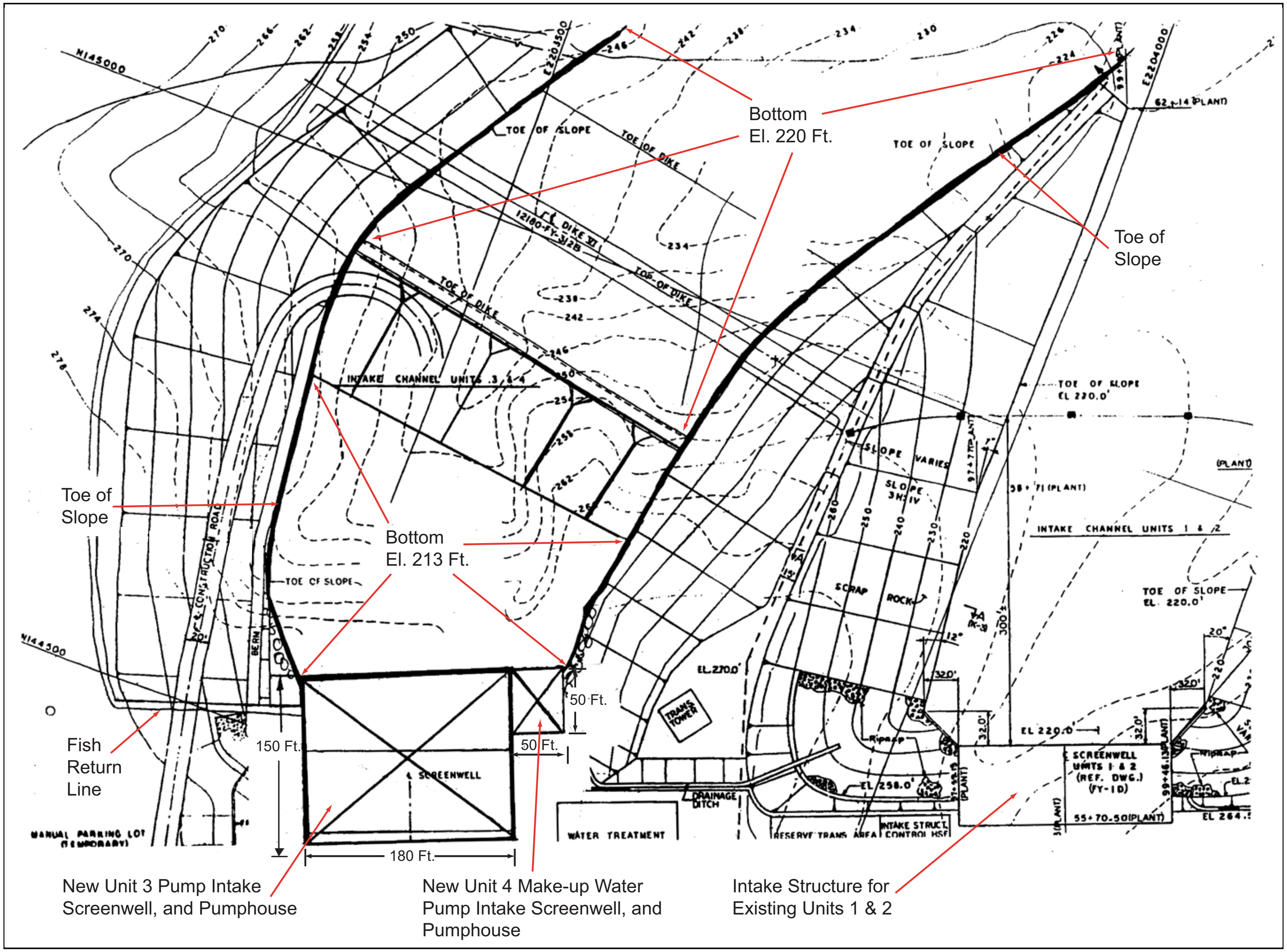

Figure 5.3-2 Intake Structure and Approach Channel for the New Units and the Existing Units

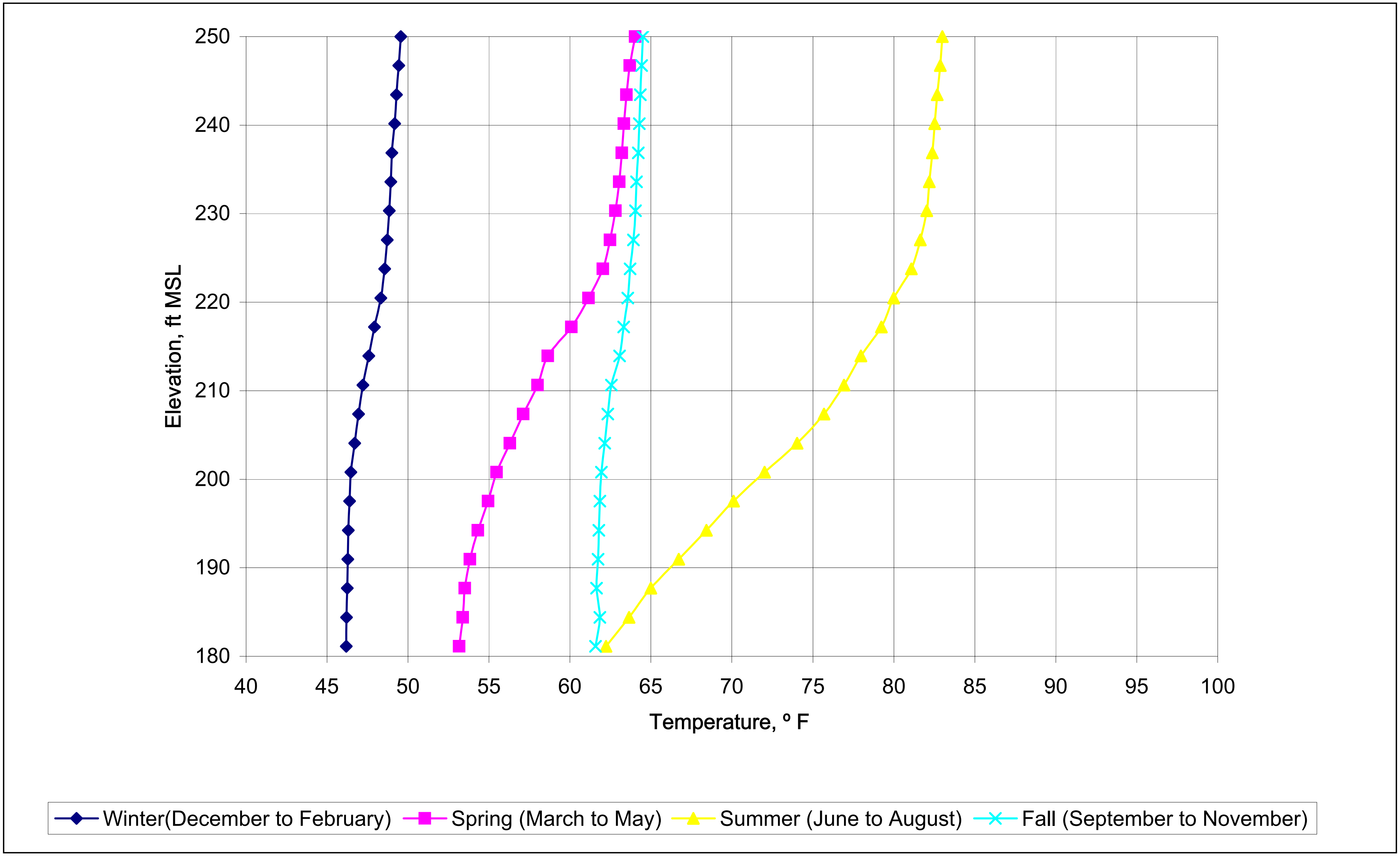

Figure 5.3-3 Observed Seasonal Average Vertical Temperature Profiles at Monitoring Station A Near North Anna Dam

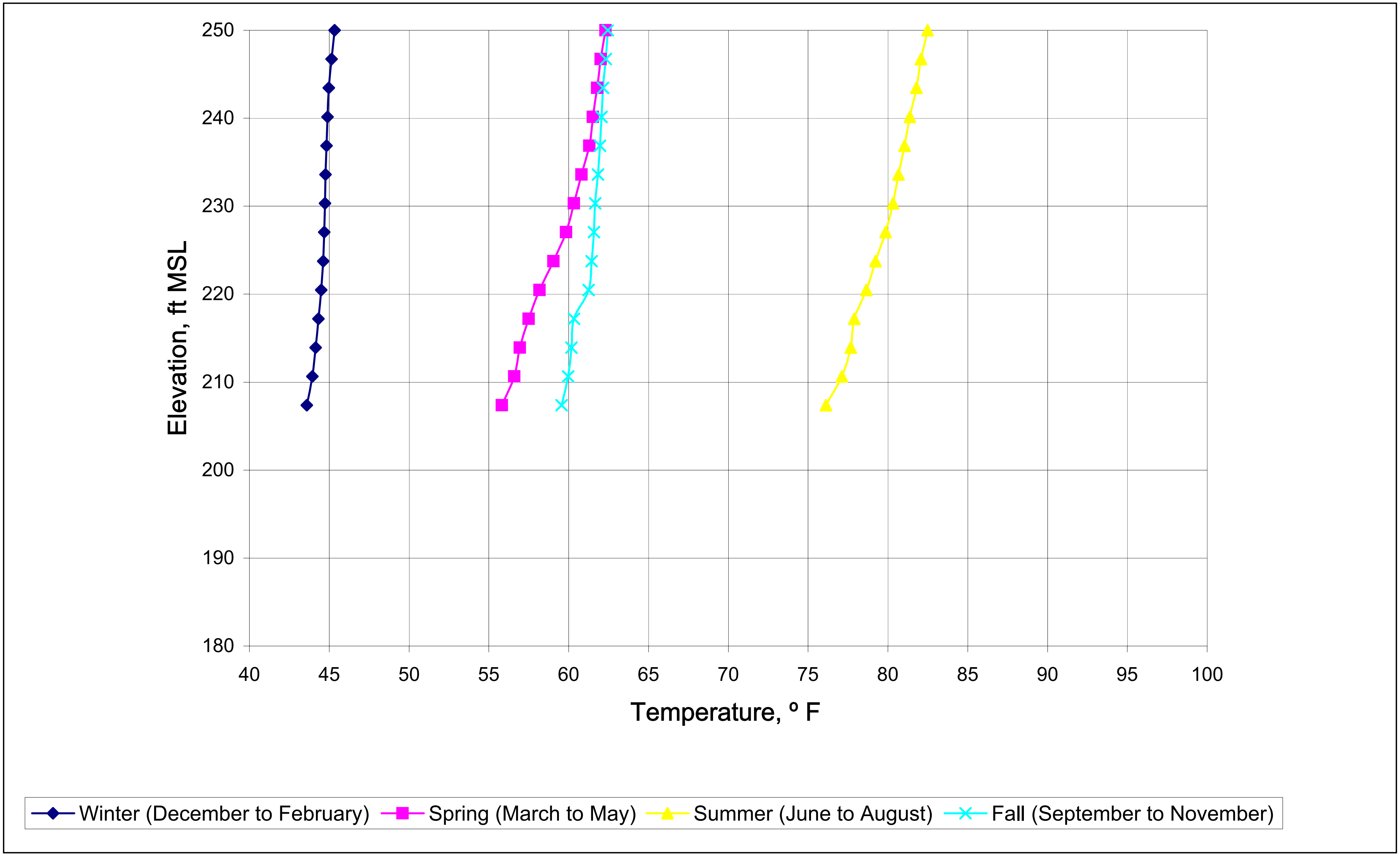

Figure 5.3-4 Observed Seasonal Average Vertical Temperature Profiles at Monitoring Station I near the Intake

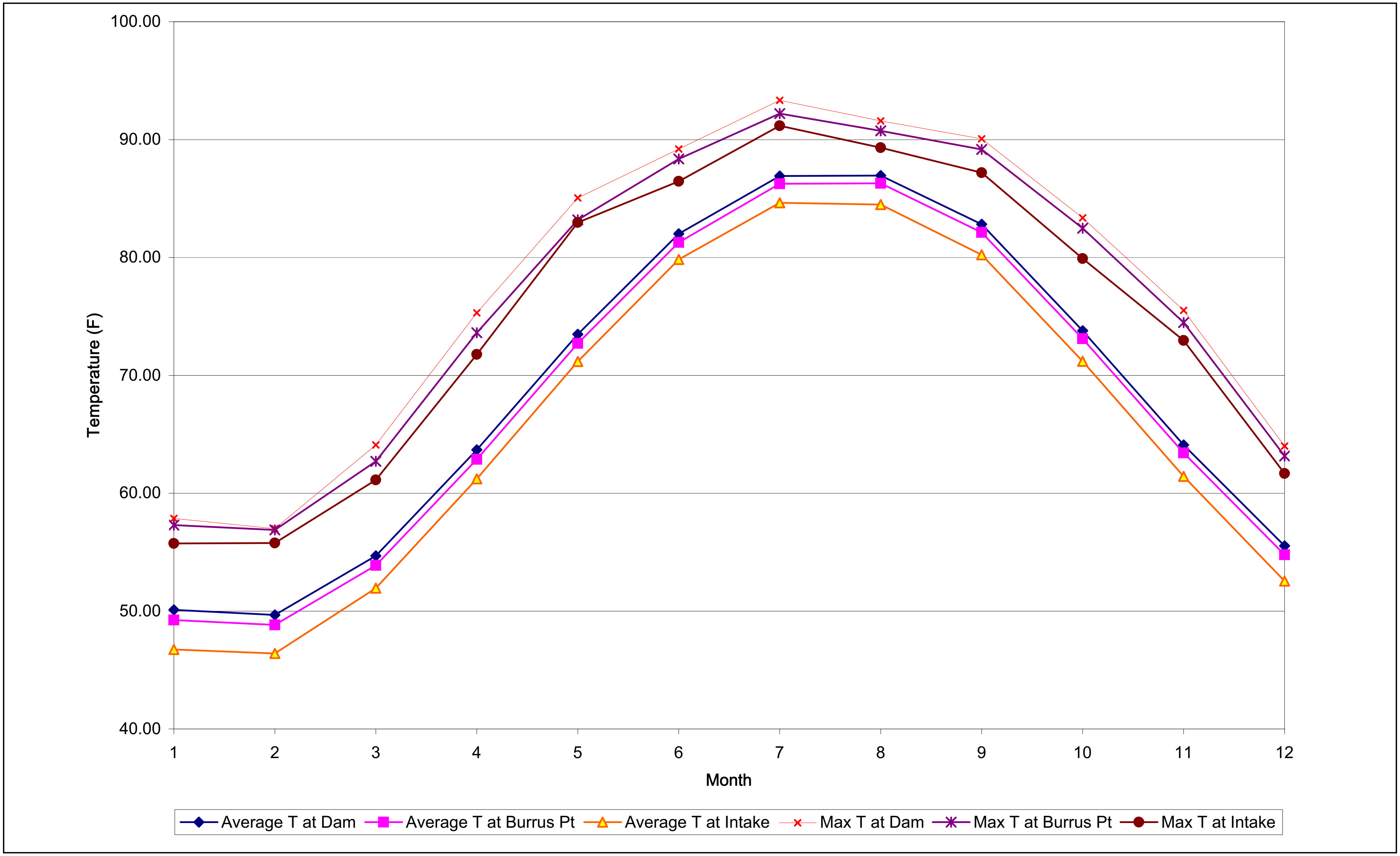

Figure 5.3-5 Predicted Monthly Temperature for Scenario 1

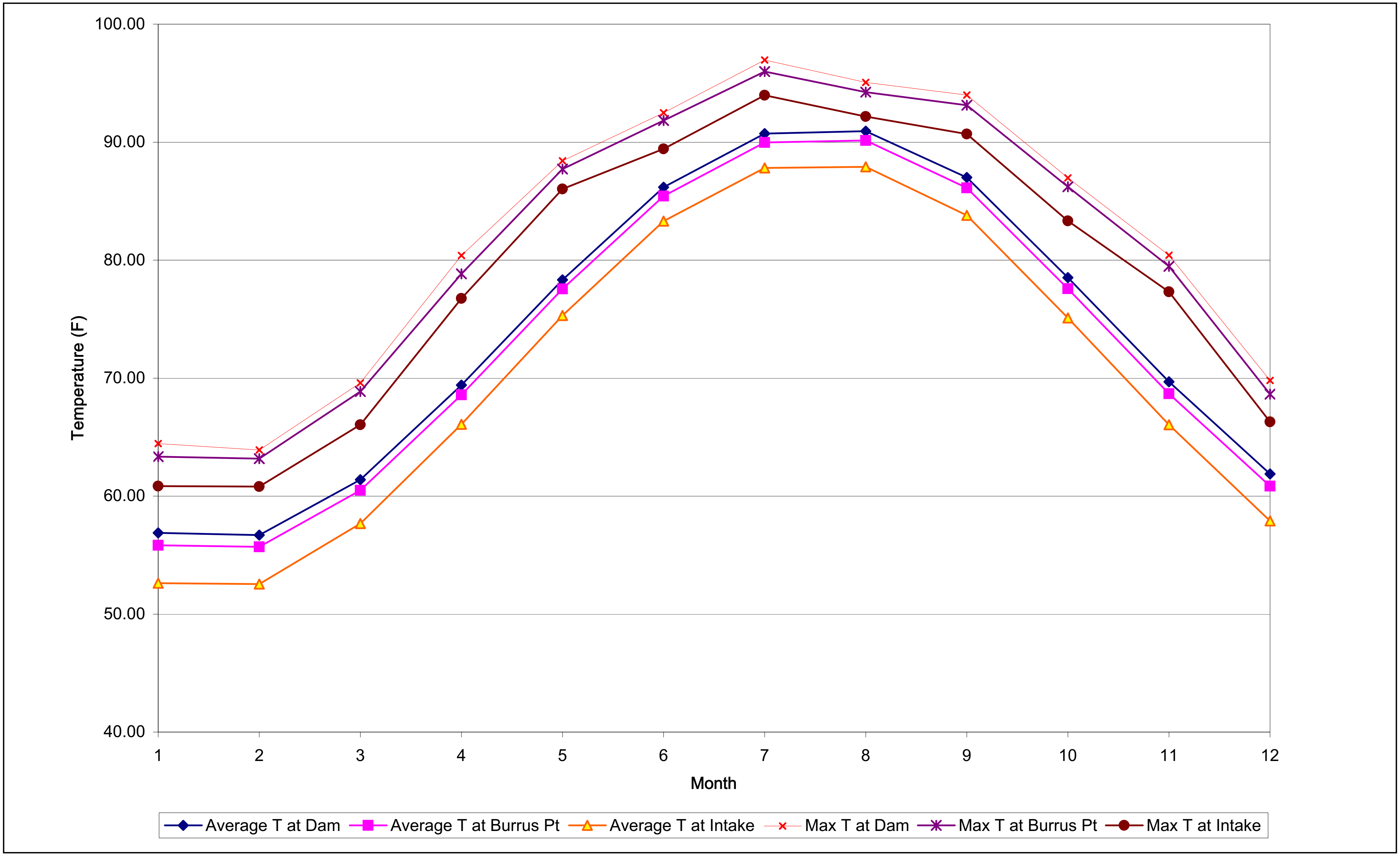

Figure 5.3-6 Predicted Monthly Temperature for Scenario 2

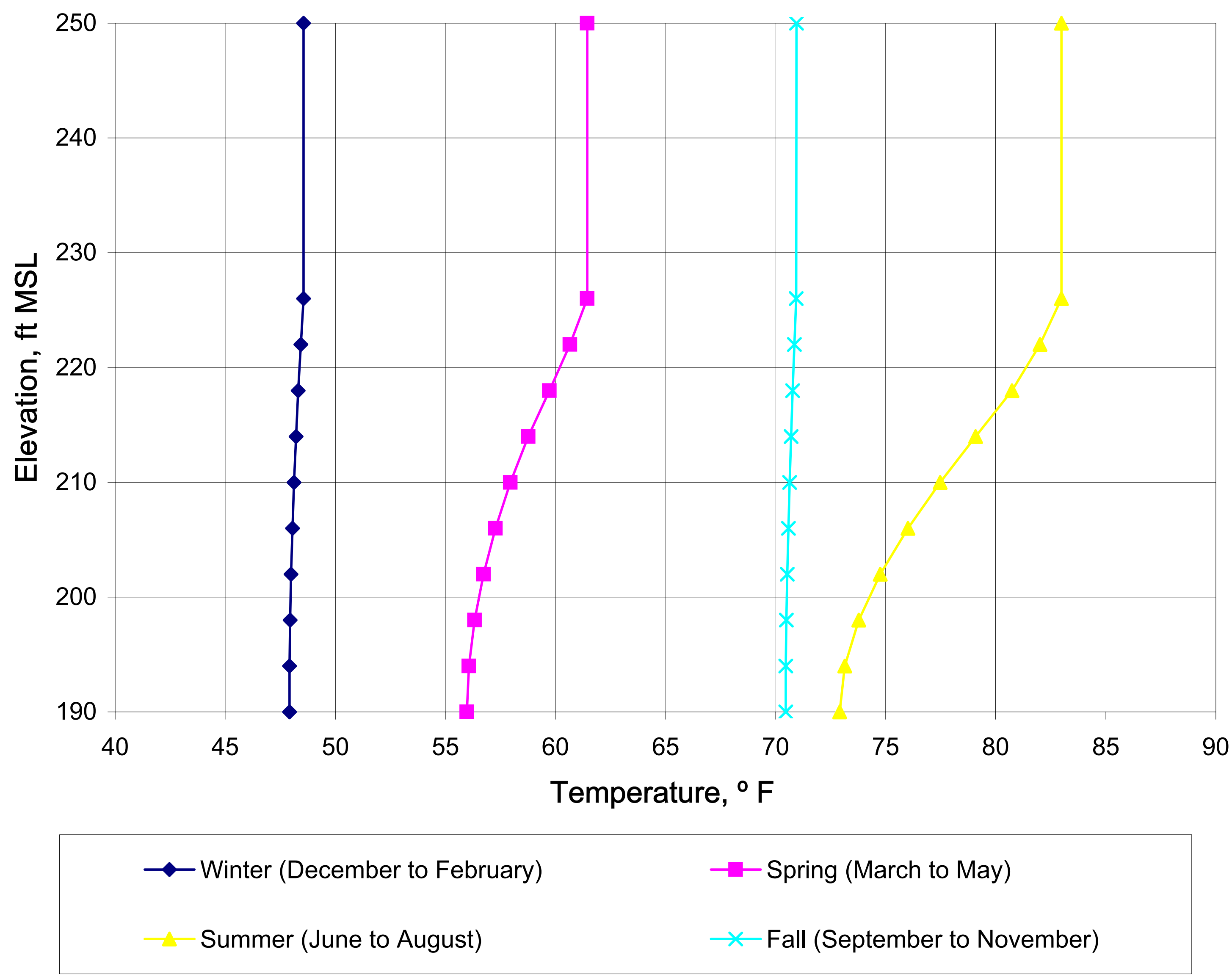

Figure 5.3-7 Predicted Seasonal Average Vertical Temperature Profiles at Intake for Existing Units (Scenario 1)

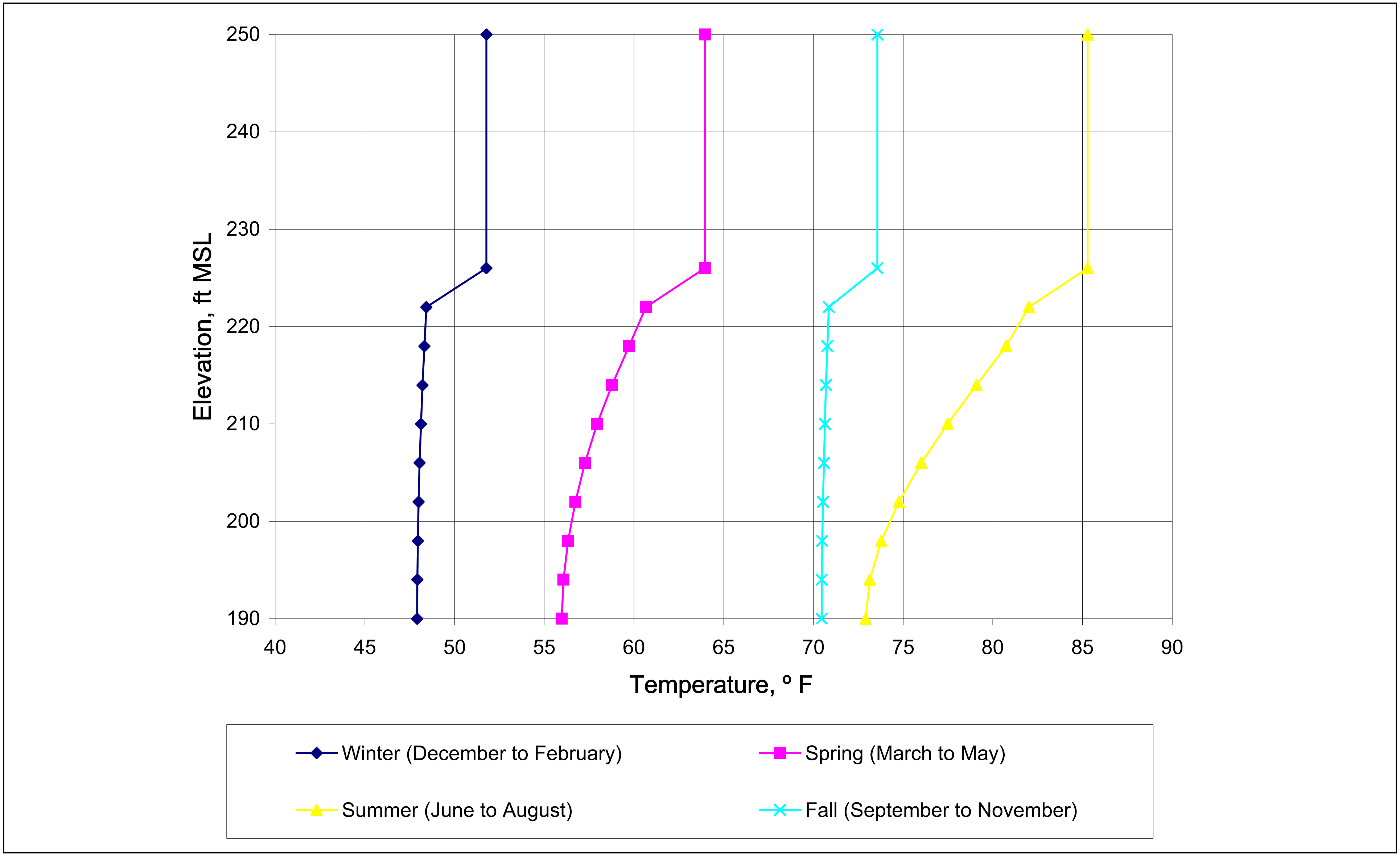

Figure 5.3-8 Predicted Seasonal Average Vertical Temperature Profiles at North Anna Dam for Existing Units (Scenario 1)

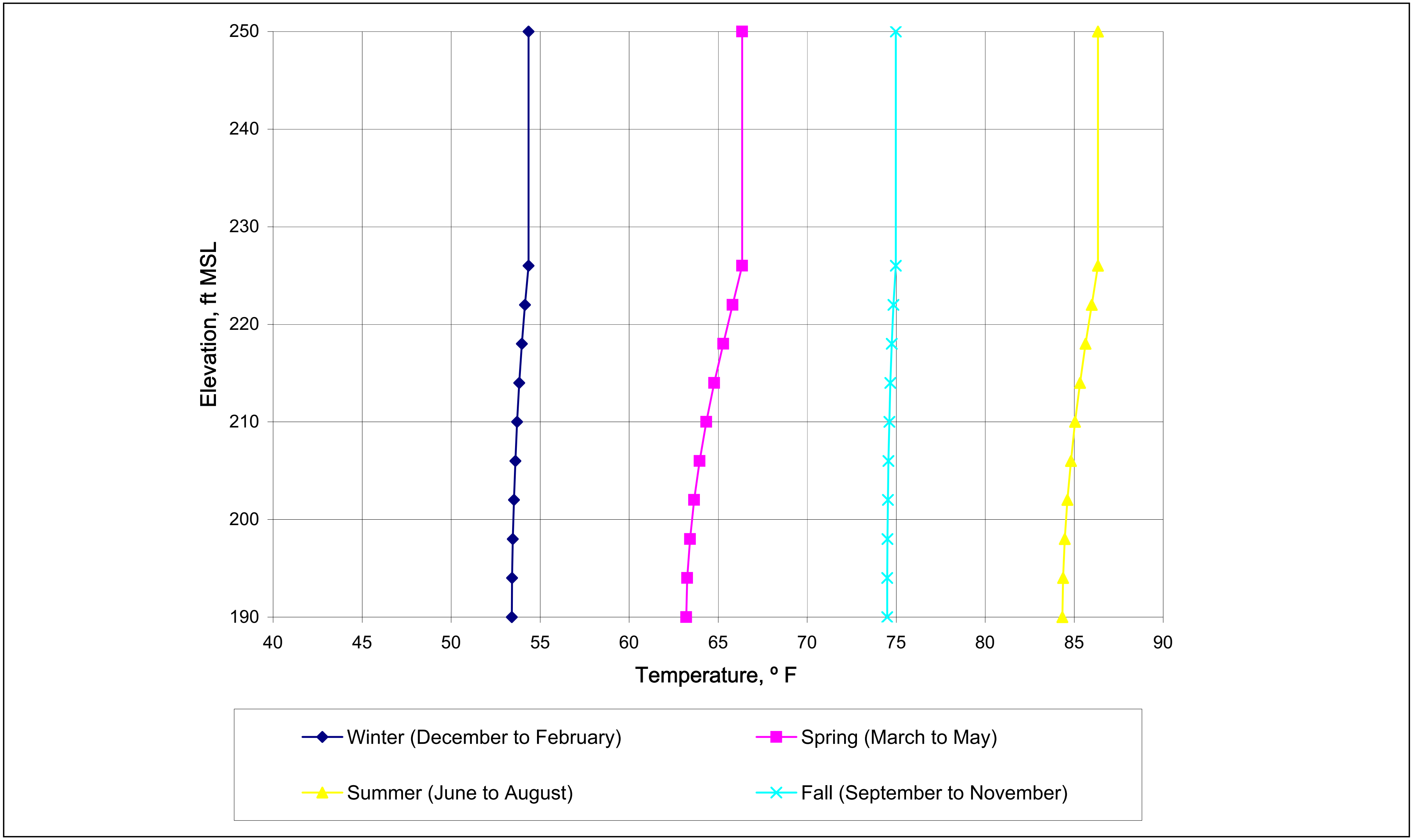

Figure 5.3-9 Predicted Seasonal Average Vertical Temperature Profiles at Intake for Existing Units and One New Once-through Unit (Scenario 2)

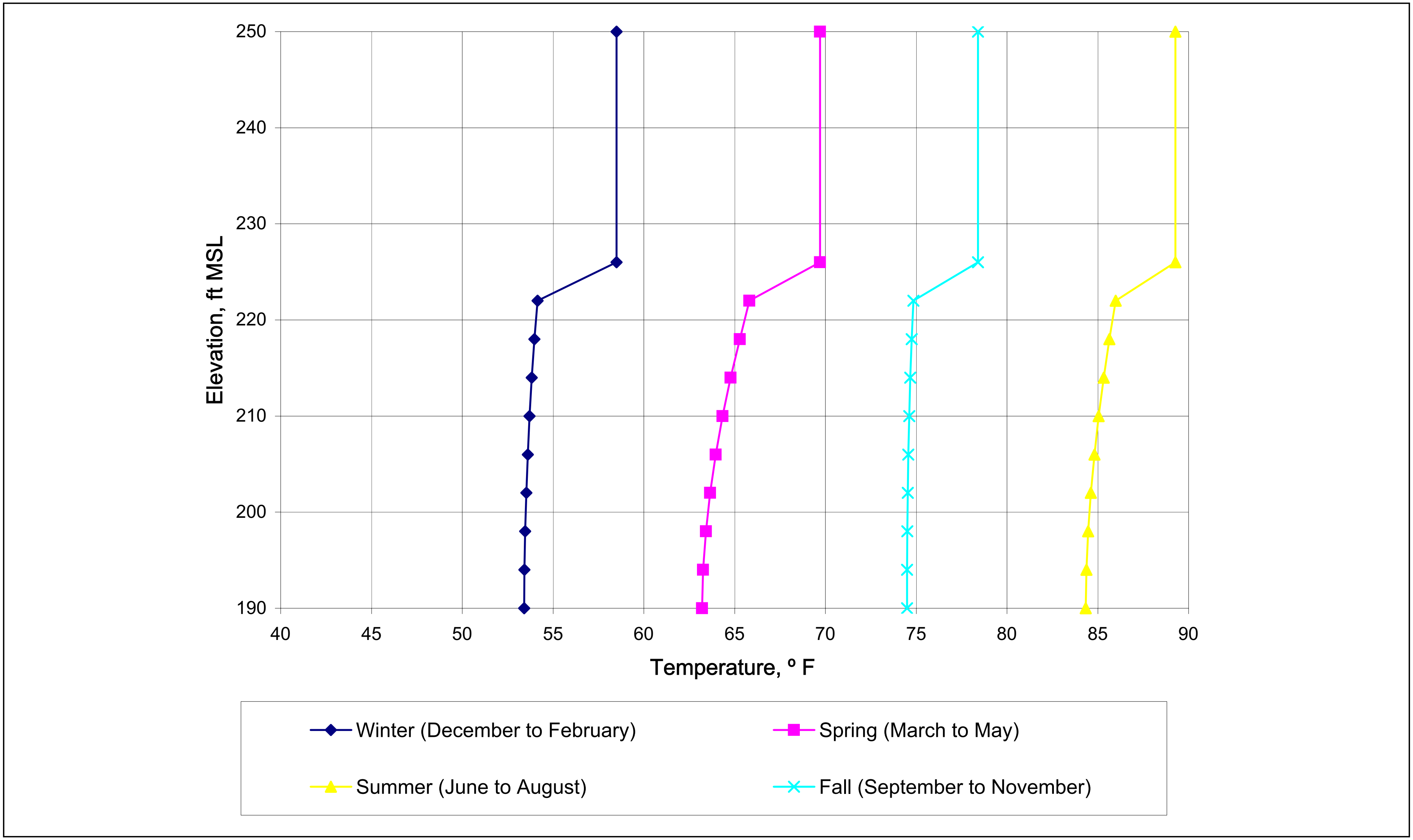

Figure 5.3-10 Predicted Seasonal Average Vertical Temperature Profiles at North Anna Dam for Existing Units and One New Once-through Unit (Scenario 2)

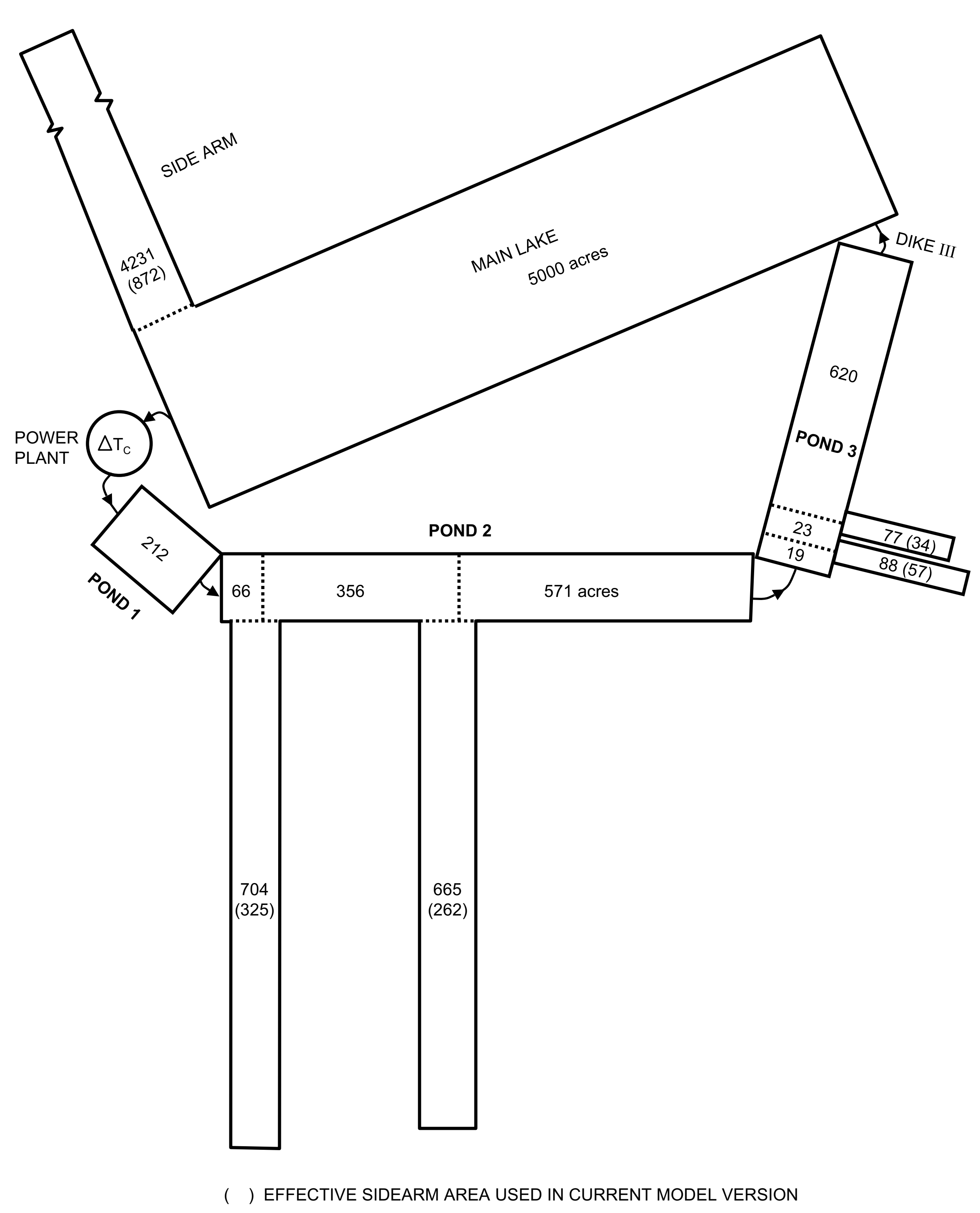

Figure 5.3-11 Schematization of the North Anna Cooling Lake System Used in the Seqmented Model

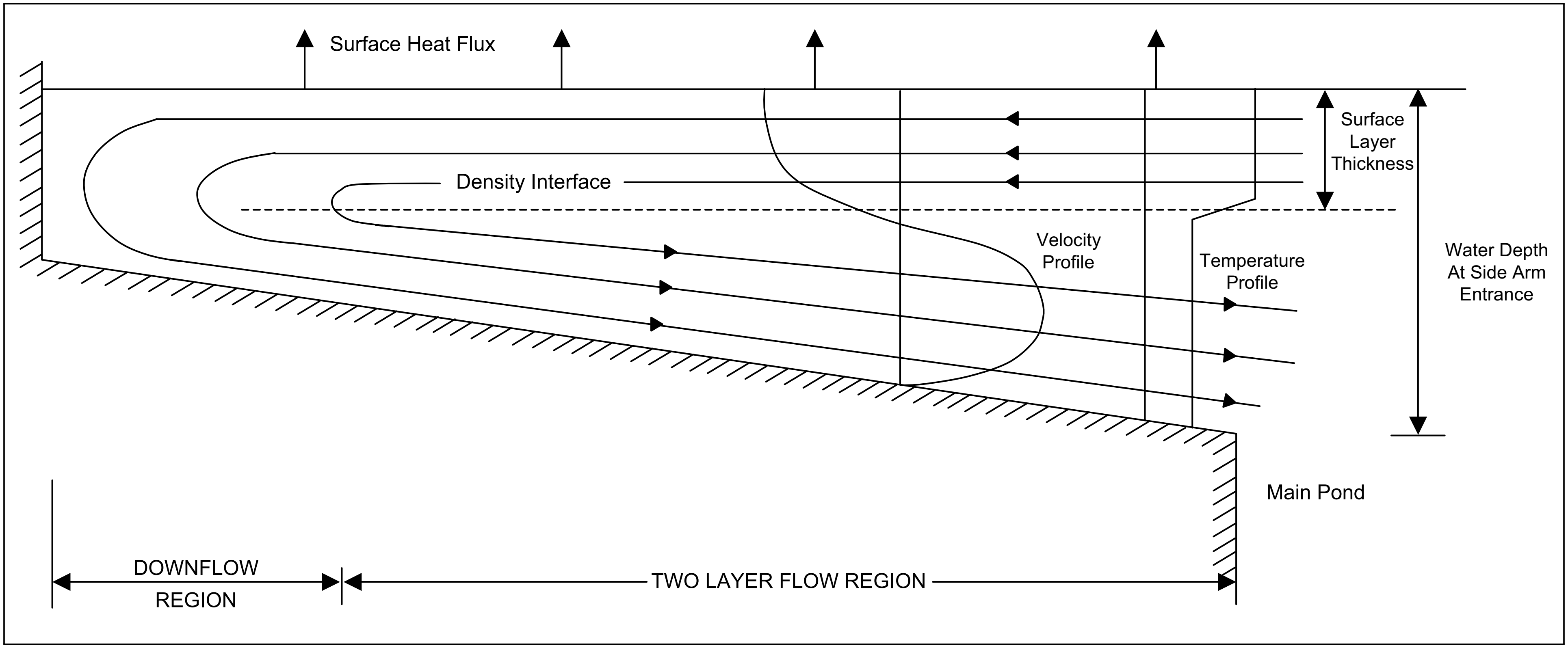

Figure 5.3-12 Schematization of Convective Circulation in a Dead-End Side Arm

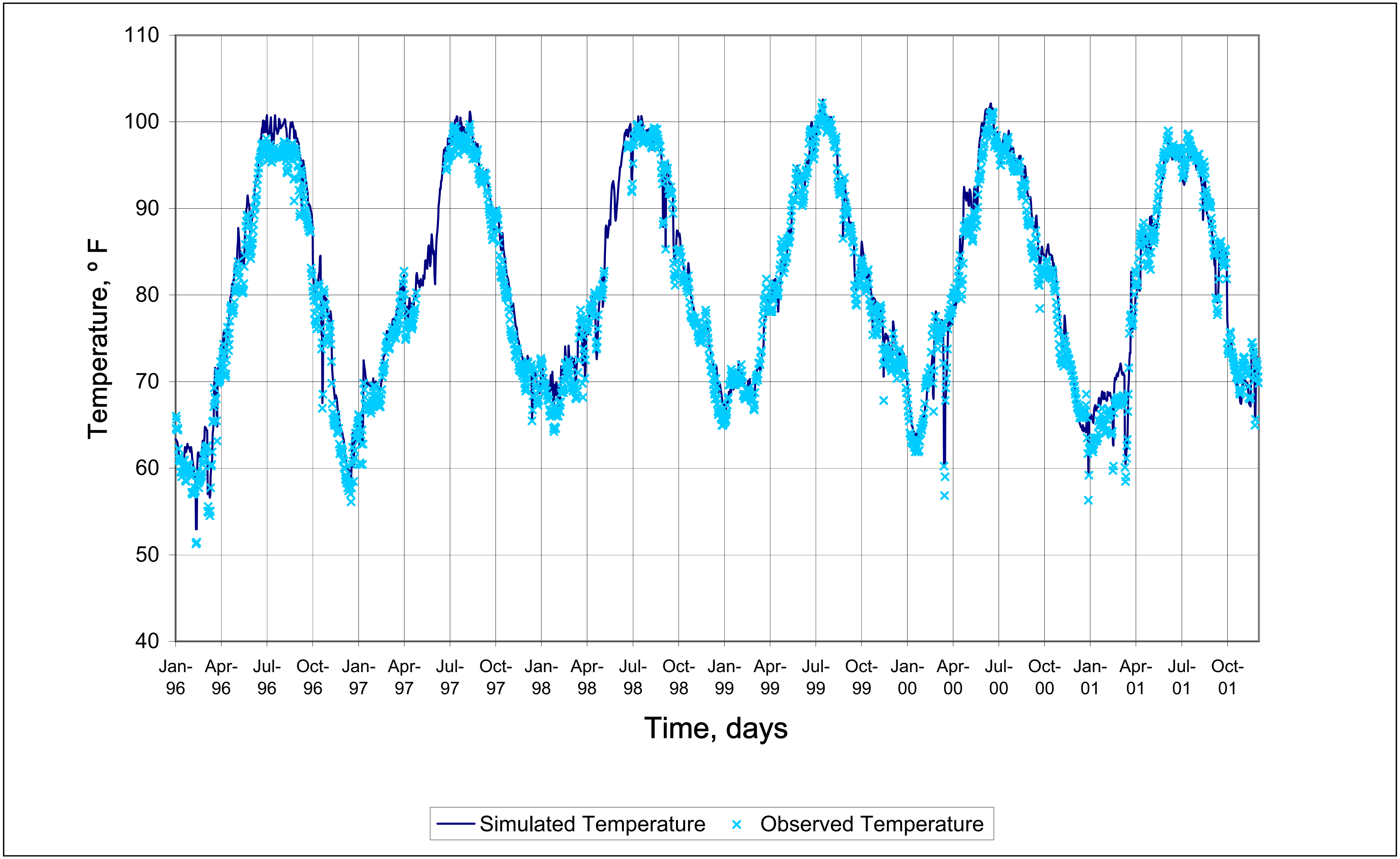

Figure 5.3-13 Measured and Predicted Surface Temperature at Discharge for Calibration Run from 1/1996 to 12/2001

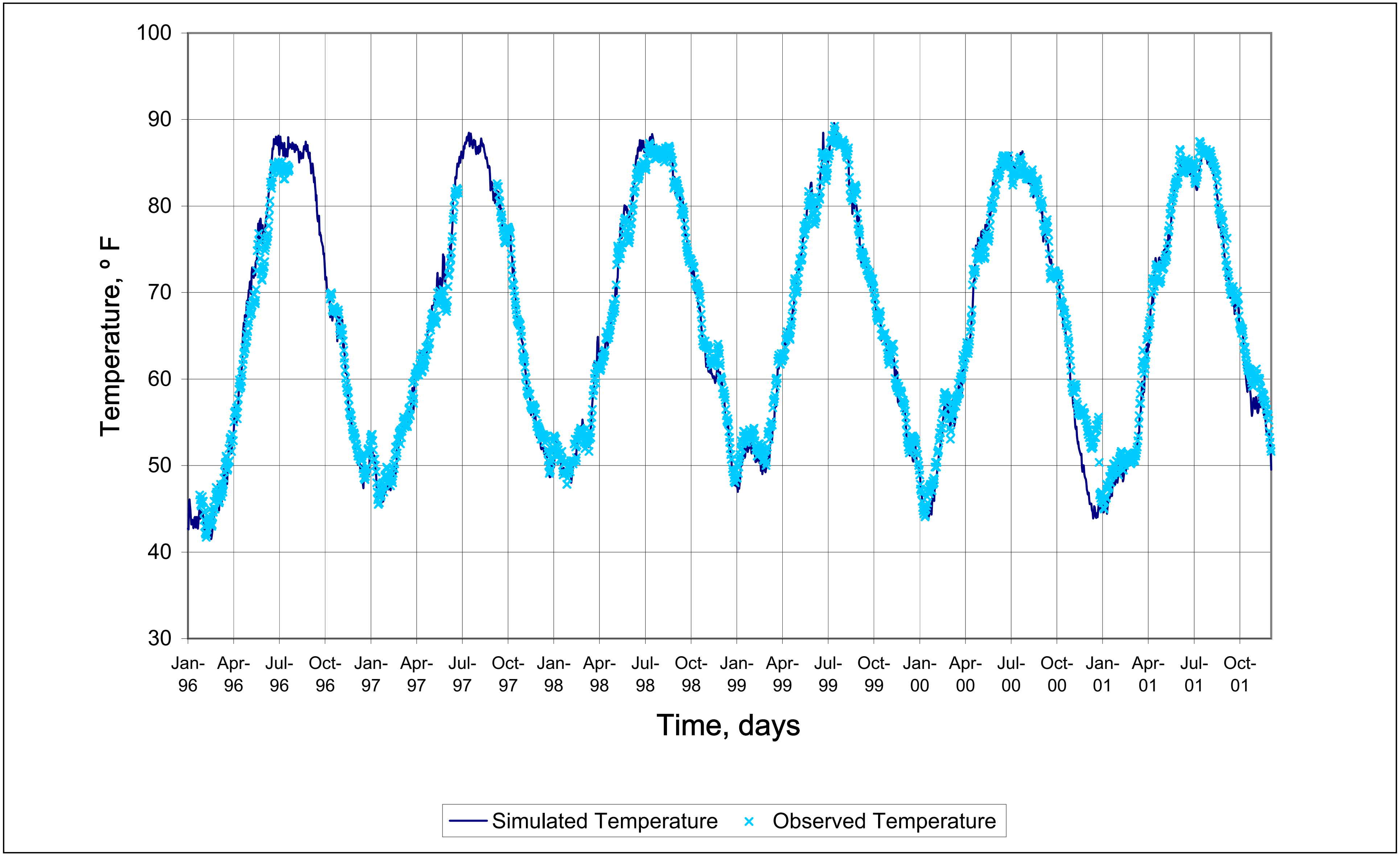

Figure 5.3-14 Measured and Predicted Surface Temperature at Burrus Point for Calibration Run from 1/1996 to 12/2001

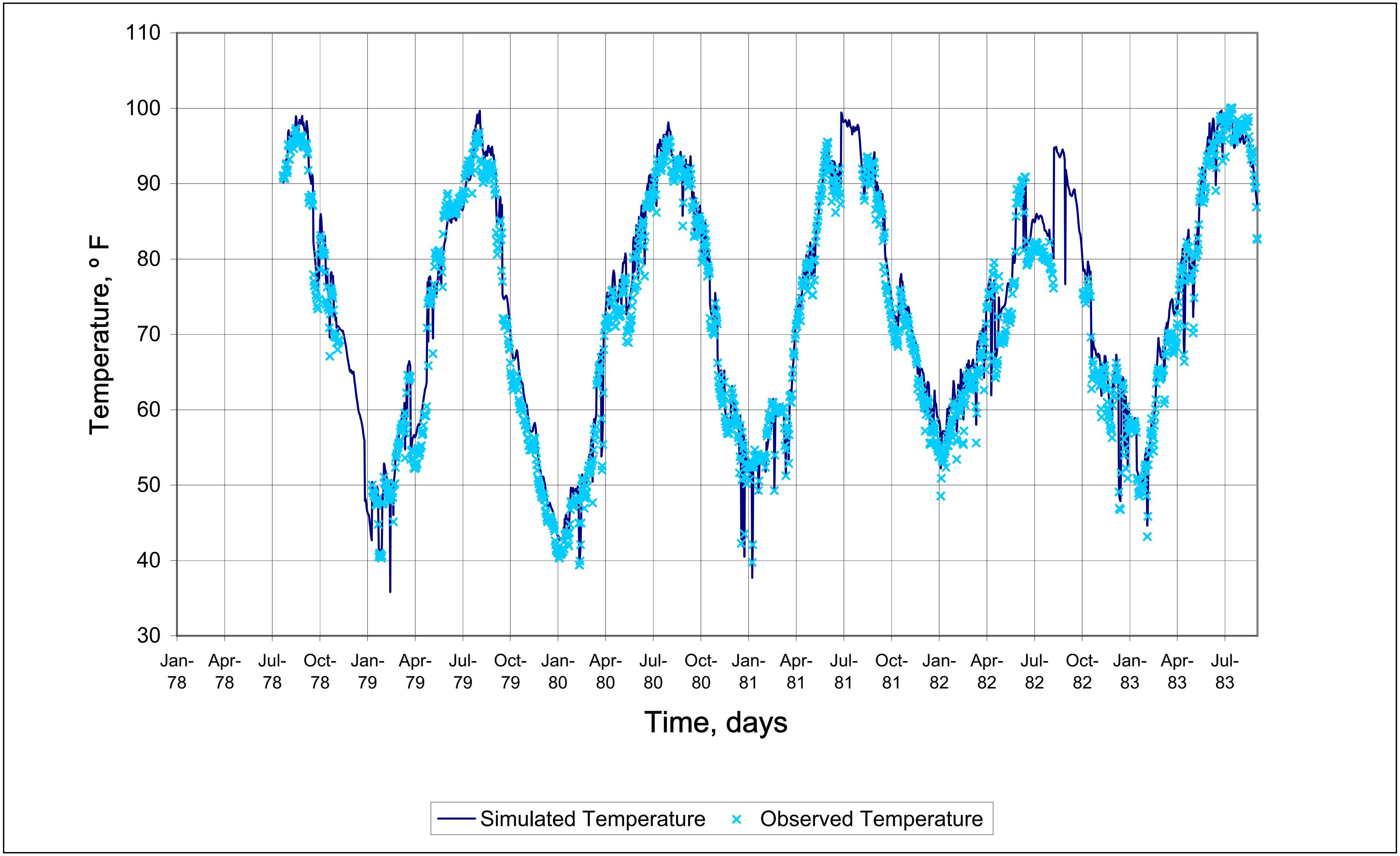

Figure 5.3-15 Measured and Predicted Surface Temperature at Discharge for Validation Run from 7/1978 to 9/1983

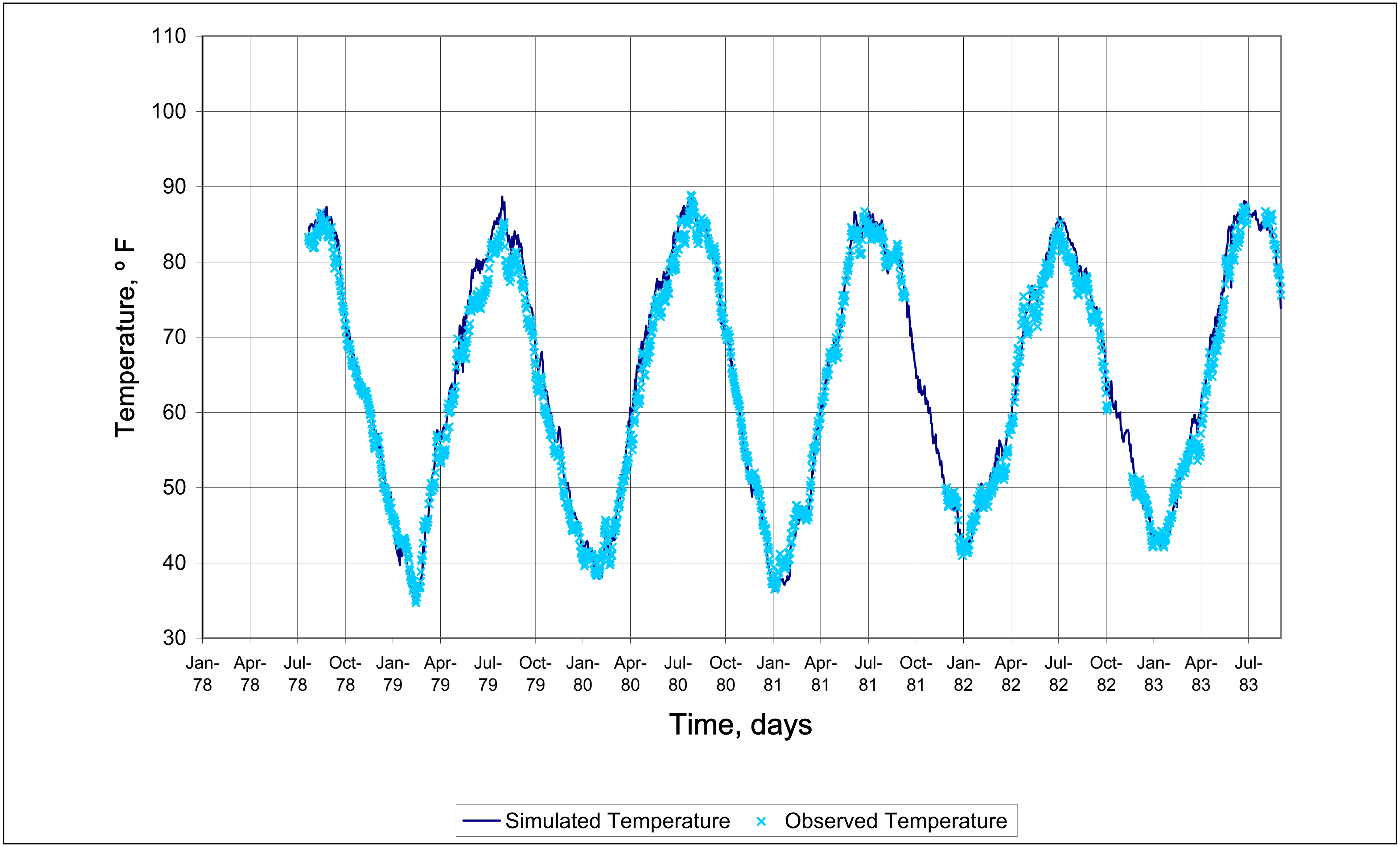

Figure 5.3-16 Measured and Predicted Surface Temperature at Burrus Point for Validation Run from 7/1978 to 9/1983

5.4 Radiological Impacts of Normal Operation

This section describes the radiological impacts of normal plant operation on members of the public and biota. Section 5.4.1 describes the exposure pathways by which radiation and radioactive effluents can be transmitted from the new units to organisms living near the plant. Section 5.4.2 estimates the maximum doses to the public from the operation of one new unit. Section 5.4.3 evaluates the impacts of these doses by comparing them to regulatory limits for one unit. In addition, the impact of two new units in conjunction with the two existing units is compared to the corresponding regulatory limit. Finally, Section 5.4.4 considers the impact to biota that appear along the exposure pathways or that are on endangered species lists.

5.4.1 **Exposure Pathways**

Small quantities of radioactive liquids and gases would be discharged to the environment during normal operation of the new units. The impact of these releases and any direct radiation to individuals, population groups, and biota in the vicinity of the new units was evaluated by considering the most important pathways from the release to the receptors of interest. The major pathways are those that could yield the highest radiological doses for a given receptor. The relative importance of a pathway is based on the type and amount of radioactivity released, the environmental transport mechanism, and the consumption or usage factors of the receptor.

The exposure pathways considered and the analytical methods used to estimate doses to the maximally exposed individual (MEI) and to the population surrounding the new units are based on RGs 1.109 and 1.111 (Reference 1 and Reference 2, respectively). A MEI is a hypothetical member of the public located to receive the maximum possible calculated dose. The MEI allows dose comparisons with established criteria for the public.

5.4.1.1 **Liquid Pathways**

The new units would release effluents to the WHTF through the discharge canal used for Units 1 and 2.

The LADTAP II computer program (Reference 3) was used to calculate the doses to the MEI, population groups, and biota. This program implements the radiological exposure models described in RG 1.109 for radioactivity releases in liquid effluent. The following exposure pathways are considered in LADTAP II:

- Ingestion of aquatic foods
- Ingestion of drinking water
- External exposure to shoreline sediments
- External exposure to water through boating and swimming

Irrigation was not considered as a pathway because the use of the water from Lake Anna for this purpose is negligible (Reference 4).

The input parameters for the liquid pathway are presented in Table 5.4-1 and Table 5.4-2. It should be noted that the dilution factor is a conservative low value of 10 with no credit taken for the transit time from the release point to the receptors. Furthermore, an impoundment reconcentration model is not used because Lake Anna serves as an impoundment as well as the receiving water body.

5.4.1.2 **Gaseous Pathways**

The GASPAR II computer program (Reference 5) was used to calculate the doses to the MEI, population groups, and biota. This program implements the radiological exposure models described in RG 1.109 to estimate the radioactivity releases in gaseous effluent and the subsequent doses. The following exposure pathways are considered in GASPAR II:

- External exposure to airborne plume
- External exposure to contaminated ground
- Inhalation of airborne activity
- Ingestion of contaminated agricultural products

The input parameters for the gaseous pathway are presented in Table 5.4-3 and Table 5.4-5, and the receptor locations are shown in Table 5.4-4.

5.4.1.3 **Direct Radiation from Station Operation**

Contained sources of radiation at the new units would be shielded. An evaluation of all operating plants by the NRC states that:

> "…because the primary coolant of an LWR is contained in a heavily shielded area, dose rates in the vicinity of light water reactors are generally undetectable and are less than 1 mrem/year at the site boundary. Some plants [mostly BWRs] do not have completely shielded secondary systems and may contribute some measurable off-site dose."

The NRC concludes that the direct radiation from normal operation results in "small contributions at site boundaries" (Reference 6, Section 4.6.1.2). Since the advanced reactor designs being considered are expected to provide shielding that is at least as effective as existing light water reactors, direct dose contribution from the new units would be negligible

5.4.2 **Radiation Doses to Members of the Public**

In this section, doses to MEIs from liquid and gaseous effluents from one new unit are estimated using the methodologies and parameters specified in Section 5.4.1.

5.4.2.1 **Liquid Pathway Doses**

Based on the parameters shown in Table 5.4-1 and Table 5.4-2, the LADTAP II computer program was used to calculate doses to the MEI via the following activities:

- Eating fish and invertebrates caught near the point of discharge

- Drinking water from Lake Anna
- Boating, swimming, and using the shoreline for recreational purposes

The liquid activity releases (source terms) are shown in Table 5.4-6. These are bounding, composite activities, calculated by using the maximum activity listed in the PPE for each isotope. The calculated annual doses to the total body, the thyroid, and the maximally exposed organ are presented in Table 5.4-8. The maximum annual dose of 1.7 mrem would be received by the liver of the maximally exposed child. These calculations are conservative and do not represent actual doses near the ESP site.

5.4.2.2 Gaseous Pathway Doses

Based on the parameters in Table 5.4-3 and Table 5.4-5, the GASPAR II computer program was used to calculate doses to the maximally exposed adult, teenager, child, and infant at the following locations:

- Nearest site boundary
- Nearest vegetable garden
- Nearest residence
- Nearest meat cow

The gaseous activity releases (source terms) are shown in Table 5.4-7. These are bounding, composite activities, calculated by using the maximum activity listed in the PPE for each isotope. The calculated annual total body, thyroid, and skin doses are presented in Table 5.4-9. These calculations are conservative and do not represent actual doses to individuals near the ESP site.

5.4.3 Impacts to Members of the Public

In this section, the radiological impacts to individuals and population groups from liquid and gaseous effluents are estimated using the methodologies and parameters specified in Section 5.4.1.

Table 5.4-10 shows the total body and organ doses to the MEI from liquid effluents and from gaseous releases from a new unit. The calculated doses for both sources are within the design objectives of 10 CFR 50, Appendix I (Reference 7). The total site liquid and gaseous effluent doses from the two existing units and two new units would be well within the regulatory limits of 40 CFR 190 (Reference 8), as shown in Table 5.4-11. Table 5.4-12 shows the population doses attributable to the new units for the population within 50 miles of the ESP site.

5.4.4 Impacts to Biota Other than Members of the Public

Radiation exposure pathways to biota were examined to determine if the pathways could result in doses to biota greater than those predicted for humans. This assessment used surrogate species that provide representative information about the various dose pathways potentially affecting

broader classes of living organisms. Surrogates were used since important attributes of these species are well defined and are accepted as a method for judging doses to biota.

Important biota considered are federally- and state-listed species that are endangered or threatened, commercially and recreationally valuable species, and species important to the local ecosystem. Table 5.4-13 identifies the important species near the ESP site and the assigned surrogates employed in the assessment of radiation doses. The aquatic species listed in the table are those that may potentially exist in the counties immediately adjacent to Lake Anna, the North Anna River upstream or downstream of Lake Anna, and tributary streams crossed by transmission lines. The terrestrial species listed are those that exist or may potentially exist within the ESP site or the associated transmission line rights-of-way. The doses are calculated using pathway models adopted from RG 1.109.

5.4.4.1 Liquid Pathway

The LADTAP II computer program was used to calculate doses to the biota via the following exposure pathways:

- Fish, invertebrates – Internal exposure from bioaccumulation of radionuclides and external exposure from swimming and shoreline activities
- Algae – Internal exposure from bioaccumulation of radionuclides and external exposure from immersion in water
- Muskrat, duck – Internal exposure from ingestion of aquatic plants and external exposure from swimming and shoreline activities
- Raccoon – Internal exposure from ingestion of invertebrates and external exposure from shoreline activities
- Heron – Internal exposure from ingestion of fish and external exposure from swimming and shoreline activities

Food consumption rates, body masses, and effective body radii used in the dose calculations are shown in Table 5.4-14, while the residence times for swimming and shoreline exposure are shown in Table 5.4-15. In determining shoreline doses, adjustments were made for the fact that biota would be closer to any potential shoreline contamination than humans. Other biota parameters are taken from RG 1.109 and NUREG/CR-4013 (Reference 3).

5.4.4.2 Gaseous Pathway

Gaseous effluents contribute to the terrestrial doses. Immersion and ground deposition doses are largely independent of organism size, and the doses for the MEI, as described in Section 5.4.2, can be applied to biota. However, the external ground deposition doses, as calculated by GASPAR II, were increased to account for the closer proximity of terrestrial organisms to the ground, similar to the adjustments made for biota exposures to shoreline sediments in LADTAP II.

5.4.4.3 **Biota Doses**

Maximum calculated doses to biota from liquid and gaseous effluents are shown in Table 5.4-16. Assuming mrem and mrad to be approximately equivalent, the maximum calculated doses to all biota, except fish, exceed the regulatory limit (40 CFR 90) for humans of 25 mrem/yr. Although there are no regulatory limits specifically for biota, there is no scientific evidence that chronic dose rates below 100 mrad/day are harmful to plants and animals (Reference 9). The biota doses in Table 5.4-16 are all less than 1 mrad/day.

Section 5.4 References

1. Regulatory Guide 1.109, *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*, Revision 1, U. S. Nuclear Regulatory Commission, October 1977.

2. Regulatory Guide 1.111, *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors*, Revision 1, U. S. Nuclear Regulatory Commission, July 1977.

3. NUREG/CR-4013, *LADTAP II – Technical Reference and User Guide*, Prepared for the U. S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, April 1986.

4. Virginia Agricultural Statistics Service website, www.nass.usda.gov/va/va.pdf.

5. NUREG/CR-4653, *GASPAR II – Technical Reference and User Guide*, Prepared for the U. S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, March 1987.

6. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, U. S. Nuclear Regulatory Commission, May 1996.

7. 10 CFR 50, Appendix I, *Code of Federal Regulations*, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low As is Reasonably Achievable’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents.”

8. 40 CFR 190, *Code of Federal Regulations*, “Environmental Radiation Protection Standards for Nuclear Power Operations.”

9. NUREG-1555, *Standard Review Plans for Environmental Reviews of Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, October 1999.

10. *North Anna Power Station Updated Safety Analysis Report*, Revision 38.

11. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2001 to December 31, 2001)*, Virginia Electric and Power Company, 2002.

Table 5.4-1 Liquid Pathway Parameters

Parameter	Value
Release source terms	Table 5.4-6
Effluent discharge rate	100 gpm with 10,000 gpm dilution
Dilution factor for discharge	10
Transit time to receptor	0
Impoundment reconcentration model	None
Population distribution	Table 2.5-8
Sport fishing harvest in 2040	2.6E+05 kg/yr

Table 5.4-2 Liquid Pathway Consumption Factors for Maximally Exposed Individual

	Annual Rate			
Consumption Factor	Adult	Teen	Child	Infant
Fish consumption (kg/yr)	21	16	6.9	0
Invertebrate consumption (kg/yr)	5	3.8	1.7	0
Drinking water consumption (l/yr)	730	510	510	330
Shoreline usage (hr/yr)	300	300	300	300
Swimming exposure (hr/yr)	200	200	200	200
Boating usage (hr/yr)	500	500	500	500

Source: Reference 1 (Table E-5) and Reference 10 (Section 11B.4.1).

Table 5.4-3 Gaseous Pathway Parameters

Parameter	Value
Release source terms	Table 5.4-7
Population distribution	Table 2.5-8
Milk production rate within 50 miles	6.9E+08 l/yr
Meat production rate within 50 miles	1.7E+09 kg/yr
Vegetable/fruit production rate within 50 miles	5.2E+08 kg/yr
Atmospheric dispersion factors	Table 2.7-17 to Table 2.7-19
Ground deposition factors	Table 2.7-20

Note:Production rates are projected for year 2040.

Table 5.4-4 Gaseous Pathway Receptor Locations

Receptor	Direction	Distance (miles)
Nearest site boundary	ESE	0.88
Nearest vegetable garden	NE	0.94
Nearest residence	NNE	0.96
Nearest meat animal	SE	1.37

Note:This data is taken from Table 2.7-14. There are no milk cows or goats within 5 miles of the plant (see Table 2.7-13).

Table 5.4-5 Gaseous Pathway Consumption Factors for Maximally Exposed Individual

	Annual Rate			
Consumption Factor	Adult	Teen	Child	Infant
Leafy vegetable consumption (kg/yr)	64	42	26	0
Meat consumption (kg/yr)	110	65	41	0
Milk consumption (l/yr)	310	400	330	330
Vegetable/fruit consumption (kg/yr)	520	630	520	0

Source: Reference 1, Table E-5.

Table 5.4-6 Release of Activities in Liquid Effluent

Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)
C-14	4.4E-04	Rb-88	2.7E-04	Ru-106	7.4E-02	Cs-134	9.9E-03
Na-24	3.1E-03	Rb-89	4.8E-05	Rh-103m	4.9E-03	Cs-136	6.3E-04
P-32	2.0E-04	Sr-89	1.2E-04	Rh-106	7.4E-02	Cs-137	1.3E-02
Cr-51	8.4E-03	Sr-90	3.8E-05	Ag-110m	1.1E-03	Cs-138	2.1E-04
Mn-54	2.8E-03	Sr-91	9.8E-04	Ag-110	1.4E-04	Ba-137m	1.2E-02
Mn-56	4.2E-03	Sr-92	8.8E-04	Sb-124	6.8E-04	Ba-140	5.5E-03
Fe-55	6.4E-03	Y-90	3.4E-06	Te-129m	1.2E-04	La-140	7.4E-03
Fe-59	2.0E-04	Y-91M	1.0E-05	Te-129	1.5E-04	Ce-141	1.3E-04
Co-56	5.7E-03	Y-91	1.2E-04	Te-131m	9.0E-05	Ce-143	1.9E-04
Co-57	7.9E-05	Y-92	6.6E-04	Te-131	3.0E-05	Ce-144	3.2E-03
Co-58	3.4E-03	Y-93	9.8E-04	Te-132	2.4E-04	Pr-143	1.3E-04
Co-60	1.0E-02	Zr-95	1.0E-03	I-131	1.4E-02	Pr-144	3.2E-03
Ni-63	1.5E-04	Nb-95	1.9E-03	I-132	2.8E-03	W-187	1.3E-04
Cu-64	8.2E-03	Mo-99	9.1E-04	I-133	1.1E-02	Np-239	3.4E-03
Zn-65	4.1E-04	Tc-99M	8.8E-04	I-134	1.9E-03	Total w/o H-3	3.2E-01
Br-84	2.0E-05	Ru-103	4.9E-03	I-135	8.2E-03	H-3	3.1E+03

Note: These composite values are somewhat different than those in Table 3.1-7 because these reflect ABWR releases at an uprated power level of 4300 MWth.

Table 5.4-7 Release of Activities in Gaseous Effluent

Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)
H-3	3.5E+03	Kr-85	4.1E+03	Ru-103	3.8E-03	Xe-135m	4.4E+02
C-14	1.0E+01	Kr-87	2.8E+01	Rh-103m	1.2E-04	Xe-135	5.0E+02
Na-24	4.4E-03	Kr-88	4.6E+01	Ru-106	7.8E-05	Xe-137	5.6E+02
P-32	1.0E-03	Kr-89	2.6E+02	Rh-106	2.1E-05	Xe-138	4.7E+02
Ar-41	3.0E+02	Kr-90	3.5E-04	Ag-110m	2.2E-06	Xe-139	4.4E-04
Cr-51	3.8E-02	Rb-89	4.7E-05	Sb-124	2.0E-04	Cs-134	6.8E-03
Mn-54	5.9E-03	Sr-89	6.2E-03	Sb-125	6.1E-05	Cs-136	6.5E-04
Mn-56	3.8E-03	Sr-90	1.2E-03	Te-129m	2.4E-04	Cs-137	1.0E-02
Fe-55	7.1E-03	Y-90	5.0E-05	Te-131m	8.3E-05	Cs-138	1.9E-04
Co-57	8.2E-06	Sr-91	1.1E-03	Te-132	2.1E-05	Ba-140	3.0E-02
Co-58	2.3E-02	Sr-92	8.6E-04	I-131	2.8E-01	La-140	2.0E-03
Co-60	1.4E-02	Y-91	2.6E-04	I-132	2.4E+00	Ce-141	1.0E-02
Fe-59	8.9E-04	Y-92	6.8E-04	I-133	1.9E+00	Ce-144	2.1E-05
Ni-63	7.1E-06	Y-93	1.2E-03	I-134	4.1E+00	Pr-144	2.1E-05
Cu-64	1.1E-02	Zr-95	1.7E-03	I-135	2.6E+00	W-187	2.1E-04
Zn-65	1.2E-02	Nb-95	9.2E-03	Xe-131m	1.8E+03	Np-239	1.3E-02
Kr-83m	9.2E-04	Mo-99	6.5E-02	Xe-133m	8.7E+01	Total	1.7E+04
Kr-85m	3.6E+01	Tc-99m	3.3E-04	Xe-133	4.6E+03		

Note: These composite values are somewhat different than those in Table 3.1-8 because these reflect ABWR releases at an uprated power level of 4300 MWth.

Table 5.4-8 Liquid Pathway Doses for Maximally Exposed Individuals at Lake Anna

	Dose (mrem/yr)		
Pathway	**Total Body**	**Thyroid**	**Liver**
Fish	4.9E-01	0.0E+00	5.9E-01
Invertebrate	6.6E-02	0.0E+00	9.9E-02
Drinking	6.9E-01	1.3E+00	9.4E-01
Shoreline	3.0E-02	3.0E-02	3.0E-02
Swimming	3.0E-04	3.0E-04	3.0E-04
Boating	3.7E-04	3.7E-04	3.7E-04
Total	1.3E+00	1.3E+00	1.7E+00
Age group receiving maximum dose	Adult	Infant	Child

Note: Doses are from one new unit. Liver of the child is the organ receiving the maximum dose.

Table 5.4-9 Gaseous Pathway Doses for Maximally Exposed Individuals

		Dose (mrem/yr)		
Location	**Pathway**	**Total Body**	**Thyroid**	**Skin**
Nearest Site Boundary (0.88 mi ESE)	Plume	1.4E+00	0.0E+00	4.2E+00
	Inhalation			
	Adult	3.0E-01	1.3E+00	0.0E+00
	Teen	3.0E-01	1.6E+00	0.0E+00
	Child	2.7E-01	1.9E+00	0.0E+00
	Infant	1.6E-01	1.6E+00	0.0E+00
Nearest Garden (0.94 mi NE)	Vegetable			
	Adult	4.1E-01	2.9E+00	0.0E+00
	Teen	5.4E-01	3.9E+00	0.0E+00
	Child	9.9E-01	7.4E+00	0.0E+00
Nearest Residence (0.96 mi NNE)	Plume	9.0E-01	0.0E+00	2.7E+00
	Inhalation			
	Adult	2.0E-01	8.3E-01	0.0E+00
	Teen	2.0E-01	1.0E+00	0.0E+00
	Child	1.8E-01	1.2E+00	0.0E+00
	Infant	1.0E-01	1.0E+00	0.0E+00
Nearest Meat Cow (1.37 mi SE)	Meat			
	Adult	5.7E-02	1.0E-01	0.0E+00
	Teen	4.4E-02	7.6E-02	0.0E+00
	Child	7.0E-02	1.2E-01	0.0E+00

Note: Doses are from one new unit. There are no milk cows or goats within 5 miles (SeeTable 2.7-13). There are no infant doses for the vegetable and meat pathways because infants do not consume these foods (See Table 5.4-5).

Table 5.4-10 Comparison of Maximally Exposed Individual Doses with 10 CFR 50, Appendix I Criteria

Type of Dose	Location	Annual Dose per Unit: Calculated	Annual Dose per Unit: Limit
Liquid Effluent			
Total Body (mrem)	Lake Anna	1.3	3
Maximum Organ - LIver (mrem)	Lake Anna	1.7	10
Gaseous Effluent			
Gamma Air (mrad)	Site Boundary	2.1	10
Beta Air (mrad)	Site Boundary	3.5	20
Total Body (mrem)	Site Boundary	1.7	5
Skin (mrem)	Site Boundary	4.2	15
Iodines and Particulates (All Effluents)			
Maximum Organ - Thyroid (mrem)	Lake Anna/ Nearest Garden	7.7	15

Note:Doses are from one new unit.

Table 5.4-11 Comparison of Maximally Exposed Individual Doses with 40 CFR 190 Criteria

	Dose (mrem/yr)					
	Two New Units			Existing Units	Site Total	Regulatory Limit
	Liquid	Gaseous	Total			
Total Body	2.6E+00	3.4E+00	5.9E+00	3.2E-01	6.2E+00	2.5E+01
Thyroid	2.6E+00	1.5E+01	1.7E+01	4.6E-01	1.8E+01	7.5E+01
Other Organ - Bone	2.3E+00	5.7E+00	8.0E+00	4.6E-01	8.4E+00	2.5E+01

Note: Doses for existing units are from Reference 11.

Table 5.4-12 Collective Total Body Doses Within 50 Miles

	Dose (person-rem/yr)	
	Each New Unit	Both Units
Liquid	1.3E+01	2.7E+01
Noble Gases	2.7E+00	5.4E+00
Iodines and Particulates	1.3E+00	2.6E+00
H-3 and C-14	1.3E+01	2.6E+01
Total	3.1E+01	6.1E+01
Natural Background	3.5E+05	3.5E+05

Note: Natural background dose is based on a dose rate of 125 mrem/person-yr (Reference 10, Table 11B-8) and a population of 2.8E+06 (Table 2.5-8). Occupational workforce doses are not shown.

Table 5.4-13 Important Biota Species and Analytical Surrogates

Ecology	Specie Type	Species	Status	Surrogate Species
Terrestrial	Bird	Bald eagle	Federal threatened, State threatened	Heron
		Loggerhead shrike	State threatened	Heron
Aquatic	Invertebrate	Dwarf wedgemussel	Federal endangered, State endangered	Invertebrate
		Slippershell mussel	State endangered	Invertebrate
		Fluted kidneyshell mussel	Candidate for federal listing	Invertebrate
	Fish	Various	Recreationally valuable	Fish

Source: Section 2.4.1 and Section 2.4.2.

Table 5.4-14 Terrestrial Biota Parameters

Biota	Effective Body Radius (cm)	Body Mass (kg)	Consumption of Food (g/day)	Food Organism
Muskrat	6	1	100	Aquatic plants
Raccoon	14	12	200	Invertebrates
Heron	11	4.6	600	Fish
Duck	5	1	100	Aquatic plants

Source: NUREG/CR-4013 (Reference 3).

Table 5.4-15 Parameters for Shoreline and Swimming Exposure to Biota

	Exposure Time (hr/yr)	
Biota	Shoreline	Swimming
Fish	4380	8760
Invertebrates	8760	8760
Algae	NA	8760
Muskrat	2922	2922
Raccoon	2191	Not Applicable
Heron	2922	2920
Duck	4383	4383

Source: NUREG/CR-4013 (Reference 3).

Table 5.4-16 Biota Doses from Liquid and Gaseous Effluents

	Dose (mrad/yr)			
Biota	**Liquid Effluent**	**Gaseous Effluent**	**Total**	**Dose (mrad/day)**
Fish	6.7E+00	0.0E+00	6.7E+00	1.8E-02
Invertebrates	4.5E+01	0.0E+00	4.5E+01	1.2E-01
Algae	3.9E+01	0.0E+00	3.9E+01	1.1E-01
Muskrat	2.2E+01	2.7E+01	4.9E+01	1.3E-01
Raccoon	4.9E+00	2.7E+01	3.2E+01	8.9E-02
Heron	5.0E+01	2.7E+01	7.7E+01	2.1E-01
Duck	2.2E+01	2.7E+01	4.9E+01	1.3E-01

5.5 Environmental Impact of Waste

This section describes the environmental impacts that could result from the operation of the non-radioactive waste system and from storage and disposal of mixed wastes. As defined in the Atomic Energy Act (AEA) of 1954, as amended, (42 USC 2011 et seq.), mixed waste contains hazardous waste and a low-level radioactive source, special nuclear material, or byproduct material. Federal regulations governing generation, management, handling, storage, treatment, disposal, and protection requirements associated with these wastes are contained in 10 CFR (NRC regulations) and 40 CFR (EPA regulations). The section is divided into two subsections: non-radioactive waste system impacts and mixed waste impacts.

5.5.1 Nonradioactive-Waste-System Impacts

Descriptions of the existing units' waste systems and waste systems for the new units' non-radioactive wastes are presented in Section 3.6.

All non-radioactive wastes generated at the NAPS site, including those from the new units (i.e., solid wastes, liquid wastes, air emissions) would continue to be managed in accordance with applicable federal, Virginia, local laws and regulations, and permit requirements. Management practices would be the same as those implemented for the existing units and would include the following:

- Non-radioactive solid waste (e.g., office waste, glass bottles, scrap wood) would be collected temporarily on the NAPS site and disposed of at offsite licensed commercial waste disposal site(s).
- Debris (e.g., vegetation) collected on trash screens at the water intake structure(s) would be disposed of off site as solid waste, in accordance with the existing VPDES Permit. (Reference 1)
- Scrap metal would be collected temporarily on the NAPs site and transported to an offsite permitted recycling facility.
- Water from cooling and auxiliary systems would be discharged through the WHTF to the North Anna Reservoir via Dike 3.
- Wastewater treatment sludge would be taken to the Louisa County Sewage Treatment Plant for further processing and disposal.
- Used oil and antifreeze would be collected temporarily on the NAPS site and recycled through an offsite environmental services contractor.

For further descriptions of plant systems generating non-radioactive wastes, refer to Section 3.6. There would be no other site-specific waste disposal activities unique to the new units. The assessment of potential impacts resulting from the discharge of non-radioactive wastes is discussed in the following subsections.

5.5.1.1 **Discharge Constituents and Characteristics**

Non-radioactive wastewater discharges to surface water would increase as a result of several aspects of new units' operation, such as additional cooling water system volume, new auxiliary systems, and storm water runoff from new impervious surfaces. The PPE lists possible water treatment chemicals that would be used for the new units, along with estimates of constituent concentrations in the cooling and auxiliary system discharges. Section 3.6 contains information regarding the engineering controls that would prevent or minimize the release of harmful levels of constituents to Lake Anna. Concentrations of constituents in the cooling water discharge would be minimal or non-detectable in the North Anna Reservoir (see Section 5.3.2.2).

Smaller volume discharges associated with plant auxiliary systems would be discharged in accordance with the applicable VPDES water quality standards. Therefore, potential impacts from constituents in the cooling water and plant auxiliary systems' discharges from the new units would be small.

With regard to changes in volume and constituent concentrations in storm water discharge, Dominion would coordinate with Virginia Power to revise the existing units' SWPPP which is required by the VPDES permit to prevent or minimize the release of harmful levels of pollutants within the storm water discharge. Impacts from increases in volume or pollutants in the storm water discharge would be small.

5.5.1.2 **Impacts of Discharges to Land**

Operation of the new units would result in an increase in the total volume of solid waste generated at the NAPS site. However, no new solid waste streams would be generated. All applicable federal, Virginia, and local requirements and standards would be met with regard to the handling, transportation, and offsite land disposal of the solid waste. All non-radioactive solid waste would be reused or recycled to the extent possible. Solid wastes appropriate for recycling (e.g., used oil, antifreeze, scrap metal) would be managed through use of approved and appropriately licensed contractors. All non-radioactive solid waste destined for offsite land disposal would be disposed of at approved and licensed offsite commercial waste disposal site(s). Therefore, potential impacts from land disposal of non-radioactive solid wastes would be small.

5.5.1.3 **Impacts of Discharges to Air**

Operation of the new units would increase gaseous and particulate emissions to the air. The primary sources would be drift from cooling towers and additional minor air emission sources (e.g., diesel engines) associated with plant auxiliary systems. Cooling tower impacts on terrestrial ecosystems are addressed in Section 5.3.3.2. Potential impacts associated with drift from the cooling towers would be small and restricted within the NAPS site boundary. Other minor air emission sources associated with the new units would be operated in accordance with federal, Virginia, and local air quality control laws and regulations. Impacts to air would be small.

5.5.1.4 Sanitary Waste

The existing units' sanitary waste treatment system (see Section 3.6) would be modified to accommodate the increases in sanitary wastes generated as a result of the operation of the new units. Sanitary wastes would be managed on site and disposed of off site in compliance with applicable laws, regulations, and permit conditions imposed by federal, Virginia, and local agencies. Potential impacts associated with increases in sanitary waste from operation of the new units would be small.

5.5.2 Mixed Waste Impacts

The term "mixed waste" refers specifically to waste that is regulated as both radioactive and hazardous waste. Radioactive materials at nuclear power plants are regulated by the NRC under the Atomic Energy Act (AEA) (Reference 2). Hazardous wastes are regulated by the EPA or an Authorized State (a state authorized by the EPA to regulate those portions of the federal act) under the Resource Conservation and Recovery Act (RCRA) (Reference 3).

Mixed waste generated on site is assessed based on the following regulatory guidance. The radioactive component of mixed waste must satisfy the definition of low-level radioactive waste in the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985 (Reference 4). The hazardous component must exhibit at least one of the hazardous waste characteristics identified in 40 CFR 261, Subpart C, or be listed as a hazardous waste in 40 CFR 261, Subpart D (Reference 5). Entities who generate, treat, store, or dispose of mixed wastes are subject to the requirements of the Atomic Energy Act, the Solid Waste Disposal Act of 1965 as amended by the RCRA in 1976, and the Hazardous and Solid Waste Amendments, which amended the RCRA in 1984. The federal agencies responsible for ensuring compliance with these statutes are the NRC and the EPA.

5.5.2.1 Plant Systems Producing Mixed Waste

Proper chemical handling techniques, pre-job planning, and compliance with an approved facility waste minimization plan would ensure that only small quantities of mixed waste would be generated by the new units. For example, the Westinghouse AP1000 would produce (Reference 6):

- Expected generation of 15 ft^3/yr mixed liquid waste and 5 ft^3/yr of mixed solid waste
- Maximum generation of 30 ft^3/yr mixed liquid waste and 10 ft^3/yr of mixed solid waste

These quantities represent less than 1 percent of the total waste generation for the AP1000 design, and they are consistent with the experience at existing operating plants, where the volume of mixed waste accounts for less than 3 percent of the annual low-level waste generated (Reference 7).

A 1990 survey by the NRC identifies the following types of mixed low-level waste at reactor facilities (Reference 8):

- Waste oil from pumps and other equipment

- Chlorinated fluorocarbons (CFC) resulting from cleaning, refrigeration, degreasing, and decontamination activities
- Organic solvents, reagents, and compounds, and associated materials such as rags and wipes
- Metals such as lead from shielding applications and chromium from solutions and acids
- Metal-contaminated organic sludges and other chemicals
- Aqueous corrosives consisting of organic and inorganic acids

Primary importance would be placed on source reduction efforts to prevent pollution and eliminate or reduce the generation of mixed waste. Potential pollutants and wastes that cannot be eliminated or minimized would be evaluated for recycling. Treatment for reducing the quantity, toxicity, or mobility of the mixed waste before storage or disposal would be considered only when prevention or recycling is not possible or practical. A waste minimization plan is described in Section 5.5.2.4.

5.5.2.2 **Mixed Waste Storage and Disposal Plans**

The volume of mixed waste could be reduced or eliminated by one or more of the following treatments prior to disposal: decay, stabilization, neutralization, filtration, or chemical or thermal destruction by an offsite vendor.

Some small quantities of mixed waste must be temporarily stored onsite due to the lack of treatment options or disposal sites. For this reason, impacts resulting from occupational exposure to chemical hazards and radiological doses could be higher than otherwise expected. Occupational chemical and radiological exposures could occur during the testing of mixed wastes to determine if the constituents are chemically hazardous.

Potential disposal facilities for mixed waste that would be shipped for treatment and disposal rather than stored would be identified. Dominion would identify one disposal facility as the primary facility and a second as an alternate.

5.5.2.3 **Environmental Impacts**

Minimal environmental impacts would result from storage or shipment of mixed wastes. In the event of a spill, emergency procedures would be implemented to limit any onsite impacts. Emergency response personnel would be properly trained and would maintain a current facility inventory, which would include types of waste, volumes, locations, hazards, control measures, and precautionary measures to be taken in the event of a spill.

Generation and temporary storage of mixed waste could expose workers to hazards associated with the chemical component(s) of the mixed waste matrix from leaks and spills. Dominion would require appropriate procedures if it was necessary to store mixed wastes temporarily on the ESP site. These procedures would include proper labeling of containers, installation of fire detection and suppression equipment (if required), use of fences and locked gates, availability of emergency shower and eyewash facilities, posting of hazard signs, and regular inspections. Dominion would

also develop and implement contingency plans, emergency preparedness plans, and spill prevention procedures that would be implemented in the event of a mixed waste spill. Personnel who are designated to handle mixed waste or to respond to mixed waste emergency spills would receive appropriate training to enable them to perform their work properly and safely.

Offsite shipment, treatment, and disposal options depend on the hazard levels and radiological characteristics of the mixed waste. Because personnel performing packaging and shipping could be exposed to radiation from the mixed waste, appropriate controls would be implemented to ensure that ALARA goals are not exceeded. EPA mandates that waste storage containers in temporary storage be inspected weekly and certain aboveground portions of waste storage tanks be inspected daily. The purpose of these inspections is to detect leakage from, or deterioration of, containers (Reference 9). The NRC recommends that waste in storage be inspected at least quarterly (Reference 10). Waste inspection methods could include direct visual monitoring or remote monitoring for detecting leakage or deterioration. Additionally, measures would be provided to promptly locate and segregate or mitigate leaking containers.

5.5.2.4 **Waste Minimization Plan**

A waste minimization program would be developed and implemented. The following would be some of the key elements of such a program:

- Inventory Management – Inventory management or control techniques would be used to reduce the amount of excess or out-of-date chemicals or hazardous substances. Techniques would be used to reduce the inventory of hazardous chemicals and the size of the containers, and also monitor inventory turnover.
- Maintenance Program – Equipment maintenance programs would be periodically reviewed to establish improvements in corrective and preventive maintenance that would reduce equipment failures that could generate mixed waste. Maintenance procedures would be reviewed to determine which were contributing to the production of waste in the form of process materials, scrap, and cleanup residue. In addition, the need for revising operational procedures, modifying equipment, and segregating and recovering the mixed waste source would be determined.
- Recycling and Reuse – Recycling of waste would be considered. Opportunities for reclamation and reuse of waste materials would be used whenever feasible. Tools, equipment, and materials would be decontaminated for reuse or recycle whenever possible to minimize the amount of waste for disposal. Impediments to recycling, whether regulatory or procedural, would be challenged to enable generators to recycle whenever possible.
- Segregation – If radiological or hazardous waste is generated, proper handling, containerization, and separation techniques would be employed. This would minimize cross contamination and the unnecessary generation of mixed waste.

- Decay in Storage – Some portion of the mixed waste would be radionuclides with relatively short half-lives. The NRC generally allows facilities to store waste containing radionuclides with half-lives of less than 65 days until 10 half-lives have elapsed and the radiation emitted from the unshielded surface of the waste is indistinguishable from background levels. The waste could then be disposed of as a nonradioactive waste. Radioactive waste could also be stored for decay under certain circumstances in accordance with 10 CFR 20. For mixed waste, storage for decay would be particularly advantageous, because the waste could be managed solely as a hazardous waste after the radionuclides decayed to background levels, thus simplifying the management and regulation of these wastes.
- Work Planning – Pre-job planning would be performed to determine what materials and equipment would be needed to perform the anticipated work. One objective of this planning would be to prevent pollution and minimize the amount of mixed waste that may be generated and to use only the resources necessary to accomplish the work. Planning would also prevent mixing of materials or waste types.
- Tracking Systems – A tracking system would be developed, if required, to identify waste generation data and waste minimization opportunities. This would provide essential feedback to successfully guide future efforts. The data collected by the system would be used for internal reporting. The tracking system would provide feedback on the progress of the waste minimization program, including the results of the implementation of pollution prevention technologies. In addition, it would facilitate reporting pollution prevention data to the NRC and EPA.
- Training and Awareness Programs – A successful waste minimization program requires employee commitment. By educating employees in the principles and benefits of such a program, solutions to current and potential environmental management problems would be found. The broad objective of the waste minimization program would be to educate employees in the environmental aspects of activities occurring at the plant and in their community.

5.5.3 **Conclusions**

Minimal chemical constituents would be discharged to the water or air from operation of the new units. Waste minimization programs would reduce the amount of wastes, including mixed wastes, generated by operation of the new units. No new waste streams would be generated. Impacts of waste generation would be small and would not warrant mitigation.

Section 5.5 References

1. VPDES Permit. Permit Number: VA0052451. January 2001.
2. 42 USC 2011 et seq., *United States Code*, Title 42, Chapter 23, “Development and Control of Atomic Energy,” (Atomic Energy Act of 1954).

3. 42 USC 6901 et seq., *United States Code*, Title 42, Chapter 82, “Solid Waste Disposal,” (Resource Conservation and Recovery Act of 1976).

4. 42 USC 2021b et seq., *United States Code*, Title 42, Chapter 23, “Development and Control of Atomic Energy,” (Low-Level Radioactive Waste Policy Amendments Act of 1985).

5. 40 CFR 261, *Code of Federal Regulations*, “Identification and Listing of Hazardous Waste.”

6. AP1000 Document No. APP-GW-GL-700, *AP1000 Design Control Document*, Tier 2 Material, Westinghouse, Revision 2, 2002.

7. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Vol. 1, U. S. Nuclear Regulatory Commission, April 1996.

8. NUREG/CR-5938, *National Profile on Commercially Generated Low-Level Radioactive Mixed Waste*, U. S. Nuclear Regulatory Commission, December 1992.

9. 40 CFR 264, *Code of Federal Regulations*, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.”

10. 10 CFR 20, *Code of Federal Regulations*, “Standards for Protection Against Radiation.”

5.6 Transmission System Impacts

This section discusses the environmental impacts of the transmission system during operation of the new units. As described in Section 3.7, based on an initial evaluation, the current ESP site transmission lines and corridors appear to have sufficient capacity for the total output of the existing and new units.

The current corridor maintenance activities are in compliance with applicable federal, state, and local laws and regulations, and applicable permit requirements. Section 5.6.1 and Section 5.6.2 discuss the terrestrial and aquatic impacts associated with current maintenance activities. Current maintenance practices would continue if two new units were built at the ESP site. Section 5.6.3 discusses the current potential impacts to members of the public.

5.6.1 Terrestial Ecosystems

Refer to Section 2.2.2 for a description of the terrestrial ecology along the existing units' transmission corridors. In addition to the information presented in this application, Section 2.4 and Section 2.5 of the ER prepared for the North Anna License Renewal application provide further detail of the activities summarized below and more detail regarding terrestrial ecosystems. (Reference 1)

5.6.1.1 Impacts of Routine Maintenance Practices

As part of a three-year cycle for maintenance, slow helicopter inspections are conducted to support more detailed surveys of facilities and rights-of-way (Reference 1, Sections 2.4 and 2.5). Impacts of helicopter inspections are primarily air emission and noise from the aircraft.

Aircraft engines emit carbon dioxide, oxides of nitrogen, oxides of sulphur, water vapor, hydrocarbons and particulates. Noise generated by the fly-overs may cause local fauna to become nervous, startled, or temporarily displaced. These impacts are short-term and limited to a localized area; there are no long-term impacts. Impact(s) associated with helicopter inspections would be small.

The transmission corridors are managed (e.g., brush cutting and tree trimming) to prevent woody growth from encroaching on the transmission lines and potentially causing disruption in service or be a general safety hazard. As part of a three-year maintenance cycle, transmission lines and corridors are inspected from the ground and monitored for clearance at locations of concern identified during fly-overs. These inspections involve the use of light equipment (e.g., saws, mowers), herbicides, and hand tools. Mowing is the primary method for maintaining the corridors. Tree and brush trimming is performed in accordance with the Commonwealth of Virginia's tree trimming policy (Reference 2). In areas where mowing is impractical or undesirable, hand cutting and/or non-restricted herbicides are used. In areas where the ground is saturated (e.g., wetlands or wet areas), hand-cutting is the preferred alternative. These activities are regulated by federal and

state laws as well as applicable permit conditions and landowner agreements and have been incorporated into corridor management plans. (Reference 1, Sections 2.4 and 2.5)

Keeping the corridors free of woody vegetation can provide suitable habitat for protected plant species (e.g., rare, threatened, endangered) that depend on open conditions. Virginia Power has cooperated with the VDCR Natural Heritage Program in rare plant surveys within transmission corridors. Although several rare plant species have been located along transmission corridors, no threatened or endangered plant species have been identified or recorded. Locations of rare or sensitive plant species are marked on cutting sketches that Virginia Power maintains for its transmission lines. These cutting sketches, along with specifications and guidelines regarding herbicide use and brush cutting, are provided to corridor maintenance contractors so that adverse impacts on the environment can be avoided. (Reference 1, Sections 2.4 and 2.5)

The bald eagle and the loggerhead shrike (*Lanius ludovicianus*), are known to exist in central Virginia Piedmont areas (see Section 2.4.1), however, no federally and/or state-listed species designated as endangered or threatened are known to exist along the transmission corridors. Therefore, no special protection measures for such species is incorporated in the existing corridor system maintenance procedures.

The use of light equipment (e.g., pick-up trucks, farm tractors with mower attachments, small-engine hand tools) could result in incidental spills of fuel and/or lubricants. Whenever these materials are taken into the field, adequate spill response materials are immediately available to clean-up any such occurrences. Additionally, personnel are trained in how to respond to, clean-up, and report a spill, if one should occur. Contaminated material is managed and disposed of in accordance with federal and state laws and regulations.

Herbicides are handled and applied by specialty contractors in accordance with manufacturer specifications and guidance from jurisdictional regulatory agencies. Contractors are appropriately trained and licensed to perform such work. Herbicide applications are scheduled at appropriate times of the year (e.g., late summer when plants senesce). Furthermore, to prevent environmental impacts from herbicides, their use is prohibited:

- within 100 feet of a river or highway crossing or within 50 feet of a stream crossing
- on protected flora or habitats identified as being environmentally or commercially sensitive to the use of herbicides
- on desirable groundcover (e.g., dogwood, redbud, holly, rhododendron, wax myrtle)
- during high or unfavorable winds, when the risk of an uncontrolled application is increased
- on wild cherry trees growing in pasture lands or areas where livestock may be present.

5.6.1.2 Impacts of Special Maintenance Practices

Special maintenance practices are sometimes necessary for important habitats or wildlife-management requirements not addressed by applicable laws, regulations, or permit requirements. No areas designated by the USFWS as “critical habitat” for endangered species have been identified along or adjacent to NAPS transmission lines. The transmission corridors do not cross state or federal parks, wildlife refuges, or wildlife management areas (Reference 1, Sections 2.4 and 2.5).

5.6.1.3 Conclusion

Potential impacts associated with corridor maintenance activities would be small.

5.6.2 Aquatic Ecosystems

Refer to Section 2.2.2 for a description of the aquatic ecology along the existing units’ transmission corridors. In addition to the information presented in application, Section 2.4 and Section 2.5 of the ER prepared for the North Anna License Renewal application, provide further details of the activities summarized below and more detail regarding aquatic ecosystems. (Reference 1, Sections 2.4 and 2.5)

5.6.2.1 Impacts of Routine Maintenance Practices

Routine maintenance practices in and near wetlands and other water bodies are performed in accordance with the practices described in Section 5.6.1.1. As noted in Section 5.6.1.1, tree trimming and brush cutting is done by hand in aquatic resource areas. Herbicide applications are prohibited within 50 feet of a stream crossing or where winds are likely to increase the risk of misapplication to aquatic resources.

5.6.2.2 Impacts of Special Maintenance Practices

Special maintenance practices are sometimes necessary for important habitats or wildlife management requirements not addressed by applicable laws, regulations, or permit requirements. No threatened or endangered aquatic species have been identified in the water bodies crossed by the NAPS transmission corridors.

Based on the VDGIF Fish and Wildlife Information Service Database (Reference 3), two state- and federally-listed freshwater mussel species [i.e., green floater (*Lasmigona subviridis),* and yellow lance *(Elliptio lanceolata)*] could exist in watercourses that the transmission corridors cross. Neither of these mussel species has been observed in the watercourses crossed by the transmission corridors. They have, been collected from other locations in the counties through which the transmission corridors run.

A third mussel species, the fluted kidney shell mussel (*Ptychobranchus subtentum*), has been reported within the vicinity of the ESP site. This mussel is a candidate for federal listing, and the

database referenced above lists this species as existing in a stream or streams in Louisa County, but not on the ESP site. All confirmed accounts of this species are confined to mountain streams in southwestern Virginia. (Reference 3) These streams comprise part of the Tennessee River watershed, and it is unlikely that fluted kidney shell mussel populations in such streams would be impacted, either directly or indirectly, by maintenance practices on the transmission line corridors, most of which cross streams in watersheds flowing toward the Atlantic Ocean.

5.6.2.3 Conclusion

Impacts of routine and special maintenance procedures for transmission corridors on aquatic resources would be small.

5.6.3 Impacts to Members of the Public

This section discusses the potential impacts on members of the public from electrical shock, electromagnetic field (EMF) exposure, noise, and aesthetics associated with the existing NAPS site transmission lines. Four transmission lines currently originate from the NAPS site. Three of the lines are 500 kV-transmission lines designed and built in the late 1970s in accordance with the National Electrical Safety Code (NESC) and industry guidance that was current at the time. The fourth line is a 230 kV line to South Anna, designed and built in 1984 in accordance with the NESC and industry guidance that was current at the time. (Reference 1, Section 4.13)

5.6.3.1 Electrical Shock

Virginia Power analyzed the potential impacts of electrical shock for the transmission lines in its environmental report for the existing units operating licenses renewal application. This analysis would be unaffected by the new units. The analysis of the induced current along the transmission lines began with the identification of the limiting case for each transmission line. By definition, the limiting case is the configuration along each transmission line where the potential for current-induced shock would be greatest. Because transmission corridors leaving the NAPS site contain only one transmission line per corridor, the limiting case was defined primarily by ground clearance and tower configuration of a single-line corridor. (Reference 4)

Once the limiting case was identified, the electrostatic field strength and the associated induced current for each transmission line was calculated using a computer algorithm (ENG01814), developed by Cincinnati Gas & Electric Company, and used by Virginia Power since 1978. The input parameters for ENG01814 included the design features of the limiting-case scenario, a calculated line sag at 120°F conductor temperature (i.e., NESC requirement and based on design clearances), and an assumed maximum vehicle size under the lines of a tractor-trailer (i.e., 55 ft x 8 ft x 11 ft). Model results were then field-verified through actual electric field measurements under energized transmission lines.

The computer analysis, confirmed by field verification, concluded that none of the four transmission lines have the capacity to induce more than 5 milliamperes in a vehicle parked beneath the lines. Therefore, the four transmission line designs conform to the NESC provisions for preventing electric shock from induced current. The analysis results for each transmission line are provided in Table 5.6-1. Impacts to members of the public from existing transmission lines would be small.

Table 5.6-1 Results of Induced Current Analysis

Transmission Line	Voltage (kV)	Limiting Case Electric Field Strength (kV/meter)	Limiting Case Induced Current (mA)
South Anna NUG (255)	230	4.35	3.10
Morrisville (573)	500	6.95	4.95
Ladysmith (575)	500	6.40	4.56
Midlothian (576)	500	6.68	4.77

5.6.3.2 Electromagnetic Field Exposure

In 1996, after 17 years of research that examined more than 500 studies, the National Research Council released the results of a study that stated, “The findings to date do not support claims that EMFs are harmful to a person's health.” Furthermore the report added there is no conclusive evidence that EMF plays a role in the development of cancer, or reproductive or other abnormalities in humans. (Reference 5) Impacts to members of the public attributable to EMF exposure would be small.

5.6.3.3 Noise

Noise emitted from high-voltage lines is caused by the discharge of energy that occurs when the electrical field strength on the conductor surface is greater than the breakdown strength (i.e., the field intensity necessary to start a flow of electric current) of the surrounding air. The energy loss is known as corona loss. The higher voltages at which modern transmission lines operate have increased the nuisance noise problem.

The intensity of the noise, is affected by two conditions:

- Ambient weather conditions (e.g., humidity, air density, wind, precipitation)
- Irregularities on the conductor surface (e.g., sharp points)

Aging or weathering of the conductor surface typically reduces the significance of these factors. To limit corona activity, transmission lines are constructed and maintained so that during dry weather they operate below the corona-inception voltage. However, during wet weather, the likelihood of corona loss increases, contributing to nuisance noise. Corona-induced noise levels along the

existing transmission system are low and do not pose a health risk to humans. Additionally, Virginia Power has not received any reports from the public of nuisance noise due to transmission lines. Impacts to members of the public attributable to noise from the transmission lines would be small.

5.6.3.4 **Visual Impacts**

Visual impacts to members of the public from the transmission system were addressed qualitatively during the development of the Final Environmental Impact Statement (FEIS) for the existing units (Reference 6). The FEIS notes that the visual impact of the transmission lines would be diminished by several techniques including use of russet-brown tower structures that blend with the rural landscape and gray-painted H-frame structures to support conductor spans over the North Anna reservoir. The FEIS also notes that the route of transmission lines would, in most locations, be along existing ground contours thereby partially concealing the lines and eliminating long views of the line through woods and up slopes. In addition, the FEIS recommended that natural vegetation be retained, where possible, at road crossings to help minimize ground-level visual impacts. This specific recommendation from the FEIS has been incorporated into transmission corridor routine maintenance practices for vegetation control. Contractors performing routine vegetation control activities on the transmission lines are instructed to maintain a screen of natural vegetation in the right-of-way on each side of major highways and rivers unless otherwise directed. Based on the design conditions and ongoing routine vegetation control practices, the visual impact to members of the public from the transmission system would be small.

5.6.3.5 **Conclusions**

Potential impacts from electric shock, EMF exposure, noise or visual impacts from the existing NAPS site transmission lines would be small.

Section 5.6 References

1. *North Anna Power Station, Units 1 and 2 Application for Renewed Operating Licenses Environmental Report*, (Appendix E) Dominion, May 2001.

2. Policy for Tree and Brush Trimming, Virginia Department of Transportation, as seen on the TLC for Trees Project, www.tlcfortrees.info/virginia_department_of_transport.htm, accessed July 29, 2003.

3. Virginia Department of Game & Inland Fisheries' Fish and Wildlife Information Service Database, Website address: vafwis.org/perl/vafwis.pl/vafwis Online database accessed on February 26, 2003.

4. *Transmission Line Electric Shock Analysis, Virginia Power Bulk Power Delivery Transmission Lines*, Donald Koonce, Director, Transmission O&M Support. Virginia Power, December 1999.

5. Possible Health Effects of Exposure to Residential Electric and Magnetic Fields, National Research Council, October 1996.

6. Atomic Energy Commission (AEC), Docket Nos. 50-338 and 50-339, Final Environmental Impact Statement (FEIS) Section 4.1, "Effect on Land Use," Virginia Electric and Power Company, April 1973.

5.7 Uranium Fuel Cycle Impacts

This section addresses the uranium fuel cycle environmental impacts and is divided into two main subsections. The first subsection addresses the LWR designs presently being considered. The second subsection addresses the gas-cooled reactor designs also being considered. This split addresses the regulatory distinction made in 10 CFR 51.51 for LWRs.

5.7.1 Light-Water-Cooled Reactors

10 CFR 51.51(a) states that "Every environmental report prepared for the construction permit stage of a light-water-cooled nuclear power reactor, and submitted on or after September 4, 1979 shall take Table S-3, *Table of Uranium Fuel Cycle Environmental Data*, as the basis for evaluating the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and management of low level waste and high level wastes related to uranium fuel cycle activities to the environmental costs of licensing the nuclear power plant. Table S-3 shall be included in the environmental report and may be supplemented by a discussion of the environmental significance of the data set forth in the table as weighed in the analysis for the proposed facility."

Table S-3 of 10 CFR 51.51 is reproduced in its entirety herein as Table 5.7-3. Specific categories of natural-resource use included in the table relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high- and low-level wastes, and radiation doses from transportation and occupational exposures. The contributions in the table for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); that is, the cycle that results in the greater impact is used.

Descriptions of the environmental impact assessment of the uranium fuel cycle as related to the operation of LWRs are well documented by the USNRC. The environmental impact of an LWR on the U.S. population from radioactive gaseous and liquid releases (including radon and technetium) due to the uranium fuel cycle is small when compared with the impact of natural background radiation. In addition, the non-radiological impacts of the uranium fuel cycle are acceptable.

The LWR technologies being considered to demonstrate site suitability include the ABWR, the ESBWR, the AP-1000 (Advanced Passive PWR), the IRIS, and the ACR-700 (Advanced light-water-cooled version of the CANDU Reactor). The standard configuration for each of these reactor technologies is as follows. The ABWR is a single-unit, 4300 MWt, nominal 1500 MWe reactor. The ESBWR is a similar BWR: single-unit, 4000 MWt, nominal 1390 MWe. The AP-1000 is a single-unit, 3400 MWt, nominal 1117–1150 MWe PWR. The IRIS is a three-module PWR configuration for a total of 3000 MWt and nominal 1005 MWe. And the ACR-700 is a twin-unit, 3964 MWt, nominal 1462 MWe, light-water-cooled CANDU reactor.

These reactor technologies are all LWRs with uranium dioxide fuel and therefore Table S-3 of 10 CFR 51.51(b) provides the basis for evaluating the environmental effects from the uranium fuel cycle for these reactor technologies. The Table S-3 values are normalized for a 1000 MWe reference LWR. Since the ESP site may be used for up to 3200 MWe, the fuel cycle impacts resulting from operation of new LWRs at the ESP site would be no more than 3.2 times the Table S-3 values.

5.7.2 Gas-cooled Reactors

5.7.2.1 Introduction and Background

This section provides an assessment of the environmental impacts of the fuel cycle, as related to the operation of the gas-cooled reactor technologies, based on a comparison of the key parameters that were used to generate the impacts listed in 10 CFR 51.51, Table S-3 (and repeated in Table 5.7-3). The key parameters are energy usage, material involved, number of shipments, etc. associated with the major fuel cycle activities. The major fuel cycle activities are mining and milling, uranium hexafluoride conversion, enrichment, fuel fabrication, and radioactive waste disposal. Basically, the premise is that if less energy is needed, if fewer shipments are required, and if less material is involved in the process, then with all other things being equal, the overall impacts are less.

There are two gas-cooled reactor technologies being considered at this time. The GT-MHR is a four-module, 2400 MWt, nominal 1140 MWe reactor that operates at a unit capacity of 88 percent. The PBMR is an eight module, 3200 MWt, nominal 1320 MWe reactor operating at a 95 percent unit capacity.

A key reference is NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,* May 1996, which provides a very detailed look at the impacts to the environment from the nuclear fuel cycle. The document also looks at the sensitivity of the changes to the nuclear fuel cycle on the impacts to the environment.

Table 5.7-1 was prepared to succinctly capture the major features of the reference LWR fuel cycle that were used to develop Table S-3 and compare these same features with the gas-cooled reactor technologies being considered. This comparison can then help to demonstrate that the previously accepted environmental impacts identified in Table S-3 are comparable to the impacts for these gas-cooled technologies. The premise is that if the values of the major contributors to the health and environmental impacts that were used for the reference LWR fuel cycle are greater than those comparable values for the gas-cooled reactor technologies, then the published, previously accepted impacts would also be greater than the impacts from the new reactor technologies. It is important to point out that even though the contributors are being examined individually, it is the overall impact that is of concern. As such, there can be increases in individual contributors, yet the total impacts can still be bounded, if offset by decreases in other contributors.

The information to conduct the comparison was taken from 10 CFR 51.51, Table S-3 “Uranium Fuel Cycle Environmental Data,” WASH-1248, *Environmental Survey of the Uranium Fuel Cycle*, and Supplement 1 to WASH-1248, (also known as NUREG-0116) *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*. The “reference LWR” refers to the model 1000 MWe LWR used as a basis for studying annual fuel related requirements as described in WASH-1248. For the gas-cooled reactor technologies, information was gathered from the reactor vendors, United States Enrichment Corporation (USEC) and ConverDyn.

5.7.2.2 **Analytic Approach**

The major activities of the reference LWR fuel cycle that were considered in the WASH-1248 report were uranium mining, uranium milling, uranium hexafluoride production, uranium enrichment, fuel fabrication, irradiated fuel reprocessing, radioactive waste management which includes decontamination and decommissioning, and transportation. Three comments pertinent to this analysis are: 1) the WASH-1248 report and this evaluation only address the uranium fuel cycle (other fuel cycles such as thorium and plutonium are not part of this effort), 2) irradiated fuel reprocessing is not being considered by any of the new reactor technologies and is not included in this analysis, and 3) the transportation impacts are addressed based on the following premise - if the quantity of material required by the new gas-cooled reactor technologies at each major step of the fuel cycle is less than the reference plant, then the transportation impacts are also less. Comparing only the number of shipments of material is appropriate since there is little if any radioactivity in the fuel cycle shipments considered by Table S-3.

The main features of the major activities of the reference LWR fuel cycle that were identified as being the primary contributors to the health and environmental impacts are as follows. For the mining operation, annual ore supply is the major determinant of environmental and health impacts. Less ore would necessitate less energy, fewer emissions, less water usage, and less land disturbed. Secondarily, the mining technique can play a significant role in any impacts. Open pit mining has by far the most environment impact, followed by underground mining, with *in situ* leaching being the most environmentally benign.

For the milling operation, annual yellowcake (U_3O_8) production is the metric of interest. If a plant requires less U_3O_8 than the reference plant, then there would be less energy needed, fewer emissions, and less water usage. This is especially true if *in situ* leaching was used to obtain the ore, because the major milling steps of crushing and grinding are not required.

For the uranium conversion process, annual uranium hexafluoride (UF_6) production is the primary determinant of environmental impacts. If the new technology requires less UF_6 than the reference plant, then there would be less energy required, fewer emissions and less water used. As with the mining step, the conversion process (wet versus dry) is also a consideration. However, NUREG-1437 states that in either case “the environmental releases are so small that changing

from 100 percent use of one process to 100 percent of the other would make no significant difference in the totals given in Tables S-3 or S-4."

For the enrichment operation, there are two quantities of interest. The first quantity is the separative work units (SWU) needed to enrich the fuel, and the second quantity is the amount of enriched UF_6. The SWU is a measure of energy required to enrich the fuel. More SWUs would indicate not only more energy required but also more emissions associated with the production of the energy needed and with that more water usage. However, this assumes the same technology is used to achieve the enrichment. As discussed in NUREG-1437, the centrifuge process uses 90 percent less energy than the gaseous diffusion process. Since the major environmental impacts for the entire fuel cycle are from the emissions from the fossil fueled plants needed to supply the energy demands of the gaseous diffusion plant, this reduction in energy requirements results in a fuel cycle with much less environmental impact. With regard to the amount of enriched UF_6 produced, the major effect would be the number of shipments. More UF_6 would necessitate more shipments, while less UF_6 would require fewer shipments. Slight increases or decreases would probably result in the same number of shipments.

For the fuel fabrication process, the quantity of UO_2 produced is the value of interest. This is really equivalent to the annual fuel loading in MTU, which would also be evaluated. Here again, the production of more UO_2 would require more energy, greater emissions, and increased water usage. New reactor technologies with an annual fuel loading less than the reference LWR plant would have less environmental impact, requiring less energy, fewer emissions and less water usage.

The last activity to be addressed is radioactive waste management. There are two aspects of radioactive waste that are considered as part of Table S-3: operations and reactor decontamination and decommissioning (D&D). For these activities, curies of low-level waste (LLW) from annual operations and Ci of LLW from reactor (D&D) are the measures to consider. Curies by themselves are not a direct indicator of the potential environmental impacts. The radionuclide, its half-life and type of emission, and its physical and chemical form are the main contributors to risk. While we recognize this distinction, for this bounding analysis we will use curies as was done in the WASH-1248. More curies generally indicate the potential for greater impacts, while fewer curies indicate lesser impacts.

One of the clearest ways to conduct this comparison between the reference LWR and the gas-cooled reactor technologies is to start with the annual fuel loading in MTU for each of the reactor technologies. The other activities more accurately originate from the need for a certain amount of fuel. Using annual fuel loading as the starting point, the analysis will proceed in the reverse direction for the fuel cycle until the mining has been addressed, then the radioactive waste will be addressed. Before beginning this comparison, it is important to recognize that the plants being considered are a different size, have a different electrical rating and have a different capacity factor from the reference LWR. The reference LWR is a 1000 MWe plant with a capacity factor of 80 percent. In order to make a proper comparison, we need to evaluate the activities based on the

same criterion. In this case, electrical generation is the metric of choice. Electrical generation is why the plants are being built and we want to know if these new reactor technologies, for the same electrical output, have a greater or lesser impact on human health and environment. Based on this, the reactor technologies will be normalized to 800 MWe using plant specific electrical rating and capacity factor.

5.7.2.3 Analysis and Discussion

5.7.2.3.1 Fuel Fabrication/Operations

The reference LWR required 35 MTU on an annual basis. This is equivalent to 40 MT of enriched UO_2, the annual output needed from the fuel fabrication plant. In comparison, the normalized annual fuel needs for the new gas-cooled reactor technologies ranged from 4.3 MTU to 5.3 MTU, approximately 88 percent to 85 percent lower than the reference plant. Similarly, the annual output needed from the fuel fabrication plant range from a low of 4.89 MT of UO_2 to 6.0 MT of UO_2, again approximately 88 percent to 85 percent lower than the reference plant. The specific breakdowns are shown on Table 5.7-1. One important distinction is that the fuel form for the gas-cooled reactors is also different. For the GT-MHR, the fuel is a two-phase mixture of enriched UO_2 AND UC_2, usually referred to as UCO. For the PBMR the fuel kernel is UO_2. Both fuels are then TRISO coated. For the GT-MHR these TRISO fuel particles are blended and bonded together with a carbonaceous binder. These fuel compacts are then stacked within a graphite block. For the PMBR, the fuel unit is a 6 cm diameter graphite sphere containing approximately 15000 fuel particles.

Before concluding the potential impacts from the fuel fabrication process are less, the gas-cooled reactors require a different fuel fabrication process altogether. The TRISO coated fuel kernel is quite different from the UO_2 sintered fuel pellet and as such would require a different type of facility. Ideally, to verify the environmental impacts of this change in fabrication process are bounded by the reference LWR fuel fabrication plant, a comparison of the land use, energy demand, effluents, etc., is in order. However, because there are no planned or currently operating plants in the United States, a direct comparison cannot be made at this time. Therefore, we have provided information on the reference fuel fabrication plant along with conceptual design information for a TRISO fabrication plant that was planned for the New Production Reactor and conceptual design information received from one of the gas-cooled reactor vendors.

From WASH-1248, the reference LWR fuel fabrication plant produced fuel for 26 plants ($\approx$910 MTU), was located on a site of about 100 acres, required 5.2 million gallons of water per annual fuel requirement of 35 MTU, and required 1,700 MW-hours of electricity per 35 MTU. The WASH-1248 report also states that nearly all of the airborne chemical effluents resulted from the combustion of fossil fuels to produce electricity to operate the fabrication plant. These numbers represented a very small portion of the overall fuel cycle. For example, the electrical usage represented less than 0.5 percent of that needed for the enrichment process, and the water use was less than 2 percent of the overall fuel cycle.

The fuel fabrication facility for the New Production Reactor was for a modular high temperature gas reactor (MHTGR) design and was sized for just one plant, so the much larger reference LWR fuel fabrication plant are not readily comparable. The dimensions for the fuel fabrication building were 230 ft x 150 ft. The annual production was about 2 MTU. The plant required 960 kW of electrical power and 45 liters per minute of water. Effluents consisted of 60 m^3/yr of miscellaneous non-combustible solids and filters; 50 m^3/yr of combustible solids; 50 m^3/yr of process off-gas and HVAC filters; 2.0 m^3/yr of tools and failed equipment; and process off-gases of 900,000 m^3/yr. The process off-gases consisted of 74 percent N_2, 12 percent O_2, 7.2 percent Ar, 6.4 percent CO_2, 0.2 percent CO, and 0.02 percent CH_3CCl_3. The activity associated with this off-gas: 0.01 pCi alpha/m^3, and 0.01 pCi beta/m^3.

The information gathered from one of the current reactor vendors was for a plant producing 6.3 MTU, about 19 percent more than the annual reload of 5.31 MTU for its reactor. Again this plant was sized for just one reactor. This plant would require 10 MW of electrical power with an annual electrical usage of 35,000 MW-hr. The gaseous emissions consist of 80 MT of nitrogen, 52 MT of argon, 22.4 MT of CO, 22 MT of hydrogen and 3.7 MT of CO_2. The solid waste totals about 84 m^3 of LLW, 3 m^3 of intermediate level waste, and the remainder sanitary/industrial wastes. The liquid processing system would generate an additional 3.8 m^3 of LLW, would discharge about 3700 m^3 of low activity aqueous effluent, and would discharge about 45,000 m^3 of industrial cooling water.

Because of the differences in scale and the state of design of the facilities, it is not possible or appropriate to make a direct comparison of the impacts. Obviously, there are economies of scale and design improvements that would occur for a plant comparable in size to the reference plant. Regardless, the projected impacts of a TRISO fuel plant based on the two conceptual designs are not inconsistent with the reference plant and would be operated within existing air, water, and solid waste regulations. Furthermore, like the impacts associated with the sintered UO_2 pellet plant, the impacts from a TRISO fuel plant would still be a minor contributor to the overall fuel cycle impacts. By characterizing the impacts as “not inconsistent,” it is meant that while certain parameters such as electrical usage for fuel fabrication might be higher for the gas-cooled plants on an annual fuel loading basis, the environmental impacts from the TRISO plants as conceptualized would still be bounded by the overall LWR fuel cycle impacts.

5.7.2.3.2 **Uranium Enrichment**

In order to produce the 40 MT of enriched UO_2 for the reference LWR, the enrichment plant needed to produce 52 MT of UF_6, which required 127 MT of SWU. The normalized enriched UF_6 needs for the new gas-cooled reactor technologies ranged from 6.38 MT of UF_6 to 7.9 MT of UF_6, approximately 88 percent to 85 percent lower. To produce these quantities of UF_6 requires from 124 MT of SWU to 163 MT of SWU, slightly lower to 28 percent higher. The enrichment SWU calculation for the new reactor technologies was performed using the USEC SWU calculator and assumes a 0.30 percent tails assay, the same value as for the reference LWR. Using this calculator for the reference LWR plant yielded 126 MT of SWU versus the NUREG value of 127. This is very

close indicating that this latest version of the USEC SWU calculator is appropriate for use in this computation. Table 5.7-2 gives the details of the computations.

The 28 percent increase in the MTU of SWU would by itself indicate greater environmental impacts. However, a close look at the original WASH-1248 analysis shows that the environmental impacts are almost totally from the electrical generation needed for the gaseous diffusion process. These impacts result from the emissions from the electrical generation that is assumed to be from coal plants and from the associated water to cool the plants. Today, and in the future, the enrichment process is and will be different. A significant fraction of the enrichment services to U.S. utilities today is provided from European facilities using centrifuge technology rather than the fifty-year-old gaseous diffusion technology. For the future, two private companies, United States Enrichment Corporation and Louisiana Energy Services, are planning to develop centrifuge technology in the U.S. In fact, NRC has just recently accepted United States Enrichment Corporation's centrifuge license application for technical review. Centrifuge technology requires less than 10 percent of the energy needed for the gaseous diffusion process and as such the environmental impacts associated with the electrical generation would be correspondingly less. This tremendous reduction in energy and the associated environmental impacts more than offsets a 28 percent increase in SWU.

5.7.2.3.3 **Uranium Hexafluoride Production**

In order to provide the feed needed for the reference LWR to the enrichment plant, the uranium hexafluoride plant needed to produce 360 MT of UF_6. The normalized feed needed for the new gas-cooled reactor technologies, the output from the uranium hexafluoride plant, ranged from 241 to 303 MT of UF_6, well below the reference plant. The feed calculations were performed using the USEC SWU calculator. Using this calculator for the reference LWR yielded 353 MT of UF_6 versus 360 MT specified for the reference LWR in NUREG-0166. Again this value is very close (<2 percent) to the published value.

5.7.2.3.4 **Uranium Milling**

To produce the 360 MT of UF_6 for the reference LWR, 293 MT of yellowcake (U_3O_8) from the mill was required. The normalized new gas-cooled reactor technologies needs ranged from 193 MT of U_3O_8 to 243 U_3O_8, well below the reference plant. These yellowcake numbers were generated using the relationship 2.61285 lb of U_3O_8 to 1 kg of UF_6. This conversion factor was obtained from ConverDyn.

5.7.2.3.5 **Uranium Mining**

The raw ore needed to produce the 293 MT of yellowcake (U_3O_8) for the reference LWR was 272,000 MT. Now assuming a 0.1 percent ore body and a 90 percent recovery efficiency, the normalized new gas-cooled reactor technologies ore requirements ranged from 215,000 to 270,000 MT of ore, both below the reference plant. Of note, the value of 272,000 MT specified for

the reference LWR in NUREG-0116 should be about 325,600 using the same assumptions. In any case, the gas-cooled reactor technologies are below the published reference plant value.

Uranium mining completes the front end of the fuel cycle. However, there are two areas on the down stream cycle to be considered. These are the LLW generated by operations and the LLW generated as part of the D&D process. As mentioned earlier, spent fuel reprocessing is not germane to this analysis, and therefore, not discussed.

5.7.2.3.6 **Solid Low-Level Radioactive Waste - Operations**

For the reference LWR, 10 CFR 51.51, Table S-3, Table of Uranium Fuel Cycle Environmental Data, states that there are 9,100 Ci of LLW generated annually from operations. The range of activity of LLW generated annually projected by the new gas-cooled reactor technologies is 65.4 Ci to 1,100 Ci, far below the reference LLW. This decrease would also suggest many fewer shipments to the disposal facility and less worker exposure.

5.7.2.3.7 **Solid Low-Level Radioactive Waste – Decontamination and Decommissioning**

10 CFR 51.51, Table S-3, states 1,500 Ci per Reactor Reference Year (RRY) “comes from reactor decontamination and decommissioning – buried at land burial facilities.” Based on this small quantity and the modifying phrase “buried at land burial facilities” it is clear that only waste suitable for shallow land burial was being considered as a basis for the Table S-3 line item. At this time, only general conclusions can be drawn to indicate these gas-cooled reactor technologies would generate less D&D LLW than the reference plant. The new plants would operate much cleaner than the reference LWR as evidenced by the annual generation of much less LLW. Improvements in fuel integrity and differences in fuel form as well as the use of the chemically and radiologically inert helium as the coolant are responsible for this reduction and also should contribute to both a lower level and less overall contamination to be managed during the D&D process. The plants higher thermal efficiency and higher fuel burnup would produce less heavy metal radioactive waste. Lastly, the plants, with the exception of the reactor core, are typically more compact than the reference LWR contributing to less D&D waste. For these reasons, it is expected that the D&D LLW generation from the gas-cooled reactor designs would be comparable or less than that associated with the reference LWR.

The key areas of impact from D&D LWR for the gas-cooled reactor are expected to be identical to those of the reference LWR, namely transportation and land use supporting waste disposal. As discussed in WASH-1248, the contributions from the D&D LLW to the overall environmental impacts are relatively quite small. WASH-1248 points out that by far the major environmental impacts are dominated by the front end phases (mining, milling, enrichment) of the fuel cycle, e.g., land use from mining and power consumption to support enrichment, related water usage, and power plant emissions.

As noted above, the D&D LLW impacts related to the gas-cooled reactor designs are expected to be comparable or less than that of the reference LWR. However, even if the gas-cooled reactor

D&D LLW activities and/or volumes were larger, the overall reference LWR fuel cycle impacts would continue to be bounding.

5.7.2.4 **Summary and Conclusion**

To recap, there are only two instances where any part of the uranium fuel cycle is/might be exceeded by the new gas-cooled reactor technologies. These fuel cycle steps are enrichment, a 28 percent increase and possibly D&D. As discussed above, the enrichment requirement for SWU, while slightly larger, can be conducted in a much more environmentally benign manner, centrifuge versus gaseous diffusion, from current overseas sources or expected new domestic facilities. The net effect would be that the environmental and health impacts would be less than those identified in Table S-3. The second area, decontamination and decommissioning, is a minor contributor to the fuel cycle impacts. While definitive D&D LLW information was not readily available for the gas-cooled reactor technologies, for several qualitative reasons, the impacts are expected to be comparable or less than the reference LWR. However, even an increase in the D&D LLW impacts would be more than offset by the significant decreases in the impacts due to reduction in fuel needs and changes in the enrichment process and mining technique.

In conclusion, this detailed comparison of the underpinnings of Table S-3 show qualitatively that the existing WASH-1248 environmental and health effects are conservative and appropriate for use by these new gas-cooled reactor technologies. Collectively, improvements in both past practices as well as changes in technology have resulted in a fuel cycle with lower environmental impact.

5.7.3 **Methodology Assessment**

The selection of a reactor design to be used for the ESP Facility is still under consideration. Selection of a reactor to be used at the ESP site may not be limited to those considered above. However, the methodology utilized above is appropriate to evaluate the final selected reactor. Further, should the selected design be shown to be bounded by the above evaluation, then the selected design would be considered to be within the acceptable fuel cycle environmental impacts considered for this ESP.

Section 5.7 References

1. 10 CFR 51.51, Table S-3, Table of Uranium Fuel Cycle Environmental Data.

2. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,* May 1996.

3. WASH-1248, *Environmental Survey of the Uranium Fuel Cycle*, April 1974.

4. Supplement 1 to WASH-1248, also known as NUREG-0116, *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*, October 1976.

5. EGG-NPR-8522, Rev. B, *NPR-MHTGR Generic Reactor Plant Description and Source Terms*, March 1991.

Table 5.7-1 Gas-Cooled Fuel Cycle Impact Evaluation

Reactor Technology Facility/Activity	**Reference LWR** (Single unit) (≈1000 MWe) 80% Capacity	**GT-MHR** (4 Modules) (2400 MWt total) (≈1150 MWe total) 88% Capacity	**PBMR** (8 Modules) (3200 MWt total) (≈1280 MWe total) 95% Capacity
Mining Operations			
Annual ore supply MT	272,000	337140	337140
Normalized annual ore supply MT	272,000	269712	214739
Fraction of reference LWR	1	0.99	0.79
Calculated number	314,011	269712	214739
Milling Operations			
Annual yellowcake MT	293	303	303
Normalized annual yellowcake MT	293	243	193
Fraction of reference LWR	1	0.83	0.66
Calculated number	283	243	193
UF_6 Production			
Annual UF_6 MT	360	379	379
Normalized annual UF_6 MT	360	303	241
Fraction of reference LWR	1	0.84	0.67
Calculated number	353	303	241
Enrichment Operations			
Enriched UF_6 (MT)	52	8.0	12.3
Normalized enriched UF_6 (MT)	52	6.38	7.9
fraction of reference LWR	1	0.12	0.15
Calculated number	52	6.38	7.9
Annual SWU (MT)	127	204	194
Normalized annual SWU (MT)	127	163	124
fraction of reference LWR	1	1.29	0.97
Calculated number	126	163	124

Table 5.7-1 Gas-Cooled Fuel Cycle Impact Evaluation

Reactor Technology Facility/Activity	**Reference LWR** (Single unit) (≈1000 MWe) 80% Capacity	**GT-MHR** (4 Modules) (2400 MWt total) (≈1150 MWe total) 88% Capacity	**PBMR** (8 Modules) (3200 MWt total) (≈1280 MWe total) 95% Capacity
Fuel Fabrication Plant Operations			
Enriched UO_2 (MT)	40	6.11	9.5
Normalized enriched UO_2 (MT)	40	4.89	6.0
fraction of reference LWR	1	0.12	0.15
Calculated number	40	4.89	6.0
Annual Fuel Loading (MTU)	35	5.39	8.34
Normalized annual fuel loading (MTU)	35	4.3	5.31
fraction of reference LWR	1	0.12	0.15
Reprocessing Plant Operations			
Annual spent fuel reprocessing MTU	35	0	0
Solid Radioactive Waste			
Annual LLW from reactor operations Ci	9,100	1100 Ci; 98 m^3	65.4 Ci; 800 drums
fraction of reference LWR	1	0.12	0.01
LLW from Reactor Decontamination & Decommissioning Ci per RRY	1,500	Data not available	Data not available
TRU and HLW Ci	1.1×10^7	Reprocessing is not considered in this evaluation.	Reprocessing is not considered in this evaluation.
Yellow indicates a value larger than Table S-3.			

References:

1. 10 CFR 51.51, Table S-3 Table of Uranium Fuel Cycle Environmental Data
2. 10 CFR 51.51, Table S-3 Table of Uranium Fuel Cycle Environmental Data

Table 5.7-1 Gas-Cooled Fuel Cycle Impact Evaluation

Reactor Technology Facility/Activity	**Reference LWR** (Single unit) (≈1000 MWe) 80% Capacity	**GT-MHR** (4 Modules) (2400 MWt total) (≈1150 MWe total) 88% Capacity	**PBMR** (8 Modules) (3200 MWt total) (≈1280 MWe total) 95% Capacity

Notes:

1. The enrichment SWU calculation was performed using the USEC SWU calculator and assumes a 0.30% tails assay.
2. The information on the reference reactor (mining, milling, UF_6, enrichment, fuel fabrication values) taken from NUREG-0116, Table 3.2, no recycling.
3. The information on the reference reactor (solid radioactive waste) taken from 10 CFR 51.51, Table S-3.
4. The calculated information on the reference reactor uses the same methodology as for the reactor technologies.
5. The normalized information is based on 1000 MWe and the reactor vendor supplied unit capacity factor.
6. For the new reactor technologies, the annual fuel loading was provided by the reactor vendor.
7. The USEC SWU calculator also calculated the kgs of U feed. This number was multiplied by 1.48 to get the necessary amount of UF_6.
8. The annual yellowcake number was generated using the relationship 2.61285 lb. of U_3O_8 to 1 kg U of UF_6; 1.185 kgs of U_3O_8 to 1.48 kg.
9. The annual ore supply was generated assuming an 0.1% ore body and a 90% recovery efficiency.
10. Co-60 with a 5.26 year half-life and Fe-55 with a 2.73 year half-life are the main nuclides listed for the PBMR D&D waste.

Table 5.7-2 SWU and Feed Calculation Results

Reactor Technology	kg Uranium Product	Weight Percent U_{235}	SWU Quantity	kg of U Feed Required	Tails Assay
ABWR	32,760	4.5	204,127.56	334,774.44	0.30%
ESBWR	32,760	4.5	204,127.56	334,774.44	0.30%
AP-1000	24,400	4.51	152,500.00	249,929.20	0.30%
IRIS	18,800	4.85	129,851.60	208,134.8	0.30%
ACR-700	66,200	2.00	112,341.40	273,803.20	0.30%
GT-MHR	5,394	19.80	204373.27	255,918.33	0.30%
PBMR	8,340	12.90	194,413.74	255,679.38	0.30%
NUREG-0116	35,000	3.10	126,175	238,455	0.30%
WASH-1248	35,000	3.20	147,280	223,965	0.25%

Notes:

1. The reactor vendor supplied the kg uranium product and weight percent U_{235}.
2. The tails assay was assumed to be 0.3% to match NUREG-0116 with the exception of WASH-1248 which used a tail assay of 0.25%.
3. The SWU Quantity and kg Feed Required were calculated using the USEC SWU Calculator.
4. The results have not been normalized to equivalent electrical generation.

Table 5.7-3 10 CFR 51.51, Table S-3- of Uranium Fuel Cycle Environmental Data[a]

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]
[See Footnotes at end of this table]

Environmental Considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Natural Resource Use		
Land (acres)		
Temporarily committed[b]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to a 110 MWe coal-fired power plant.
Permanently committed	13	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MWe coal-fired power plant.
Water (millions of gallons)		
Discharged to air	160	=2% of model 1,000 MWe LWR with cooling tower.
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	<4% of model 1,000 MWe LWR with once through cooling.
Fossil Fuel:		
Electrical energy (thousands of MW-hour)	323	<5% of model 1,000 MWe output
Equivalent coal (thousands of MT)	118	Equivalent to the consumption of a 45 MWe coal-fired power plant.
Natural gas (millions of scf)	135	<0.4% of model 1,000 MWe energy output.
Effluents-Chemical (MT)		
Gases (including entrainment)[c]		
SO_x	4,400	
NO_x[d]	1,190	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	

Table 5.7-3 10 CFR 51.51, Table S-3- of Uranium Fuel Cycle Environmental Data[a]
[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]
[See Footnotes at end of this table]

Environmental Considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Other gases		
F	0.67	Principally from UF_6, production, enrichment, and reprocessing. Concentration within range of state standards- below level that has effects on human health.
HCl	0.014	
Liquids		
$SO\text{-}_4$	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3-600 cfs., NO_3-20 cfs., Fluoride-70 cfs.
$NO\text{-}_3$	25.8	
Fluoride	12.9	
CA^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	0.4	
Tailings Solutions (thousands of MT)	240	From mills only-- no significant effluents to environment.
Solids	91,000	Principally from mills-- no significant effluents to environment.
Effluents—Radiological (curies)		
Gases (including entrainment)		
Rn-222		Presently under reconsideration by the Commission.
Ra-226	0.02	
Th-230	0.02	
Uranium	0.034	

Table 5.7-3 10 CFR 51.51, Table S-3- of Uranium Fuel Cycle Environmental Data[a]

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]
[See Footnotes at end of this table]

Environmental Considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Tritium (thousands)	18.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	0.14	Principally from fuel reprocessing plants.
I-129	1.3	
I-131	0.83	
Tc-99		Presently under consideration by the Commission
Fission products and transuranics	0.203	
Liquids		
Uranium and daughters	2.1	Principally from milling-- included tailings liquor and returned to ground -- no effluents; therefore, no effect on the environment.
Ra-226	0.0034	From UF_6 production.
Th-230	.0015	
Th-234	.01	From fuel fabrication plants-- concentration 10 percent of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Fission and activation products	5.9×10^{-6}	
Solids (buried on site)		
Other than high level (shallow)	11,300	9,100 Ci comes from low level reactor wastes and 1,5000 Ci comes from reactor decontamination and decommissioning -- buried at land burial facilities. 600 Ci comes from mills -- included in tailing returned to ground. Approximately 60 Ci comes from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^{7}	Buried at Federal Repository
Effluents-- thermal (billions of British thermal units)	4,063	<5 percent of model 1,000 MWe LWR.
Transportation (person-rem):		
Exposure of workers and general public	2.5	

Table 5.7-3 10 CFR 51.51, Table S-3- of Uranium Fuel Cycle Environmental Data[a]

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]
[See Footnotes at end of this table]

Environmental Considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Occupational exposure	22.6	From reprocessing and waste management.

[49FR9381, Mar. 12, 1984; 49FR10922, Mar. 23, 1984]

a. In some cases where no entry appears it is clear from the background documents that the matter was addressed and that, in effect, the Table, should be read as if a specific zero entry had been made. However there are other areas that are not addressed at all in the Table. Table S-3 does not include health effects from the effluents described in the Table, or estimates of releases of Radon-222 from the uranium fuel cycle or estimates of Technetium-99 released from waste management or reprocessing activities. These issues may be the subject of litigation in the individual licensing proceedings.

   Data supporting this table are given in the Environmental Survey of the Uranium Fuel Cycle," WASH-1248, April 1974; the "Environmental Survey of Reprocessing and Waste Management Portion of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248); the "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248): and in the record of final rulemaking pertaining to Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3. The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the two fuel cycles (uranium only and fuel recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in Table S-4 of §51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of Table S-3A of WASH-1248.

b. The contributions to temporarily committed land from reprocessing are not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years.

c. Estimated effluents based upon combustion of equivalent coal for power generation.

d. 1.2 percent from natural gas use and process.

5.8 Socioeconomic Impacts

Section 5.8 describes the socioeconomic impacts of operating the new units. For this ER, socioeconomic impacts include potential impacts on individual communities, the surrounding region, and minority and low-income populations. This section has been segregated into three subsections:

- Physical impacts
- Social and economic impacts
- Environmental justice impacts

5.8.1 Physical Impacts of Station Operation

This section describes the assessment of the potential physical impacts on the nearby communities due to operation of the new units. Potential impacts include noise, odors, exhausts, thermal emissions, and visual intrusions. These physical impacts would be managed to comply with applicable federal, state and local environmental regulations and would not significantly affect the ESP site and its vicinity.

5.8.1.1 Plant Site and Vicinity

There are no residential areas located within the NAPS site boundary. Lake Anna, which was created to meet the cooling supply needs of the station, has public access and is the nearest recreational facility to the ESP site.

The region surrounding the lake is covered with forest and brushwood interspersed with occasional farmland. The population immediately surrounding the lake is about 980 and about 2940 between 2.5 and 5 miles from the ESP site (see Section 2.5.1). The town of Mineral, located about 7 miles southwest of the ESP site, is a small rural community that includes small businesses, houses, and farm buildings. Mineral has a population of 424, according to the Year 2000 census. Because of Mineral's distance from the ESP site, its residents would not experience any physical impacts from operation of the new units.

5.8.1.2 Noise

The new units would produce noise from the operation of pumps, transformers, turbines, generators, and switchyard equipment. The noise levels would be controlled in accordance with applicable local county regulations. As described in Section 5.3.4, Virginia has no state regulations or guidelines regarding noise limits. The nearby counties (Louisa and Spotsylvania) maintain county ordinances to prohibit unnecessary, unreasonable, or disturbing noise (Reference 1) (Reference 2).

Most equipment would be located inside structures reducing the outdoor noise level. Noise would be further attenuated by distance to the NAPS site boundary. Since the closest EAB is about

300 feet away from the planned cooling tower location, the noise level generated by the towers would be lower than NRC-defined significant levels at the EAB (see Section 5.3.4).

The nearest residence is about 3000 feet to the north of the planned cooling tower location (see Figure 5.8-1). Noise levels below 60 to 65 dBA are considered to be of small significance (Reference 3). Therefore, the noise impact at the nearest residence would be small and no mitigation would be warranted.

Air-cooled condensers could be used for heat dissipation for new Unit 4. In order to dissipate enough heat and to minimize the generation of local air turbulence, fans used for air-cooled condensers are large and slow. Low speed fans produce low frequency noise that could travel relatively long distances under certain meteorological conditions. Noise impacts could be significant if air-cooled condensers are located near residential areas. Although noise would not cause adverse offsite impacts, a noise study would be performed as part of the final selection of the Unit 4 cooling system and the results described in the COL application.

Ambient noise heard by recreational users of Lake Anna under normal conditions includes noise from the existing units. The noise level generated by the operation of the new units would not affect the recreational use of the lake (see Section 5.3.4).

Commuter traffic would be controlled by speed limits. The access roads to the ESP site would be paved. Good road conditions and appropriate speed limits would minimize the noise level generated by the work force commuting to the ESP site.

Section 2.7 of RG 4.2 requires an assessment of the ambient noise level within 5 miles of the ESP site. Particular attention is directed toward obtaining acoustic levels associated with high voltage transmission lines(Reference 4). As discussed in Section 3.7.1, the evaluation of the need for noise impact from the transmission system would be completed at a suitable time within Dominion's future planning work and after a decision has been made to proceed with the new capacity. This evaluation would include assessment of noise impacts.

5.8.1.3 **Air**

The new units would have standby diesel generators and auxiliary power systems. Air permits acquired for these generators would ensure that air emissions comply with regulations. In addition, standby diesel generators would be operated on a limited short-term basis. The impact of the operation of the new units on air quality would be small, and would not warrant any mitigation.

The operation of cooling towers may contribute to salt drift near the ESP site. As described in Section 5.3.3.1, the modeling results indicate that the mechanical cooling tower's salt deposition rates would never exceed 1 kg/ha/month, beyond the ESP site. Section 5.3.3.1 also concludes that natural draft cooling towers would not deposit significant amounts of salt on nearby vegetation due to their height and thermal plume rise.

Section 5.3.3.1 also concludes that fogging and icing impacts would be small.

Good access roads and appropriate speed limits would minimize the amount of dust generated by the commuting work force.

During normal plant operation, the new units would not use a large amount of chemicals that would generate odors exceeding the odor threshold value.

5.8.1.4 **Thermal Emissions**

Heat dissipation to the atmosphere from operation of the Unit 4 cooling towers is described in Section 5.3.1.1. Vapor plumes resulting from wet-type cooling towers would rise due to their thermal effect. Because there is no residential area within the NAPS site boundary, there would be no heat impacts on nearby communities.

5.8.1.5 **Visual Intrusions**

The nearest residential area is about 3000 feet north of the ESP site and is shielded by forested land. Given this distance, residents near the site would not have a clear view of the new units. However, recreational users on the Lake Anna Reservoir and some residents along the lake would be able to see the new units in addition to the other developed areas of the NAPS site already in their view.

The existing units' Turbine Building is about 100 feet above grade and the existing units' containment buildings are about 130 feet above grade. Because the new units' turbine building could be approximately 230 feet above grade and natural draft cooling towers would be about 500 feet tall, moderate visual impacts would result.

The mechanical draft cooling towers would be plume-abated; therefore, no visible plumes would occur under most meteorological conditions. If natural draft cooling towers are used, a visible plume would be inevitable. Under certain moist atmospheric conditions, the visible plume impact due to the operation of the natural draft tower could be moderate.

The reactor design and ancillary facilities (i.e., cooling water system) have not yet been selected. Depending on the design selected, a visual impact study would be performed and described in the COL application.

5.8.1.6 **Other Related Impacts**

Water withdrawal and the associated discharge of heated water from the new units would be conducted in accordance with federal, state and local regulations that govern water quality. As described in Section 3.4.1, new Unit 3 would use a once-through cooling system with the North Anna Reservoir as the cooling water supply and the WHTF as the primary heat sink. New Unit 4 would use a closed cycle cooling system using mechanical or natural draft cooling towers for heat dissipation and makeup water potentially from the lake supplemented by an external source. If both the existing units and the new units were operated continuously during critical low flow periods, an external water source would be required to temporarily supplement the makeup water supply for

Unit 4. The requirement of an external water supply and the environmental impact of bringing this water to Unit 4 would be assessed as part of detailed engineering and described in the COL application.

Roads within the vicinity of the ESP site would experience a temporary increase in traffic at the beginning and the end of the workday period. However, the current road network has sufficient capacity to accommodate the increase, as detailed in Section 5.1.1.1. Therefore, no significant congestion would result from operation of the new units.

5.8.2 Social and Economic Impacts of Station Operation

The social and economic impacts from the operation of new units at the ESP site would be associated with activities related to the daily operation of the new units, and with the social and economic demands on the surrounding region.

Approximately 720 workers would be required for the operation of the new units, about the same as currently required for the existing units. These 720 workers would relocate into the area with their families and, therefore, would represent both a source of income to the community and a potential demand on community services, such as schools and police protection. These 720 employees would translate into an increase in population of about 2900 to the region, assuming each new employee represents a family of four and relocates into the region.

The expected number of permanent workers needed to operate the new units, and their families, would be a small fraction of the total projected population growth in the region. Assuming that the geographic distribution of new employees would be the same as for the existing units, about 200 would settle in Louisa County, 157 in Spotsylvania County, and 102 in Orange County. The remaining 261 would settle in Henrico and Hanover Counties and the City of Richmond.

5.8.2.1 Economic Impacts

The main economic impacts of the new workers and their families on the area would be related to taxes, housing, and purchase of goods and services. Economic impacts related to the operation of the new units would be associated mainly with payment of the plant property taxes.

5.8.2.1.1 Potential Non-Income Taxes related to Operation of New Unit(s)

In Virginia, counties and towns collect most of their tax revenue through property taxes and sales taxes.

The assessed value of the new units would exceed that of the existing units, which have depreciated with time. It is not possible to estimate the actual taxes that would be paid to the regional governments or of the expenditures that the regional governments would incur to accommodate the workforce, at this time. The expenditures by the regional governments would, in part, be related to the size and age distribution of the families of the new employees. Based on the assumption that the new employees would come from outside the region, the regional governments

would experience both outflows and inflows of monies as a result of the operation of the new units. Expenditures would be related to the impacts on the local and regional infrastructure due to the increased usage of the school, recreational, medical, fire and police, and transportation systems. The types of non-income taxes and their bases can be addressed and are presented below.

a. **Sales and Use Taxes**

The Commonwealth of Virginia and Louisa County would experience an increase in the amount of sales and use taxes associated with the operation of the new units, as will other, more developed counties, such as Spotsylvania.

Additional sales and use tax revenues would also be generated by retail expenditures (restaurants, hotels, and merchant sales) by the new employees and by their families. It is estimated that about half of the day-to-day expenditures during operation would occur in the region.

The current combined sales and use tax rate in counties adjoining the ESP site is 4.5 percent. Of the 4.5 percent tax rate, 3.5 percent would be paid to the Commonwealth, and 1 percent to the locality.

b. **Property Taxes**

The surrounding counties about the ESP site and the City of Richmond would benefit from additional property tax revenues from two sources associated with the new units: the new units and the new employees through their purchase of housing.

Property taxes would be levied for the increase in value of the NAPS site due to the new units. The property tax payments to Louisa County are discussed in Section 2.5.2 and identified as a large beneficial impact for Louisa County. The addition of the new units to the NAPS site would substantially increase the property tax payments.

The existing units have contributed more than 50 percent of the property taxes paid to Louisa County over the past decade, which has allowed the property tax assessment rates within the county to remain substantially below those of neighboring counties. The construction and operation of the new units would serve to maintain the very high percent of the property taxes paid by the various DRI subsidiaries. Overall, the property taxes paid to Louisa County by Virginia Power amounted to about 22.5 percent of the total budget for the County during the 1995–2000 time period. Operation of the NAPS site will continue to be a major benefit to Louisa County when the new units start operating.

The GEIS (Reference 5) points out that the potential effects of electric utility deregulation within Virginia are not known. However, it is reasonable to conclude that the operation of new units should result in a substantial increase in property tax payments.

5.8.2.1.2 Housing

A review of Table 2.5-22 shows that the number of housing units for sale in the region could easily accommodate the expected permanent workforce of 720 new employees. Furthermore, as discussed in Section 4.4.2.1.2, the counties in the vicinity of the NAPS site and within the region are addressing the needs of the projected increases in population in their Comprehensive Plans. Because the new workforce income would be good relative to other incomes in the region, it can be expected that the housing purchases would be on the high end of the price range. However, as is discussed in more detail in Section 5.8.2.2, the new workers and their families are a small percentage of the populations that the VEC has projected for the Counties and the City of Richmond over the next thirty years. Therefore, the impact of the property taxes paid for housing by these families would be a positive, but not necessarily a very large, benefit to the Counties and the City of Richmond.

Currently, the planned outages of each existing unit (approximately every 18 months per unit) are staggered so that only about 700 to 1000 additional workers per unit would be onsite for a period of 30 to 40 days per outage. It is expected that the planned outages for the new units would be scheduled so that multiple units would not be worked on simultaneously. This would also reduce the potential for demand exceeding the availability of short-term housing in the immediate vicinity of the NAPS site.

As discussed in Section 4.4.2, within the region — particularly in the City of Richmond and Henrico County — there are sufficient numbers of housing units available for rent, if needed, to accommodate the total workforce required in the event there are simultaneous outages of two or more units.

5.8.2.2 Social Impacts

The communities with the greatest potential for social impact associated with the installation and operation of new units at the NAPS site are in Henrico, Hanover, Louisa, Orange, and Spotsylvania Counties, and in the City of Richmond. The permanent new employees, would relocate with their families to the region. Depending on the number of families that move into a given area and the number of children and their ages, it is possible that social impacts would be recognized locally.

The VEC has developed for the counties and some cities in Virginia preliminary local population projections for years 2000 to 2030. These projections are presented in Table 5.8-1 for the counties within a 50-mile radius around the ESP site and for the City of Richmond (Reference 6). The population of the City of Richmond is projected to remain flat from year 2000 to 2020 and then to increase by about 13,000 between 2020 and 2030, while Henrico County will grow about 15 percent over the 30-year period for a total increase in population of 41,900. Hanover and Spotsylvania Counties are projected to have the greatest sustained growth over this period with Spotsylvania doubling in population and Hanover increasing by 53,014, about a 60 percent increase in population. Louisa and Orange Counties are projected to grow by 10,587 (41 percent

increase) and 12,723 (49 percent increase), respectively, over the thirty years, with fairly steady growth projected to occur over the entire time period.

Table 5.8-1 VEC Preliminary Local Population Projections, 2000–2030

County	2000	2010	2020	2030	Total Increase
Louisa County	25,627	29,123	32,565	36,214	10,587
Hanover County	86,320	105,934	122,751	139,334	53,014
Spotsylvania County	90,395	124,933	153,032	181,394	90,999
Orange County	25,881	30,414	34,384	38,604	12,723
Henrico County	262,300	271,632	281,059	304,200	41,900
Richmond City	197,790	198,390	199,329	212,337	14,547

If, as assumed, the distribution of the permanent work force would be about the same as the current distribution, then the increase in operating personnel would have a small impact on the infrastructure or social services in the vicinity or in the general region of the ESP site.

The estimated peak workforce of 5000 over a 5-year construction period would have a moderate effect on the transportation network in the vicinity and region. However, permanent mitigation measures to reduce or eliminate this effect would be implemented, as necessary, during, or prior to, construction. These permanent measures would also effectively reduce or eliminate any such impacts during operation because the total operating workforce for the existing and new units is not expected to exceed 1500 workers.

Implementation of the permanent transportation mitigation measures proposed for the construction of the new units would also result in small transportation-related impacts during operation of the new units.

5.8.2.2.1 **Schools and Recreational Areas**

a. **Schools**

As discussed in Section 2.5.2, only Louisa and Orange Counties currently have potential limits to the number of students that could be assimilated by their systems into each grade level if a sudden large influx of families were to relocate into these areas. However, it is reasonable to conclude that the future updates to the County Comprehensive Plans for these counties would include funding for new schools, given the projected increases in their populations. Therefore, an increase of 200 families in Louisa County and about 157 families in Orange County should have a small impact on the school system.

b. **Recreational Areas**

Recreational areas are described in Section 2.5.2. By the year 2020, Louisa County population is projected to increase by about 7,000. Of these, only about 800 would be due to the new employees and their families (i.e., 200 workers and their families) relocating into the county. The numbers of new workers relocating with their families into the counties other than Louisa County or into the City of Richmond would be less than those relocating into Louisa County.

The population increase in the potentially impacted counties other than Louisa County is expected to be equal to or greater than that the increase in Louisa County. To accommodate these increases in population, the surrounding counties would need to address and fund new recreational areas as they update their Comprehensive Plans.

The GEIS concludes that impacts of the existing employees and their families on the parks and other recreational areas within the region are small. This would also apply to the employees of the new units and their families who would relocate to the area because they represent a small fraction of the projected population growth for the area.

5.8.2.2.2 Public Services

Public services addressed include water supply, sewer systems, transportation network, and police, fire and medical facilities. The baseline for these services is provided in Section 2.5.2.

a. **Water and Sewer Systems**

As discussed in Section 2.5.2, water supply would not be a problem for Henrico County, the City of Richmond, Spotsylvania County, or Hanover County, because they currently have sufficient water sources and are expanding their water systems. Except for the towns in Louisa and Orange Counties, groundwater is the source of water for the residents and there is no concern about the availability of such groundwater for future growth in the two counties, as identified in the SEIS.

Sewer systems in the more urbanized counties and the City of Richmond are expected to accommodate their projected population growths. The residents in the more rural counties normally have individual septic systems, which are expected to be able to accommodate the projected population growth. Only a few towns in these rural counties have connections to a sewer system with a publicly-owned treatment works, and these towns are not currently planning major expansions of their sewer systems.

For Louisa County and Orange County, the projected growth in population between 2000 and 2010 is 3,496 and 4,533, respectively; values that greatly exceed the projected number of new employees and their families. These projections for population growth and their possible impacts on the local infrastructure, including water and sewer services, have been incorporated into the comprehensive land use plans for both counties. Although there are

plans to construct new treatment plants or to expand existing facilities in the towns of Louisa County and Orange County, these are not expected to accommodate many new houses. The limited number of sewer and water hookups that will be available would serve to restrict the number of new homes that will be built in the existing towns.

Louisa County is planning for construction of about 300 houses per year for the foreseeable future. New employees who wish to relocate their families to Louisa County should have sufficient new housing in the County. However, because most of this housing would be outside the towns, the relocated families' impacts on these water and sewer systems would be small.

b. **Transportation Network**

Section 4.4.2 discusses a number of permanent changes to the regional and local transportation network that would reduce any potential adverse impacts generated by the influx of 5,000 construction workers during construction of the new units. These permanent changes would also reduce or eliminate any potential adverse impacts that could be generated by the operating workforce of about 720 for the new units who have relocated with their families into the region.

c. **Police, Fire, and Medical Facilities** Section 2.5.2

Section 2.5.2 addresses police, fire, and medical facilities.

The police and fire departments within ten miles of the NAPS site are part of the existing emergency response plan for the existing units. The police departments are responsible for the proper evacuation of the area in the event of an emergency at the NAPS site. This would continue to be the case when the new units become operational.

Medical facilities generally consist of local physicians' offices in the surrounding counties. However, there are major medical facilities in Fredericksburg, Charlottesville, Mechanicsville, and the City of Richmond that are readily accessible to the counties' residents.

A review of the Comprehensive Plans for the counties reveals that the need for additional medical, fire, and police facilities is being assessed. Where the planners assess that the demands of the growth in population would create a need, the intent of the various county plans is to add new facilities or expand existing facilities. The increase of 720 new employees and their families would represent a small fraction of the expected population growth in the vicinity and region around the NAPS site. Therefore, no unforeseen demands would result from the operation of the new units.

5.8.2.3 Impacts on Lake Anna Recreational Area

Lake Anna is a recreational area that attracts year-round residents (including both commuters and retirees) as well as visitors during the summer and early fall months. Any impacts that would reduce the number of visitors in the area due to the operation of the new units could have a socioeconomic impact on the local area.

Section 5.8.1 assesses the relative physical impacts on the environment created by the operation of the new units and concludes that these impacts would be small. Since the types of reactor and ancillary facilities (especially the cooling water system for a second unit) have not yet been selected, there is the potential for an aesthetic impact on the users of Lake Anna. The potential heights of the containment (reactor) building and of cooling towers are larger than the sizes of the existing structures, which have the potential to result in a visual impact. There would also be a visible plume part of the year if a natural draft cooling tower were selected. The cooling system design would take into consideration the need to keep the size of any cooling tower small, to the extent reasonable and practicable. Based on the design selected, a visual impact study would be performed and described in the COL application. The study would assess the physical layout on the site of the reactor and ancillary facilities with respect to the existing facilities that would reduce the potential aesthetic impact of the new units on the users of the lake to the extent reasonable and practicable.

Although not expected to be a major issue, a noise study may be appropriate prior to final selection of the cooling system, if a fan-assisted cooling tower is part of the design for the new units' cooling system. If a noise study determines that the incremental increase in noise created by the operation of the new units is intrusive to continued recreational enjoyment of the lake, then commonly applied mitigation measures would be considered to determine if they are effective in reducing the noise and if they are reasonable and practicable at the ESP site.

5.8.3 Environmental Justice Impacts

This section addresses the potential for disproportionately high and adverse human health or environmental impacts during the operation of the new units on minority or low-income populations who reside within a 50-mile radius of the new units at the ESP site.

5.8.3.1 New Unit(s) at the North Anna Power Station Site

The geographic distribution of minority and low-income populations within 80 km (50 miles) of the NAPS site are those that were determined for Section 2.5.4, that is, for purposes of this section, the distribution of such populations within the region is assumed to remain the same as, or about the same as, that identified in the 2000 Census. The analysis for Section 2.5.4 is based on data from the 2000 Census and applies the following definitions:

A minority population or low-income population exists if either of the following criteria are met:

1. A "minority population" is considered to be present if: 1) the minority population in the census block group or environmental impact site exceeds 50 percent, or 2) the minority population percentage of the environmental impact area is significantly greater (typically at least 20 percentage points) than the minority population percentage in the geographic area chosen for the comparative analysis, for example, the county or State, or

2. A “low-income population” is considered to be present if: 1) the low-income population in the census block group or the environmental impact area exceeds 50 percent, or 2) the percentage of households below the poverty level in an environmental impact area is significantly greater (typically at least 20 percentage points) than the low-income population percentage in the geographic area chosen for the comparative analysis.

As discussed in Section 2.5.4, the census tracts with at least 50 percent of their area within the 80-km (50-mile) distance from the NAPS site were included in the analysis. The distribution of minority and low-income populations is discussed in the text and is graphically presented in Figure 2.5-14 and Figure 2.5-15.

The assessment of the potential for environmental justice impacts associated with the operation of the new units at the ESP site was based on the following information:

- The results of the analyses of the physical impacts of operation presented in Section 5.8.1 and the social and economic impact analyses presented in Section 5.8.2.
- The design basis accident analyses presented in Section 7.1.
- There are relatively few minority and low-income populations in the environmental impact area and none in proximity to the ESP site. The nearest minority or low-income populations are 20 km (about 12 miles) from the ESP site.

Section 5.8.1 identifies no large or moderate physical impacts from the operation of the new units at the ESP site. Therefore, there could be no large or moderate physical impacts on the minority or low-income populations.

Socioeconomic impacts identified in Section 5.8.2 would be beneficial throughout the region. The potential does exist for adverse visual and/or noise impacts related to the size of the new units and associated ancillary equipment. However, these potential adverse social impacts would be small and restricted to the immediate area of the site. Socioeconomic impacts would, therefore, not be an issue at the distance of the nearest minority or low-income populations.

The calculated environmental doses due to radiological impacts from DBAs are analyzed in Section 7.1. The analyses demonstrated that the evaluated dose consequences of such accidents would be within the regulatory limits. These doses are calculated at the EAB and the LPZ using NRC-approved methodology. The EAB is 5000 feet and the LPZ is six miles from the existing units, much closer to the ESP site than the nearest minority or low-income populations.

Given the distances to the nearest minority or low-income populations, the calculated low environmental doses from the DBA analyses at the EAB and LPZ, and the small potential socioeconomic impacts, no disproportionately high or adverse human health or environmental impacts on minority or low-income populations would arise from operation of the new units, alone or in combination with the existing units at the NAPS site.

Section 5.8 References

1. Louisa County Ordinance, Section 51-3, Louisa County, Virginia.

2. Spotsylvania County Ordinance, Section 14-14, Spotsylvania County, Virginia.

3. NUREG-1555, Standard Review Plan for Environmental Reviews for Nuclear Power Plants, U.S. Nuclear Regulatory Commission, October 1999.

4. Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations, U.S. Nuclear Regulatory Commission, Revision 2, July 1976.

5. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 7, Regarding North Anna Power Station, Units 1 and 2, NUREG-1437, U.S. Nuclear Regulatory Commission (SEIS), November 2002.

6. Virginia Employment Commission (VEC) Website, www.vec.state.va.us, accessed on March 28, 2003.

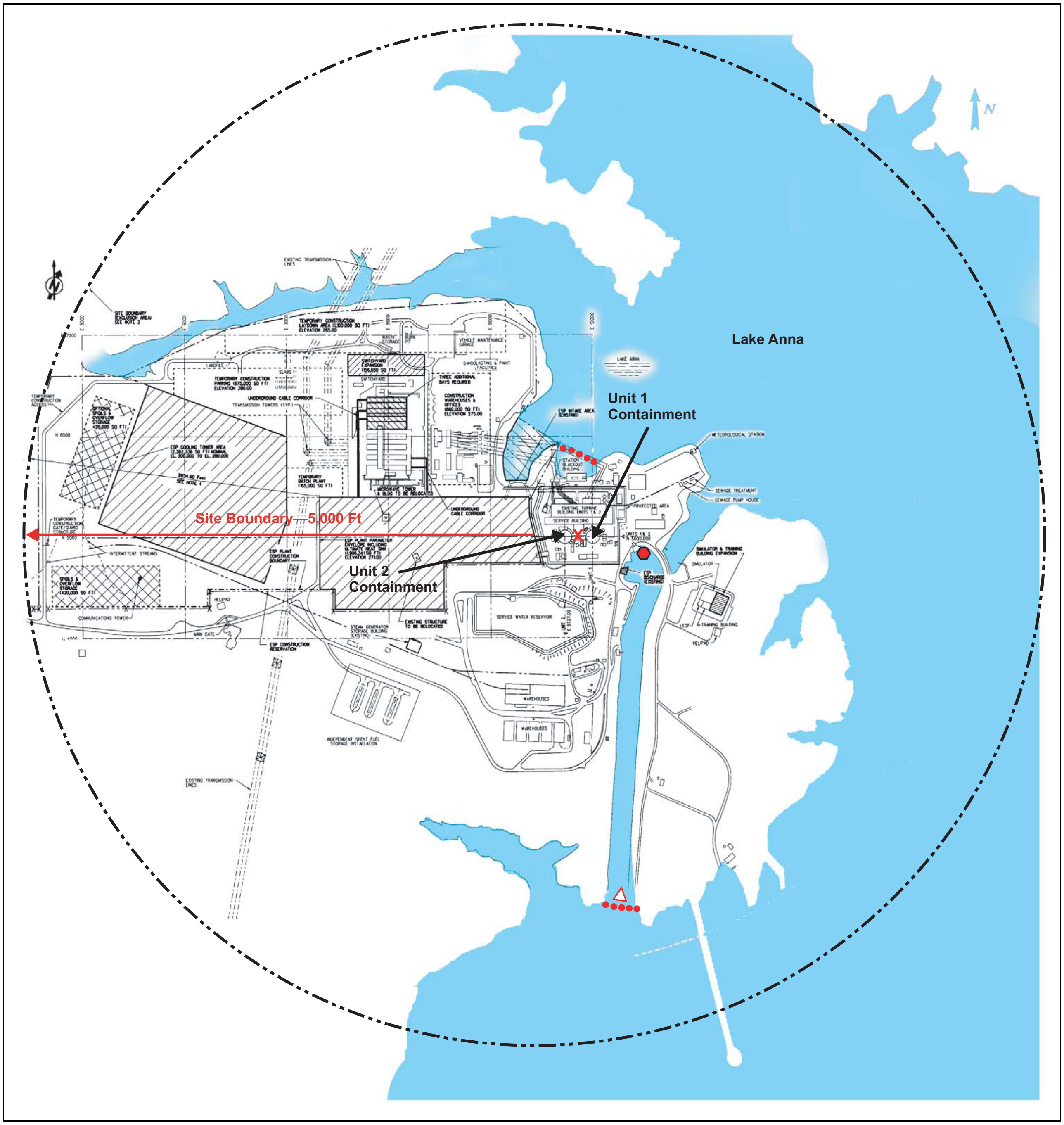

Figure 5.8-1 Site Boundary and Cooling Tower Envelope Area

5.9 Decommissioning

According to Section 5.9 of NUREG-1555 (Reference 1), studies of social and environmental effects of decommissioning large commercial power generating units have not identified any significant impacts beyond those considered in the Final Generic Environmental Impact Statement (GEIS) on decommissioning (Reference 2). The GEIS evaluates the environmental impact of the following three decommissioning methods:

- DECON – The equipment, structures, and portions of the facility and site that contain radioactive contaminants are removed or decontaminated to a level that permits termination of the license shortly after cessation of operations.
- SAFSTOR – The facility is placed in a safe stable condition and maintained in that state until it is subsequently decontaminated and dismantled to levels that permit license termination. During SAFSTOR, a facility is left intact, but the fuel has been removed from the reactor vessel and radioactive liquids have been drained from systems and components and then processed. Radioactive decay occurs during the SAFSTOR period, thus reducing the quantity of contaminated and radioactive material that must be disposed of during the decontamination and dismantlement.
- ENTOMB – This alternative involves encasing radioactive structures, systems, and components in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license.

NRC regulations do not require an ESP applicant to select one of these decommissioning alternatives or to prepare definite plans for decommissioning. These plans are required by 10 CFR 50.82 after a decision has been made to cease operations. General decommissioning environmental impacts are summarized in this section, since detailed plans or a selection of alternatives is not required for an ESP.

Decommissioning of a nuclear facility that has reached the end of its useful life has a positive environmental impact (Reference 2). The major environmental impact, regardless of the specific decommissioning option selected, is the commitment of small amounts of land for waste burial in exchange for the potential re-use of the land where the facility is located (Reference 2).

Dominion would control radiological doses during decommissioning with appropriate work procedures, shielding, and other occupational dose control measures similar to those used during plant operation. Experience with decommissioned power plants has shown that the occupational exposures during the decommissioning period are comparable to those associated with refueling and plant maintenance when it is operational (Reference 2). Each potential decommissioning alternative would have radiological impacts from the transport of materials to their disposal sites. The expected impact from this transportation activity would not be significantly different from normal operations(Reference 1, Section 5.9).

NRC regulations do not require the establishment of decommissioning financial assurances to support an ESP application (Reference 1, Section 5.9). Therefore, this environmental report does not discuss decommissioning financial assurances.

Section 5.9 References

1. NUREG-1555, *Environmental Standard Review Plan*, U.S. Nuclear Regulatory Commission, March 2000.

2. NUREG-0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities,* U.S. Nuclear Regulatory Commission, October 2001.

5.10 Measures and Controls to Limit Adverse Impacts During Operation

This section summarizes the potential adverse impacts, along with the measures and controls to be used to minimize those impacts as identified in Section 5.1 through Section 5.9.

The following measures and controls would be used in limiting adverse environmental impacts:

- Compliance with the applicable federal, Virginia, and local laws, ordinances, and regulations that prevent or minimize environmental impacts (e.g., solid waste management, erosion and sediment control, air emission control, noise control, storm water management, spill response and cleanup, hazardous material management).
- Compliance with applicable requirements of permits and licenses required for operation (e.g., VPDES Permit, Operating License).
- Compliance with Virginia Power procedures applicable to environmental control and management.

The measures and controls presented above would be implemented in concert with the specific measures and controls shown in Table 5.10-1. These measures and controls are considered feasible from both a technical and economic standpoint. In addition, they are expected to be adequate to avoid or mitigate the identified potential adverse impacts associated with operation of the new units.

The columns in Table 5.10-1 listed under the "Potential Impact Significance" are those elements listed in NUREG-1555, Section 5.10, relating to the various issues addressed in the operational impact assessment sections of the Environmental Report (i.e., Sections 5.1 – 5.9). The significance rating (i.e., [S]mall, [M]oderate, or [L]arge) provided for each element in the table has been determined by viewing the potential impact in terms of its significance following implementation of the associated mitigation measures and controls.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b]: Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.1 Land-Use Impacts																
5.1.1 The Site and Vicinity				S		S		S							• The NAPS site is zoned by Louisa County as "industrial." This designation would not change due to operation of the new units. • New water discharges from WHTF may affect recreational use • Potential land use changes due to fogging, icing, and salt disposition from the operation of new cooling towers. Analysis indicates that impacts would be of small significance and limited to areas on or near the ESP site. • Increased traffic loads on existing network from workforce during operations	• Comply with VPDES permit requirements imposed on water discharges from operation of the new units. • No new public roads needed for operation of the new units. Potential increases in traffic would be mitigated through effective traffic management.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b]: Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.1.2 Transmission Corridors and Offsite Areas															• The existing transmission lines and corridors have sufficient capacity for the total output of the existing and new units.	None
5.1.3 Historic Properties														S	• No impacts identified beyond those associated with construction of the proposed new units.	None
5.2 Water-Related Impacts																
5.2.1 Hydrologic Alterations and Plant Water Supply									S						• Reduction in the volume of water available to be released from the North Anna Dam • Reductions in Lake Anna water levels from current values during periods of extended drought	• Practices to minimize the hydrologic alterations may be implemented. • In the COL Application, options to mitigate water use and lake level impacts would be further evaluated including: use of an external source of makeup water supply for the new Unit 4 cooling towers, use of an external source of makeup water supply during critical low flow periods, and the use of a dry cooling tower concept for new Unit 4.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.2.2 Water-Use Impacts									S						• Reduction in the volume of water available to be released from the North Anna Dam • Reductions in Lake Anna water levels from current values during periods of extended drought • Because of the high dilution factor, water-quality impacts of dissolved solids contained in blowdown from the Unit 4 cooling towers would be small.	• In the COL Application, options to mitigate water use and lake level impacts would be further evaluated including: use of an external source of makeup water supply for the new Unit 4 cooling towers, use of an external source of makeup water supply during critical low flow periods, and the use of a dry cooling tower concept for new Unit 4.
5.3.1 Intake System															The cooling water intake system would consist of an intake structure and a dredged channel located in a cove on the south shore of Harris Creek to withdraw water from North Anna Reservoir. The area to be occupied by this intake system, originally planned for the intake of the previously abandoned Units 3 and 4, is adjacent to the cove that houses the intake of the existing units.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.3.1.1 Hydrodynamic Descriptions and Physical Impacts															• Evaluation concludes that the potential for scouring of the lake bottom, erosion of the shoreline, increased turbidity, and increased siltation fromoperation of the new units would be small.	• Stabilizing the banks of the channel to the screen house and pump house would be considered.
5.3.1.2 Aquatic Ecosystems															• Increase in impingement of fish from new water intake system. Increases in impingement by important species would represent only a small percentage of the estimated standing crop in Lake Anna. Any increased impingement would be offset by natural compensation due to a stable, healthy, and diverse fish population.	• The intake structure for the new units at the ESP site would meet Section 316(b) of the Clean Water Act and the implementing regulations, as applicable. • A fish return system based on the latest technology available during detailed engineering would be considered for incorporation into the intake system.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.3.1.2 Aquatic Ecosystems (con't)															• Increase in entrainment of larval fish from new water intake system. Mortality rates for eggs and larval fish of important species in Lake Anna due to natural causes are extremely high. The fishery in Lake Anna has remained stable, healthy, and productive. Any increases in mortality due to entrainment from the additional intake systems would have only a small impact on the Lake Anna fishery.	

Columns Noise through Other (site-specific) are grouped under: Potential Impact Significance [a, b]

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.3.1.2 Aquatic Ecosystems (con't)															• Options to be considered in the COL application to mitigate increased lake temperatures (submerged intake or curtain wall, helper towers, spray cooling systems) would not adversely impact impingement and entrainment.	
5.3.2 Discharge System						S			S		S				Details of the discharge system for the new units are described in Section 3.4.2. The resulting thermal distribution and the potential physical impact on the lake caused by the cooling water discharge are described in Section 5.3.2.1, and the potential impact to the aquatic ecosystems is discussed in Section 5.3.2.2.	
5.3.2.1 Thermal Description and Physical Impacts						S									• Thermal modeling results indicate that the heat load from new Unit 3 would result in a small increase in lake temperature. • Thermal modeling results indicate that if Unit 4 also used once-through cooling, further increase in lake temperatures would result.	• In the COL application, options to mitigate increases in lake temperature would be evaluated including submerged intake or curtain wall, helper towers, and spray cooling systems in the WHTF discharge canal.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.3.2.1 Thermal Description and Physical Impacts (con't)															• Assuming new Unit 3 on once-through cooling and new Unit 4 on a closed cycle cooling system, there are no expected impacts such as scouring of the lakebed or erosion of the shoreline at the current discharge point (i.e., Dike 3) from operation of the existing units in combination with the new units. No mitigation measures or control are proposed beyond overall cooling system design. • Evaluation concludes that the potential for scouring of the lake bottom, erosion of the shoreline, increased turbidity, and increased siltation from operation of the new units would be small.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.3.2.2 Aquatic Ecosystems						S			S		S				• Potential impact from scouring and sediment transport due to increased water discharge flows.	• If needed, adjust baffles at Dike 3 to accommodate increased volume and maintain acceptable discharge velocity, limiting scouring and sediment transport. • Maintain compliance with VPDES water quality standards and permitted discharge limits for cooling water discharges to the North Anna Reservoir.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.3.2.2 Aquatic Ecosystems (con't)															• Thermal modeling indicates that the addition of new units would have a small impact on the overall fish population in Lake Anna. Striped bass are the most thermally-sensitive species in the lake and could be expected to move away from any increased temperatures to deeper water or stream/spring-fed inlets. Sudden changes in discharge temperature are typically minimal with a nuclear power facility since units do not come on and off-line regularly. This limits the potential for heat or cold shock to fish.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b]: Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.3.2.2 Aquatic Ecosystems (con't)															• Increased thermal discharge could have a small positive impact on reducing the presence and/or density of the nuisance Asiatic clam.	
5.3.3 Heat-Discharge System															N/A	
5.3.3.1 Heat Dissipation to the Atmosphere			S							S		S			• Potential visual impact of plume downwind of cooling towers and ground level fogging and icing. • Potential visibility impacts at nearby airport • Salt deposition rates would be less than 1 kg/ha/mo at offsite locations. • Impact from shadowing and increased precipitation would be localized to the NAPS site. The site does not contain sensitive vegetation.	• Mechanical draft cooling towers would include plume abatement technology, thereby reducing both the visual impact and the local potential for fogging and icing. Installation of a natural draft tower would elevate plume and reduce fogging and icing at the ground level.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.3.3.1 Heat Dissipation to the Atmosphere (con't)															• Other permitted air emission sources at the existing units (e.g., standby diesel generators and auxiliary power systems) are used for testing and emergencies only. Therefore interactions with plume would be very limited.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.3.3.2 Terrestial Ecosystems	S		S	S		S				S		S		S	• Salt deposition rates near the cooling towers would be below thresholds considered damaging to plants. Deposition rates would be less than 1 kg/ha/mo at offsite locations. • Impact from shadowing and increased precipitation would be localized to the NAPS site. The site does not contain important species. • Predicted noise from heat dissipation system would be similar to or less than NAPS site current operating levels. • Potential for avian collisions with cooling towers would be small.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.3.4 Impacts to Members of the Public	S				S	S	S		S		S				• Thermal effluent discharge from the cooling systems would not significantly alter the temperature regime in Lake Anna. Assessed temperature increases would remain too low to support thermophilic micro-organisms in the WHTF or alter the recreational uses of Lake Anna. • The recently upgraded on-site sewage treatment plant at the NAPS site includes disinfection to reduce coliform bacteria and other micro-organism to levels that meet Virginia water quality standards.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.3.4 Impacts to Members of the Public (con't)															• Small potential for offsite noise impacts from cooling system operation. Modeled peak noise levels from operation of the composite cooling system would be below threshold levels.	
5.4 Radiological Impacts of Normal Operation																
5.4.1 Exposure Pathways			S			S	S	S	S	S	S	S	S		• Potential for small discharges of radioactive liquids and gases to the environment. • Direct dose contribution from the new units would be negligible.	• Sources of radiation at the new units would be contained similar to the existing units.
5.4.2 Radiation Doses to Members of the Public													S		See Section 5.4.3 for discussion of impacts to members of the public.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference		**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Feasible and Adequate Measures/Controls**
5.4.3	Impacts to Members of the Public													S		• Potential doses to the public from liquid radwaste effluent releases to the discharge canal and WHTF and gaseous pathway releases. Calculated doses to public through liquid and gaseous pathways are within the design objectives of 10 CFR 50 Appendix I and within regulatory limits of 40 CFR 190.	None
5.4.4	Impacts to Biota Other than Members of the Public													S		• Potential doses to biota from liquid and gaseous effluents. Although there are no acceptance criteria specifically for biota, there is no scientific evidence that chronic dose rates below 100 mrad/day are harmful to plants and animals. The biota doses are all less than 1 mrad/day.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

		Potential Impact Significance [a, b]															
Section Reference		**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Feasible and Adequate Measures/Controls**
5.5	Environmental Impact of Waste																
5.5.1	Nonradioac-tive-Waste-System Impacts			S		S	S			S		S				• Increased volume of discharged effluent. • Increased chemicals and other pollutants in the discharge effluent. • Increased storm water discharge • Increase in total volume of solid waste generated. • Potential increase in gaseous and particulate emissions. • Increase in total volume of sanitary waste generated.	• Water availability issues regarding the North Anna River are addressed via regulated releases from the North Anna Dam. • Comply with applicable VPDES water quality standards for any discharge from Dike 3. • Prepare and implement a new operational Storm Water Pollution Prevention Plan to avoid and/or minimize releases of contaminated storm water. • Use approved transporters and offsite landfills for disposal of solid waste. Continue existing units' program for reuse and recycling of nonradwastes. • Cooling towers would include drift elimination system to reduce drift. Operate any new minor air emission sources in accordance with applicable regulations and permits. • Modify (if necessary) existing sanitary waste treatment systems to accommodate increased volume.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b]														Impact Description or Activity	Feasible and Adequate Measures/Controls
	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)		
5.5.2 Mixed Waste Impacts					S	S	S		S				S	S	• Expected annual generation of between 15–30 cubic feet of mixed liquid waste and 5–10 cubic feet of mixed solid waste. • Potential chemical hazardous and occupational exposure to radiological materials during handling and storage onsite. • Potential exposures to onsite workers and emergency response personnel during accidental releases and cleanup activities.	• Limit need to manage and dispose of mixed waste through: 1) source reduction; 2) recycling options; 3) treatment. • Develop a Waste Minimization Program, to address mixed waste inventory management; equipment maintenance; recycling and reuse; segregation; treatment (decay in storage); work planning; waste tracking; and awareness training. • Implement a program to manage wastes stored onsite in compliance with applicable EPA and NRC regulatory requirements. • Implement spill prevention and response plans and procedures to address hazards associated with managing mixed wastes. Include in plans and procedures measures for response personnel training and protective equipment.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference		Potential Impact Significance [a, b] Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.6	Transmission System Impacts																
5.6.1	Terrestial Ecosystems	S		S							S					• Air emissions and nuisance noise from use of helicopter to maintain transmission corridors. Virginia Power's current maintenance activities for the transmission corridors are infrequent and limited to the localized areas of the corridor. No new maintenance practices are expected for the new units.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b]: Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.6.2 Aquatic Ecosystems											S				• Potential impacts to mussel species from maintenance of transmission corridors. Although some mussel species occur in Louisa County, there are no confirmed accounts of mussels in watercourses crossed by existing transmission lines. There are no mitigation measures since there are no planned changes to transmission corridor maintenance practices for the proposed new units.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.6.3 Impacts to Members of the Public	S													S	Based on an initial evaluation, the existing transmission lines and corridors have sufficient capacity for the total output of the existing and new units. Mitigation of potential impacts from electric shock, EMF exposure, noise, or visual impacts would be unchanged.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

		Potential Impact Significance [a, b]															
Section Reference		Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.7	Uranium Fuel Cycle Impacts																
5.7	Uranium Fuel Cycle Impacts (i.e., relative to the reference LWR)			S			S							S		• Yellowcake production and uranium conversion impacts such as energy required, emissions, and water. • Air emissions from fossil fuel plants supplying the gaseous diffusion plant. • Production of UO_2 during fuel fabrication • Radioactive waste management from operations, and decontamination and decommissioning.	• Select mining techniques that minimize potential impacts. • Consider use of new technology that requires less uranium hexafluoride. • Consider use of centrifuge process over gaseous diffusion process, which can significantly reduce energy requirements and environmental impacts. • Consider use of new technologies with less fuel loading to reduce energy, emissions and water usage. Projected impacts of TRISO fuel plant would be less than existing air, water, and solid waste regulations. • Consider use of new gas-cooled reactor technologies that can result in generation of far less low-level wastes.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference		Potential Impact Significance [a, b]: Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.8	Socioeconomic Impacts																
5.8.1	Physical Impacts of Station Operation	S		S	S				S						M	• Noise associated with cooling towers would be below level considered nuisance to public at the nearest residence. Conduct noise study prior to final selection of cooling system. • Potential impacts from air emissions associated with diesel generators and auxiliary power systems • Potential impacts from fogging and icing • Potential visual impacts to surrounding areas due to new buildings and cooling towers and cooling tower plumes	• Comply with applicable VDEQ permit limits and regulations when installing and operating air emission sources. • Fogging and icing impacts would be mitigated through use of drift eliminators on towers. • Install plume abatement system to reduce plume visibility. Natural draft cooling towers, if used, would pose a moderate visual impact to surrounding areas near the NAPS site. Conduct visual impact study during final plant design.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.8.1 Physical Impacts of Station Operation (con't)															• Local roads would experience increased operations traffic but have sufficient capacity without implementation of additional mitigation measures or controls.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Feasible and Adequate Measures/Controls**
5.8.2 Social and Economic Impacts of Station Operation												S		S	• Increase need for community services up to 2900 persons. Overall impact to services in the surrounding counties would be small. Predicted workforce is a small fraction of the total projected population growth in the region. • Revenue from sales and use taxes would be beneficial to Louisa County. • Property taxes paid by new workers in the region would be beneficial but small relative to those already obtained from the regional population. • Potential aesthetic impacts (e.g., visual, noise) to residences and recreational users of Lake Anna	• Perform visual impact study as part of final plant design to identify and minimize visual impacts. • Perform noise study prior to final selection of cooling system to assess potential impacts to residents and recreation users of Lake Anna.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference		Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
		Potential Impact Significance [a, b]															
5.8.3	Environmental Justice Impacts															• No disproportionatly high impacts on minority or low-income populations resulting from operation of the proposed new units.	None
5.9	Decommissioning																
5.9	Decommissioning															• Potential radiation exposure related to decommissioning, including transportation of materials to disposal sites. • Decommissioning methods are expected to produce impacts equivalent to operations.	• The significance of the impacts is unknown because the decommissioning methods have not been chosen. No mitigation measures or controls are proposed at this time.

a. The assigned significance levels [(S)mall, (M)oderate, or (L)arge are based on the assumption that for each impact, the associated proposed mitigation measures and controls (or equivalents) would be implemented.

b. A blank in the elements column denotes “no impact” on that specific element due to the assessed impacts.

Chapter 6 Environmental Measurements and Monitoring Programs

This chapter describes the environmental measurement and monitoring programs for the new units. Some of the programs at the existing units would constitute the primary monitoring efforts that would be relied on if a decision to add additional capacity at the ESP site was made.

The discussion of environmental measurements and monitoring programs is divided into the following sections:

- Thermal Monitoring (Section 6.1)
- Radiological Monitoring (Section 6.2)
- Hydrological Monitoring (Section 6.3)
- Meteorological Monitoring (Section 6.4)
- Ecological Monitoring (Section 6.5)
- Chemical Monitoring (Section 6.6)
- Summary of Monitoring Programs (Section 6.7)

Monitoring details (e.g., sampling equipment, constituents, parameters, frequency, and locations) for each specific phase of the overall program are described in each of these sections.

6.1 Thermal Monitoring

This section describes the thermal monitoring program that would be implemented to monitor the effects of new units at the ESP site.

6.1.1 Existing Thermal Monitoring Program

Thermal monitoring is currently being conducted in Lake Anna in accordance with VPDES permit number VA-0052451, which was established by VDEQ for the existing units (Reference 1). The permit limits the total maximum rejected heat load from the existing units to 1.354×10^{10} BTU per hour and requires reporting of the daily rejected heat, measured as a percentage of the combined rated power level. The permit also prescribes a thermal monitoring program that consists of taking two sets of water temperature measurements in the cooling lake system: a) continuous water temperature monitoring; and b) water temperature profiling (thermal plume survey). The temperature monitoring program is described in more detail below.

Fixed water temperature recorders continuously record water temperatures at 11 locations: 10 in the North Anna Reservoir and WHTF areas, and one in the North Anna River downstream of the dam (Table 6.1-1 and Figure 6.1-1) (Reference 1). Temperature measurements at all stations, except NALST10, are taken near the water surface. At station NALST10, the water temperature measurement is taken at 3 m below the water surface. Temperature readings are reported in

degrees Celsius in accordance with the VPDES permit on the following basis: 1) monthly maximum daily temperature, and 2) monthly mean of daily high, daily mean, and daily low.

During water temperature profiling, water temperatures are recorded during daylight hours from the surface to the bottom at one-meter intervals at Stations A to N (Figure 6.1-2) (Reference 1). The temperature profiling is conducted during at least two quarters per year, such that one measurement quarter is always during the July-to-September quarter, and the remaining quarter is alternated every year.

6.1.2 Pre-Application, Pre-Operational, and Operational Thermal Monitoring

The current thermal monitoring plan has provided sufficient thermal data to establish baseline conditions prior to any construction. This program would be continued for pre-operational monitoring of the new units (while under construction) to establish a baseline for identifying and assessing the environmental impacts resulting from operation of the new units. The same program would be used for operational monitoring of the new units to establish resulting changes in water temperature.

Because additional heat load would be discharged to the WHTF and the North Anna Reservoir, a new or amended VPDES permit would be necessary for the future combined operation of the existing units and the new units.

Section 6.1 References

1. VPDES Permit No. VA 0052451, *Authorization to Discharge Under the Virginia Pollutant Discharge Elimination System and The Virginia State Water Control Law*, Commonwealth of Virginia, Department of Environmental Quality, January 11, 2001.

Table 6.1-1 Water Temperature Recorder Station Locations

Station	Site Description	Monitoring Depth
NALST10	Lake Anna: Mid-level in Lake in the flow through Lake Anna Dike 3	At 3 m water depth
NALBRPT	Lake Anna: near Burruss Point	Surface
NALTHIS	Lake Anna: near Thurman Island	Surface
NALIN	Lake Anna: at North Station intakes	Surface
NAL208	Lake Anna: Route. 208 Bridge	Surface
NADISC1	At end of station discharge in Lagoon (Pond) 1	Surface
NAWHTF2	Lagoon (Pond) 2	Surface
NAWHTF3	Lagoon (Pond) 3	Surface
NAL719S	North Anna River arm of Lake Anna at Route 719 bridge	Surface
NAL719N	Pamunkey Creek arm of Lake Anna at Route 719 bridge	Surface
NARIV601	Route 601 crossing	Surface

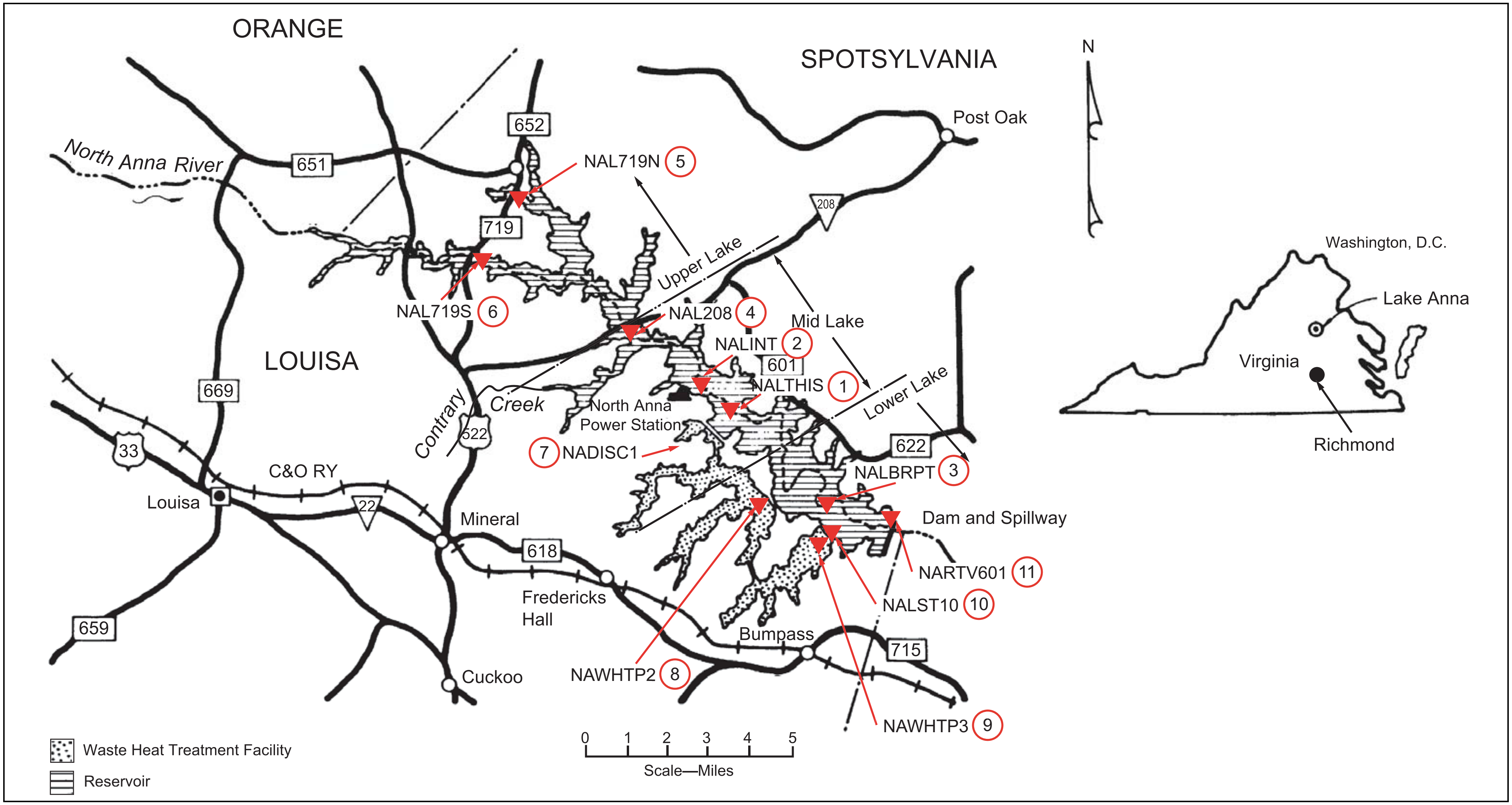

Figure 6.1-1 Locations of Water Temperature Monitoring Stations

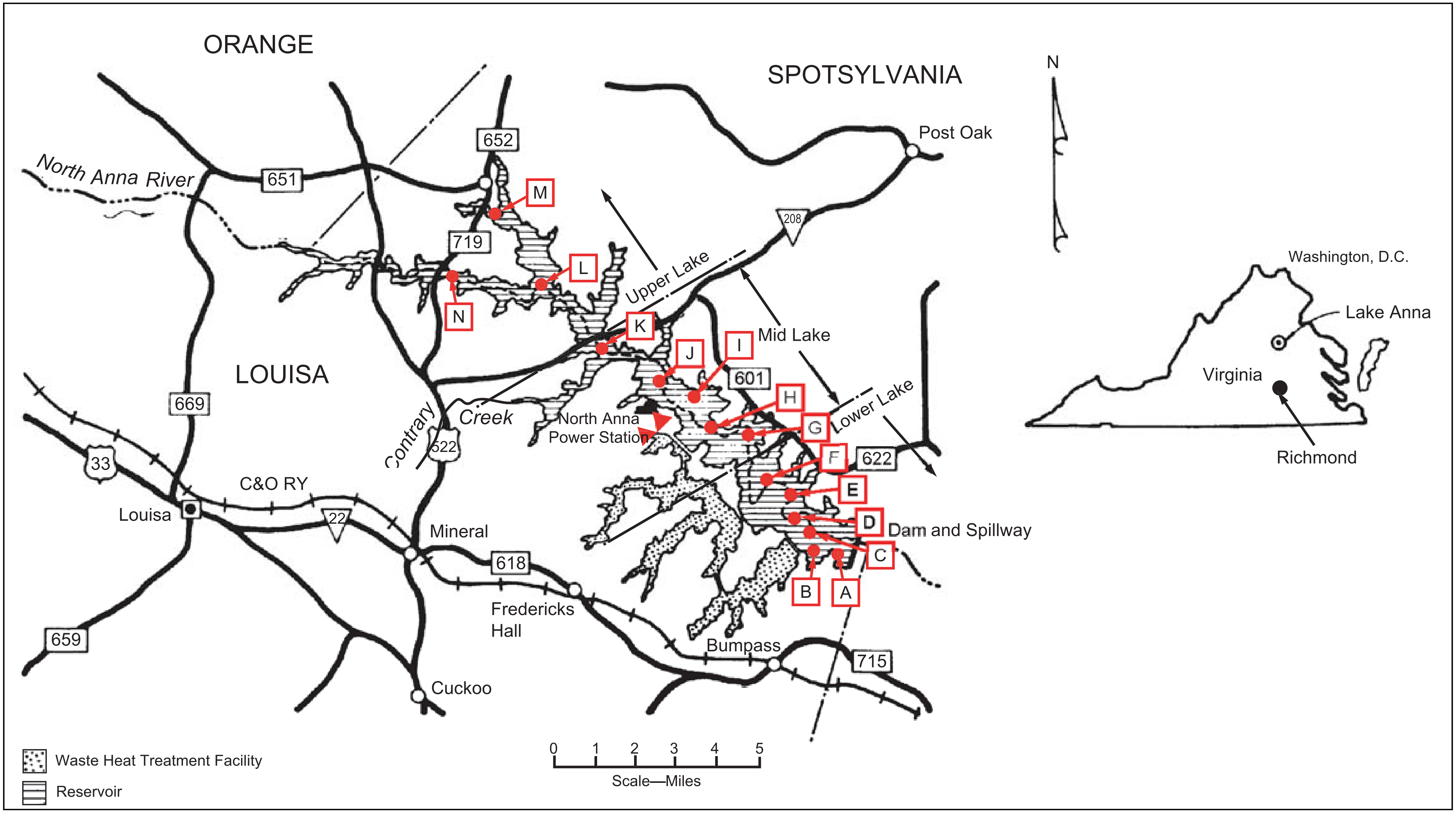

Figure 6.1-2 Temperature Profiling Stations A Through N

6.2 Radiological Monitoring

This section presents the basis, contents, reporting, and quality assurance of the ESP site Radiological Environmental Monitoring Program.

6.2.1 Radiological Environmental Monitoring Program Basis

The Radiological Environmental Monitoring Program (REMP) for the ESP site would be based on NUREG-0472 Revision 3 (Reference 1) and the NRC's Branch Technical Position Paper, *Acceptable Radiological Environmental Monitoring Program*, Revision 1 (Reference 2). The structure of the ESP site REMP would be based on the necessary components of the monitoring program established for the existing units, which encompasses the entire NAPS site and would be expanded to include radiological environmental monitoring for the new units. This expanded REMP would continue to be in accordance with the existing units' Technical Specifications and is described in the NAPS UFSAR Section 11.6 (Reference 2). It would be implemented through the existing units' Offsite Dose Calculation Manual (ODCM), and via administrative and technical procedures.

6.2.2 Radiological Environmental Monitoring Program Contents

The pre-operational and operational radiological monitoring program incorporates measurements to evaluate the possible effects from plant operation and to ensure that changes in environmental radioactivity can be detected. Pre-operational data provided a baseline for the existing units and the current REMP data would provide a baseline for the new units. The measurement of radiation levels, concentrations (including surface area), and/or other quantities of radioactive material, are used to evaluate potential exposures and doses to members of the public and the environment.

The following exposure pathways to radiation would be monitored.

- Direct (including dosimeters)
- Airborne (including iodine and particulates)
- Waterborne (including ground and precipitation)
- Aquatic (including tissue analysis)
- Ingestion (including milk and crops)
- Vegetation (including soil)

Sampling results and locations can be evaluated to determine effects from seasonal yields and variations. Figure 6.2-1 shows existing sampling locations for the REMP which would apply for the ESP site and expanded program. Table 6.2-1 provides details of the radiation exposure pathways monitored and the monitoring frequencies for those pathways. Sensitivity analyses provide information regarding changes in background levels and determine the adequacy of analysis techniques in light of program results and changes in technology, when compared to baseline

measurements. Changes in program implementation (including sampling techniques, frequencies and locations) may be added in response to monitoring results.

6.2.3 **Radiological Environmental Monitoring Program Reporting**

An annual Radiological Environmental Operating Report for the NAPS site would be written and submitted in accordance with the existing units Technical Specifications. Results from REMP implementation and evaluation would be compared to the previous years' results for measurement trends, methodology consistency, and indications that program changes are needed.

An Inter-laboratory Comparison Program exists to verify correctness of vendor results of samples sent for their analysis of radioactive materials. These results would be reported in an Annual Radiological Environmental Monitoring Report.

A land use census would be conducted within a designated distance of the NAPS site, currently 5 miles, to determine sampling yields and locations, and to ascertain if changes to the Radiological Environmental Monitoring Program are warranted. Parameters that have been reported include locations of nearest residence, milk production yield, and broad leaf vegetation.

6.2.4 **Quality Assurance Program**

Quality assurance is provided in the existing NRC-approved Radiological Environmental Monitoring Program through quality training, program implementation by periodic tests, the Inter-laboratory Comparison Program, and administrative and technical procedures. In addition, the existing units' Technical Specifications direct an audit of the REMP and its results under cognizance of the offsite Management Safety Review Committee.

Quality and credibility in the ESP Radiological Environmental Monitoring Program would be consistent with existing program components, regulatory guidance, and best management practices.

Section 6.2 References

1. NUREG-0472, Revision 3, *Standard Radiological Effluent Technical Specifications for Pressurized Water Reactors*, U.S. Nuclear Regulatory Commission, January 1983.

2. Branch Technical Position Paper, Revision 1, *Acceptable Radiological Environmental Monitoring Program*, U.S. Nuclear Regulatory Commission, November 1979.

3. Updated Final Safety Analysis Report, North Anna Power Station, Units 1 and 2, Revision 38.

Table 6.2-1 Radiation Pathway Monitoring

Radiation Exposure Pathways Monitored	Parameters	Frequency
Direct	Radiation Levels	Quarterly
Airborne, including Gaseous, Particulate, and Iodine	Radiation Levels Concentrations Radioactive Material Quantities	Continuous Weekly Quarterly
Waterborne, including Surface, Ground, and Sediment	Concentrations Radioactive Material Quantities	Monthly, Quarterly, Semi-annually
Ingestion, including Milk, Aquatic, Vegetation, and Food products	Concentrations Radioactive Material Quantities	Monthly Semi-annually

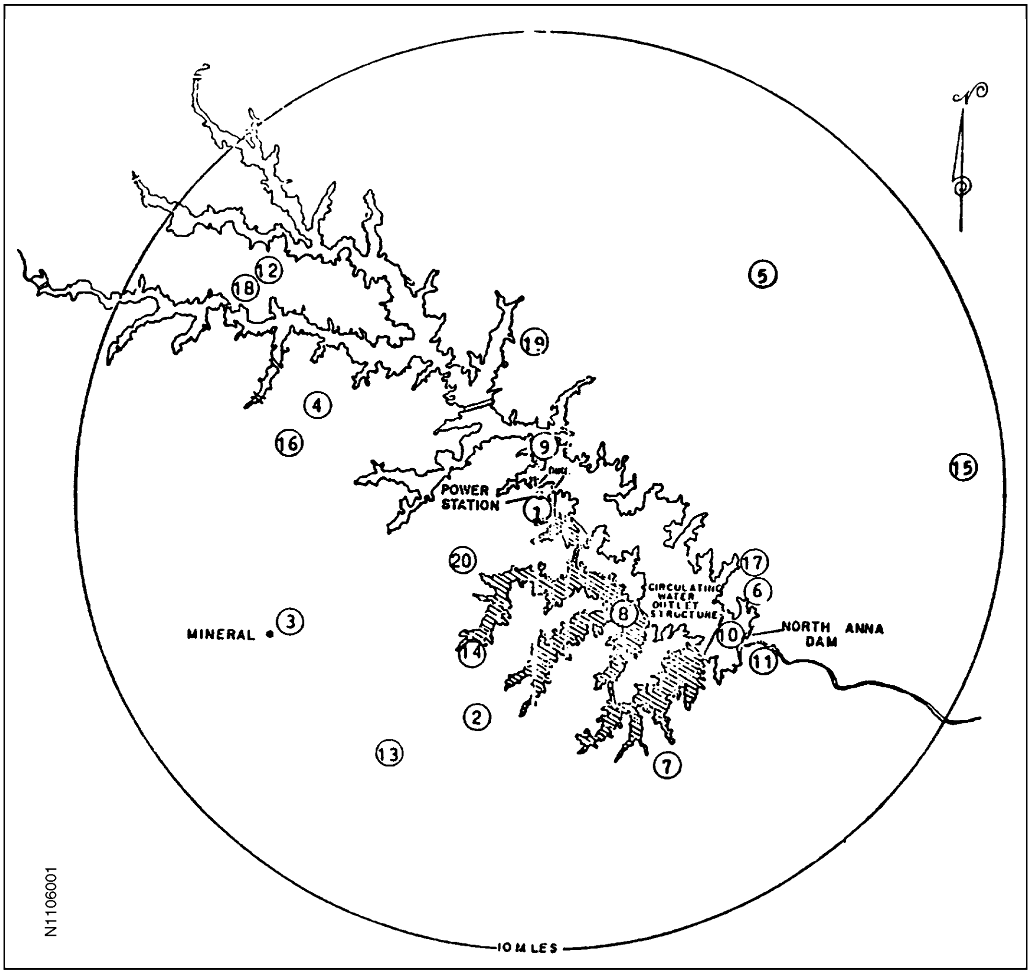

Figure 6.2-1 Preoperational Radiological Environmental Sampling Program Sample Station Locations

6.3 Hydrological Monitoring

This section discusses the hydrological monitoring program that would be implemented to monitor the effects of the new units at the ESP site, including monitoring of flow rates, water levels, sediment loads, and groundwater levels.

6.3.1 Existing Hydrological Monitoring

Presently, Virginia Power conducts hydrological monitoring in accordance with VPDES Permit No. VA0052451 (Reference 1). The hydrological measurements required by this permit are shown in Table 6.3-1. In addition to the flow measurements required for the VPDES permit, hourly lake water level readings are recorded at the North Anna Dam for use in regulating outflow from the dam.

Groundwater levels are the subject of an ongoing monitoring program at the ESP site. Nine groundwater observation wells were installed at the ESP site during November and December 2002 to determine groundwater levels, flow paths, and gradients. Tests were performed in these wells to determine the permeability of the subsurface materials. These wells, together with nine existing monitoring wells around the SWR for the existing units and one monitoring well at the ISFSI, are being used to measure groundwater levels on a quarterly basis to observe seasonal variations. Wells around the existing SWR are monitored every six months to evaluate the reservoir for leakage, assess the effectiveness of horizontal drains beneath the existing units pump house, and determine the flow rate and clarity of the associated discharge water.

6.3.2 Construction and Pre-Operational Monitoring

The VPDES Permit monitoring and lake water level monitoring would continue through the construction phase and prior to operation of the new units. This monitoring, in addition to the groundwater monitoring currently ongoing, would establish the baseline hydrological conditions for both Lake Anna and groundwater near the ESP site. Although no significant impacts to Lake Anna or groundwater aquifers are anticipated during construction, continual monitoring, as described in Section 6.3.1, would provide a means of detecting any unanticipated changes should they occur.

Also, prior to construction of the new units, an approved Erosion and Sediment Control Plan would be developed and implemented in accordance with state and local regulations (Reference 2). The Erosion and Sediment Control Plan would require periodic visual inspection of erosion and sediment control best management practices that have been implemented. If erosion or sediment deposition is discovered outside the defined limits of disturbance, measures would be implemented to correct the problem. Additionally, any hydrological monitoring required in conjunction with permits associated with construction of the circulating water intake structure or removal of the existing coffer dam at the intake location would be implemented via a specific construction monitoring plan, if necessary.

6.3.3 **Operational Monitoring**

An operational monitoring program would be developed in coordination with the VDEQ to establish a new or amended VPDES discharge permit. Since the permitted site is a nuclear power station, it is anticipated that the monitoring requirements of the new/amended permit would be similar to the existing permit. Monitoring of the Lake Anna water levels at North Anna Dam would continue during plant operation.

The NAPS site groundwater use is currently less than 100 gpm, and it is not expected to increase significantly after the addition of the new units. No changes to existing groundwater monitoring programs would be necessary.

Section 6.3 References

1. VPDES Permit No. VA0052451, *Authorization to Discharge Under the Virginia Pollutant Discharge Elimination System and The Virginia State Water Control Act, Effective January 11, 2002, Expiration January 11, 2006*, Department of Environmental Quality, Commonwealth of Virginia.

2. Virginia Erosion and Sediment Control Handbook, 3rd Edition, Division of Soil and Water Conservation, Virginia Department of Conservation, 1992.

Table 6.3-1 VPDES Hydrological Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
001 - Discharge of Condenser Cooling Water from Heat Treatment Facility at Dike 3	Flow (mgd)	1/month	Calculated
103 - Process Waste Clarifier	Flow (mgd)	2/month	Estimate
104 - Oil Water Separator and Storm Water	Flow (mgd)	2/month	Estimate
105 - Bearing Cooling Tower Blowdown	Flow (mgd)	1/month	Estimate
107 - Bearing Cooling Tower System Discharge-Lake to Lake Operation	Flow (mgd)	1/month	Estimate
108 - Service Water Overflow	Flow (mgd)	1/month	Estimate
109 & 110 - Hot Well Drains	Flow (mgd)	1/month	Estimate
111 - Sewage	Flow (mgd)	1/day	Estimate
112 & 113 - Steam Generator Blowdown Units 1 & 2	Flow (mgd)	1/month	Estimate
114 - Service Water Pipe Vault Drain	Flow (mgd)	1/month	Estimate
115 - Service Water System Blowdown	Flow (mgd)	1/month	Estimate
009 - Ground Water, Storm Water, Backwash from Sand Filters and RO Units	Flow (mgd)	1/month	Estimate
013 - Turbine Building Sump #1 and Storm Water	Flow (mgd)	1/month	Estimate
014 - Turbine Building Sump #2 and Storm Water	Flow (mgd)	1/month	Estimate
016 - Intake Screen Wash Water	Flow (mgd)	1/year	Estimate
020 - RO Reject	Flow (mgd)	2/month	Estimate
021 - RO Drain Line	Flow (mgd)	1/month	Estimate
022 – 026 - Storm Water Outfalls	Flow	1/storm event	Estimate

Data Source: Reference 1

6.4 Meteorological Monitoring

6.4.1 General Description – Onsite Meteorological Monitoring Program

Dominion plans to use the existing NAPS meteorological monitoring program for the ESP site. The existing program is described in the NAPS UFSAR, Section 2.3 (Reference 1). The existing program is suited for the ESP-required onsite meteorological measurements because the ESP site is adjacent to the existing units within the existing NAPS site. Additionally, the ESP site is relatively flat and free of elevated terrain features that generate complex airflows. Therefore, the airflow patterns throughout the site area would be similar.

The current onsite NAPS meteorological measurements program conforms to the requirements of 10 CFR 50.47 (Reference 2) and the guidance criteria set forth in NUREG-0696 (Reference 3), NUREG-0737 (Reference 4), NUREG-0654, Appendix 2 (Reference 5), Section C.4 of RG 1.111 (Reference 6), RG 1.21 (Reference 7), and RG 1.23 (Reference 10). System accuracy conforms to RG 1.23, Proposed Revision 1 (Reference 8).

The meteorological program has the following basic functions:

- Collecting meteorological data
- Generating real-time predictions of atmospheric effluent transport and diffusion
- Providing the appropriate organizations access (remote interrogation) to the atmospheric measurements and predictions

Meteorological measurements are available from both a primary tower and a backup tower, as required in 10 CFR 50, Appendix E (Reference 9). The backup system is designed to function even when the primary system is out of service, thus providing assurance that basic meteorological information would be available during and immediately following an accidental airborne radioactivity release.

Descriptions of the onsite meteorological monitoring program are from the NAPS UFSAR, unless otherwise indicated. The primary meteorological monitoring site at the NAPS site consists of a Rohn Model 80, guyed, 160-ft (48.8-m) tower approximately 1900 ft (580 m) east of the Unit 1 containment building. Sensors are located at the 32.8-ft (10-m) level, the 158.9-ft (48.4-m) level, and ground level. Wind speed, wind direction, horizontal wind direction fluctuation, ambient temperature, one-half of differential temperature, and dew point temperature are measured at the 10-m elevation. Wind speed, wind direction, horizontal wind direction fluctuation, and one-half of the differential temperature are measured at the 48.4-m elevation. Precipitation is monitored at the ground level. Signal cables are routed through conduit from each location into the instrument shelter at the base of the tower. Inside the shelter, the signals are routed to the appropriate signal-conditioning equipment. The equipment outputs are directed to digital data recorders and to an interface with the intelligent remote multiplex system.

The backup meteorological monitoring site consists of a Rohn Model 25, freestanding 32.8-ft (10-m) tower. This tower is approximately 1300 ft (396 m) northeast of the Unit 1 containment building. A sensor at the top of the mast monitors wind speed, wind direction, and horizontal wind direction fluctuation. The signal path, instrument shelter and data recording are similar to those at the primary tower. All parameters are interfaced to the intelligent remote multiplexing system.

Because of the proximity of the ESP site to the existing units, meteorological parameters collected at the onsite primary and backup towers are representative of the dispersion conditions at the ESP site.

6.4.1.1 Location, Elevation, and Exposure of Instruments

The location of the primary meteorological tower is shown on the topographical map, Figure 2.7-1. Distances and bearings to ground features in the vicinity of the tower are shown on Figure 2.7-2. Onsite structures have been evaluated as having no adverse structural influence on the measurements taken at the tower. Trees in the immediate vicinity of the tower have been topped to heights of 10-15 ft (3-4.6 m). The nearest contiguous tree line is more than 500 ft (152 m) away from the tower and those tree heights are 40 to 50 ft (12 to 15 m).

Ground cover at the location is native grasses. Comparable cover is maintained at the base of the tower.

The PPE shows that the highest structure for new units at the ESP site would not be more than 234 ft (71.3 m) above grade level. Both the existing primary and backup towers are located more than 10 building heights away from the tallest expected structure within the ESP site plant envelope area. Therefore, these structures would not have any influence on the meteorological measurements.

6.4.1.2 Wind System

The wind sensors at both towers are positioned such that the tower does not influence the prevailing south-southwest wind flow detected by the sensors. The wind speed, wind direction, and horizontal wind direction fluctuation sensors are mounted on booms longer than the tower face width. Wind speed, wind direction, and horizontal wind direction fluctuation are measured at both the lower and upper tower levels. Electro-mechanical instruments are used to measure wind speed and wind direction. Horizontal wind direction fluctuation is calculated by the digital data acquisition system.

For the primary meteorological monitoring site, wind speed, wind direction, and horizontal wind direction fluctuation are measured at the 32.8-ft (10-m) level and at the 158.9-ft (48.4-m) level. The wind speeds are recorded with an accuracy of ±0.22 m/s (0.5 mph) for speeds less than 11.13 m/s (25 mph), with a starting threshold of less than 0.45 m/s (1 mph). The wind direction is measured with an accuracy of at least ±5 degrees of azimuth with a starting threshold of less than 0.45 m/s

(1.0 mph). Wind speed accuracy, wind direction, and starting threshold values conform to the guidance of RG 1.23, Proposed Revision 1.

The backup meteorological monitoring sensor at the top of the mast monitors wind speed, wind direction, and horizontal wind direction fluctuation to the same accuracy as the primary monitoring system.

6.4.1.3 **Temperature Systems**

At the primary meteorological monitoring site, temperature is measured at the 32.8-ft (10-m) level and differential temperature is measured between the 32.8-ft (10-m) and 158.9-ft (48.4-m) levels. The system consists of two temperature sensors. One single-element, high-precision, platinum resistance temperature sensor located at the 158.9-ft (48.4-m) level measures temperature in support of the differential temperature calculation. The other single-element, precision, platinum resistance sensor located at 32.8-ft (10-m) level measures ambient temperature and provides input to the differential temperature calculation. The sensors' signals are input into a temperature/delta temperature processor to provide output signals proportional to one ambient and one differential (ΔT) temperature. The temperature sensors record the data with an accuracy of at least ±0.5°C (0.9°F). The temperature difference is recorded with an accuracy of at least ±0.15°C (0.27°F) per 164 ft (50-m) height interval. These accuracy levels meet the guidance presented in RG 1.23, Proposed Revision 1.

Temperature and differential temperature sensors are housed in motor-aspirated shields to insulate them from thermal radiation. These shields support temperature measurement, which have less than 0.2°F (0.11°C) error, assuming maximum solar radiation of 1.6 gm-cal/cm^2/min). The backup tower does not measure differential temperature. The temperature sensor of the backup tower is also housed in a motor-aspirated shield.

6.4.1.4 **Dew Point Systems**

At the primary meteorological monitoring site, a lithium chloride dew point sensor measures dew point temperature at the 32.8-ft (10-m) level. The sensor signals are input into a dew point processor, which provides output signals proportional to the ambient dew point temperatures. The dew point levels are recorded to an accuracy of at least ±1.5°C (2.7°F), in accordance with RG 1.23, Proposed Revision 1.

Dew point temperature sensors are housed in motor-aspirated shields to insulate them from thermal radiation. These shields support temperature measurement with less than 0.2°F (0.11°C) error, assuming maximum solar radiation of 1.6 gm-cal/cm^2/min. The backup tower does not collect dew point temperature.

6.4.1.5 Precipitation Systems

At the primary meteorological monitoring site, precipitation is monitored at the ground level. The precipitation is measured with a recording rain gauge that has a resolution of 0.25 mm (0.01 in.). The accuracy is at least ±10 percent of the total accumulated catch, in accordance with RG 1.23, Proposed Revision 1. The backup tower does not collect precipitation.

6.4.2 Instrument Calibration and Maintenance

The meteorological monitoring system is calibrated at least semi-annually at both the primary and backup towers. Inspection, service, and maintenance are performed, as necessary, to ensure not less than 90 percent data recovery in accordance with the guidance of RG 1.23, Proposed Revision 1. Site-based instrument technicians have the requisite expertise to service and, in the event of a system failure, to repair the monitoring equipment.

In the event of a system outage, an inventory of spare sensors and parts is maintained for the replacement of major components. Redundant recording systems are incorporated into the program to further minimize data loss due to recorder failure. As an example, for this ESP application, the data recovery rates for more recent observations are presented in Table 6.4-1. Those data recovery rates for meteorological parameters (wind direction, wind speed, and atmospheric stability class) used for the dispersion analyses, as discussed in Section 2.7, are very high and exceed the 90 percent guidance criteria in RG 1.23, Proposed Revision 1.

6.4.3 Data Recording Systems

6.4.3.1 Control Room Systems

Table 6.4-2 and Table 6.4-3 list each meteorological input parameter collected by the current system and the location to which the data are transmitted for the primary tower and backup tower, respectively. Parameters provided in Table 6.4-2 and Table 6.4-3 are available for remote interrogation at any time. During emergency conditions, selected meteorological parameters can be made available to the NRC through the ERF system.

6.4.3.2 Tower Base Shelter Systems

A nominally 8 ft x 8 ft x 18 ft (2.4 m x 2.4 m x 5.5 m) shelter is located at the primary and backup tower bases. The shelter is insulated. A thermostatically controlled heat and air conditioning system maintains the shelter interior temperature within a range appropriate for proper equipment operation. The enclosure is located so as to minimize any micrometeorological effects on the tower instrumentation. Equipment and circuitry for two separate data recording systems are housed in the shelter.

Microprocessor-based data acquisition systems are the primary method of data acquisition. The sensor analog signals are collected, processed, and telemetered to a system computer. The data

acquisition systems have a built-in battery, which maintains the time and date and initialized parameters. In addition to the power-up diagnostic checks, memory diagnostic tests are continually performed to insure data integrity. The instruments and data acquisition systems as detailed herein are consistent with the current level of technology for meteorological monitoring and the accuracy of the components meets the guidance of RG 1.23, Proposed Revision 1.

6.4.4 Meteorological Data Analysis Procedure

The collected data are used to generate a sequential file of 1-hour values for each parameter. The average values are calculated by the digital data collection system.

In addition to being transmitted real-time to the ERF system, the data are telemetered daily to a computer in the corporate office. Virginia Power personnel check the data for representativeness and reasonableness. The data are compared with data collected from other offsite meteorological towers as well as with the real-time data received at the Virginia Power Meteorological Operations Center. The data is maintained on computers and is used as the database for data summaries and historical calculations.

Routine data summaries are generated for each day, each calendar month, and each calendar year for certain meteorological parameters recorded on strip charts in the existing units control room. Annual summaries of this data are provided within Virginia Power.

The format of the onsite data summaries conforms to the recommended format found in Reference 10, Table 1, and RG 1.21. To facilitate comparison, these summaries include joint frequency distributions of wind speed and wind direction for each stability class, as defined by horizontal wind sigma and differential temperature.

6.4.5 Preoperational and Operational Monitoring

Per the guidance of NUREG-0654, Appendix 2 (Reference 5), all meteorological data systems should have the capability of being remotely interrogated. Also, the guidance of NUREG-1555, Section 6.4 (Reference 11) states that the meteorological monitoring program should establish a baseline for identifying and assessing environmental impacts during pre-operational and operational stages. As stated in NAPS UFSAR (Reference 1, Section 2.3.3.2.6), the meteorological data collected onsite are transmitted on real-time basis to the ERF, the data are telemetered daily to a computer in the corporate office. This satisfies the guidance provided in NUREG-0654.

In conclusion, the current NAPS meteorological monitoring program would serve as the preoperational monitoring program for the new units. The existing database adequately establishes a baseline for identifying and assessing environmental impacts that would result from operation of the new units. This database satisfies the guidance specified in RG 1.111, Section C.4, for providing representative meteorological data for evaluating environmental impacts.

Because the existing onsite meteorological monitoring program is conducted in accordance with the guidance criteria of RG 1.23 and the system accuracy specified in RG 1.23, Proposed Revision 1, the current system would serve as the basis for the operational monitoring program for any new units at the ESP site. Additional data links to the existing and new facilities would be required for the new units. After selection of a specific reactor design, actual data recording system designs would be defined in the COL application.

Section 6.4 References

1. *Updated Final Safety Analysis Report,* North Anna Power Station Units 1 and 2, Revision 38.

2. 10 CFR 50.47, *Emergency Plans,* January 19, 2001.

3. NUREG-0696, *Functional Criteria for Emergency Response Facilities, Final Report,* U.S. Nuclear Regulatory Commission, 1981.

4. NUREG-0737, *Clarification of TMI Plan Requirements,* U.S. Nuclear Regulatory Commission, 1980.

5. NUREG-0654, *FEMA-REP-1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,* Rev. 1, U.S. Nuclear Regulatory Commission, 1996.

6. Regulatory Guide 1.111, *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,* Rev. 1, U.S. Nuclear Regulatory Commission, 1977.

7. Regulatory Guide 1.21, *Measuring, Evaluating, and Reporting Radioactivity in Solid Waste and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants,* Rev. 1, U.S. Nuclear Regulatory Commission, 1974.

8. Regulatory Guide 1.23, *Meteorological Programs in Support of Nuclear Power Plants,* Proposed Revision 1, U.S. Nuclear Regulatory Commission, September 1980.

9. 10 CFR 50, Appendix E, *Emergency Planning and Preparedness for Production and Utilization Facilities (Integrated),* Code of Federal Regulations, June 14, 1996.

10. Regulatory Guide 1.23, *Onsite Meteorological Programs,* U.S. Nuclear Regulatory Commission, February 1972.

11. NUREG-1555, *Standard Review Plan for Environmental Reviews for Nuclear Power Plants,* U.S. Nuclear Regulatory Commission, October 1999.

Table 6.4-1 Meteorological Data Recovery Rates (percent) (North Anna, January 1, 1996–December 31, 2001)

	Delta T Included		Delta T Not Included	
Year	**33-ft Wind Data**	**150-ft Wind Data**	**33-ft Wind Data**	**150-ft Wind Data**
1996	98.88	99.30	98.92	99.48
1997	98.96	90.09	99.36	99.20
1998	99.12	99.34	99.21	99.43
1999	98.91	98.90	99.45	99.44
2000	98.73	98.76	99.23	99.24
2001	98.88	91.78	99.76	92.59

Note: Data in this table are for the primary site.

Table 6.4-2 Primary Tower Meteorological Parameters

	Transmitted Locations		
Parameter	**ERF Data Base**	**Control Room**	**Remote Interrogation**
Wind Direction (upper)	X	X	X
Wind Speed (upper)	X	X	X
Sigma theta (upper) (S_t)			X
Wind Direction (lower)	X	X	X
Wind Speed (lower)	X	X	X
Sigma theta (lower) (S_t)			X
Ambient Temperature (lower)	X	X	X
Dew point (lower)			X
Delta Ambient Temperature (upper-lower)	X	X	X
Precipitation			X

Note: All parameters going to the ERF database are available for printout in the existing TSC and EOF. The Units 1 & 2 control room parameters are hardwired.

Source: Reference 1

Table 6.4-3 Backup Tower Parameters

Parameter	ERF Data Base	Control Room	Remote Interrogation
Wind Speed	X	X	X
Wind Direction	X	X	X
Sigma Theta (S_t)	X	X	X

Note: All parameters going to the ERF database are available for printout in the existing TSC and EOF. The Units 1 & 2 control room parameters are hardwired.

Source: Reference 1

6.5 Ecological Monitoring

NUREG-1555 recommends that ecological monitoring programs encompass the elements of the ecosystems for which a causal relationship is established or strongly suspected between the construction or operation of a new unit and adverse change (Reference 1, Section 6.5).

Ecological monitoring programs have been conducted at the NAPS site on a periodic basis since the early 1970s. The data collected under these programs is summarized in Section 2.4. The existing ecological monitoring programs and associated databases would be supplemented, as necessary, to support new units.

6.5.1 Terrestial Ecology and Land Use

The following sections describe the prescribed pre-application, construction/pre-operational, and operational monitoring programs for terrestrial ecology and land use of the ESP site and transmission corridors that may be impacted by the new units.

6.5.1.1 Pre-Application Monitoring

The pre-application monitoring program has two objectives: 1) to provide supplemental information that aids in assessing the suitability of the ESP site, and 2) to support the assessment of potential impacts on the terrestrial environment that could result from construction and operation of the new units. The pre-application monitoring program comprises the existing NAPS terrestrial ecological database and the ongoing NAPS-based ecological monitoring programs.

The existing units terrestrial monitoring program was initiated in 1973 to monitor the local wildlife and vegetation communities in response to the expected major changes in the terrestrial environment associated with the creation of Lake Anna and NAPS. The program was designed to provide baseline data about existing ecological communities. The program specifically identified vegetation types around Lake Anna, compiled an inventory of wildlife in the area, and evaluated local land use patterns. (Reference 2) Some of the terrestrial monitoring programs continued to monitor the variations within existing communities during the construction and operation of the existing units.

The following sections describe the vegetation, avian, and mammalian community monitoring programs performed to date, highlight the present status of “important” related ecological species and habitats, and identify the on-going related monitoring programs.

6.5.1.1.1 Vegetation

As described in Section 2.4.1, much of the NAPS site consists of existing generation and maintenance facilities, parking lots, roads, cleared areas, and mowed grass. Hardwood forests exist in areas that have not been cleared for the construction and operation of the existing units. These wooded areas are remnants of forests that were used for timber production, prior to the land acquisition by Virginia Power, and are dominated by a variety of oak, yellow poplar, sweet gum, and

red maples. Scattered loblolly pines, Virginia pines, and short-leaf pines exist in some wooded areas. (Reference 3, Sections 2.4 and 2.5) (Reference 4, Section 2.2.6)

The transmission corridors are regularly managed by Virginia Power to prevent woody growth from reaching the transmission lines. The removal of woody species can provide outstanding grassland and bog-like habitat for many rare plant species dependent on open conditions. No endangered or threatened plants have been recorded along the transmission corridors. (Reference 3, Sections 2.4 and 2.5)

Virginia Power currently conducts a transmission corridor rare plant survey program in cooperation with the VDCR’s Natural Heritage Program (see Section 2.2.2 and Section 5.6.1). The Natural Heritage Program prepares annual reports from these surveys.

No additional monitoring would be performed for the new units.

6.5.1.1.2 **Avian Communities**

Common bird species recorded in upland areas on and near the ESP site include the American crow, blue jay, Carolina chickadee, mourning dove, black vulture, turkey vulture, European starling, song sparrow, white-throated sparrow, dark-eyed junco, Northern cardinal, house finch, tufted titmouse, red-bellied woodpecker, downy woodpecker, and Northern flicker.

Several species of residential and migratory wading birds and waterfowl use Lake Anna. Virginia Power biologists have documented breeding at Lake Anna by mallards, wood ducks, and Canada geese. Virginia Power, in association with the Louisa County Chapter of Ducks Unlimited, has placed wood duck nest boxes on Lake Anna and wood ducks have used several of these nest boxes. Belted kingfishers, great blue herons, and green-backed herons are present at Lake Anna throughout the year and presumably nest on or near the Lake Anna shoreline (see Section 2.4.1.4).

Even though the bald eagle and loggerhead shrike have been observed in the local area, terrestrial species that are listed by the federal and/or the Commonwealth of Virginia governments as endangered or threatened species are not known to exist at the NAPS site or along the transmission corridors. No areas designated by the USFWS as “critical habitat” for endangered species exist at or near the NAPS site or associated transmission lines. In addition, the transmission corridors do not cross any Commonwealth or federal parks, wildlife refuges, or wildlife management areas.

Virginia Power annually has participated with the National Audubon Society in conducting the “Christmas Bird Counts” during either December or January (see Section 2.4.1.3). Bird species were recorded in upland areas on and near the NAPS site during this count.

6.5.1.1.3 **Small Mammals**

Wildlife species resident in the forested portions of the NAPS site are typical of those found in upland Piedmont forests of north-central Virginia. As discussed in Section 2.4.1.2, frequently observed mammals such as the white-tailed deer, raccoon, opossum, gray squirrel, and gray fox

occur on site, as do smaller mammals such as moles, shrews, and a variety of mice and voles. Woodchucks exist in grassy areas near the forest edges of the NAPS site, and beavers exist in Lake Anna and its tributaries. Various birds, reptiles (e.g., snakes, lizards), and amphibians (e.g., frogs, salamanders) exist in uplands and along the edge of Lake Anna.

No areas designated by the USFWS as "critical habitat" for endangered species exist at the NAPS site or along/adjacent to transmission corridors. In addition, the transmission corridors do not cross any Commonwealth or federal parks, wildlife refuges, or wildlife management areas.

No additional mammal-related monitoring would be performed for the new units.

6.5.1.2 Construction and Pre-Operational Monitoring

Construction of the new units would result in the removal of substantial portions of the existing forested habitat on the NAPS site. The construction site and support areas do not contain any old growth timber, unique or sensitive plants, or unique or sensitive plant communities. Therefore, construction would not significantly reduce the local or regional diversity of plants or plant communities. As the potentially impacted forested habitat on site represents a small portion of the available undeveloped land in the region of the NAPS site, the displacement and construction-related mortality of wildlife would be small, relative to wildlife populations in the region.

Noise-related impacts and bird collisions due to construction activities and equipment would be negligible. Section 2.4.1 and Section 4.3.1 conclude that while there is potential for bird collisions with the buildings and equipment during the facility construction phase, the additional impact of construction-related structures would be small, given the proximity of existing units structures and the relative absence of evidence of previous avian collisions with these structures. Finally, no federal or Commonwealth threatened or endangered plants or animals are known to exist in the construction site and support areas, and these areas do not contain any designated critical habitats. Thus, construction would not adversely impact any threatened or endangered species, or trigger the need to conduct additional terrestrial monitoring.

6.5.1.3 Operational Monitoring

Operation of the new units would not pose any additional impacts to areas outside those previously disturbed by NAPS site or new unit construction. New unit operation would not impact critical habitats, or important, threatened, or endangered species. Thus, additional terrestrial monitoring would not be warranted.

6.5.2 Aquatic Ecology

The following sections describe the pre-application, construction/pre-operational, and operational monitoring programs for aquatic ecology. These programs would support any required assessments of aquatic impacts associated with new unit construction and operation.

6.5.2.1 **Pre-Application Monitoring**

The objective of the pre-application aquatic monitoring program is to provide information that aids in the assessment of site suitability and supports the assessment of potential impacts on the aquatic environment that would result from the construction and operation of the new units. This monitoring program comprises the existing NAPS aquatic ecological database and the related ongoing NAPS aquatic monitoring programs. The following subsections summarize the previous aquatic monitoring programs, the current status of “important” aquatic species and habitats, and the nature of ongoing aquatic monitoring programs.

6.5.2.1.1 **Previous Aquatic Ecology Monitoring Programs**

The earliest aquatic monitoring program was initiated by Virginia Power in the early 1970s, prior to the creation of Lake Anna and the construction of the existing units. This program was designed to provide baseline data about the ecology of the North Anna River basin, to support the evaluation of impacts from dam construction on the North Anna River and the upper section of the Pamunkey River. This aquatic monitoring program was followed in the summer of 1972 by a more intensive post-impoundment aquatic ecological monitoring program. This program collected biological samples at 10 stations distributed upstream and downstream of the North Anna dam. Epiphytes, macrobenthic fauna, and fish were collected during the summer months of 1972. Later in the year, following the filling of Lake Anna, a new aquatic ecology monitoring program was initiated, which sampled phytoplankton, zooplankton, benthos, and fishes at stations in the Lake. Prior to the construction and operation of the existing units, this program generated a database that characterized the newly formed Lake Anna biota. (Reference 2, Section 6.1) Supplemental studies of phytoplankton, zooplankton, and benthic organisms followed from 1973 through 1985 (see Section 2.4.2.2).

Section 2.4.2.2 discusses fish community studies. From 1975 through 1985, Virginia Power evaluated the abundance and distribution of adult fish using a variety of sampling methods. Virginia Power also conducted larval fish studies, creel surveys, and a number of special studies, focusing on the reproduction and growth of important recreational species, such as largemouth bass (*Micropterus salmoides*). Using ultrasonic tags, Virginia Power investigated the seasonal movement and habitat preferences of striped bass (*Morone saxatilis*). (Reference 3, Sections 2.4 and 2.5)

6.5.2.1.2 **Important, Threatened, and Endangered Species**

As described in Section 2.4.2.2, from 1975 through 1985, 39 species of fish (representing 12 families) were found in Lake Anna. The species include those historically found in the North Anna River, those in local farm ponds inundated by the new lake, and nine species (four non-natives) introduced by the VDGIF. (Reference 4, Section 2.2.5) Section 2.4.2.2 also reports that fish monitoring conducted over a more recent six-year period (1995–2000) shows a balanced reservoir fish community of healthy top-of-the-food-chain predators (e.g., largemouth bass and

striped bass), the forage species on which they feed (e.g., threadfin shad, and gizzard shad), pan fish (e.g., bluegill, red ear sunfish, redbreast, crappie), and catfish.

No Commonwealth of Virginia or federally-listed (e.g., endangered, threatened, species of concern) fish species or critical habitats are found in Lake Anna or the North Anna River (see Section 2.4.2.2.5 and Section 2.4.2.3.5). No Commonwealth or federally-listed fish species have been collected in any surveys or operational monitoring studies. While VDGIF ecological databases indicate that three Commonwealth and federally-listed species – the Commonwealth freshwater mussel species dwarf wedge mussel *(Alasmidonta heterodon*), the Atlantic pig toe (*Fusonaia mason*), and James spiny mussel (*Pleurobema collina*) – could occur in local streams, none have been observed or collected in local streams. A fourth mussel species, the kidney mussel (*Ptychobranchus subtentum*), a candidate for federal listing, has been reported to have been observed in the vicinity of the ESP site. However, these observations may be in error, since confirmed observations limit this species to more western mountain streams that drain to the Gulf of Mexico. (Reference 3, Sections 2.4 and 2.5) (Reference 4, Section 2.2.5)

6.5.2.1.3 **Current Monitoring Programs**

Virginia Power has monitored fish populations in Lake Anna since 1986. Virginia Power conducts quarterly electro-fishing sampling at nine stations (five stations in the North Anna Reservoir, four in the WHTF, and six gillnetting stations (four in the reservoir and two in the WHTF). These surveys are designed to document: 1) the types of fish species present in Lake Anna, 2) their relative numbers by species, and 3) their size class distribution. In the North Anna River below the dam, Virginia Power biologists have also gathered abundance and distribution data on largemouth and smallmouth bass via direct (snorkel) observation. The biologists swim established transects, counting and categorizing (by size) all bass that are observed, and noting the type of cover being used. Other fish abundance and distribution information in the North Anna River is collected by electro-fishing at 4 stations, 3 times per year.

In response to NRC Generic Letter 89-13, Virginia Power initiated a semi-annual sampling program in the fall of 1990 to monitor Asiatic clams (*Corbicula flumenia)* in the North Anna Reservoir, the WHTF, and the SWR. Virginia Power continues to collect replicate samples at two North Anna Reservoir stations (i.e., Intake and Mid-Lake), two WHTF stations, and a single station in the SWR, and they report the total number and density of clams at the stations and discuss population trends in semi-annual reports. In the course of monitoring *Corbicula* populations, Virginia Power assesses the micro-fouling potential of Asiatic clams and looks for evidence that the exotic zebra mussel (*Dreissena polymorpha*) has invaded Lake Anna. As of the end of 2002, Virginia Power had observed no zebra mussels in Lake Anna.

Virginia Power biologists have also conducted studies in the North Anna River in response to reduced flow due to drought conditions. The studies included physical habitat measurements at different flows, dissolved oxygen, temperature, and collection of benthic macro-invertebrates. Each

fall, when warranted, an aerial and ground-based monitoring program that focuses on identifying the presence of a nuisance submerged aquatic macrophyte, Hydrilla verticillata is conducted.

As discussed in Section 2.4.2.2.3, the VDGIF also conducts aquatic ecology monitoring as part of their management responsibilities for the fisheries of Lake Anna. VDGIF district biologists monitor and research the fishes of Lake Anna, annually, focusing primarily on the largemouth and striped bass, two species that are highly esteemed by local anglers. Other species, such as black crappie, walleye, channel catfish, and gizzard and threadfin shad, are monitored by VDGIF.

6.5.2.2 **Construction and Pre-Operational Monitoring**

Construction of the new units would result in minor temporary disruptions of some aquatic habitats. The addition of a new Lake Anna intake structure, installation of a discharge structure on the discharge canal, and removal of the existing intake cofferdam would contribute to temporary increases in the turbidity of the water in these disturbed areas. The land clearing and earthwork associated with construction of the new units could similarly result in temporary increases in the turbidity in adjacent surface water bodies. As appropriate, soil erosion and sedimentation controls and construction-phase storm water management practices would be employed to minimize the sediment-related impacts to these surface water resources. Therefore, new unit construction would not reduce the local or regional diversity of aquatic species.

No federally or Commonwealth-listed threatened or endangered aquatic plants or important species are known to live in areas that would be impacted by construction of the new units, nor do these areas contain any designated critical habitats. Therefore, construction of the new units would not adversely impact any threatened or endangered aquatic species.

The Virginia Power aquatic ecology monitoring programs (i.e., quarterly fish surveys, semi-annual shellfish surveys, Hydrilla inspections) and the VDGIF-sponsored annual fish monitoring program would continue. Therefore, construction of the new units would not require additional aquatic ecology monitoring programs or efforts.

6.5.2.3 **Operational Monitoring**

While the addition of the new units would increase water withdrawal, discharge rates, and thermal loadings to the lake, operation of the new units would be fundamentally similar to the operation of the existing units. Operation of the new units and corresponding increases in water temperature are predicted to have potential for habitat reductions for striped bass, especially in the summer months. Other aquatic species would not be affected. Consequently, the operational-phase aquatic ecological monitoring program for the new units would be an extension of the ongoing Virginia Power and VDGIF monitoring programs.

Section 6.5 References

1. NUREG-1555, *Standard Review Plans for Environmental Review for Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, October 1999.

2. *North Anna Power Station Final Environmental Statement,* United States Atomic Energy Commission, April 1973.

3. *North Anna Station Application for Renewed Operating Licenses (Appendix E – Environmental Report)*, Dominion Energy, May 2001.

4. NUREG-1437*, Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants, Supplement 7*, U.S. Nuclear Regulatory Commission, November 2002.

6.6 Chemical Monitoring

The following section describes the chemical monitoring program for surface water and groundwater quality, which includes the following topics:

- Pre-application monitoring that supports the baseline environmental hydrologic and water quality descriptions in Chapter 2 and Chapter 3.
- Construction/pre-operational monitoring that would evaluate anticipated impacts from site preparation and new unit construction and that would establish a baseline for identifying and assessing environmental impacts from operation of the new units.
- Operational monitoring that would identify impacts from operation of the new units.

The proposed chemical monitoring programs contain the elements necessary to evaluate potential impacts on water quality in accordance with the guidance of NUREG-1555 (Reference 1, Section 6.6).

6.6.1 **Pre-Application Monitoring**

The objective of the pre-application monitoring program is to provide information that aids in the assessment of site suitability and supports the assessment of potential impacts that could result from the construction and operation of the new units. The pre-application monitoring program is composed of the existing NAPS water quality database and the ongoing VPDES permit-mandated surface water and NAPS groundwater monitoring programs

6.6.1.1 **Surface Water Monitoring**

A series of pre-operational water quality programs were initiated for the NAPS site in the early 1970s. Lake Anna was created to supply plant cooling water for the power station. The initial pre-impoundment program focused on evaluating the local water quality effects of pyrite-mine drainage from Contrary Creek and its tributaries. A post-impoundment water quality monitoring program began in the summer of 1971. During this monitoring period, temperature, total solids, turbidity, flow rate, dissolved oxygen (DO), salinity, biological oxygen demand (BOD), alkalinity, pH, iron, magnesium, manganese, copper, zinc, mercury, lead, nitrates, and sulfates were measured bi-monthly at 10 monitoring stations located downstream of the North Anna Dam and the upper Pamunkey River. A 3-year pre-operational water quality monitoring program was initiated in March 1972 to monitor temperature, DO, pH, conductivity, alkalinity, nutrients, iron, magnesium, copper, strontium, calcium, manganese, chromium, aluminum, zinc, and potassium at 12 locations in the recently fully developed Lake Anna. In addition, Secchi disk and radiological analyses were conducted at these stations. All of these measurements were conducted monthly, except during the summer months, when they were performed bi-weekly. (Reference 2, Section 6.1)

As part of the NAPS CWA Section 316(a) Demonstration in 1985, a revised temperature-monitoring program was initiated at seven local monitoring stations. Temperatures were recorded hourly at most of these stations through 1985 (Reference 3, Section 2.2).

Virginia Power continues to measure Lake Anna water temperatures at a number of monitoring stations in the Lake in accordance with VPDES permit conditions (Reference 4). Specific monitoring details (location, parameters, frequency) of this ongoing permit-based water quality and temperature monitoring program are provided in Table 6.6-1 and Figure 6.6-1, Figure 6.6-2, and Figure 6.6-3.

Dominion would continue to conduct the water quality monitoring program mandated by the VPDES permit.

6.6.1.2 Groundwater Monitoring

NAPS groundwater use is currently less than 100 gpm. Operation of the new units would not significantly increase groundwater use (see Section 2.3.2.2.1). Given the regular and small usage of groundwater at the NAPS site, the quality of the groundwater has not been the subject of any recent systematic monitoring efforts. Current groundwater use would not change during new unit construction, pre-operational periods, or operating periods. Therefore, groundwater impacts will continue to be viewed as minimal, and mitigation and related water quality monitoring measures are not warranted. (Reference 5, Section 4.5)

Groundwater levels have been, and continue to be, the subject of an on-going monitoring program. Nine groundwater observation wells were installed (November and December 2002) at the ESP site to determine water elevations, flow paths, and gradients. Tests have been performed in these wells to determine the permeability of the subsurface materials. These wells, together with 9 existing monitoring wells around the SWR and one monitoring well at the ISFSI, are used to measure groundwater elevations on a quarterly basis for one year to determine seasonal variations. Virginia Power would continue to monitor wells around the SWR to evaluate the SWR for leakage, to assess the effectiveness of horizontal drains beneath the existing units pump house, and to determine the flow rate and clarity of the water discharge. An existing well at the NAPS metrology lab is also being monitored quarterly for radiological purposes.

6.6.2 Construction and Pre-Operational Monitoring

The VPDES-mandated temperature and water quality monitoring program and the groundwater level monitoring program for the existing units would continue. Construction of the new units would require Dominion to seek a permit for storm water discharges from construction activities. This permit would not trigger the need to conduct additional storm water-related monitoring beyond that required for the existing units. The ongoing surface and groundwater monitoring programs for the existing units would provide the data necessary to assess potential changes in water quality associated with construction of the new units. These ongoing programs would also provide a

baseline for the identification and measurement of water quality impacts from operation of the new units.

6.6.3 **Operational Monitoring**

An operational monitoring program would be implemented to identify any changes in water quality that may result from the operation of the new units and to assess the effectiveness of the related effluent treatment systems. The specific elements of the operational monitoring program would be developed in consultation with the VDEQ during the process to revise the existing VPDES permit. Given that the new units would represent an expansion of the existing nuclear power generation facilities, any new monitoring would be similar to that described in the current VPDES-mandated program.

Section 6.6 References

1. NUREG-1555, *Environmental Standard Review Plan*, U.S. Nuclear Regulatory Commission, October 1999.

2. *North Anna Power Station Final Environmental Statement,* United States Atomic Energy Commission, April 1973.

3. *North Anna Station Application for Renewed Operating Licenses* (Appendix E – Environmental Report), Dominion Energy, May 2001.

4. Virginia Discharge Elimination System Permit No. VA0052451, Virginia Department of Environmental Quality, July 11, 2001.

5. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants*, Supplement 7, U.S. Nuclear Regulatory Commission, November 2002.

Table 6.6-1 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
001 - Discharge of Condenser Cooling Water from Heat Treatment Facility at Dike 3 (Note 1)	Flow (mgd)	1/month	Calculated
	pH	1/year	Grab
	Heat Rejected ($\times 10^9$ BTU/hr)	1/day	Calculated
	Total Residual Chlorine (mg/l)	1/month	Grab
	Copper	1/5 years beginning 2004	Grab
	Nickel	1/5 years beginning 2004	Grab
	Acute and Chronic Toxicity Test	August/September 2004 or 2005 1/3 months if test fails for one year. Annually thereafter	48-hour static test using *Ceriodaphnia dubia* to determine No Observable Adverse Effects Concentration (NOAEC).
103 – Process Waste Clarifier (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Oil and Grease (mg/l)	1/3 months	Grab
104 – Oil Water Separator and Storm Water (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Oil and Grease (mg/l)	1/3 months	Grab

Data Source: Reference 4

Notes: 1. See Figure 6.6-3 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.6-2 for location.

Table 6.6-1 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
105 – Bearing Cooling Tower Blowdown (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Free Available Chlorine	1/month	Grab
	Priority Pollutants (mg/l) Note: 126 Priority Pollutants contained in cooling tower treatment chemicals except for total chromium and total zinc)	1/3 months	Grab
	Total Chromium (mg/l)	1/3 months	Grab
	Total Zinc (mg/l	1/3 months	Grab
107 - Bearing Cooling Tower System Discharge-Lake to Lake Operation (Note 1)	Flow (mgd)	1/month	Estimate
	Total Residual Chlorine (mg/l)	1/month	Grab
108 – Service Water Overflow (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
109 & 110 – Hot Well Drains (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
111 - Sewage (Note 1)	Flow (mgd)	1/day	Estimate
	pH	1/month	Grab
	BOD - 5-day (mg/l)	1/6 months	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Total Residual Chlorine (mg/l) or Fecal Coliform (n/100 ml)	1/day 1/week	Grab Grab

Data Source: Reference 4

Notes: 1. See Figure 6.6-3 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.6-2 for location.

Table 6.6-1 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
112 & 113 – Steam Generator Blowdown Units 1 & 2 (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/6 months	Grab
	Oil and Grease (mg/l)	1/6 months	Grab
114 – Service Water Pipe Vault Drain (Note 1)	Flow (mgd)	1/month	Estimate
115 – Service Water System Blowdown (Note 1)	Flow (mgd)	1/month	Estimate
009 – Groundwater, Storm Water, Backwash form Sand Filters and RO Units (Note 1)	Flow (mgd)	1/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
013 - Turbine Building Sump #1 and Storm Water (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
014 - Turbine Building Sump #2 and Storm Water (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
016 – Intake Screen Wash Water (Note 1)	Flow (mgd)	1/year	Estimate
020 – RO Reject (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Total Residual Chlorine	2/month	Grab

Data Source: Reference 4
Notes: 1. See Figure 6.6-3 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.6-2 for location.

Table 6.6-1 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
021 – RO Drain Line (Note 1)	Flow (mgd)	1/month	Estimate
022 to 026 Storm Water Associated with Industrial Activities (Note 1)	Total Recoverable Iron	2/year for years 2005 and 2006, immediately after applicable storm event (> 0.1 inch)	Grab
	Visual Inspection	1/3 months immediately following applicable storm event (> 0.1 inch)	Visual observation
Station 1 – 9 & 11 (Note 2)	Temperature (°C)	Hourly during summer quarter and one other alternating quarter of year	Automated surface measurement
Station 10 (Note 2)	Temperature (°C)	Hourly during summer quarter and one other alternating quarter of year	Automated 3 meter deep measurement
Stations A – N (Note 3)	Temperature (°C)	Hourly measurements during daylight hours	Automated surface to bottom measurements at one meter intervals

Data Source: Reference 4
Notes: 1. See Figure 6.6-3 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.6-2 for location.

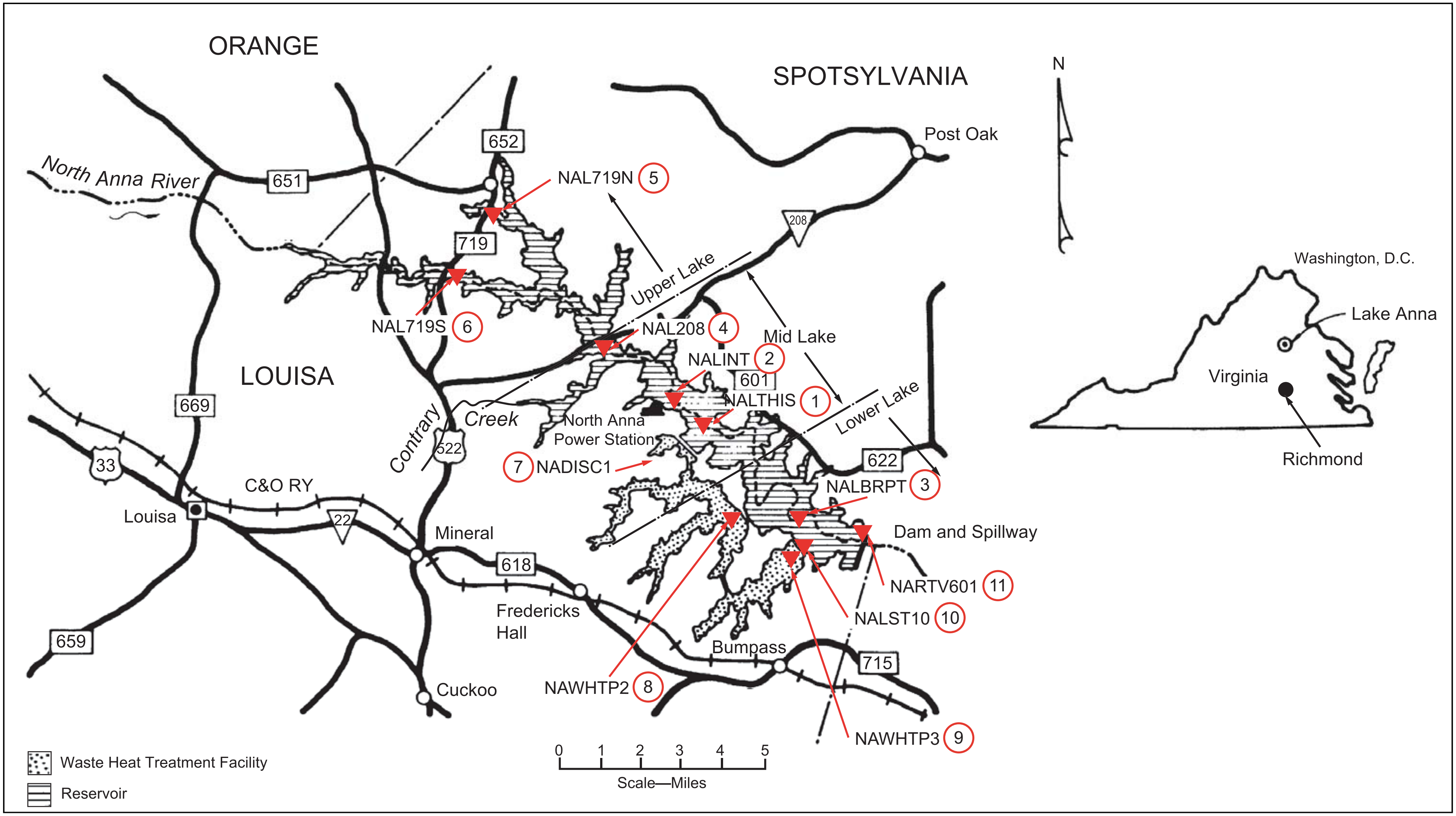

Figure 6.6-1 Location of Temperature Sensors – Lake Anna

Data source: Reference 4

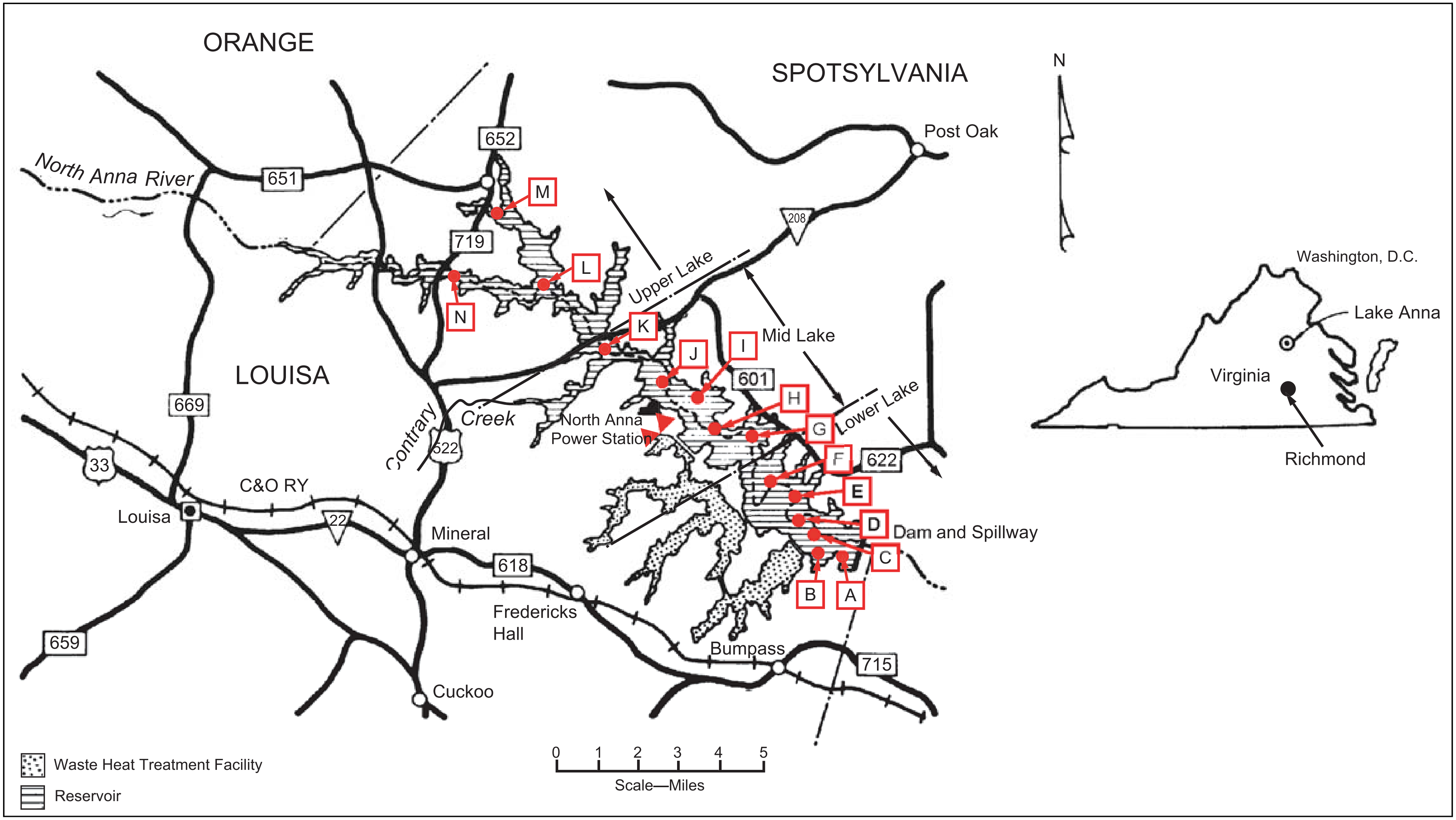

Figure 6.6-2 Location of Thermal Plume Sampling Stations – Lake Anna

Data source: Reference 4

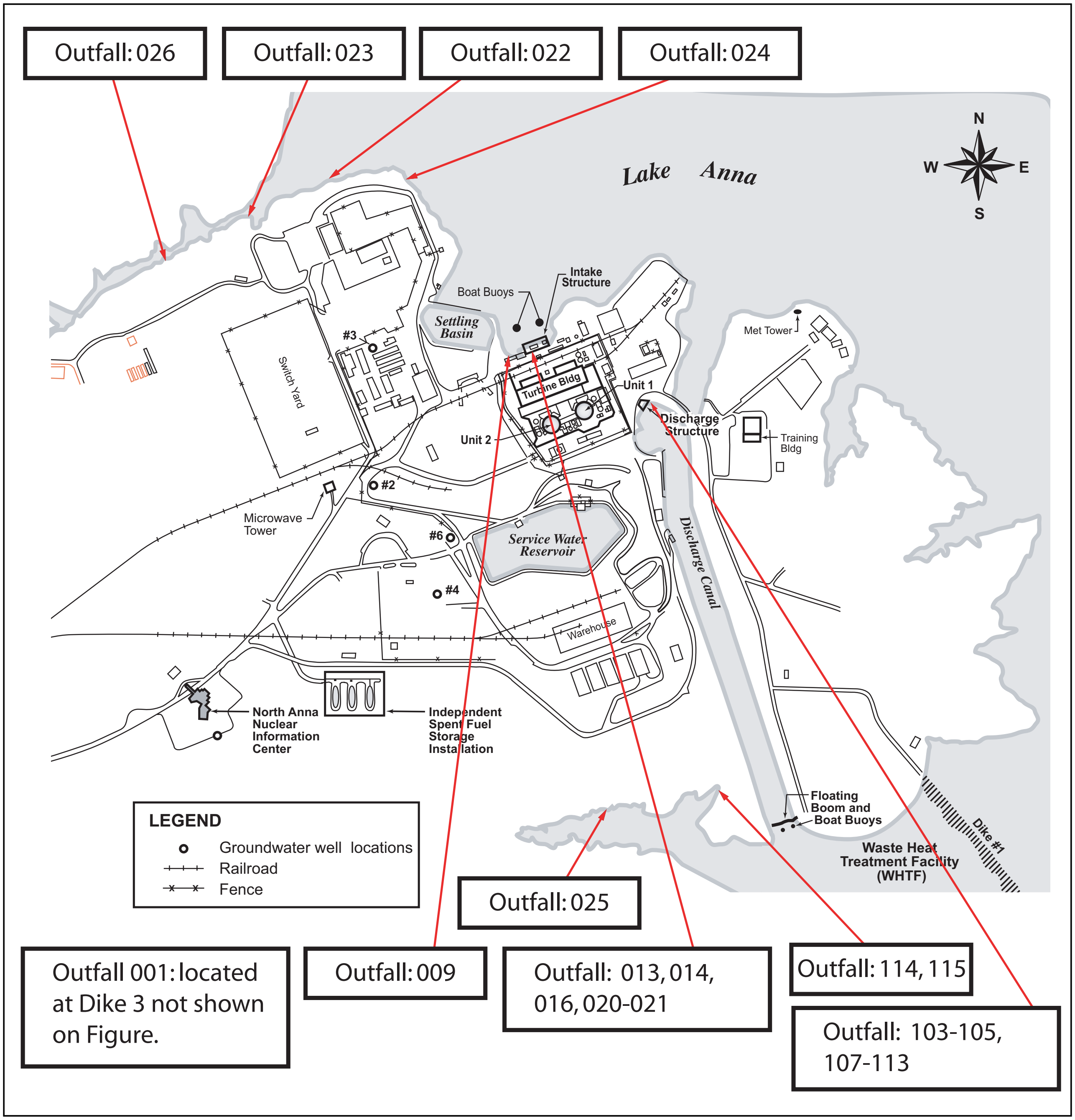

Figure 6.6-3 Location of Monitored VPDES Permit Outfalls

6.7 Summary of Monitoring Programs

This section summarizes all of the environmental monitoring programs described in Chapter 6. The summary is divided into three sections:

- Pre-application monitoring
- Construction and Pre-Operational monitoring
- Operational monitoring

6.7.1 Pre-Application Monitoring

Table 6.7-1 through Table 6.7-6 summarize the pre-application monitoring programs. These programs represent continuations of the thermal, radiological, hydrological, meteorological, ecological, and chemical monitoring programs currently being performed at the NAPS site.

6.7.2 Construction and Pre-Operational Monitoring

The current thermal, radiological, hydrological, meteorological, ecological, and chemical monitoring programs for the existing units would be continued through the construction and pre-operational phases of the new units. Table 6.7-1 through Table 6.7-6 reflect this continuation.

6.7.3 Operational Monitoring

While specific operational monitoring requirements and programs for the new units have not been established at this time, they would be similar to those monitoring programs outlined in Table 6.7-1 through Table 6.7-6. The operational monitoring programs may be modified as a result of future consultations with appropriate VDEQ and other Commonwealth of Virginia and municipal authorities. The need for further modifications (e.g., changes in monitoring locations, parameters, collection, or analytical procedures) would be assessed prior to and during the course of operation.

Section 6.7 References

None

Table 6.7-1 Pre-Application, Construction/Pre-Operational, and Operational Thermal Monitoring Program

Sites	Monitoring Location	Sampling Methodology	Sampling Frequency
NALST10	Lake Anna: Mid-level in Lake in the flow through Lake Anna Dike 3	Mid-level depth at 3 m water depth	2/year
NALBRPT	Lake Anna: near Burruss Point	Surface	2/year
NALTHIS	Lake Anna: near Thurman Island	Surface	2/year
NALIN	Lake Anna: at North Station intakes	Surface	2/year
NAL208	Lake Anna: Route. 208 Bridge	Surface	2/year
NADISC1	At end of station discharge in Lagoon (Pond) 1	Surface	2/year
NAWHTF2	Lagoon (Pond) 2	Surface	2/year
NAWHTF3	Lagoon (Pond) 3	Surface	2/year
NAL719S	North Anna River arm of Lake Anna at Route 719 bridge	Surface	2/year
NAL719N	Pamunkey Creek arm of Lake Anna at Route 719 bridge	Surface	2/year
NARIV601	Route 601 crossing	Surface, at Route 601 crossing	4/year

Table 6.7-2 Pre-Application, Construction/Pre-Operational, and Operational Radiological Monitoring Program

Radiation Exposure Pathways Monitored	Parameters	Frequency
Direct	Radiation Levels	Quarterly
Airborne, including Gaseous, Particulate, and Iodine	Radiation Levels Concentrations Radioactive Material Quantities	Continuous, Weekly, Quarterly
Waterborne, including Surface, Ground, and Sediment	Concentrations Radioactive Material Quantities	Monthly, Quarterly, Semi-annually
Ingestion, including Milk, Aquatic, Vegetation, and Food products	Concentrations Radioactive Material Quantities	Monthly, Semi-annually

Table 6.7-3 Pre-Application, Construction/Pre-Operational, and Operational Hydrological Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
001 - Discharge of Condenser Cooling Water from Heat Treatment Facility at Dike 3	Flow (mgd)	1/month	Calculated
103 - Process Waste Clarifier	Flow (mgd)	2/month	Estimate
104 - Oil Water Separator and Storm Water	Flow (mgd)	2/month	Estimate
105 - Bearing Cooling Tower Blowdown	Flow (mgd)	1/month	Estimate
107 - Bearing Cooling Tower System Discharge - Lake to Lake Operation	Flow (mgd)	1/month	Estimate
108 - Service Water Overflow	Flow (mgd)	1/month	Estimate
109 & 110 - Hot Well Drains	Flow (mgd)	1/month	Estimate
111 - Sewage	Flow (mgd)	1/day	Estimate
112 & 113 - Steam Generator Blowdown Units 1 & 2	Flow (mgd)	1/month	Estimate
114 - Service Water Pipe Vault Drain	Flow (mgd)	1/month	Estimate
115 - Service Water System Blowdown	Flow (mgd)	1/month	Estimate
009 - Ground Water, Storm Water, Backwash from Sand Filters and RO Units	Flow (mgd)	1/month	Estimate
013 - Turbine Building Sump #1 and Storm Water	Flow (mgd)	1/month	Estimate
014 - Turbine Building Sump #2 and Storm Water	Flow (mgd)	1/month	Estimate
016 - Intake Screen Wash Water	Flow (mgd)	1/year	Estimate
020 - RO Reject	Flow (mgd)	2/month	Estimate
021 - RO Drain Line	Flow (mgd)	1/month	Estimate
022 – 026 - Storm Water Outfalls	Flow	1/storm event	Grab

Table 6.7-4 Pre-Application, Construction/Pre-Operational, and Operational Meteorological Monitoring Program

Primary Tower Meteorological Parameters			
	Transmitted Locations		
Parameter	ERF Data Base	Control Room	Remote Interrogation
Wind Direction (upper)	X	X	X
Wind Speed (upper)	X	X	X
Sigma theta (upper)			X
Wind Direction (lower)	X	X	X
Wind Speed (lower)	X	X	X
Sigma theta (lower)			X
Ambient Temperature (lower)	X	X	X
Dew point (lower)			X
Delta Ambient Temperature (upper-lower)	X	X	X
Precipitation			X
Backup Tower Meteorological Parameters			
Wind Speed	X	X	X
Wind Direction	X	X	X
Sigma Theta	X	X	X

Note: All parameters are continuously monitored. All parameters going to the ERF database would be available for printout in the existing TSC and EOF. The Units 1 & 2 control room parameters are hardwired.

Table 6.7-5 Pre-Application, Construction/Pre-Operational, and Operational Ecological Monitoring Program

Category	Monitoring Location	Summary	Sampling Methodology	Sampling Frequency
Ecological (Terrestrial)	Site property and immediate vicinity	Bird count in December or January	Visual observation	Variable
Ecological (Terrestrial)	Transmission line corridors	Rare plant survey (National Heritage Program)	Ground-base inspection	Variable
Ecological (Aquatic)	Lake Anna, WHTF	Fish surveys (species, numbers, size distributions)	Electro-fishing, gillnetting	4/year
Ecological (Aquatic)	North Anna River	Smallmouth and largemouth bass abundance survey	Snorkel observations along transects	6/year
Ecological (Aquatic)	Lake Anna, WHTF, and Service Water Reservoir	Shellfish surveys	Virginia Power biologist collection of replicate samples	2/year
Ecological (Aquatic)	North Anna River	Benthic macro-invertebrate studies	Virginia Power biologist collection	Periodic in drought conditions
Ecological (Aquatic)	Lake Anna	Hydrilla inspections	Aerial and ground-based inspection	
Ecological (Aquatic)	Lake Anna	VDGIF-sponsored fish monitoring program		1/year
Ecological (Aquatic)	North Anna River	Monitor fin fish population	Electro-fishing	3/year

Table 6.7-6 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
001 - Discharge of Condenser Cooling Water from Heat Treatment Facility at Dike 3 (Note 1)	Flow (mgd)	1/month	Calculated
	pH	1/year	Grab
	Heat Rejected ($\times 10^9$ BTU/hr)	1/day	Calculated
	Total Residual Chlorine (mg/l)	1/month	Grab
	Copper	1/5 years beginning 2004	Grab
	Nickel	1/5 years beginning 2004	Grab
	Acute and Chronic Toxicity Test	August/September 2004 or 2005 1/3 months if test fails for one year. Annually thereafter.	48-hour static test using Ceriodaphnia dubia to determine No Observable Adverse Effects Concentration (NOAEC).
103 – Process Waste Clarifier (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Oil and Grease (mg/l)	1/3 months	Grab
104 – Oil Water Separator and Storm Water (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Oil and Grease (mg/l)	1/3 months	Grab
105 – Bearing Cooling Tower Blowdown (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Free Available Chlorine	1/month	Grab
	Priority Pollutants (mg/l) Note: 126 Priority Pollutants contained in cooling tower treatment chemicals except for total chromium and total zinc.	1/3 months	Grab
	Total Chromium (mg/l)	1/3 months	Grab
	Total Zinc (mg/l	1/3 months	Grab

Table 6.7-6 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
107 - Bearing Cooling Tower System Discharge-Lake to Lake Operation (Note 1)	Flow (mgd)	1/month	Estimate
	Total Residual Chlorine (mg/l)	1/month	Grab
108 – Service Water Overflow (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
109 & 110 – Hot Well Drains (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
111 - Sewage (Note 1)	Flow (mgd)	1/day	Estimate
	pH	1/month	Grab
	BOD _ 5day (mg/l)	1/6 months	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Total Residual Chlorine (mg/l) or Fecal Coliform (n/100 ml)	1/day 1/week	Grab Grab
112 & 113 – Steam Generator Blowdown Units 1 & 2 (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/6 months	Grab
	Oil and Grease (mg/l)	1/6 months	Grab
114 – Service Water Pipe Vault Drain (Note 1)	Flow (mgd)	1/month	Estimate
115 – Service Water System Blowdown (Note 1)	Flow (mgd)	1/month	Estimate
009 – Groundwater, Storm Water, Backwash form Sand Filters and RO Units (Note 1)	Flow (mgd)	1/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab

Table 6.7-6 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
013 - Turbine Building Sump #1 and Storm Water (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
014 - Turbine Building Sump #2 and Storm Water (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
016 – Intake Screen Wash Water (Note 1)	Flow (mgd)	1/year	Estimate
020 – RO Reject (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Total Residual Chlorine	2/month	Grab
021 – RO Drain Line (Note 1)	Flow (mgd)	1/month	Estimate
022 to 026 Storm Water Associated with Industrial Activities (Note 1)	Total Recoverable Iron	2/year for years 2005 and 2006, immediately after applicable storm event (>0.1 inch)	Grab
	Visual Inspection	1/3 months immediately following applicable storm event (>0.1 inch)	Visual observation
Station 1 – 9 & 11 (Note 2)	Temperature (°C)	Hourly during summer quarter and one other alternating quarter of year	Automated surface measurement.
Station 10 (Note 2)	Temperature (°C)	Hourly during summer quarter and one other alternating quarter of year	Automated 3 m deep measurement

Table 6.7-6 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
Stations A – N (Note 3)	Temperature (°C)	Hourly measurements during daylight hours	Automated surface to bottom measurements at one meter intervals

Data Source: VPDES Permit
Notes: 1. See Figure 6.6-3 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.6-2 for location.

Chapter 7 Environmental Impacts of Postulated Accidents Involving Radioactive Materials

The purpose of this section is to assess the environmental impacts of postulated accidents involving radioactive materials. Section 7.1 evaluates DBAs, Section 7.2 considers the impact of severe accidents, Section 7.3 addresses severe accident mitigation alternatives (SAMA), and Section 7.4 pertains to transportation accidents.

7.1 Design Basis Accidents

7.1.1 Selection of Accidents

The radiological consequences of accidents are assessed to demonstrate that new units could be constructed and operated at the ESP site without undue risk to the health and safety of the public. The assessment uses site-specific accident meteorology with the radiological analyses in selected reactor design certifications to analyze the suitability of the ESP site. The assessment uses a robust and conservative set of surrogate DBAs that is representative of the range of reactor designs being considered for the ESP site. The DBAs include a spectrum of events, including those of relatively greater probability of occurrence as well as those that are less probable but have greater severity.

The set of accidents selected focuses on two light water reactor (LWR) designs: AP1000 and ABWR. These two designs are used because they have (or are based on) previously certified standard designs and have recognized bases for postulated accident analyses. The accidents for some of the newer reactor types being considered are not as well defined as those for these LWRs and, hence, the accepted analytical methodologies and assumptions applied to LWRs may not apply to these newer reactors. However, because of their greater potential for inherent safety, the accident radiological consequences of the other reactors being considered for the site are expected to be bounded by the AP1000 and the ABWR. If one of these other designs is eventually selected for the ESP site, the COL application would verify that the AP1000 and ABWR doses are bounding or provide a complete evaluation of accident radiological consequences compared with regulatory limits.

The following LWR accidents are identified in NUREG-1555, Section 7.1, Appendix A (Reference 1), as those that should be considered for radiological consequences, based on the SRP, NUREG-0800 (Reference 2):

- SRP Section 15.1.5, PWR Main Steam Line Break
- SRP Section 15.2.8, PWR Feedwater System Pipe Break
- SRP Section 15.3.3, Locked Rotor Accident
- SRP Section 15.3.4, Reactor Coolant Pump Shaft Break

- SRP Section 15.4.9, BWR Control Rod Drop Accident
- SRP Section 15.6.2, Failure of Small Lines Carrying Primary Coolant Outside Containment
- SRP Section 15.6.3, PWR Steam Generator Tube Failure
- SRP Section 15.6.5, Loss-of-Coolant Accident
- SRP Section 15.7.4, Fuel Handling Accident

RG 1.183 (Reference 3) includes the following additional accidents:

- PWR Rod Ejection Accident (corresponds to SRP Section 15.4.8)
- BWR Main Steam Line Break (corresponds to SRP Section 15.6.4)

The radiological consequences from the above DBAs are analyzed. This set of accidents provides a reasonable basis for evaluating the suitability of the ESP site.

7.1.2 Evaluation Methodology

Doses for the representative DBAs are evaluated at the EAB and the LPZ. These doses must meet the site acceptance criteria in 10 CFR 50.34 and 10 CFR 100 (Reference 4 and Reference 5, respectively). Although the emergency safety features are expected to prevent core damage and mitigate releases of radioactivity, the loss-of-coolant accidents (LOCAs) analyzed presume substantial core melt with the release of significant amounts of fission products. The postulated LOCAs are expected to more closely approach 10 CFR 50.34 limits than the other DBAs of greater probability of occurrence but lesser magnitude of activity releases. For these accidents, the calculated doses are compared to the acceptance criteria in RG 1.183 and NUREG-0800, to demonstrate that the consequences of the postulated accidents are acceptable.

The evaluations use short-term accident atmospheric dispersion factors (χ/Q). The χ/Qs are calculated using the methodology of RG 1.145 (Reference 6) and site-specific meteorological data. The following site-specific 50th percentile χ/Q values from Section 2.7.5.2 are used in these evaluations, per NUREG-1555:

- EAB – 3.14E-5 sec/m^3
- LPZ – 1.36E-6 sec/m^3

The accident dose calculations are performed using the activity releases for the following time intervals:

- EAB – 0 to 2 hours
- LPZ – 0 to 8 hours, 8 to 24 hours, 24 to 96 hours, and 96 to 720 hours

The accident doses are expressed as TEDE, consistent with 10 CFR 50.34. The TEDE consists of the sum of the committed effective dose equivalent (CEDE) from inhalation and the deep dose equivalent (DDE) from external exposure. The CEDE is determined using the dose conversion

factors in Federal Guidance Report 11 (Reference 7), while the DDE is based on dose conversion factors in Federal Guidance Report 12 (Reference 8).

7.1.3 Source Terms

Doses are calculated based on the time-dependent activities released to the environment during each DBA. The activities are based on the analyses used to support the reactor standard safety analysis reports. Different reactor technologies use different source terms and approaches in defining the activity releases. The ABWR source term is based on TID-14844 (Reference 9). Environmental releases are calculated using the guidance in the NUREG-0800 and RGs 1.3 and 1.25 (Reference 10 and Reference 11, respectively). The AP1000 source terms, methodologies, and assumptions are based on the alternative source term methods outlined in RG 1.183. The IRIS and ACR-700 source term information are preliminary, but the AP1000 LOCA is expected to bound the worst-case accident releases for these advanced reactor concepts. Similarly, the worst-case accident releases for the ESBWR are expected to be bounded by the ABWR.

The advanced gas reactor designs (GT-MHR and PBMR) use mechanistic accident source terms and postulate relatively small environmental releases, compared with the water reactor technologies. The activity releases to the environment are typically provided by the reactor vendors as part of their standard design packages.

7.1.4 Radiological Consequences

For the accidents identified in Section 7.1.1, site-specific doses are calculated by multiplying the design certification doses by the ratio of site χ/Qs to design certification χ/Qs. The following design certification χ/Qs are used (Reference 12 and Reference 13):

Table 7.1-1 Design Certification χ/Q Values

		χ/Q (sec/m^3)	
	Time (hr)	**AP1000**	**ABWR**
EAB	0 - 2	6.00E-04	1.37E-03
LPZ	0 - 8	1.35E-04	1.56E-04
	8 - 24	1.00E-04	9.61E-05
	24 - 96	5.40E-05	3.36E-05
	96 - 720	2.20E-05	7.42E-06

Details about the methodology and assumptions pertaining to each of the accidents, such as activity release paths and the credited mitigation features, may be found in the design certification documents for the AP1000 (Reference 12) and the ABWR (Reference 13). As the ABWR design certification document presents whole body and thyroid doses, an equivalent TEDE value is

estimated by multiplying the thyroid dose by 0.03 and adding the product to the whole body dose in accordance with RG 1.183. Also, the ABWR doses are scaled up from a power level of 4005 MWt (102 percent of 3926 MWt, as specified in the design certification) to 4386 MWt (102 percent of 4300 MWt, the power proposed for a new ABWR unit at ESP site). A summary of the resulting accident doses is presented in Table 7.1-2. This table also compares the environmental doses to the recommended limits in RG 1.183 and NUREG-0800 and shows that the evaluated dose consequences are within the recommended limits.

The TEDE dose limits in Table 7.1-2 are taken from RG 1.183, Table 6, for all accidents except PWR Reactor Coolant Pump Shaft Break (SRP Section 15.3.4) and Failure of Small Lines Carrying Primary Coolant Outside Containment (SRP Section 15.6.2). For these two accidents, NUREG-0800 indicates that the dose limit is a “small fraction” or 10% of the 10 CFR 100 guideline of 25 Rem, meaning a limit of 2.5 Rem.

The doses summarized in Table 7.1-2 are based on the time-dependent doses presented in Table 7.1-3 to Table 7.1-28 for each of the accidents. In addition to doses, the latter tables also show the activities released to the environment.

Section 7.1 References

1. NUREG-1555, *Standard Review Plans for Environmental Reviews of Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, October 1999.

2. NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Report for Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, 1987.

3. Regulatory Guide 1.183, *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors*, U. S. Nuclear Regulatory Commission, July 2000.

4. 10 CFR 50.34, *Code of Federal Regulations*, “Contents of applications; technical information.”

5. 10 CFR 100, *Code of Federal Regulations*, “Reactor Site Criteria.”

6. Regulatory Guide 1.145, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, February 1983.

7. Federal Guidance Report 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, U. S. Environmental Protection Agency, EPA-520/1-88-020, 1993.

8. Federal Guidance Report 12, *External Exposure to Radionuclides in Air, Water, and Soil*, U. S. Environmental Protection Agency, EPA-402-R-93-081, 1993.

9. TID-14844, *Calculation of Distance Factors for Power and Test Reactor Sites*, U. S. Atomic Energy Commission, March 1962.

10. Regulatory Guide 1.3, *Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors*, U. S. Nuclear Regulatory Commission, June 1974.

11. Regulatory Guide 1.25 (Safety Guide 25), *Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors*, U. S. Nuclear Regulatory Commission, March 1972.

12. AP1000 Document No. APP-GW-GL-700, *AP1000 Design Control Document*, Tier 2 Material, Westinghouse, Revision 2, 2002.

13. Document 23A6100, *ABWR Standard Safety Analysis Report*, General Electric, Revision 8.

Table 7.1-2 Summary of Design Basis Accident Doses

SRP Section	Accident	Reactor	TEDE (Rem) EAB	TEDE (Rem) LPZ	TEDE (Rem) Limit
15.1.5	PWR Main Steam Line Break				
	Pre-Existing Iodine Spike	AP1000	3.6E-02	6.8E-03	25
	Accident-Initiated Iodine Spike	AP1000	4.1E-02	2.8E-02	2.5
15.2.8	PWR Feedwater System Pipe Break	AP1000	4.1E-02	2.8E-02	2.5
15.3.3	Reactor Coolant Pump Rotor Seizure (Locked Rotor Accident)	AP1000	1.3E-01	6.0E-03	2.5
		ABWR	Not Postulated		
15.3.4	Reactor Coolant Pump Shaft Break	AP1000	1.3E-01	6.0E-03	2.5
		ABWR	Not Postulated		
15.4.8	PWR Rod Ejection Accident	AP1000	1.6E-01	2.0E-02	6.3
15.4.9	BWR Control Rod Drop Accident	ABWR	Not Postulated		6.3
15.6.2	Failure of Small Lines Carrying Primary Coolant Outside Containment	AP1000	6.7E-02	3.0E-03	2.5
		ABWR	5.9E-03	2.6E-04	2.5
15.6.3	PWR Steam Generator Tube Rupture				
	Pre-Existing Iodine Spike	AP1000	1.6E-01	3.6E-03	25
	Accident-Initiated Iodine Spike	AP1000	7.8E-02	2.8E-03	2.5
15.6.4	BWR Main Steam Line Break				
	Pre-Existing Iodine Spike	ABWR	7.0E-02	3.1E-03	25
	Accident-Initiated Iodine Spike	ABWR	3.5E-03	1.5E-04	2.5
15.6.5	Loss-of-Coolant Accident	AP1000	1.3E+00	1.2E-01	25
		ABWR	2.4E-01	1.0E+00	25
15.7.4	Fuel Handling Accident	AP1000	1.2E-01	6.0E-03	6.3
		ABWR	8.6E-02	3.8E-03	6.3

Notes:

The AP1000 design certification indicates that the doses associated with the feedwater system pipe break are bounded by the main steam line break (Reference 12, Section 15.2.8.3).

The AP1000 design certification indicates that the doses for the reactor coolant pump shaft break are bounded by the reactor coolant pump rotor seizure (Reference 12, Section 15.3.4.2).

The ABWR design certification indicates that there are no radiological consequences for the reactor coolant pump rotor seizure, the reactor coolant pump shaft break, and the control rod drop accident (Reference 13, Sections 15.3.3.5, 15.3.4.5, and 15.4.10.6).

Table 7.1-3 Activity Releases for AP1000 Main Steam Line Break, Pre-Existing Iodine Spike

	Activity Release (Ci)				
Isotope	**0-2 hr**	**2-8 hr**	**8-24 hr**	**24-72 hr**	**Total**
Kr-85m	2.30E-01	3.82E-01	2.26E-01	2.03E-02	8.58E-01
Kr-85	9.47E-01	2.83E+00	7.47E+00	2.17E+01	3.29E+01
Kr-87	9.24E-02	4.49E-02	1.76E-03	2.84E-07	1.39E-01
Kr-88	3.77E-01	4.59E-01	1.34E-01	2.72E-03	9.73E-01
Xe-131m	4.28E-01	1.27E+00	3.26E+00	8.78E+00	1.37E+01
Xe-133m	5.31E-01	1.51E+00	3.45E+00	6.69E+00	1.22E+01
Xe-133	3.95E+01	1.15E+02	2.87E+02	7.03E+02	1.14E+03
Xe-135m	1.02E-02	4.44E-05	0.00E+00	0.00E+00	1.02E-02
Xe-135	1.04E+00	2.31E+00	2.78E+00	1.11E+00	7.24E+00
Xe-138	1.34E-02	3.81E-05	0.00E+00	0.00E+00	1.34E-02
I-130	4.98E-01	4.74E-01	6.95E-01	4.36E-01	2.10E+00
I-131	3.37E+01	4.05E+01	1.03E+02	2.67E+02	4.44E+02
I-132	4.02E+01	1.39E+01	2.68E+00	2.16E-02	5.68E+01
I-133	6.03E+01	6.35E+01	1.17E+02	1.30E+02	3.71E+02
I-134	8.24E+00	5.47E-01	4.77E-03	1.50E-08	8.79E+00
I-135	3.56E+01	2.73E+01	2.51E+01	5.60E+00	9.36E+01
Cs-134	1.91E+01	6.52E-01	1.72E+00	5.00E+00	2.65E+01
Cs-136	2.84E+01	9.57E-01	2.47E+00	6.69E+00	3.85E+01
Cs-137	1.38E+01	4.70E-01	1.24E+00	3.61E+00	1.91E+01
Cs-138	1.02E+01	3.41E-03	1.48E-06	0.00E+00	1.02E+01
Total	2.93E+02	2.72E+02	5.58E+02	1.16E+03	2.28E+03

Table 7.1-4 Doses for AP1000 Main Steam Line Break, Pre-Existing Iodine Spike

	TEDE (Rem)	
Time	**EAB**	**LPZ**
0 - 2 hr	3.63E-02	
0 - 8 hr		2.42E-03
8 - 24 hr		1.09E-03
24 - 96 hr		3.27E-03
96 - 720 hr		0.00E+00
Total	3.63E-02	6.78E-03
Limit	25	25

Table 7.1-5 Activity Releases for AP1000 Main Steam Line Break, Accident-Initiated Iodine Spike

	Activity Release (Ci)				
Isotope	**0-2 hr**	**2-8 hr**	**8-24 hr**	**24-72 hr**	**Total**
Isotope	0-2 hr	2-8 hr	8-24 hr	24-72 hr	Total
Kr-85m	2.30E-01	3.82E-01	2.26E-01	2.03E-02	8.58E-01
Kr-85	9.47E-01	2.83E+00	7.47E+00	2.17E+01	3.29E+01
Kr-87	9.24E-02	4.49E-02	1.76E-03	2.84E-07	1.39E-01
Kr-88	3.77E-01	4.59E-01	1.34E-01	2.72E-03	9.73E-01
Xe-131m	4.28E-01	1.27E+00	3.26E+00	8.78E+00	1.37E+01
Xe-133m	5.31E-01	1.51E+00	3.45E+00	6.69E+00	1.22E+01
Xe-133	3.95E+01	1.15E+02	2.87E+02	7.03E+02	1.14E+03
Xe-135m	1.02E-02	4.44E-05	0.00E+00	0.00E+00	1.02E-02
Xe-135	1.04E+00	2.31E+00	2.78E+00	1.11E+00	7.24E+00
Xe-138	1.34E-02	3.81E-05	0.00E+00	0.00E+00	1.34E-02
I-130	6.84E-01	3.33E+00	5.27E+00	3.30E+00	1.26E+01
I-131	3.92E+01	1.92E+02	5.18E+02	1.35E+03	2.10E+03
I-132	9.12E+01	3.26E+02	7.46E+01	6.00E-01	4.92E+02
I-133	7.75E+01	3.81E+02	7.54E+02	8.34E+02	2.05E+03
I-134	3.03E+01	6.23E+01	8.85E-01	2.78E-06	9.35E+01
I-135	5.57E+01	2.59E+02	2.61E+02	5.82E+01	6.34E+02
Cs-134	1.91E+01	6.52E-01	1.72E+00	5.00E+00	2.65E+01
Cs-136	2.84E+01	9.57E-01	2.47E+00	6.69E+00	3.85E+01
Cs-137	1.38E+01	4.70E-01	1.24E+00	3.61E+00	1.91E+01
Cs-138	1.02E+01	3.41E-03	1.48E-06	0.00E+00	1.02E+01
Total	4.09E+02	1.35E+03	1.92E+03	3.00E+03	6.68E+03

Table 7.1-6 Doses for AP1000 Main Steam Line Break, Accident-Initiated Iodine Spike

	TEDE (Rem)	
Time	**EAB**	**LPZ**
0 - 2 hr	4.15E-02	
0 - 8 hr		6.45E-03
8 - 24 hr		5.71E-03
24 - 96 hr		1.59E-02
96 - 720 hr		0.00E+00
Total	4.15E-02	2.80E-02
Limit	2.5	2.5

Table 7.1-7 Activity Releases for AP1000 Locked Rotor Accident

Isotope	Activity Release (Ci) 0–2 hr
Kr-85m	4.09E+02
Kr-85	3.77E+01
Kr-87	6.05E+02
Kr-88	1.05E+03
Xe-131m	1.87E+01
Xe-133m	1.02E+02
Xe-133	3.33E+03
Xe-135m	1.63E+02
Xe-135	8.01E+02
Xe-138	6.48E+02
I-130	4.15E+00
I-131	1.83E+02
I-132	1.33E+02
I-133	2.31E+02
I-134	1.44E+02
I-135	2.04E+02
Cs-134	5.83E+00
Cs-136	1.85E+00
Cs-137	3.42E+00
Cs-138	3.05E+01
Rb-86	6.69E-02
Total	8.11E+03

Table 7.1-8 Doses for AP1000 Locked Rotor Accident

	TEDE (Rem)	
Time	**EAB**	**LPZ**
0 - 2 hr	1.30E-01	
0 - 8 hr		6.04E-03
8 - 24 hr		0.00E+00
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	1.30E-01	6.04E-03
Limit	2.5	2.5

Table 7.1-9 Activity Releases for AP1000 Rod Ejection Accident

	Activity Release (Ci)					
Isotope	0-2 hr	2-8 hr	8-24 hr	24-96 hr	96-720 hr	Total
Kr-85m	2.85E+02	6.48E+01	3.87E+01	3.53E+00	5.01E-05	3.92E+02
Kr-85	1.24E+01	5.60E+00	1.49E+01	6.70E+01	5.71E+02	6.71E+02
Kr-87	4.86E+02	2.60E+01	1.03E+00	1.67E-04	0.00E+00	5.13E+02
Kr-88	7.49E+02	1.18E+02	3.49E+01	7.18E-01	1.68E-08	9.03E+02
Xe-131m	1.22E+01	5.46E+00	1.42E+01	5.72E+01	2.31E+02	3.20E+02
Xe-133m	6.62E+01	2.81E+01	6.49E+01	1.69E+02	1.06E+02	4.34E+02
Xe-133	2.18E+03	9.58E+02	2.40E+03	8.53E+03	1.68E+04	3.09E+04
Xe-135m	2.18E+02	5.30E-02	4.33E-09	0.00E+00	0.00E+00	2.18E+02
Xe-135	5.39E+02	1.72E+02	2.09E+02	8.69E+01	3.58E-01	1.01E+03
Xe-138	8.89E+02	1.38E-01	3.19E-09	0.00E+00	0.00E+00	8.89E+02
I-130	5.93E+00	7.28E+00	4.32E+00	4.06E-01	5.88E-04	1.79E+01
I-131	1.64E+02	2.45E+02	2.31E+02	6.20E+01	3.33E+01	7.35E+02
I-132	1.90E+02	9.94E+01	9.85E+00	1.65E-02	0.00E+00	2.99E+02
I-133	3.29E+02	4.40E+02	3.18E+02	4.56E+01	4.81E-01	1.13E+03
I-134	2.18E+02	2.85E+01	1.37E-01	8.96E-08	0.00E+00	2.47E+02
I-135	2.91E+02	2.97E+02	1.19E+02	4.79E+00	1.46E-04	7.12E+02
Cs-134	3.15E+01	6.22E+01	6.03E+01	1.55E+01	1.03E+01	1.80E+02
Cs-136	8.98E+00	1.75E+01	1.67E+01	4.10E+00	1.31E+00	4.86E+01
Cs-137	1.83E+01	3.62E+01	3.51E+01	9.04E+00	6.05E+00	1.05E+02
Cs-138	1.13E+02	7.05E+00	1.68E-03	0.00E+00	0.00E+00	1.20E+02
Rb-86	3.70E-01	7.27E-01	6.96E-01	1.73E-01	6.79E-02	2.03E+00
Total	6.81E+03	2.62E+03	3.57E+03	9.06E+03	1.78E+04	3.98E+04

Table 7.1-10 Doses for AP1000 Rod Ejection Accident

	TEDE (Rem)	
Time	EAB	LPZ
0 - 2 hr	1.56E-01	
0 - 8 hr		1.41E-02
8 - 24 hr		3.54E-03
24 - 96 hr		1.16E-03
96 - 720 hr		7.42E-04
Total	1.56E-01	1.95E-02
Limit	6.3	6.3

Table 7.1-11 Doses for AP1000 Failure of Small Lines Carrying Primary Coolant Outside Containment

	TEDE (Rem)	
Time	EAB	LPZ
0 - 2 hr	6.74E-02	
0 - 8 hr		3.02E-03
8 - 24 hr		0.00E+00
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	6.74E-02	3.02E-03
Limit	2.5	2.5

Note: No activity release information is available for this accident.

Table 7.1-12 Activity Releases for ABWR Failure of Small Lines Carrying Primary Coolant Outside Containment

	Activity Release (Ci)		
Isotope	**0-2 hr**	**2-8 hr**	**Total**
I-131	2.01E+00	2.16E+00	4.17E+00
I-132	1.76E+01	1.76E+01	3.52E+01
I-133	1.36E+01	1.43E+01	2.79E+01
I-134	2.93E+01	2.69E+01	5.62E+01
I-135	1.95E+01	2.01E+01	3.96E+01
Total	8.20E+01	8.11E+01	1.63E+02

Table 7.1-13 Doses for ABWR Failure of Small Lines Carrying Primary Coolant Outside Containment

	TEDE (Rem)	
Time	**EAB**	**LPZ**
0 - 2 hr	5.92E-03	
0 - 8 hr		2.59E-04
8 - 24 hr		0.00E+00
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	5.92E-03	2.59E-04
Limit	2.5	2.5

Table 7.1-14 Activity Releases for AP1000 Steam Generator Tube Rupture, Pre-Existing Iodine Spike

	Activity Release (Ci)			
Isotope	**0-2 hr**	**2-8 hr**	**8-24 hr**	**Total**
Kr-85m	5.67E+01	1.91E+01	2.50E-02	7.58E+01
Kr-85	2.25E+02	1.07E+02	4.44E-01	3.32E+02
Kr-87	2.46E+01	3.56E+00	3.02E-04	2.82E+01
Kr-88	9.44E+01	2.61E+01	1.80E-02	1.21E+02
Xe-131m	1.02E+02	4.82E+01	1.96E-01	1.50E+02
Xe-133m	1.26E+02	5.83E+01	2.19E-01	1.85E+02
Xe-133	9.37E+03	4.41E+03	1.75E+01	1.38E+04
Xe-135m	3.61E+00	5.78E-03	0.00E+00	3.62E+00
Xe-135	2.51E+02	1.00E+02	2.35E-01	3.51E+02
Xe-138	4.78E+00	4.99E-03	0.00E+00	4.78E+00
I-130	1.81E+00	6.12E-02	2.90E-01	2.16E+00
I-131	1.22E+02	5.97E+00	3.32E+01	1.61E+02
I-132	1.43E+02	8.53E-01	2.08E+00	1.46E+02
I-133	2.19E+02	8.68E+00	4.41E+01	2.72E+02
I-134	2.78E+01	5.16E-03	4.57E-03	2.78E+01
I-135	1.28E+02	3.06E+00	1.26E+01	1.44E+02
Cs-134	1.65E+00	6.35E-02	2.27E-01	1.94E+00
Cs-136	2.45E+00	9.30E-02	3.30E-01	2.87E+00
Cs-137	1.19E+00	4.58E-02	1.64E-01	1.40E+00
Cs-138	5.71E-01	3.07E-06	6.00E-07	5.71E-01
Total	1.09E+04	4.79E+03	1.12E+02	1.58E+04

Table 7.1-15 Doses for AP1000 Steam Generator Tube Rupture, Pre-Existing Iodine Spike

	TEDE (Rem)	
Time	EAB	LPZ
0 - 2 hr	1.56E-01	
0 - 8 hr		3.22E-03
8 - 24 hr		3.54E-04
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	1.56E-01	3.58E-03
Limit	25	25

Table 7.1-16 Activity Releases for AP1000 Steam Generator Tube Rupture, Accident-Initiated Iodine Spike

	Activity Release (Ci)			
Isotope	**0-2 hr**	**2-8 hr**	**8-24 hr**	**Total**
Kr-85m	5.67E+01	1.91E+01	2.50E-02	7.58E+01
Kr-85	2.25E+02	1.07E+02	4.44E-01	3.32E+02
Kr-87	2.46E+01	3.56E+00	3.02E-04	2.82E+01
Kr-88	9.44E+01	2.61E+01	1.80E-02	1.21E+02
Xe-131m	1.02E+02	4.82E+01	1.96E-01	1.50E+02
Xe-133m	1.26E+02	5.83E+01	2.19E-01	1.85E+02
Xe-133	9.37E+03	4.41E+03	1.75E+01	1.38E+04
Xe-135m	3.61E+00	5.78E-03	0.00E+00	3.62E+00
Xe-135	2.51E+02	1.00E+02	2.35E-01	3.51E+02
Xe-138	4.78E+00	4.99E-03	0.00E+00	4.78E+00
I-130	7.30E-02	1.19E-02	3.13E-02	1.16E-01
I-131	4.90E+00	1.15E+00	3.55E+00	9.60E+00
I-132	5.79E+00	1.75E-01	2.30E-01	6.20E+00
I-133	8.79E+00	1.68E+00	4.73E+00	1.52E+01
I-134	1.12E+00	1.18E-03	5.21E-04	1.12E+00
I-135	5.15E+00	6.01E-01	1.36E+00	7.11E+00
Cs-134	1.65E+00	6.35E-02	2.27E-01	1.94E+00
Cs-136	2.45E+00	9.30E-02	3.30E-01	2.87E+00
Cs-137	1.19E+00	4.58E-02	1.64E-01	1.40E+00
Cs-138	5.71E-01	3.07E-06	6.00E-07	5.71E-01
Total	1.03E+04	4.78E+03	2.93E+01	1.51E+04

Table 7.1-17 Doses for AP1000 Steam Generator Tube Rupture, Accident-Initiated Iodine Spike

	TEDE (Rem)	
Time	**EAB**	**LPZ**
0 - 2 hr	7.78E-02	
0 - 8 hr		1.81E-03
8 - 24 hr		9.79E-04
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	7.78E-02	2.79E-03
Limit	2.5	2.5

Table 7.1-18 Activity Releases for ABWR Main Steam Line Break

	Activity Release (Ci)	
Isotope	Pre-Existing	Accident Initiated
I-131	4.32E+01	2.16E+00
I-132	4.20E+02	2.10E+01
I-133	2.95E+02	1.48E+01
I-134	8.25E+02	4.14E+01
I-135	4.32E+02	2.16E+01
Kr-83m	7.22E-02	1.20E-02
Kr-85m	1.27E-01	2.12E-02
Kr-85	4.02E-04	6.68E-05
Kr-87	4.35E-01	7.22E-02
Kr-88	4.38E-01	7.27E-02
Kr-89	1.75E+00	2.92E-01
Kr-90	4.58E-01	7.54E-02
Xe-131m	3.13E-04	5.20E-05
Xe-133m	6.03E-03	1.00E-03
Xe-133	1.69E-01	2.80E-02
Xe-135m	5.15E-01	8.55E-02
Xe-135	4.79E-01	7.98E-02
Xe-137	2.19E+00	3.64E-01
Xe-138	1.67E+00	2.79E-01
Xe-139	7.66E-01	1.28E-01
Total	2.02E+03	1.02E+02

Table 7.1-19 Doses for ABWR Main Steam Line Break, Pre-Existing Iodine Spike

	TEDE (Rem)	
Time	EAB	LPZ
0 - 2 hr	7.04E-02	
0 - 8 hr		3.08E-03
8 - 24 hr		0.00E+00
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	7.04E-02	3.08E-03
Limit	25	25

Table 7.1-20 Doses for ABWR Main Steam Line Break, Accident-Initiated Iodine Spike

	TEDE (Rem)	
Time	EAB	LPZ
0 - 2 hr	3.48E-03	
0 - 8 hr		1.52E-04
8 - 24 hr		0.00E+00
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	3.48E-03	1.52E-04
Limit	2.5	2.5

Table 7.1-21 Activity Releases for AP1000 Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	0-2 hr	2-8 hr	8-24 hr	24-96 hr	96-720 hr	Total
Kr-85m	6.31E+02	3.14E+03	1.87E+03	1.71E+02	2.43E-03	5.82E+03
Kr-85	3.22E+01	2.64E+02	7.05E+02	3.17E+03	2.70E+04	3.12E+04
Kr-87	6.87E+02	1.26E+03	4.97E+01	8.11E-03	0.00E+00	1.99E+03
Kr-88	1.50E+03	5.76E+03	1.70E+03	3.49E+01	8.16E-07	8.99E+03
Xe-131m	3.20E+01	2.62E+02	6.79E+02	2.74E+03	1.11E+04	1.48E+04
Xe-133m	1.74E+02	1.37E+03	3.15E+03	8.21E+03	5.15E+03	1.80E+04
Xe-133	5.71E+03	4.62E+04	1.16E+05	4.11E+05	8.10E+05	1.39E+06
Xe-135m	3.33E+01	2.62E+00	2.14E-07	0.00E+00	0.00E+00	3.59E+01
Xe-135	1.31E+03	8.33E+03	1.01E+04	4.21E+03	1.73E+01	2.40E+04
Xe-138	1.14E+02	6.83E+00	1.58E-07	0.00E+00	0.00E+00	1.20E+02
I-130	3.22E+01	4.58E+01	2.96E+00	1.11E+00	1.99E-02	8.21E+01
I-131	9.13E+02	1.45E+03	1.56E+02	3.74E+02	1.12E+03	4.01E+03
I-132	8.77E+02	7.93E+02	7.64E+00	2.29E-02	0.00E+00	1.68E+03
I-133	1.81E+03	2.70E+03	2.16E+02	1.63E+02	1.62E+01	4.91E+03
I-134	7.16E+02	3.04E+02	1.26E-01	1.07E-07	0.00E+00	1.02E+03
I-135	1.53E+03	1.97E+03	8.31E+01	9.55E+00	4.95E-03	3.59E+03
Cs-134	1.46E+02	2.16E+02	8.06E+00	1.88E-01	1.59E+00	3.72E+02
Cs-136	4.15E+01	6.13E+01	2.25E+00	4.72E-02	2.03E-01	1.05E+02
Cs-137	8.50E+01	1.26E+02	4.70E+00	1.10E-01	9.39E-01	2.17E+02
Cs-138	2.67E+02	5.25E+01	6.92E-04	0.00E+00	0.00E+00	3.19E+02
Rb-86	1.72E+00	2.54E+00	9.37E-02	2.03E-03	1.05E-02	4.37E+00
Sb-127	1.10E+01	2.01E+01	7.13E-01	1.16E-02	1.60E-02	3.18E+01
Sb-129	2.63E+01	3.65E+01	4.83E-01	1.01E-04	1.00E-09	6.33E+01
Te-127m	1.42E+00	2.64E+00	9.83E-02	2.27E-03	1.77E-02	4.18E+00
Te-127	9.83E+00	1.59E+01	3.65E-01	5.63E-04	2.72E-06	2.61E+01
Te-129m	4.85E+00	9.00E+00	3.33E-01	7.47E-03	4.79E-02	1.42E+01
Te-129	1.35E+01	9.71E+00	8.54E-03	7.27E-10	0.00E+00	2.32E+01
Te-131m	1.46E+01	2.60E+01	8.29E-01	6.86E-03	1.60E-03	4.14E+01

Table 7.1-21 Activity Releases for AP1000 Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	**0-2 hr**	**2-8 hr**	**8-24 hr**	**24-96 hr**	**96-720 hr**	**Total**
Te-132	1.46E+02	2.68E+02	9.42E+00	1.44E-01	1.60E-01	4.24E+02
Sr-89	4.16E+01	7.74E+01	2.87E+00	6.54E-02	4.60E-01	1.22E+02
Sr-90	3.59E+00	6.68E+00	2.48E-01	5.82E-03	4.97E-02	1.06E+01
Sr-91	4.64E+01	7.52E+01	1.74E+00	2.76E-03	1.44E-05	1.23E+02
Sr-92	3.80E+01	4.50E+01	3.26E-01	1.06E-05	0.00E+00	8.33E+01
Ba-139	3.64E+01	2.98E+01	4.73E-02	2.03E-08	0.00E+00	6.63E+01
Ba-140	7.35E+01	1.36E+02	5.00E+00	1.05E-01	4.41E-01	2.15E+02
Mo-99	9.77E+00	1.78E+01	6.19E-01	8.79E-03	7.72E-03	2.82E+01
Tc-99m	7.30E+00	1.10E+01	1.94E-01	1.08E-04	2.73E-08	1.85E+01
Ru-103	7.82E+00	1.45E+01	5.38E-01	1.21E-02	8.11E-02	2.30E+01
Ru-105	4.19E+00	5.87E+00	7.97E-02	1.82E-05	2.40E-10	1.01E+01
Ru-106	2.57E+00	4.79E+00	1.78E-01	4.16E-03	3.46E-02	7.58E+00
Rh-105	4.71E+00	8.45E+00	2.76E-01	2.64E-03	8.48E-04	1.34E+01
Ce-141	1.76E+00	3.26E+00	1.21E-01	2.71E-03	1.72E-02	5.16E+00
Ce-143	1.59E+00	2.84E+00	9.20E-02	8.29E-04	2.34E-04	4.51E+00
Ce-144	1.32E+00	2.47E+00	9.19E-02	2.14E-03	1.77E-02	3.91E+00
Pu-238	4.13E-03	7.70E-03	2.86E-04	6.71E-06	5.73E-05	1.22E-02
Pu-239	3.63E-04	6.77E-04	2.52E-05	5.90E-07	5.04E-06	1.07E-03
Pu-240	5.34E-04	9.92E-04	3.69E-05	8.65E-07	7.39E-06	1.57E-03
Pu-241	1.19E-01	2.23E-01	8.30E-03	1.94E-04	1.66E-03	3.52E-01
Np-239	2.04E+01	3.72E+01	1.27E+00	1.67E-02	1.17E-02	5.89E+01
Y-90	3.68E-02	6.70E-02	2.32E-03	3.25E-05	2.75E-05	1.06E-01
Y-91	5.35E-01	9.94E-01	3.69E-02	8.43E-04	6.09E-03	1.57E+00
Y-92	4.18E-01	5.46E-01	5.77E-03	5.86E-07	0.00E+00	9.70E-01
Y-93	5.81E-01	9.48E-01	2.25E-02	4.05E-05	2.91E-07	1.55E+00
Nb-95	7.20E-01	1.34E+00	4.95E-02	1.11E-03	7.23E-03	2.12E+00
Zr-95	7.17E-01	1.33E+00	4.94E-02	1.13E-03	8.29E-03	2.11E+00
Zr-97	6.66E-01	1.15E+00	3.26E-02	1.38E-04	7.58E-06	1.84E+00

Table 7.1-21 Activity Releases for AP1000 Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	**0-2 hr**	**2-8 hr**	**8-24 hr**	**24-96 hr**	**96-720 hr**	**Total**
La-140	7.66E-01	1.38E+00	4.58E-02	4.84E-04	1.97E-04	2.19E+00
La-141	5.37E-01	7.26E-01	8.69E-03	1.31E-06	0.00E+00	1.27E+00
La-142	3.47E-01	3.06E-01	6.67E-04	6.96E-10	0.00E+00	6.53E-01
Nd-147	2.79E-01	5.16E-01	1.89E-02	3.88E-04	1.49E-03	8.16E-01
Pr-143	6.28E-01	1.16E+00	4.27E-02	9.01E-04	3.95E-03	1.84E+00
Am-241	5.40E-05	1.00E-04	3.74E-06	8.75E-08	7.48E-07	1.59E-04
Cm-242	1.27E-02	2.37E-02	8.81E-04	2.04E-05	1.64E-04	3.75E-02
Cm-244	1.56E-03	2.91E-03	1.08E-04	2.53E-06	2.16E-05	4.61E-03
Total	1.72E+04	7.52E+04	1.35E+05	4.30E+05	8.54E+05	1.51E+06

Table 7.1-22 Doses for AP1000 Loss-of-Coolant Accident

	TEDE (Rem)	
Time	**EAB**	**LPZ**
0 - 2 hr	1.29E+00	
0 - 8 hr		9.27E-02
8 - 24 hr		4.49E-03
24 - 96 hr		7.81E-03
96 - 720 hr		1.79E-02
Total	1.29E+00	1.23E-01
Limit	25	25

Table 7.1-23 Activity Releases for ABWR Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	**0-2 hr**	**2-8 hr**	**8-24 hr**	**24-96 hr**	**96-720 hr**	**Total**
I-131	2.84E+02	1.25E+02	1.01E+03	9.52E+03	6.80E+04	7.90E+04
I-132	3.85E+02	3.63E+01	3.55E+01	0.00E+00	0.00E+00	4.57E+02
I-133	5.92E+02	2.21E+02	1.29E+03	3.64E+03	7.39E+02	6.48E+03
I-134	5.62E+02	1.17E+00	0.00E+00	0.00E+00	0.00E+00	5.63E+02
I-135	5.62E+02	1.45E+02	3.63E+02	1.83E+02	0.00E+00	1.25E+03
Kr-83m	3.57E+02	5.09E+02	1.66E+02	0.00E+00	0.00E+00	1.03E+03
Kr-85	4.47E+01	3.38E+02	2.40E+03	2.38E+04	3.13E+05	3.40E+05
Kr-85m	9.24E+02	3.17E+03	4.78E+03	7.69E+02	0.00E+00	9.64E+03
Kr-87	1.31E+03	1.07E+03	1.01E+02	0.00E+00	0.00E+00	2.48E+03
Kr-88	2.32E+03	5.48E+03	3.76E+03	3.25E+02	0.00E+00	1.19E+04
Kr-89	1.98E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E+02
Xe-131m	2.33E+01	1.65E+02	1.22E+03	1.04E+04	6.80E+04	7.98E+04
Xe-133	8.35E+03	5.85E+04	4.12E+05	3.04E+06	9.20E+06	1.27E+07
Xe-133m	3.28E+02	2.38E+03	1.51E+04	8.31E+04	7.95E+04	1.80E+05
Xe-135	1.01E+03	5.02E+03	1.66E+04	1.28E+04	0.00E+00	3.55E+04
Xe-135m	5.33E+02	8.87E-02	0.00E+00	0.00E+00	0.00E+00	5.33E+02
Xe-137	5.62E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.62E+02
Xe-138	2.19E+03	1.48E-01	0.00E+00	0.00E+00	0.00E+00	2.19E+03
Total	2.05E+04	7.72E+04	4.59E+05	3.18E+06	9.73E+06	1.35E+07

Table 7.1-24 Doses for ABWR Loss-of-Coolant Accident

	TEDE (Rem)	
Time	**EAB**	**LPZ**
0 - 2 hr	2.44E-01	
0 - 8 hr		1.84E-02
8 - 24 hr		2.17E-02
24 - 96 hr		1.54E-01
96 - 720 hr		8.43E-01
Total	2.44E-01	1.04E+00
Limit	25	25

Table 7.1-25 Activity Releases for AP1000 Fuel Handling Accident

	Activity Release (Ci)
Isotope	**0–2 hr**
Kr-85m	2.68E-03
Kr-85	1.10E+03
Xe-131m	5.36E+02
Xe-133m	1.29E+03
Xe-133	6.94E+04
Xe-135m	4.37E-01
Xe-135	1.32E+02
I-130	3.52E-02
I-131	2.90E+02
I-132	1.54E+02
I-133	1.91E+01
I-135	1.36E-02
Total	7.29E+04

Table 7.1-26 Doses for AP1000 Fuel Handling Accident

	TEDE (Rem)	
Time	EAB	LPZ
0 - 2 hr	1.24E-01	
0 - 8 hr		6.04E-03
8 - 24 hr		0.00E+00
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	1.24E-01	6.04E-03
Limit	6.3	6.3

Table 7.1-27 Activity Releases for ABWR Fuel Handling Accident

Isotope	Activity Release (Ci) 0–2 hr
I-131	1.35E+02
I-132	1.66E+02
I-133	1.39E+02
I-134	6.74E-06
I-135	2.25E+01
Kr-83m	7.04E+00
Kr-85	9.34E+01
Kr-85m	5.23E+02
Kr-87	1.35E-02
Kr-88	2.66E+01
Kr-89	8.90E-11
Xe-131m	9.14E+01
Xe-133	1.20E+03
Xe-133m	3.08E+04
Xe-135	2.42E+02
Xe-135m	6.98E+03
Xe-137	2.27E-10
Xe-138	4.70E-10
Total	4.04E+04

Table 7.1-28 Doses for ABWR Fuel Handling Accident

	TEDE (Rem)	
Time	EAB	LPZ
0 - 2 hr	8.58E-02	
0 - 8 hr		3.75E-03
8 - 24 hr		0.00E+00
24 - 96 hr		0.00E+00
96 - 720 hr		0.00E+00
Total	8.58E-02	3.75E-03
Limit	6.3	6.3

7.2 Severe Accidents

This section describes the probabilities and consequences of accidents of greater severity than the DBAs. As a class, they are considered less likely to occur, but because their consequences could be more severe, they are considered important both in terms of impact to the environment and off-site costs. These severe accidents can be distinguished from DBAs in two primary respects:

1. They involve substantial physical deterioration of the fuel in the reactor core, including overheating to the point of melting.

2. They involve deterioration of the capability of the containment system to perform its intended function of limiting the release of radioactive materials to the environment.

In NUREG-1437, the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), the NRC generically assesses the impacts of severe accidents during license renewal periods, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period (Reference 1). This methodology is used as a basis for evaluating the severe accident environmental impacts of new units at the ESP site.

7.2.1 Applicability of Existing Generic Severe Accident Studies

NUREG-1437, Section 5.3.3, presents a thorough assessment by the NRC staff of the impacts of severe accidents during the license renewal period. Methodologies are developed therein to evaluate each of the dose pathways by which a severe accident may result in adverse environmental impacts and to estimate the off-site costs of severe accidents. This assessment methodology and the resulting conclusions are considered, for reasons discussed below, broadly applicable beyond the license renewal context, including evaluation of severe accident impacts associated with determining site suitability for a nuclear power plant. The three NUREG-1437 pathways for release of radioactive material to the environment from severe accidents (atmospheric, air to surface water, and groundwater to surface water) are discussed in this section. The economic impacts from severe accidents are also comparatively evaluated in this section.

The GEIS evaluations and conclusions are based on existing assessments of severe accident impacts presented in numerous Final Environmental Statements (FES) published after 1980 and for a representative set of U.S. plants and sites in NUREG-1150 (Reference 2). The GEIS results are expressed as a range of values in terms of risk of severe accident impact per reactor-year of operation. The NRC confirms, in 61 FR 28480, that “the analyses performed for the GEIS represent adequate, plant-specific estimates of the impacts from severe accidents…” (Reference 3).

As described in the GEIS, the purpose of the evaluation of severe accidents is “to use, to the extent possible, the available severe accident results, in conjunction with those factors that are important to risk and that change with time to estimate the consequences of nuclear plant accidents for all

plants for a time period that exceeds the time frame of existing analyses." This estimation process is completed by predicting increases or decreases in consequences as the plant lifetime is extended past the normal license period by considering the projected changes in the risk factors. The primary assumption in this analysis is that regulatory controls ensure that the physical plant condition, which affects the predicted probability of and radioactive releases from an accident, is maintained at a constant level during the renewal period; therefore, the frequency and magnitude of a release remains relatively constant. In other words, significant changes in consequences would result only from changes in the plant's external environment. The logical approach, then, would be to incorporate the most significant environmental factors into calculations of consequences for subsequent correlation with existing analyses, which use the consequence computer codes.

The NRC staff concludes in NUREG-1437 that the primary factors affecting risk are the site population, which reflects the number of people potentially at risk to severe accident exposure, and wind direction, which reflects the likelihood of exposure. Secondary factors – such as terrain, rainfall, and wind stability – also have some effect on risk, but their impact is judged to be much smaller than the effects of population and wind direction. These factors are included in the FES analyses whose results are the bases for the GEIS analyses. Consequently, their effects are indirectly considered in the prediction of future risks and are reflected within the uncertainty bounds generated by the regression of the FES risk values. To ensure that the existing FES analyses cover a range of secondary factors representative of the total population of plants, the more significant secondary factors are also examined in the GEIS. Variations in these factors (precipitation, 50-mile population, 50-mile population in the direction of highest wind frequency, general terrain, and emergency planning) are found to be enveloped by the FES analyses and thus reasonably accounted for in the GEIS evaluation of severe accidents.

Detailed evaluations of severe accident consequences such as early and latent fatalities and total dose are not available for all plants considered in the GEIS. Therefore, a predictor for these consequences is developed using correlations based upon the calculated results from the existing FES severe accident analyses. This predictor is then used to infer the future consequence level of all individual nuclear plants. Correlations are developed using two environmental parameters that are available for all plants. This correlation process is well described in NUREG-1437.

While NUREG-1437 discussions deal with the environmental impacts of accidents during operation after license renewal, the primary assumption for this evaluation is that the frequency or likelihood of occurrence of an accident at a given plant would not increase during the plant lifetime, inclusive of the license renewal period, because regulatory controls ensure that the plant's licensing basis is maintained and improved, where warranted. The GEIS use of severe accident risk per reactor-year of operation as the principal metric for evaluating severe accident environmental impacts and the assumption that this risk remains constant over the life of the plant are equally applicable and appropriate in the license renewal context as in the ESP and COL contexts. Therefore, the

thorough generic analysis of severe accident impacts presented in the GEIS also provides an appropriate basis and method for evaluating severe accident impacts for early site permitting.

It is recognized, however, that the changing environment around the plant is not subject to regulatory controls and introduces the potential for changing risk. Consequently, the site-specific environmental considerations (population and meteorology) are evaluated in the GEIS and are considered in the following sections.

Specifically, the following evaluation of the significant factors associated with the environment shows these factors for the ESP site are not substantially different from those factors identified for previously analyzed sites. Thus, it follows that the environmental impacts for the ESP site would not be substantially different from the acceptable environmental impacts identified for the previously analyzed sites. Furthermore, the NRC's severe accident policy statement about new reactors (Reference 4) reinforces the concept that the results of the existing severe accident analyses would bound the consequences of the advanced reactor designs being considered for the ESP site.

7.2.2 **Evaluation of Potential Severe Accident Releases**

The significance of the impacts associated with each issue is identified as either small, moderate, or large, consistent with the criteria that the NRC established in Appendix B to Subpart A of 10 CFR 51, Table B-1, Footnote 3 as follows (Reference 4):

- Small – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.
- Moderate – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attribute of the resource.
- Large – Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

In accordance with NEPA practice, ongoing and potential additional mitigations are considered in proportion to the significance of the impact to be addressed, meaning that impacts that are small receive less mitigative consideration than impacts that are large.

7.2.2.1 **Evaluation of Potential Releases via Atmospheric Pathway**

The site-specific significant factors of demography and meteorology are considered in the evaluation of the atmospheric exposure pathway for new units at the ESP site. For this evaluation, NUREG-1437 calculates an exposure index (EI) for use in comparing the relative risk for the current fleet of nuclear power plants. NUREG-1437 provides the following discussion of EI:

> Population, which changes over time, defines the number of people within a given distance from the plant. Wind direction, which is assumed not to change from year to

> year, helps determine what proportion of the population is at risk in a given direction, because radionuclides are carried by the wind. Therefore, an EI relationship was developed by multiplying the wind direction frequency (fraction of the time per year) for each of 16 (22.5 degrees) compass sectors times the population in that sector for a given distance from the plant and summing all products. … Population varies with population growth and movement, and with the distance from any given plant. As the population changes for that plant, the EI also changes (the larger the EI, the larger the number of people at risk). Thus, EI is proportional to risk and an EI for a site for a future year can be used to predict the risk to the population around that site in that future year.

Thus, the EI is a function of population surrounding the site, weighted by the site-specific wind direction frequency, and is, therefore, a site-specific parameter. Because meteorological patterns, including wind direction frequency, tend to remain constant over time, the site meteorology would not be significantly different for the ESP site than that considered in NUREG-1437 for the NAPS site and only population can significantly affect the resulting risk in any given year of reactor operation.

The 50-mile population projection for the ESP site is 2.8 million for the year 2040 (Table 2.5-8). This is about 90 percent higher than the projection of 1.5 million in NUREG-1437 for the NAPS site for the year 2030 (Reference 1, Table 5.3). Thus, based on the new population projection, the EI values for the ESP site are expected to be about 90 percent higher than those established in NUREG-1437.

Two EI values are evaluated in NUREG-1437. A 10-mile EI is found to best correlate with early fatalities and a 150-mile EI is found to best correlate with latent fatalities and total dose. Using these indices, it is determined that the risk of early and latent fatalities from individual nuclear power plants is small and represents only a small fraction of the risk to which the public is exposed from other sources.

NUREG-1437 indicates a 10-mile EI for the NAPS site of 704 for the year 2030, while the 10-mile EI for the current generation of nuclear power plant sites ranges from 96 to 18,959 (Reference 1, Table 5.7). Even with the assumption of an EI for the ESP site 90 percent higher than that shown in NUREG-1437 for the NAPS site, the ESP site 10-mile EI is within the range of risk calculated for the existing fleet of nuclear power plants.

NUREG-1437 indicates a 150-mile EI for the NAPS site of 876,587 for the year 2030, while the 150-mile EI for the current generation of nuclear power plant sites ranges from 132,195 to 2,863,844 (Reference 1, Table 5.8). Even with the assumption of an EI for the ESP site 90 percent higher than that shown in NUREG-1437 for the NAPS site, the ESP site 150-mile EI is within the range of risk calculated for the existing fleet of nuclear power plants.

Thus, the risks for new units at the ESP site for the atmospheric exposure pathway would be within the range of those considered in NUREG-1437 as “small.” NUREG-1437, Section 5.5.2.1, indicates

that these predicted effects of a severe accident "are not expected to exceed a small fraction of that risk to which the population is already exposed."

7.2.2.2 Evaluation of Potential Releases via Atmospheric Fallout onto Open Bodies of Water

This section examines radiation exposure risk for new reactors at the ESP site in the event of a severe reactor accident in which radioactive contaminants are released into the atmosphere and subsequently deposited onto open bodies of water. In the GEIS, the drinking water pathway is treated separately, while the aquatic food, swimming, and shoreline pathways are addressed collectively. Population dose estimates for both the drinking water and aquatic food pathways are then compared with estimates from the atmospheric pathway.

As reported in NUREG-1437, analyses for both the drinking water and aquatic food pathways are performed with and without considering interdiction. In the case of the drinking-water pathway, the Great Lakes and the estuarine sites are bound by a previous site evaluation (i.e., Fermi) while small river sites with relatively low annual flow rates, long residence times, and large surface-area-to-volume ratios may potentially not be bounded by a previous analysis. In all cases, however, interdiction can reduce relative risk to levels at or below that of the previous acceptable analysis and significantly below that for the atmospheric pathway. River sites that may have relatively high concentrations of contaminants, but which remove contaminants within short periods of time (hours to several days), are amenable to short-term interdiction. A similar level of reduced risk can be achieved at those sites with longer residence times (months) by more extensive interdictive measures.

For the aquatic food pathway, the population dose and the population exposure per reactor-year are directly related to aquatic food harvest. For river sites, the population exposure for the un-interdicted pathway is lower than that for the atmospheric pathway by orders of magnitude. For Great Lakes sites, the un-interdicted population exposure is a substantial fraction of that predicted for the atmospheric pathway but is reduced significantly by interdiction. For estuarine sites with large annual aquatic food harvests, dose reduction of a factor of 2 to 10 through interdiction provides essentially the same population exposure estimates as the atmospheric pathway.

For these reasons, population dose for the drinking-water pathway is found to be a small fraction of that for the atmospheric pathway. Risk associated with the aquatic food pathway is found to be small relative to the atmospheric pathway for most sites and essentially the same as the atmospheric pathway for the few sites with large annual aquatic food harvests.

Environmental parameters important for input in performing the above analyses, and for use in analyses of additional sites, are: 1) the surface area of the receiving body, 2) the volume of water in the body, and 3) the flow rate. In the absence of rigorous site-specific analyses, these data can provide estimates of the extent of contamination in the receiving water body and the residence time of the contaminant in the affected water body. Comparing these estimates and site environmental

parameters with those for the previously evaluated site (i.e., Fermi) can provide an indication of the comparative hazard associated with drinking contaminated surface water among sites and the need for site-specific analyses. Accounting for population and meteorological data in the comparison can provide further indication of relative risk among sites.

The environmental parameters listed above have been identified in the GEIS for the NAPS site (Reference 1, Table 5.14a). These parameters are applicable for new units at the ESP site, since these parameters are generally constant for a given site, and no major changes have been identified that would impact these parameters. Thus, the drinking-water pathway and the aquatic food, swimming, and shoreline pathways for the ESP site are comparable to those considered in the GEIS evaluation. Therefore, the risk from air fallout to a water body exposure pathway generally compares favorably with the risk to the population from atmospheric releases. The risks for new units at the ESP site for the water body exposure pathway would also be within the range of those considered in NUREG-1437 as “small.”

7.2.2.3 **Evaluation of Potential Releases to Groundwater**

This section discusses the potential for radiation exposure from the groundwater pathway as the result of postulated severe accidents for new units at the ESP site. Severe accidents are the only accidents capable of producing significant groundwater contamination.

As identified in NUREG-1437, groundwater contamination due to severe accidents has been evaluated generically in NUREG-0440, Liquid Pathway Generic Study (LPGS) (Reference 5). The LPGS evaluates the consequences assuming a core melt with subsequent basemat melt-through. The LPGS examines six generic sites using typical or comparative assumptions about geology, adsorption factors, etc.

According to NUREG-1437, “the LPGS results are believed to provide generally conservative uninterdicted population dose estimates in the six generic plant-site categories. Five of these categories are site groupings in common locations adjacent to small rivers, large rivers, the Great Lakes, oceans, and estuaries. In a severe accident, contaminated groundwater could reach nearby surface water bodies and the population could be exposed to this source of contamination through drinking of surface water, ingestion of finfish and shellfish, and shoreline contact. Exposure by drinking contaminated groundwater is considered to be minor or nonexistent in these five categories because of a limited number of drinking-water wells. The sixth category is a “dry” site located either at a considerable distance from surface water bodies or where groundwater flow is away from a nearby surface water body. In this case, the only population exposure results from drinking contaminated groundwater.” (Reference 1, Section 5.3.3.4.1)

NUREG-1437 concludes that the risk from the groundwater exposure pathway generally contributes only a small fraction of that risk attributable to the population from the atmospheric pathway but in a few cases may contribute a comparable risk.

In the GEIS analysis, site-specific data of groundwater travel time; retention-adsorption coefficients; distance to surface water; and soil, sediment, and rock characteristics are compared with previous groundwater contamination analyses (Reference 1, Section 5.3.3.4). Previous analyses are contained in the LPGS and site-specific FESs. These environmental parameters have been identified in the GEIS for the NAPS site. These same parameters are applicable to new units at the ESP site, since these environmental parameters are generally constant for a given site, and no major changes have been identified that would impact these parameters. Thus, the groundwater pathway for the ESP site is comparable to that considered in the GEIS evaluation. Therefore, the risk from the groundwater exposure pathway generally compares favorably with the risk to the population from atmospheric releases. The risks for new units at the ESP site for the groundwater exposure pathway would also be within the range of those considered in NUREG-1437 as “small.”

7.2.3 Evaluation of Economic Impacts of Severe Accidents

This section discusses the potential economic impact that could result from postulated severe accidents at the ESP site. Similar to Section 7.2.2.1, the EI is used as a predictor of cost because, as identified in the GEIS, the cost should be dependent on the economic impact in the same way and for the same reason that population dose estimates are dependent on the EI values.

As noted in NUREG-1437, FES analyses use the Calculation of Reactor Accident Consequences (CRAC) computer code to calculate off-site severe accident costs for the area contaminated by the accident. The off-site costs that are considered relate to avoidance of adverse health effects and are categorized as follows:

- Evacuation costs
- Value of crops contaminated and condemned
- Value of milk contaminated and condemned
- Costs of decontamination of property where practical
- Indirect costs resulting from the loss of use of property and incomes derived therefrom, including interdiction to prevent human injury

For those FES analyses that address severe accidents, the off-site accident costs are estimated to be as high as $6 billion to $8 billion in 1994 dollars; however, the accident probabilities are extremely low (1E-6 per year), as would be expected for this class of events. Because key variables used in the FES cost analyses are strongly related to population density, NUREG-1437 further evaluates the FES results using normalization techniques and the 150-mile EI values. This evaluation, which includes the NAPS site, demonstrates that the FES cost predictions remain valid, even considering population changes represented by the EI values.

In addition, NUREG-1437 generically predicts that conditional land contamination is small (10 acres per year at most). This is consistent with WASH-1400 (Reference 6) and NUREG/CR-2239 (Reference 7). NUREG/CR-2239 is a 1982 study on siting criteria that predicts small conditional

land contamination values. The GEIS concludes that land contamination values for the evaluated plants can be considered representative of all plants, since they cover the major vendor and containment types and include sites at the upper end of annual rainfall. However, even considering that land contamination values can vary at other sites, predicted land contamination from plants at other sites are expected to vary more than one or two orders of magnitude from the values listed above and, therefore, there would still be a small impact.

Based on the evaluations of the expected economic costs and land contamination as a result of a severe accident, the GEIS concludes in Section 5.5.2.4 that the conditional impacts in both cases are of small significance for all plants. As with other aspects of the GEIS evaluation of severe accident impacts, this evaluation and conclusion are broadly applicable beyond the license renewal context. Thus the economic impacts and land contamination resulting from postulated severe accidents at new units on the ESP site would be comparable as well, falling within the range of those considered in NUREG-1437 as having a “small” impact.

7.2.4 **Consideration of Commission Severe Accident Policy**

In 1985, the NRC adopted a Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants (Reference 8), which stated the following:

> “The Commission fully expects that vendors engaged in designing new standard (or custom) plants will achieve a higher standard of severe accident safety performance than their prior designs. This expectation is based on:
>
> - The growing volume of information from industry and government-sponsored research and operating reactor experience has improved our knowledge of specific severe accident vulnerabilities and of low-cost methods for their mitigation. Further learning on safety vulnerabilities and innovative methods is to be expected.
> - The inherent flexibility of this Policy Statement (that permits risk-risk trade-offs in systems and sub-systems design) encourages thereby innovative ways of achieving an improved overall systems reliability at a reasonable cost.
> - Public acceptance, and hence investor acceptance, of nuclear technology is dependent on demonstrable progress in safety performance, including the reduction in frequency of accident precursor events as well as a diminished controversy among experts as to the adequacy of nuclear safety technology.”

Thus, based on the informed expectations of the Commission’s Severe Accident Policy, it is reasonable to conclude that the environmental impact of new units at the ESP site would be within the range of risk previously determined to be “small.”

A significant factor in the risk associated with plant design is the frequency of the considered accident sequences. As indicated above, the designs certified in accordance with 10 CFR 52 are

expected to exhibit a “higher standard of severe accident safety performance than the prior designs.” The ABWR is a currently certified design under 10 CFR 52, Appendix A, and is considered to be representative of advanced light water reactor standard designs. The NRC Safety Evaluation Report for the ABWR states, “the ABWR design and the submittals made for the ABWR in the SSAR meet the intent of the Commission's Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants” (Reference 12). Similar findings have been made for the other currently certified designs, namely System 80+ and AP-600. Thus, the Severe Accident Policy Statement expectations have been met for each of the three advanced standard designs considered to date by the NRC and are expected to continue to be met for future design certifications and COL application approvals.

7.2.5 **Conclusion**

The GEIS concludes, based on the generic evaluations presented, that the probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are “small” for all plants.

As described above, the methodology and evaluations of the GEIS are applicable to the consideration of new plants in the ESP and COL application context. Evaluation of site-specific factors for purposes of this application have shown that the ESP site is within the range of sites considered in the GEIS. Thus, the GEIS conclusion is applicable to the ESP site.

Use of pertinent site specific information to confirm the applicability of existing generic analyses is consistent with NRC staff plans for addressing severe accident environmental impacts at the ESP, as identified in SECY-91-041 (Reference 13).

In summary, the environmental impacts considered in NUREG-1437 evaluations include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. The consequences of these accidents could be severe, but due to their low likelihood of occurrence, the impacts are judged to be small. This conclusion is based on: 1) considerable experience gained with the operation of similar facilities without significant degradation of the environment, 2) the requirement that in order to obtain a license the applicant must comply with the applicable Commission regulations and requirements, and 3) a previously analyzed assessment of the risk of design-basis and severe accidents (Reference 10).

Specifically, based on the NRC and industry implementation of the 1985 policy statement, the generic NUREG-1437 risk evaluations, and the ESP site specific demography and meteorology, the radiological consequences and the societal and economic impacts of severe accidents for new units at the ESP site would be “small.”

Section 7.2 References

1. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Vol. 1, U. S. Nuclear Regulatory Commission, April 1996.

2. NUREG-1150, *Severe Accident Risks: An Assessment for Five U. S. Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, December 1990.

3. 61 FR 28467 – 28497, *Final Rule*, "Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," U. S. Nuclear Regulatory Commission, June 5, 1996.

4. 10 CFR 51, *Code of Federal Regulations*, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," U. S. Nuclear Regulatory Commission.

5. NUREG-0440, *Liquid Pathway Generic Study: Impacts of Accidental Radioactive Releases to the Hydrosphere from Floating and Land-Based Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, February 1978.

6. WASH-1400 (NUREG-75/014), *Reactor Safety Study: An Assessment of the Accident Risks in U.S. Commercial Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, October 1975.

7. NUREG/CR-2239, *Technical Guidance for Siting Criteria Development*, Prepared for U. S. Nuclear Regulatory Commission by Sandia National Laboratories, December 1982.

8. 50 FR 32138 – 32150, *Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants*, U. S. Nuclear Regulatory Commission, August 8, 1985.

9. 10 CFR 52, *Code of Federal Regulations*, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," U. S. Nuclear Regulatory Commission.

10. NUREG-1503, *Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design*, U. S. Nuclear Regulatory Commission, July 1, 1994.

11. SECY-91-0041, *Early Site Permit Review Readiness*, U. S. Nuclear Regulatory Commission, February 13, 1991.

12. NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, October 1999.

7.3 Severe Accident Mitigation Alternatives

The purpose of SAMA is to review and evaluate plant-design alternatives that could significantly reduce the radiological risk from a severe accident by preventing substantial core damage or by limiting releases from containment in the event that substantial core damage does occur.

SAMAs depend on design issues evaluated during the development and review of standard design certifications and COL applications. The design of the reactor and analyses of projected severe accidents are major contributing factors in the determination of SAMAs. To determine whether mitigation alternatives are cost beneficial, severe accident analyses must be included in these evaluations. SAMA would be evaluated for the new units in the COL application.

Section 7.3 References

None

7.4 Transportation Accidents

The assessment of transportation accidents is provided in Section 3.8, Transportation of Radioactive Materials.

Section 7.4 References

None

Chapter 8 Need for Power

The need for power would be addressed in the COL application.

Chapter 9 Alternatives to the Proposed Action

This chapter assesses alternatives to siting and developing nuclear power plants at the North Anna ESP site.

9.1 No-Action Alternative

This subject is not addressed in the ESP application.

9.2 Energy Alternatives

This subject is not addressed in the ESP application.

9.3 Alternative Sites

This section presents the alternative site evaluation to determine whether there is any obviously superior site when compared to the ESP site. The ROI for the proposed action is defined, the concept of candidate sites within the ROI is discussed, the sites selected as reasonable alternatives are identified, and the preferred site, (i.e., the ESP site) is selected.

This section includes a description of the screening process for identifying candidate sites and the methodology used in evaluating alternative sites.

9.3.1 Technical Approach

The candidate site criteria described in NUREG-1555, Section 9.3, were used to screen for candidate sites (Reference 1, Section 9.3) in the ROI.

The alternative site evaluation was performed using 45 suitability criteria as part of a study that reviewed previous nuclear industry siting information and current power plant siting approaches (Reference 2). These suitability criteria were grouped into four major categories: economic, engineering, environmental and sociological. A ranking or score for each criterion was assigned (from 0 to 5, with 5 being the most favorable). The relative importance of each criterion to the overall evaluation was established by assigning weights that reflect the collective judgment of experts involved in the process. The sum of the weighted scores for all criteria represented a total site merit score. The preferred site (i.e., the ESP site) was chosen based on the highest site merit score.

9.3.2 Region Of Interest

Prior to deregulation of the power industry, alternative sites were typically located within a utility's ROI, usually its service territory. Under deregulation, power producers cannot recover construction and operation costs associated with development of a commercial power generation facility through the cost-of-service rates process. Instead, a newly completed power generation facility has to

generate power for sale to consumers in a competitive marketplace. Dominion would only proceed with the development of such a new facility if it is economically viable.

As the parent company for Dominion, DRI's energy interests are to continue to operate and grow to a more substantial position as a natural gas and electric power provider serving customers in America's most energy-intense market: the Mid-Atlantic, Northeast, and Midwest. This energy-intense market region comprises approximately a quarter of the nation's land, but it accounts for 40 percent of the energy consumed. This market is home to DRI's ever-growing base of 4 million retail utility customers, and 1.1 million others served by DRI in the deregulated marketplace. DRI has defined its ROI for power generation to be the eastern quadrants of the United States, as shown in Figure 9.3-1. This defined ROI is based on the locations of the load centers to be supplied by the new units that would be constructed and operated at the ESP site.

9.3.3 Identification of Candidate Sites

In developing a list of reasonable candidate sites, multiple categories of sites were evaluated including federal facility sites and existing nuclear power plant sites within the identified ROI. The federal sites were considered under the assumption that such sites could accommodate new reactor technologies. The use of existing nuclear power plant sites for new power generation has many environmental and cost benefits. Additionally, Dominion evaluated the relative impacts of construction and operation of a new nuclear plant at a generic greenfield site. The review of a greenfield site was made to ensure that there are no sites that are obviously superior.

9.3.3.1 Site Screening Criteria

The candidate site criteria described in NUREG-1555 were used to screen for candidate sites. By using the criteria, sites were selected that:

- Did not pose significant issues that would preclude the use of the site for a nuclear power plant
- Did not cause significant impacts or degradation of local natural resources on the site that would be created
- Did not pose significant impacts to surrounding terrestrial and aquatic ecosystems
- Were not located in proximity to major population centers
- Did not affect site development costs significantly, when compared to the proposed site

9.3.3.2 Federal Site Review

Two of the DOE sites within DRI's ROI – Portsmouth, Ohio, and Savannah River, South Carolina – were selected as candidate sites because:

- The sites represent valuable national assets with prior or existing nuclear energy potential.
- New nuclear power facilities would represent potentially promising new missions for these sites.

- The sites have the potential to support reactor demonstrations and/or commercial reactor development.
- There is extensive site information and an available infrastructure that could help to reduce site development costs.
- Because of the partially or fully developed site environment and the available infrastructure, the incremental environmental impacts associated with the new plant construction and operation on land use, ecological resources, aesthetic, and local transportation network are reduced.
- The sites are not in proximity to major population centers.

The Portsmouth site, which is a previously developed industrial site, is a 3700-acre parcel of DOE-owned land located in a sparsely populated, rural area about 65 miles south of Columbus, Ohio. A major portion of the site and existing facilities are leased to USEC, Inc. for the Portsmouth Gaseous Diffusion plant. The Portsmouth site has substantial site characterization information and available electrical transmission facilities that were used to support operation of the diffusion plant prior to the decision to cease operations at this facility.

The 198,000-acre Savannah River site is about 25 miles southeast of Augusta, Georgia, and 19.5 miles south of Aiken, South Carolina. Augusta is the largest city in the vicinity with a 2000 Census population of 195,182. The site is located in a generally rural area on the Savannah River in southwest South Carolina. The entire area within a 5-mile radius about the center of the site is government-owned property, with approximately 95 percent of the site undeveloped. The Savannah River site has an extensive history of nuclear facilities, with substantial site characteristic information and infrastructure available to support DOE and new nuclear-related missions.

9.3.3.3 Generic Greenfield Site Review

Consideration of the effects of replacing power generation from the existing units by construction of a new unit at a greenfield site was provided in Supplement 7 of the GEIS (Reference 3). Results of the Supplement 7 evaluation indicated that the associated environmental impacts for the replacement plant located at a greenfield site were worse than the extension scenario of the existing units (see Table 9.3-1). A generic greenfield site is not a reasonable candidate ESP site for the following environmental reasons:

- A large area would need to be disturbed to build new plants which would cause large impacts on land use, ecological resources, aesthetics, and the local transportation network.
- New transmission lines and corridors may be needed to connect the new plant to the power grid, and local transportation routes and access roads may need to be built or upgraded. Such improvements could lead to additional land use, ecological resource, and aesthetic impacts.
- It is unlikely that a site in a remote area with the water supply needed by a large power plant and an adequate local transportation network would be available in the ROI.

- For a site in a rural area, the socioeconomic impacts associated with plant construction and operation would be largely due to the number of workers that would have to move into the area.

In addition, the site development costs for a greenfield site are substantial, especially with regard to building the required infrastructure and conducting the site characterization.

Finally, community acceptance of a new nuclear power plant in an area that is not familiar with their operational record is an unknown factor. This would have an impact on the ability to finance a project.

Based on the above considerations, Dominion has concluded that a generic greenfield site is not an obviously superior alternative for siting new units. Therefore, no further evaluation of greenfield sites was performed.

9.3.3.4 Existing Nuclear Sites Review

9.3.3.4.1 Benefits of Existing Nuclear Power Plant Sites

There are obvious benefits offered by locating a new nuclear power plant at an existing nuclear site rather than a non-nuclear site. These benefits are summarized below:

- Environmental Benefits
  - The existing environmental conditions and the environmental impacts of an existing nuclear station are known from data collected during years of monitoring air, water, ecological, and other parameters. Based on the knowledge of the various reactors and ancillary facilities being considered in the PPE, it is reasonable to assume that the impacts of additional units would be comparable to those of the operating units.
  - Construction of new transmission corridors may be avoided if the existing transmission system (lines and corridors) can accommodate the increased power generation. This could substantially reduce environmental impacts associated with construction of the new plant.
  - No additional land acquisitions would be necessary if a new transmission corridor can be avoided, and the resulting land use impacts of the new plant would be small.
  - The sites have already been subject to the alternative review process mandated by the NEPA.
  - The sites have extensive environmental studies performed during the original site selection process, which could be updated and used for new units.

- Constructability and Cost Benefits
  - Site physical criteria, including primarily geologic/seismic suitability, have been characterized at existing nuclear sites.
  - No additional land acquisitions would be necessary, if a new transmission corridor can be avoided and the site can accommodate the land requirements of the new units.
  - Plant construction, operation, and maintenance costs would be reduced because of existing site infrastructure (e.g., roads, transmission lines, water source, intake/discharge system) and its maintenance.
- Other Benefits
  - The existing sites have nearby power markets.
  - Existing nuclear plants are likely to have gained local community acceptance and support.
  - Existing nuclear sites have relevant nuclear experience.

9.3.3.4.2 **Nuclear Power Station Sites Owned by DRI Subsidiaries**

Existing nuclear power plants where Dominion could more readily obtain access and control are preferred over other nuclear sites. Sites that were originally designed for more generation than actually constructed also received preference.

Various DRI subsidiaries own and control three nuclear power stations within the ROI: NAPS and Surry Power Station in Virginia, and Millstone Power Station in Connecticut. The following paragraphs examine these sites for further consideration as alternative sites.

- North Anna Power Station
  - The 1803-acre NAPS site is located on Lake Anna in northeastern Virginia. Lake Anna, built to supply cooling water for the power station, is approximately 17 miles long and has 272 miles of shoreline. Two 944 MWe PWRs are currently in operation at North Anna. The site is located approximately 40 miles north-northwest of Richmond, 36 miles east of Charlottesville, and 22 miles southwest of Fredericksburg. The NAPS site was originally issued construction permits for two additional units.
- Surry Power Station
  - The 840-acre Surry site is located on the Gravel Neck Peninsula on the south side of the James River in Surry County, Virginia. The Hog Island Wildlife Management Area is situated on the tip of the peninsula. Two 855 MWe PWRs are currently in operation at Surry. The site is 7 miles south of two large tourist attractions: Colonial Williamsburg and Busch Gardens Amusement Park. Urban areas of Hampton Roads, Virginia, are 10 to 30 miles north and east of the site. The Surry site was originally issued construction permits for two additional units.

- Millstone Power Station
  - The 500-acre Millstone Power Station site sits on a peninsula on the eastern end of Long Island Sound, in Waterford, Connecticut. The station consists of three units. Unit 2, an 878 MWe PWR, and Unit 3, a 1152 MWe PWR, are currently in operation. Unit 1 is undergoing decommissioning. Parts of Connecticut, Rhode Island, and New York, including the major population centers of the Hartford and New Haven metropolitan areas in Connecticut and the Warwick and Newport areas in Rhode Island are within a 50-mile radius of the site. The east-west running portion of Interstate 95 along Long Island Sound in Connecticut passes within five miles of the site. Harkness Memorial State Park, three miles east of the site, is designed to accommodate and is used frequently as recreational facilities for persons with special needs. Rocky Neck State Park is 5 miles west of the site.

    This site was eliminated from further evaluation as an alternative site because of its proximity to a special recreational facility; an ongoing feasibility study that evaluates once-through cooling system impacts; and the potential for fogging and/or icing impacts associated with wet mechanical draft cooling towers. Furthermore, the site had not been licensed for additional units to those constructed.

9.3.4 **Alternative Sites Evaluation**

Four candidate sites: North Anna, Surry, Savannah River, and Portsmouth were identified as alternative sites. These four sites were further examined and evaluated to select the preferred site. The evaluation process and methodology used, and the findings of the evaluation are described in Reference 2.

9.3.4.1 **A Summary of the Evaluation Process**

Each site was evaluated against 45 suitability criteria, grouped into four major categories:

1. Environmental – Includes criteria (e.g., local population, groundwater, aquatic habitat and organisms) for assessing the potential adverse impacts of plant construction, operation, and decommissioning on the site, the surrounding environment, and the people.

2. Sociological – Includes criteria (e.g., socioeconomic benefits, present/planned land use, environmental justice) for assessing the potential impacts of plant construction, operation, and decommissioning on sociological issues.

3. Engineering – Includes regional, environmental, site, or other characteristics (e.g., cooling water source, site size, emergency planning requirements, site-specific seismic concerns, environmentally sensitive areas) that have the potential to impact the design, construction, operation, or decommissioning of a nuclear facility.

4. Economic – Includes criteria for assessing electricity and market projections, transmission line access, stakeholder support, and site development costs.

Table 9.3-2 provides a listing of these 45 criteria by category.

A ranking or score was assigned for each criterion. The sum of the weighted scores for all criteria is the total site merit score. In addition, a “bounding plant” was evaluated to establish a ranking score that would envelop the selected advanced reactor designs.

9.3.4.2 Discussion of Ranking Results

The bounding plant site merit scores are provided in Table 9.3-3. A “site merit” score of 500 is the maximum that can be achieved for the “total site merit” of any criteria subgroup. Results show a narrow total score spread (i.e., ranging from 351 to 377) with the North Anna ESP site ranking highest. These results further indicate that all four sites are suitable locations for additional nuclear generating units.

Based on the results of the evaluation, Dominion decided to locate the ESP site within the NAPS site. This basis included the special case provision noted in NUREG-1555, ESRP 9.3 (Subsection III(8)), that a new facility to be constructed can be located at an existing nuclear power plant site previously found acceptable from a NEPA review and/or demonstration of satisfactory environmental operating experience (Reference 1). Although the other sites were found to be environmentally acceptable, Dominion concluded that there are no obviously superior sites to the North Anna ESP site.

Section 9.3 References

1. NUREG-1555, *Environmental Standard Review Plan*, U.S. Nuclear Regulatory Commission (USNRC), October 1999.

2. *Study of Potential Sites for the Deployment of New Nuclear Plants in the United States,* U.S. Department of Energy Cooperative Agreement No. DE-FC07-02ID14313, Prepared by Dominion Energy, Inc. and Bechtel Power Corporation, September 2002. www.ne.doe.gov/Nuc Pwr 2010/ESP_Study/ESP_Study_Dominion1.pdf

3. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of a Nuclear Plant,* Supplement 7, Regarding North Anna Power Station, Units 1 and 2, Final Report, US Nuclear Regulatory Commission, November 2002.

Table 9.3-1 Summary of Environment Impacts For New Nuclear Units

Impact Areas	Phase of Project	At Existing Nuclear Site	At Generic Greenfield Site
Land Use		Moderate	Moderate to Large
Water Quality		Small	Small to Moderate
Air Quality		Small	Small
Ecological Resources		Moderate	Moderate to Large
Human Health		Small	Small
Socioeconomic Non-Transportation	During Construction During Operation	Small to Moderate Small	Large Small to Moderate
Socioeconomic Transportation	During Construction During Operation	Moderate to Large Small	Moderate to Large Small to Moderate
Waste Management		Small	Small
Aesthetics		Small	Large
Cultural Resources: Historical & Archaeological Resources		Small	Small
Environmental Justice		Small	Small to Large

Source: Supplement 7 of GEIS, November 2002

Table 9.3-2 Suitability Criteria

Economic	Engineering	Environmental	Socioeconomic
Electricity Projections	Site Size	Terrestrial Habitat	Present/Planned Land Use
Transmission System	Site Topography	Terrestrial Vegetation	Demography
Stakeholder Support	Environmentally Sensitive Areas	Aquatic Habitat/ Organisms	Socioeconomic Benefits
Site Development Costs	Emergency Planning	Groundwater	Agricultural/ Industrial
	Labor Supply	Surface Water	Aesthetics
	Transportation Access	Population	Historic/ Archaeological
	Security		Transportation Network
	Hazardous Land Use		Environmental Justice
	Ease for Decommissioning		
	Water Rights and Air Permits		
	Regulatory		
	Schedule		
	Geologic Hazards		
	Site-Specific Safe Shutdown Earthquake		
	Capable Faults		
	Liquefaction Potential		
	Bearing Material		
	Near-Surface Material		
	Groundwater		
	Flooding Potential		
	Ice Formation		
	Cooling Water Source		
	Temperature & Moisture		
	Winds		
	Rainfall		
	Snow		
	Atmospheric Dispersion		

Source: Part 2, Table 6-2 of “Study of Potential Sites for the Deployment of New Nuclear Plants in the United States”, U.S. Department of Energy Cooperative Agreement No. DE-FC07-02ID14313, Prepared by Dominion Energy, Inc. and Bechtel Power Corporation, September 2002.

Table 9.3-3 Site Merit Scores for the Four Alternative Sites

Site	Economic	Engineering	Environmental	Sociological	Total
North Anna	392	326	359	418	377
Savannah River	323	382	344	489	372
Portsmouth	321	348	345	453	358
Surry	348	304	339	416	351

Source: Extract from Executive Summary, Table 2 of “Study of Potential Sites for the Deployment of New Nuclear Plants in the United States”, U.S. Department of Energy Cooperative Agreement No. DE-FC07-02ID14313, Prepared by Dominion Energy, Inc. and Bechtel Power Corporation, September 2002.

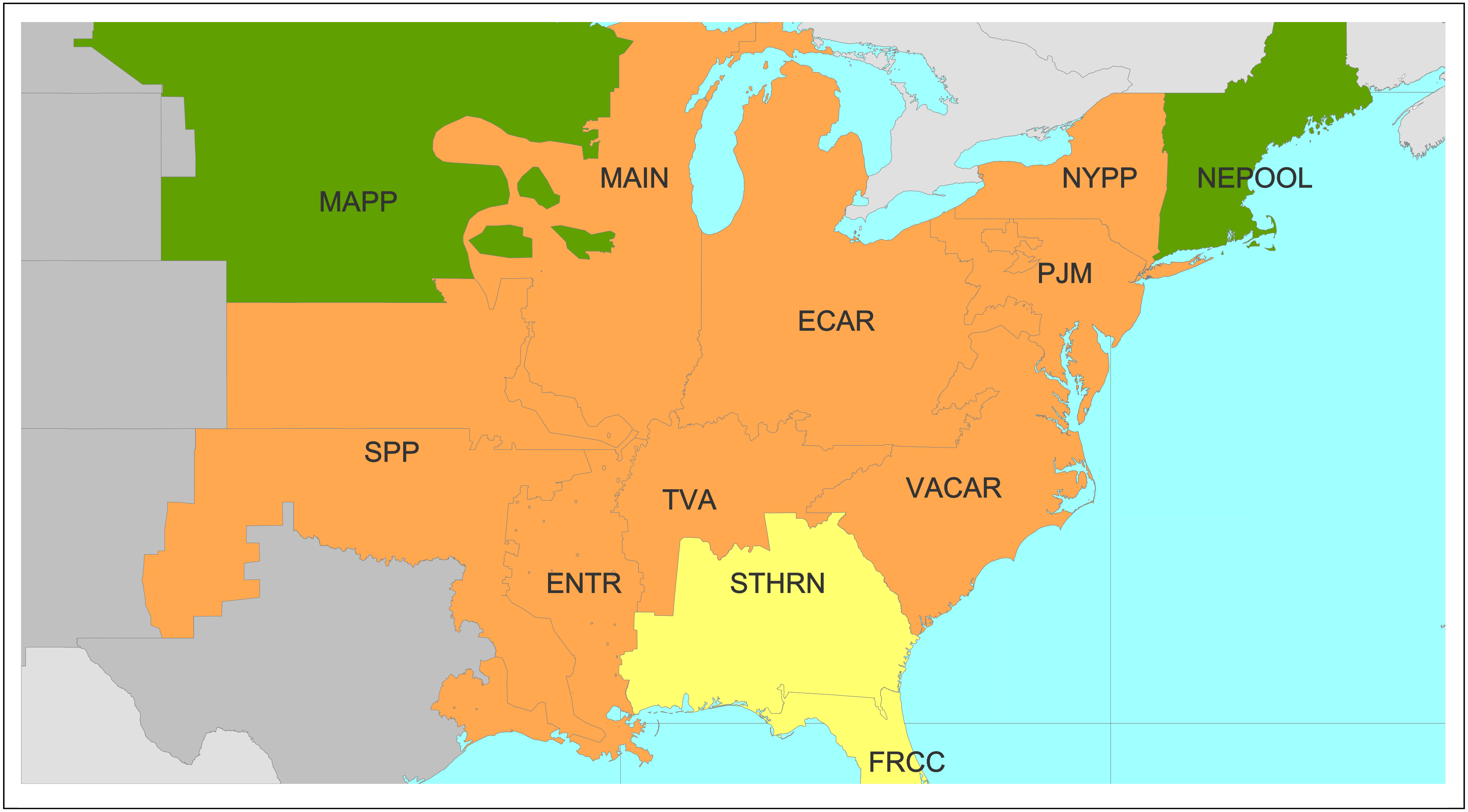

Figure 9.3-1 Region of Interest

9.4 Alternative Plant and Transmission Systems

This chapter describes the evaluation of the alternative plant and transmission systems for heat dissipation, circulating water, and power transmission, in accordance with NUREG-1555 (Reference 1, Section 9.4).

The evaluation of alternatives is segregated into the following topics:

- Heat dissipation systems
- Circulating water systems
- Transmission systems

9.4.1 Heat Dissipation Systems

This evaluation focuses on identifying alternative heat dissipation systems that are feasible, legislatively compliant, and environmentally and economically equivalent or preferable. In accordance with NUREG-1555, this evaluation first compares these alternatives with the proposed system using standardized criteria that include land use, water use, thermal and physical impacts, atmospheric effects, noise generation, aesthetics and recreational benefits, generating efficiency operating, and maintenance experience with similar units. (Reference 1, Section 9.4.1)

The proposed system and alternatives that prove to be feasible, legislatively compliant, and environmentally preferable have been economically evaluated. This economic evaluation is limited to a comparison of the relative costs of these screened alternatives.

Heat from the new units would be dissipated by two independent systems: a once-through system for Unit 3 and a closed cycle system for Unit 4. The “base case” for Unit 3 is a once-through system with its intake and pumping system on the North Anna Reservoir, and discharges to the head of the existing discharge canal. The Unit 3 base case system is compared with the following heat dissipation alternatives:

- Once-through system with helper tower (Alternative 1): This alternative would include the base case once-through system and a small multi-cell mechanical draft cooling tower system. The helper tower would operate on an as-needed basis during the warmest summer months to mitigate the peak temperatures in the WHTF and the North Anna Reservoir by transferring heat to the environment via evaporation, and directly to the atmosphere. Water would be withdrawn from the North Anna Reservoir and cooling tower blowdown would be returned to the discharge canal.
- Natural draft cooling tower system (Alternative 2): This alternative would consist of a number of free-standing, hyperbolic towers and associated intake/discharge, pumping, and piping systems. This closed-cooling system would withdraw water from the North Anna Reservoir and transfer heat to the environment via evaporation and directly to the atmosphere. Minor cooling tower blowdown discharges would be released to the existing discharge canal.

- Mechanical draft cooling tower system (Alternative 3): This alternative would consist of four multi-cell, rectangular cooling tower banks and associated intake/discharge, pumping, and piping systems. This closed-cooling system would withdraw water from the North Anna Reservoir and transfer heat to the environment via evaporation and directly to the atmosphere. Minor cooling tower blowdown discharges would be released to the existing discharge canal.
- Spray ponds (Alternative 4): This alternative would involve the addition of new surface water bodies on site and the addition of an extensive matrix of spray modules to promote evaporative cooling in the new ponds. Additional pumping and piping systems would be required.
- Air-cooled condensers (Alternative 5): This alternative would consist of a series of moderate profile (100-foot high) rectangular structures that house large fans and piping. There would be little other resources required (e.g., water, wastewater) besides land.

The Unit 4 base case would consist of a closed-loop mechanical draft cooling tower system. The Units 4 base case system is compared with the following heat dissipation alternatives:

- Once-through system (Alternative 6)
- Once-through system with helper tower (Alternative 7)
- Natural draft cooling tower system (Alternative 8)
- Spray ponds (Alternative 9)
- Air-cooled condensers (Alternative 10)

9.4.1.1 Technical, Regulatory, and Environmental Review of Heat Dissipation Systems – Unit 3

The Unit 3 base case and alternative heat dissipation systems are evaluated and compared in Table 9.4-1 through Table 9.4-3.

The Unit 3 evaluation concludes that the following heat dissipation systems are feasible, legislatively compliant, and environmentally preferable or equivalent to the base case:

- Once-through system with helper tower (Alternative 1)
- Natural draft cooling tower system (Alternative 2)
- Mechanical draft cooling tower system (Alternative 3)
- Spray ponds (Alternative 4)
- Air cooled condensers (Alternative 5)

The spray pond system (Alternative 4) posed regulatory approval barriers, as discussed in Table 9.4-2, and therefore has been removed from further consideration.

9.4.1.1.1 Relative Economic Evaluation of Heat Dissipation Systems – Unit 3

The Unit 3 base case has the lowest capital and operating costs, primarily because of the reduced equipment demands and operational efficiencies associated with once-through cooling. The wet

cooling tower alternatives (Alternatives 2 and 3) each have higher capital and operating costs due to the replacement of the cost-effective once-through cooling portion of the overall cooling system. Finally, the capital and operating costs of the dry cooling tower system (Alternative 5) would be at least double the equivalent wet cooling towers costs. (Reference 2)

9.4.1.1.2 **Alternative Heat Dissipation System Summary – Unit 3**

Table 9.4-3 offers a summary comparison of the relative natural resource (i.e., land, water) requirements, environmental impacts, regulatory barriers, operating issues, and economic considerations for the base case and the alternative heat dissipation systems for Unit 3. This comparison illustrates that the Unit 3 base case is the environmentally and economically preferable heat dissipation system.

9.4.1.1.3 **Thermal Impact and Water Level Enhancements – Unit 3**

As demonstrated in previous sections, Lake Anna is capable of handling the additional waste heat from Unit 3 from both a water temperature and water level perspective, and therefore no water temperature or water level mitigation efforts are part of the base case heat dissipation system for this new unit. However, Dominion has also considered the following supplemental options to mitigate increases in water temperature and decreases in lake level from operation of the planned Unit 3 once-through cooling system:

- Options to mitigate increased lake temperature
  - Improve WHTF sidearm efficiency
  - Modify Dike 3 discharge into lake to increase mixing
  - Reduce entrance mixing in WHTF
  - Reduce cooling water flows
  - Increase Lake Anna surface area
  - Install submerged intake
  - Add sprays in discharge canal
  - Add helper towers
- Options to mitigate reductions in lake level
  - Increase North Anna Reservoir and WHTF operating level
  - Reduce downstream releases
  - Import water

a. **Lake Temperature Mitigation**

The following temperature mitigation options were eliminated from further consideration as discussed below.

1. **Improved WHTF sidearm efficiency**

   Approximately 1500 acres from the total of 3400 acres in the WHTF consists of dead-end sidearms that are not part of the main cooling water flow path. The cooling efficiency of the WHTF could be improved by connecting the Elk Creek and Millpond Creek sidearms using a canal or a tunnel, and using a dike in the WHTF to divert flow to the upper ends of the sidearms. This approach would be expensive and disruptive, as large diameter tunnels or major canal works would be required, and construction would be close to existing residential areas.

   An alternative approach would be to enlarge the openings under the highway bridges across the mouth of the two major sidearms in Pond 2 of the WHTF, to allow more warm water, driven by buoyancy, to enter the sidearms. The bridge embankments block over 65 percent of the sidearm openings. The advantage to this approach is that construction impacts would be far from the residential areas. The disadvantages would be high construction costs and impacts on local traffic.

   Based on cooling pond simulations, the expected improvements in intake temperatures would be in the 0.5–1.0°F range. Since this level of mitigation can be achieved more economically in other ways, the combination of high costs and construction impacts eliminated this option from further consideration.

2. **Modify Dike 3 discharge into lake to increase mixing**

   The Dike 3 structure, which allows the warm water to flow from the WHTF into the North Anna Reservoir, could be modified so as to increase mixing of the warm water plume, and reduce lake surface temperatures near the North Anna Dam. This approach could have the disadvantage of reducing the overall cooling efficiency of Lake Anna, and potentially increasing the plant intake temperature. A second disadvantage could be the potential reduction in deeper cold water sections near the dam, potentially affecting fish habitat. These disadvantages outweigh the value of the slight decrease in maximum surface temperatures and this option was eliminated from further consideration.

3. **Reduce entrance mixing in WHTF**

   The mixing of warm water jets, as they enter the individual WHTF ponds from the narrow connecting canals, reduces the overall WHTF cooling efficiency. Cooling pond simulations indicate initial dilutions of 3–4 in the ponds, versus a practical minimum of 1.5. However, the overall WHTF shape involving a series of connected ponds would reduce the effect of minimizing the mixing, and only a small reduction of 0.3°F in the summer season plant

intake temperature. This option of reducing mixing by adding dikes and baffles to the WHTF ponds was eliminated from further consideration.

4. **Reduce cooling water flows**

   Cooling ponds with a relatively high temperature rise (ΔT) and low flow are more efficient than those with a higher flow rate and lower ΔT. The existing units have a ΔT of 14°F. For the third unit a temperature rise of 18°F (and a lower flow per unit of waste heat) is expected. Increasing the ΔT of the existing units to 18°F, and reducing the flow rate from 4246 to 3300 cfs would reduce the plant intake temperature by approximately 1°F. The primary advantage of this approach would be that no new structures would be required. A disadvantage would be that the plant discharge temperature would increase, and plant efficiency could drop (due to increased intake water temperatures). In addition, lake temperatures near the dam could actually increase in the wintertime. For these reasons, this approach was eliminated from further consideration.

5. **Increase Lake Anna surface area**

   An increase of 1 foot in lake level, from a nominal value of 250 ft msl to an elevation of 251 feet would increase the lake surface area by approximately 500 acres, and decrease the intake temperature by approximately 0.2°F. From the temperature mitigation viewpoint, the effect is negligible, and this alternative was eliminated from further consideration. From the viewpoint of mitigation of lake level effects, the impact would be significant.

The following temperature mitigation options would be evaluated in the COL application.

1. **Install submerged intake**

   A 2800-foot long, 30-foot deep, floating curtain, located across the mouth of the intake cove, would be considered. This type of curtain is used in front of hydroelectric intakes to control downstream temperature releases (Reference 3). Fixed structures with a similar configuration, called skimmer walls, have been used routinely for power plant intakes for the past 50 years.

   A floating curtain would cause the plant intake flow to be withdrawn primarily from below the 30-foot level, thus reducing both the long-term summer intake temperature and the short-term (e.g., diurnal) temperature fluctuations. An initial evaluation indicates reductions in the summer intake temperatures of approximately 1.0 to 1.2°F are possible, due to the increased effectiveness of the more than 4000 acres of the North Anna Reservoir located upstream from the existing intake and situated outside of the main flow path of the plant cooling waters. OOM costs for the curtain are approximately $4.5 million. Since this is lower than the spray and helper tower alternatives, this approach appears to be a cost-effective option.

A secondary benefit of the curtain would be the potential increase in oxygenated water moving into deeper zones, thereby reducing the potential for anaerobic or low dissolved oxygen (DO) zones throughout the lake in summer and early fall. A disadvantage of the curtain could be an increase in the stratified higher temperature zones in the lake.

2. **Add sprays in discharge canal**

Floating spray modules have been used to enhance cooling pond performance since the late 1960s. The concept consists of a float-mounted pump and 1–4 spray nozzles. Typical module parameters are a 75 horsepower (HP) pump with a flow rate of 10,000 gpm. Systems installed in the 1960s and 1970s generally ranged from 40 to 400 modules. The initial systems had considerable performance and reliability problems. Recent designs appear to have overcome most of the initial problems, but long-term operational data are scarce. Despite the history of questionable performance, spray modules would be evaluated further in the COL application because the configuration of the cooling system and the operational requirements for the sprays would increase the probability that the performance and operational requirements would be met.

The spray cooling concept initially evaluated would consist of 100 Aqua-Aerobic Spray modules (75 HP, 10,000 gpm) moored primarily in the existing discharge canal. New spray ponds would not be included. The modules would be operated for approximately 2 months per year, allowing plenty of time for maintenance. The relatively short operating period would reduce the impact of the high power demand of the spray system (approximately 5 MW). Based on cooling pond simulations, the system would decrease water temperature by approximately 2°F at the end of the discharge canal, by approximately 1°F at Dike 3, and by 0.5°F at the plant intake.

The advantages of the spray system are as follows:

- The system could be easily back-fitted to the existing cooling system since the individual modules are simply moored in the discharge canal.
- A partial system (1–6 modules) could be tested in advance.
- Maintenance would be straight-forward since individual modules could be moved by a small boat to a convenient location and removed from the discharge canal.
- The system could be used in partial mode or full mode, as necessary.

The primary disadvantage is that cooling the discharge canal flow would reduce the cooling efficiency of the WHTF, and, although the sprays would dissipate approximately one-third of the heat added by the third unit, the intake temperature reduction of 0.5°F is only one-sixth of the additional temperature increase due to a new Unit 3. Another disadvantage is drift losses. An OOM cost estimate for the 100 module spray system is $15 million.

3. **Add helper towers**

   Mechanical draft (helper) towers are another mitigation option. Two sizes have been initially evaluated: a 30-cell, 320,000 gpm tower to handle 33 percent of the Unit 3 heat load, and a 40-cell, 470,000 gpm tower to handle 50 percent of the Unit 3 load. The towers would be operated in a similar manner to the sprays, about 2 months per year. Towers have several advantages over sprays, including the fact that their performance and reliability are well established, and their power consumption and drift losses are smaller. Another advantage for towers is that the cooled discharge from the tower could possibly be returned directly to the North Anna Reservoir, thus avoiding any degradation in WHTF performance. This would result in a 1.2°F reduction in intake temperature for the 30-cell tower option, or twice the effect of the sprays, even though both systems dissipate the same amount of heat.

   The towers, however, have two disadvantages as compared to the sprays, namely space and cost. Unlike the sprays, which require no extra land, the towers would require several acres of space, plus a costly water distribution system. The OOM cost for the towers is $50 million for the 30-cell system, and $62 million for the 40-cell system, as compared to $15 million for the sprays. A further disadvantage would be the discharge to the lake of biocide residuals. Biocides would be necessary to control biofouling in the towers.

b. **Lake Level Mitigation**

Options initially evaluated to mitigate the impacts of Unit 3 on lake water level included increasing the North Anna Reservoir and WHTF operating level, reducing downstream releases, and importing water. Importing makeup water was determined not to be cost-beneficial and this option was eliminated from further consideration. The remaining two options would be evaluated in the COL application, although both are unlikely to be implemented as further described below.

1. **Increase North Anna Reservoir and WHTF operating level**

   The concept of raising the “normal” pool level from 250 ft to 251 ft msl has been initially evaluated. The major benefit would be an increase in the minimum lake level to provide additional water for cooling.

   However, the following disadvantages would need to be addressed before this option could receive further consideration:

   - Minor increase in probable maximum flood (PMF) level
   - Dam safety and permitting issues
   - Concerns from lakeside residents since many lakeside structures (docks and boathouses) would need to be modified
   - Flood level could exceed the design criteria for a state road near Dike 3

2. **Reducing downstream releases**

   The existing operating rule for Lake Anna is to keep the water level as close to Elevation 250 ft msl as possible, while releasing in accordance with permit requirements (normally 40 cfs). As the lake level falls to 248 feet, downstream releases are incrementally reduced to 20 cfs. The option of reducing downstream releases earlier has been initially evaluated, but the benefits appear minimal. It is unlikely, therefore, that this option would receive further consideration.

9.4.1.2 Technical, Regulatory, and Environmental Review of Heat Dissipation Systems – Unit 4

The Unit 4 base case and alternative heat dissipation systems are evaluated and compared in Table 9.4-4 through Table 9.4-6.

This Unit 4 evaluation concludes that the following heat dissipation systems are feasible, legislatively compliant, and environmentally preferred or equivalent to the base case:

- Once-through system (Alternative 6)
- Once-through system with helper tower (Alternative 7)
- Natural draft cooling tower system (Alternative 8)
- Spray ponds (Alternative 9)
- Air-cooled condensers (Alternative 10)

The once-through options (Alternative 6 and 7) and the spray pond system (Alternative 9) posed regulatory approval barriers, as discussed in Table 9.4-4 and Table 9.4-5, and therefore have been removed from further consideration.

9.4.1.2.1 Relative Economic Evaluation of Heat Dissipation Systems – Unit 4

Given that the low-cost, efficient once-through systems are infeasible for application on Unit 4, this unit's base case and the other wet tower option, Alternative 8, offer the next best combination of operational efficiencies and capital and operating costs. As discussed earlier, the capital and operating costs of the air-cooled condenser system (Alternative 10) are expected to be at least double the equivalent wet cooling towers costs. (Reference 2)

9.4.1.2.2 Alternative Heat Dissipation System Summary – Unit 4

Table 9.4-6 offers a summary comparison of the relative land and water resource needs, environmental impacts, regulatory barriers, operating issues, and economic considerations for the base case and the remaining alternative heat dissipation systems for Unit 4.

This comparison illustrates that the Unit 4 base case or natural draft tower alternative (Alternative 8) represent the preferable heat dissipation systems. Despite the large energy efficiency and cost advantages of the wet tower over air-cooled condenser systems, the dry system environmental

advantages do not allow this heat option to be discounted for future use, especially if water resources are limited.

If wet cooling towers are selected, the source of cooling tower make-up water would need to be identified and evaluated. Sources may include offsite sources, Lake Anna, or other combinations. In any case, the make-up water sources(s) would be selected such that there would be only small adverse impacts to Lake Anna and the associated environmental (e.g., land-use, ecological, transportation related) impacts would be acceptable. The Unit 4 cooling system would be described and its impacts evaluated in the COL application.

9.4.2 Circulating Water Systems

This evaluation focuses on identifying feasible circulating systems that are legislatively compliant, environmentally preferable, and economically viable. In accordance with NUREG-1555 guidance, this evaluation first compares alternative circulating water systems against the base case system using standardized criteria that include construction impacts, aquatic issues, water use, land use, and compliance with regulations (Reference 1, Section 9.4.2). As stated in NUREG-1555, the proposed system and alternatives that prove to be feasible, legislatively compliant, and environmentally preferable are then evaluated on an economic basis. In this case, a comparison of alternate circulating water system components has not revealed alternatives that are preferable on an environmental basis. Therefore, further economic analysis of alternatives is not warranted.

As discussed in Section 9.4.1, the proposed heat dissipation systems for the new units at the ESP site are a once-through system for the first new unit (Unit 3), and a mechanical draft cooling tower system for the second new unit (Unit 4). The base case circulating water system is composed of the following components:

- Intake System: Shoreline
- Intake Location: Adjacent to existing intake structure on Lake Anna
- Discharge System: Shoreline
- Discharge Location: Adjacent to existing discharge structure on Discharge Canal
- Water Supply: Unit 3 - Lake Anna, Unit 4 - to be determined in the COL application
- Water Treatment: Mechanical condenser cleaning (once-through cooling system) and chemical biocide/corrosion treatment (cooling tower systems)

The following sections evaluate this base case against a list of potential alternative system components that address intake, discharge, water supply, and water treatment issues.

9.4.2.1 Intake System

While NUREG-1555 suggests that the intake system evaluation address alternative intake systems, locations, pumping arrangements, defouling processes and screens; the base case design has not matured sufficiently to support evaluation of alternative pumping, defouling and screen systems.

Consequently, the evaluation of the intake base case and alternatives is limited to the intake system and intake location. Table 9.4-7 and Table 9.4-8 provide an evaluation or comparison of the following base case and alternative intake systems and locations:

- Systems
  - Shoreline Intake System (Base Case): Partially submerged concrete inlet structure positioned along the shoreline.
  - Offshore Intake (Alternative 1): Completely submerged intake structure(s) positioned just above the bottom of the body of water supply source, some distance from shore.
- Locations
  - Existing Intake location (Base Case): Intake location immediately adjacent to existing units intake on Lake Anna
  - Alternate intake location on Lake Anna (Alternative 2): Intake location at least several hundred feet away from the existing intake structure
  - Lower North Anna River (Alternative 3): Intake location downstream of the North Anna Dam along the North Anna River

This evaluation concludes that: 1) an offshore intake system or alternate intake locations would be difficult to permit, 2) the alternatives could generate larger environmental impacts relative to the base case intake system arrangement, and finally 3) they could trigger costly additional permitting, stakeholder consultations, and environmental restoration. Therefore, further economic evaluation of the base case and alternative intake systems is unwarranted.

9.4.2.2 **Discharge System**

While NUREG-1555 also suggests that the discharge system evaluation address alternative discharge systems, locations, and discharge port technology, the incomplete base case discharge design can only support consideration of alternate discharge systems and locations. Table 9.4-9 and Table 9.4-10 provide comparisons of the following base and alternative discharge systems and locations.

- Discharge Systems
  - Shoreline Discharge (Base Case): Concrete, partially submerged, discharge structure along shoreline of receiving body of water
  - Offshore Discharge (Alternative 4): Completely submerged discharge structure(s) positioned just above the receiving water body bottom, some distance from shore

- Discharge Location
  - Existing discharge location (Base Case): Discharge location (shoreline) at the head of the Discharge Canal immediately adjacent to the existing units discharge structures
  - Waste Heat Transfer Facility (WHTF) Location (Alternative 5): Discharge location (shoreline) in a portion of the WHTF outside of the discharge canal
  - Lake Anna (Alternative 6): Discharge location (shoreline) in publicly accessible portion of Lake Anna

This evaluation concludes that: 1) the all of the discharge system alternatives may be more difficult to permit than the base case, and 2) they could generate larger adverse environmental impacts relative to the base case intake system arrangement. Further economic evaluation of the base case and alternative discharge systems is unwarranted.

9.4.2.3 **Water Supply**

The evaluation of alternative water supplies prescribed by NUREG-1555 is amended herein because of the certainty of water supply (Lake Anna) for the Unit 3 preferred once-through cooling system and because the evaluation of water supply alternatives for Unit 4 would be included in the COL application.

9.4.2.4 **Water Treatment**

The evolving water treatment system design is not sufficiently mature to support all of the NUREG-1555 suggested water treatment evaluation processes: water treatment processes, chemical additives, and operating mode. Consequently, the evaluation of the water treatment processes focuses herein only on water treatment system issues. Table 9.4-11 provides a tabularized evaluation of the following base case and alternative water treatment systems.

- Water Treatment Systems
  - Mechanical Treatment (Base Case): Periodic mechanical cleaning of cooling water piping
  - Chemical Treatment (Alternative 7): Cooling water biofouling control using chlorine or equivalent chemical biocide
  - Non-chemical Treatment (Alternative 8): Ultraviolet light sterilization

This evaluation demonstrates that the base case mechanical condenser cleaning option poses smaller adverse environmental impacts than the other technically-feasible alternative treatment system – the chemical treatment system. Though the mechanical cleaning system represents the environmentally-preferred treatment system, the cooling tower system arrangement proposed for one of the two new units is likely to pose operational demands that require use of a chemical water treatment system. Further economic evaluation of the base case and alternative water treatment systems is unwarranted.

9.4.2.5 Summary

The evaluation of the key components (excluding water supply) of the base case and alternative circulating water systems indicates that the following base case configuration collectively represents the only environmentally preferable circulating water system:

- Intake System: Shoreline
- Intake Location: Adjacent to existing intake structure on Lake Anna
- Discharge System: Shoreline
- Discharge Location: Adjacent to existing discharge structure on discharge canal
- Water Supply: Unit 3 - Lake Anna, Unit 4 – to be determined in the COL application
- Water Treatment: Mechanical condenser cleaning for once-through cooling system and chemical biocide/corrosion treatment for cooling tower systems

9.4.3 Transmission Systems

NUREG-1555, Section 9.4.3, provides guidelines for the preparation of a summary discussion that identifies the feasible and legislatively compliant alternative transmission systems. Based on an initial evaluation, the current ESP site transmission lines and corridors have sufficient capacity for the total output of the existing and new units. There are no environmentally equivalent or more advantageous alternatives to "no action."

Section 9.4 References

1. NUREG-1555, *Environmental Standard Review Plan* U.S. Nuclear Regulatory Commission, October 1999.

2. *Platts Power Magazine*, "Cooling Tower Options Change for a Hot, Thirsty Industry," September 2002.

3. Vermeyen, T, "Use of Temperature Control Curtains to Control Reservoir Release Water Temperatures," Report No. R-97-09, Water Resources Research Lab., Bureau of Reclamation, Denver, December 1997.

4. *New All Organic Chemistry for Treatment of Closed Cooling Tower Systems*, Paper No. TP-07, Cooling Tower Institute, 2002.

Table 9.4-1 Screening of Unit 3 Alternative Heat Dissipation Systems (Base Case & Alternatives 1–2)

Factors Affecting System Selection	Once-Through (Base Case)	Once-Through with Helper Tower (Alternative 1)	Natural Draft Cooling Towers (Alternative 2)
Land Use: Onsite Land Considerations	The once-through (OT) system would have the smallest land requirements. The OT system could be placed within the confines of the existing NAPS site.	A once-through and helper tower (OTHT) system would require marginally more land than is required by the OT system alone, but less than other cooling tower systems. The OTHT system could be placed within the confines of the existing NAPS site.	A natural draft cooling tower (NDCT) system would require more land to accommodate large diameter hyperbolic towers. A NDCT system could be placed within the confines of the existing NAPS site.
Land Use: Terrain Considerations	OT systems require flat or gently rolling terrain to minimize pump head requirements. Terrain features of the site would not preclude the use of the OT system.	OTHT systems require flat or gently rolling terrain situations. Terrain features of the site are suitable for a OTHT system.	NDCT systems withdraw less water and so are less affected by substantial terrain variations. Terrain features of the site are suitable for a NDCT system.
Water Use	Per the PPE, the OT system would require nearly 50 times more water than a mechanical draft wet cooling tower system (MDCT). OT - 1,140,000 gpm Wet cooling systems - 23,950 gpm Despite this increased water intake requirement, the OT system would return most of the withdrawn water, while a MDCT system would lose a considerable portion of the lesser water withdrawal to the atmosphere through evaporation. Hydrological modeling indicates that the North Anna Reservoir could support operation of Unit 3 using the OT system alone.	A OTHT system would require the second largest water supply. Although the helper tower system would reduce water intake requirements, its use would not be essential for Unit 3 operation because the North Anna Reservoir could support operation of Unit 3 using the OT system alone.	A OT system would require nearly 50 times more water than a NDCT system. OT - 1,140,000 gpm Wet cooling systems - 23,950 gpm Despite the reduced water intake requirements, the NDCT system would have considerable evaporative losses to the atmosphere. The overall evaporative water losses would be greater for closed wet cooling tower systems compared to open cooling systems.

Table 9.4-1 Screening of Unit 3 Alternative Heat Dissipation Systems (Base Case & Alternatives 1–2)

Factors Affecting System Selection	Once-Through (Base Case)	Once-Through with Helper Tower (Alternative 1)	Natural Draft Cooling Towers (Alternative 2)
Regulatory Restrictions	The intake structure for the OT system would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The VPDES discharge permit thermal discharge limitation to the WHTF (defined as a Virginia Power "industrial facility") would need to be modified to account for the additional thermal load rejected by the new OT system. These regulatory restrictions would not negatively impact application of this heat dissipation system.	An intake structure for the OTHT systems would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The VPDES discharge permit thermal discharge limitation to the WHTF would need to be modified to account for the additional thermal load rejected by a OTHT system. These regulatory restrictions would not negatively impact application of this heat dissipation system.	An intake structure for an NDCT system would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The VPDES discharge permit thermal discharge limitation to the WHTF would need to be modified to account for the small additional thermal load from NDCT blowdown. These regulatory restrictions would not negatively impact application of this heat dissipation system.
Atmospheric Effects	Since OT systems do not produce a visible plume and the associated pond-induced fogging (steam fog) is minimal, atmospheric effects would be none to small.	A OTHT system would emit water droplets (drift) and produce visible plumes during periods when the helper tower is in operation. The particulate, salt deposition, fogging and icing and aesthetic impacts would be significantly less than the predicted small impacts from a larger, full-time operating cooling tower system (see Section 5.3.3.1)	A NDCT system would emit water droplets (drift) and intermittently produce a visible plume. The drift droplets would be a minor source of particulate matter and salt deposition. The water vapor plume would not encourage any additional fogging or icing conditions on local road systems (see Section 5.3.3.1). Visible plume aesthetic impacts are described as small in Section 5.3.3.1.
Thermal and Physical Effects	While the OT system would add thermal load to the WHTF, the resultant thermal impacts to the North Anna Reservoir would be small. The VPDES permit thermal discharge criteria would need to be revised to reflect this addition of thermal load.	A OTHT system would add thermal load to the WHTF. The helper tower would temper the thermal loading to the WHTF during the hottest summer season periods. The VPDES permit thermal discharge criteria would need to be revised to reflect this addition of thermal load.	A NDCT system would produce a smaller thermal load to the WHTF because 65-85 percent of the heat removal in these towers is associated with evaporation (Reference 2) and most of the remaining heat is dissipated directly to the atmosphere. In this case the smaller NDCT thermal load rejected to the WHTF would be additive to the existing OT thermal load. The VPDES permit thermal discharge criteria would need to be revised to reflect this addition of thermal load.

Table 9.4-1 Screening of Unit 3 Alternative Heat Dissipation Systems (Base Case & Alternatives 1–2)

Factors Affecting System Selection	Once-Through (Base Case)	Once-Through with Helper Tower (Alternative 1)	Natural Draft Cooling Towers (Alternative 2)
Noise Levels	OT system operation would generate small noise impacts from pump operation. Construction-related noise impacts would be small.	OTHT operation would generate noise from fan and pump operation and from cascading water in the towers during the periods when the helper tower is needed. The associated noise impacts would be less than MDCT impacts which were already below the NRC-defined significance levels (65 dBa) at the EAB as described in Section 5.3.4. Construction-related noise impacts would be small.	A NDCT system would produce less noise than MDCT system because of the lack of fan generated noise. Note MDCT noise levels were evaluated to be below NRC-defined significance levels (65 dBA) at the EAB (see Section 5.3.4). Construction-related noise impacts would be small.
Aesthetics and Recreational Benefits	The OT system would be wholly situated on the existing NAPS site and its primary external impact would be the discharge of heated water to the North Anna Reservoir via the WHTF. Discharges to the North Anna Reservoir, a popular recreational resource, would produce no tangible aesthetic or recreational benefits.	A OTHT system would be wholly situated on the existing NAPS site and its primary external impact would be the discharge of heated water to the North Anna Reservoir via the WHTF. Discharges to the North Anna Reservoir, a popular recreational resource, would produce no tangible aesthetic or recreational benefits.	A NCDT system would be wholly situated on the existing NAPS site and its primary external impact would be the discharge of heated water to the North Anna Reservoir via the WHTF. Discharges to the North Anna Reservoir, a popular recreational resource, would produce no tangible aesthetic or recreational benefits.
Operating and Maintenance Experience	OT systems are common to older power plants (both fossil and nuclear) and they are considered highly reliable.	While OTHT systems are less common than OT systems, they do not pose any greater operating and maintenance risks than other cooling tower systems.	NDCT systems are common to older power plants (both fossil and nuclear) and they are considered highly reliable.
Generating Efficiency	Using coal-fired power plants as a guide, OT systems are 6.9 to 8.6 percent more energy efficient than wet cooling tower systems. (Reference 2)	The additional energy requirements associated with cooling tower operation do no alter this system’s energy efficiency advantages over wet cooling tower only systems.	Using coal-fired power plants as a guide, wet cooling tower systems have a 6.9 to 8.6 percent efficiency penalty when compared to OT systems. Natural draft tower energy requirements would be less than mechanical draft systems. (Reference 2)
Is this a suitable heat dissipation system?	Yes.	Yes.	Yes.

Table 9.4-2 Screening of Unit 3 Alternative Heat Dissipation Systems (Alternatives 3–5)

Factors Affecting System Selection	Mechanical Draft Cooling Towers (Alternative 3)	Spray Ponds (Alternative 4)	Air Cooled Condensers (Alternative 5)
Land Use: Onsite Land Considerations	A mechanical draft cooling tower (MDCT) systems would require more land (as compared to the OT system) to site widely spaced towers. Since two MDCT systems could be placed within the confines of the existing NAPS site, the additional land requirement impacts would be small.	A spray pond-cooling alternative would involve the development of significant additional surface water impoundments and consequently pose the additional land requirements. It is unlikely that new spray ponds of sufficient size could be placed within the confines of the existing NAPS site.	An air cooled condenser (ACC) system would require more land than wet cooling tower systems. As ACCs could be situated within the confines of the existing NAPS site, the additional land requirement impacts would be small.
Land Use: Terrain Considerations	MDCT systems withdraw less water and so are less affected by significant terrain variations. Terrain features of the site are suitable a MDCT system.	Since spray pond construction involves substantial earthwork, such systems are most appropriate for flat or gently rolling terrain. Terrain features of the site are suitable for the addition of spray ponds.	ACC systems are unaffected by terrain considerations.
Water Use	Per the PPE, a the OT system would require nearly 50 times more water than the MDCT system. Despite the reduced water intake requirements, the MDCT system would have considerable evaporative losses to the atmosphere. The overall evaporative water losses are somewhat greater for closed wet cooling tower systems compared with open cooling systems.	A spray pond would require large volumes of water and would likely require offsite sources of water.	An ACC system would have no comparable evaporative water losses when compared with MDCTs or spray ponds. An ACC system would require minimal service water.

Table 9.4-2 Screening of Unit 3 Alternative Heat Dissipation Systems (Alternatives 3–5)

Factors Affecting System Selection	Mechanical Draft Cooling Towers (Alternative 3)	Spray Ponds (Alternative 4)	Air Cooled Condensers (Alternative 5)
Regulatory Restrictions	An intake structure for a MDCT system would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The VPDES discharge permit thermal discharge limitation to the WHTF would need to be modified to account for the minor additional thermal load rejected by the new MDCT system. These regulatory restrictions would have small impacts on this heat dissipation system.	Additional land would have to be obtained and developed to support the spray pond option. The development of this land may entail a substantial and lengthy federal, state, and local permit and approval process.	There would be little or no permit or approval-related impacts to the ACC alternative.
Atmospheric Effects	The MDCT system would emit water droplets (drift) and intermittently produce a visible vapor plume. The drift droplets would be a minor source of particulate matter and salt deposition. The water vapor plume would result in minimal additional fogging and icing conditions on local road systems. Aesthetic impacts from the visible plume would be small.	A spray pond system could produce a low-level visible water droplet plume and encourage formation of fog above the heated pond. These impacts would be localized and short-lived, and consequently small.	An ACC system would not produce a visible plume or pose particulate emission or salt deposition impacts.
Thermal and Physical Effects	The MDCT system would discharge a significantly smaller thermal load to the WHTF (compared to OT systems) because 65-85 percent of the heat removal in cooling towers is associated with evaporation (Reference 2). Most of the remaining heat is dissipated directly to the atmosphere. In this case the smaller MDCT thermal load rejected to the WHTF would be additive to the existing OT thermal load. The VPDES permit thermal discharge criteria would need to be revised to reflect this minor addition.	Since the thermal load would be rejected to the spray pond and that pond would be wholly dedicated to industrial use, the thermal impacts external to the pond would be none to small.	An ACC system would direct an invisible heated plume of air into the atmosphere, and impacts would be none to small.

Table 9.4-2 Screening of Unit 3 Alternative Heat Dissipation Systems (Alternatives 3–5)

Factors Affecting System Selection	Mechanical Draft Cooling Towers (Alternative 3)	Spray Ponds (Alternative 4)	Air Cooled Condensers (Alternative 5)
Noise Levels	MDCT operation would generate noise from fan and pump operation and from cascading water in the towers. The Section 5.3.4 noise evaluation for one MDCT system predicts noise impacts below the NRC-defined significance levels (65 dBa) at the EAB. Construction related noise impacts would be small.	Spray pond system operation would generate noise from the spray operations. Since the location of the spray ponds and associated receptor boundaries are presently undefined, the associated noise impacts cannot be evaluated at this time. Construction-related noise impacts would be small.	An ACC system would generate operational noise from fan operation. While noise impacts associated with operation with an ACC system have not been evaluated, the Section 5.3.4 noise evaluation for a MDCT system suggests that noise contributions from an ACC system would produce impacts below the NRC-defined significance levels (65 dBa) at the EAB. Construction-related noise impacts would be small.
Aesthetics and Recreational Benefits	The MDCT system would be wholly situated on the existing NAPS site and the primary external impact would be the discharge of heated water to the North Anna Reservoir via the WHTF. Discharges to the North Anna Reservoir, a popular recreational resource, would produce no tangible aesthetic or recreational benefits.	The spray ponds would be at least partially situated on land outside of the NAPS site. The resulting commitment of previously undeveloped property to industrial use would produce no tangible aesthetic or recreational benefits.	An ACC system would be wholly situated on the existing NAPS site and their primary external impact would be the discharge of heated air and noise to the atmosphere. These discharges would produce no tangible aesthetic or recreational benefits.
Operating and Maintenance Experience	MDCT systems are common to power plants (both fossil and nuclear) and are considered highly reliable.	Spray pond systems have been used on power plant sites and they pose no operational and maintenance constraints.	ACC systems are becoming more popular at power plants. Their more limited operating experience indicates that their reliability is similar to wet cooling towers. While ACC systems are less common, they do not pose any greater operating and maintenance risks than other cooling systems.
Generating Efficiency	Using coal-fired power plants as a guide, wet cooling tower systems have a 6.9 to 8.6 percent efficiency penalty when compared to OT systems. (Reference 2)	Spray ponds' efficiency penalty is greater than OT systems, but smaller than all the other cooling tower system based alternatives.	Using coal-fired power plants as a guide, ACC systems have the largest efficiency penalty when compared to OT systems. This penalty is also greater than wet cooling tower systems.

Table 9.4-2 Screening of Unit 3 Alternative Heat Dissipation Systems (Alternatives 3–5)

Factors Affecting System Selection	Mechanical Draft Cooling Towers (Alternative 3)	Spray Ponds (Alternative 4)	Air Cooled Condensers (Alternative 5)
Is this a suitable alternative heat dissipation system?	Yes.	No.	No.

Table 9.4-3 Summary Comparison of Unit 3 Heat Dissipation Systems Impacts

	Base Case	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Criteria	**OT**	**OTHT**	**NDCT**	**MDCT**	**SP**	**ACC**
Land Use	Low	Low	Medium	Medium	High	Medium
Water Use	High	High	Medium	Medium	High	Low
Regulatory Barriers	Low	Low	Low	None	High	Low
Air Impacts	None	Low	Medium	Medium	Low	Low
Thermal/Physical Impacts	High	High	Medium	Medium	Medium	Low
Noise Impacts	Low	Low	Medium	Medium	Low	High
Aesthetics & Recreational Benefits	None	None	None	None	None	None
Operating and Maintenance Experience	High	Medium	High	High	Medium	Low
Generating Efficiency	High	High	High	Medium	High	Low
Overall Environmental & Operability Ranking	Preferable	Equivalent	Equivalent	Equivalent	Unacceptable	Equivalent
Capital Costs	Low	Medium	Medium	Medium	Not evaluated	High
Operating Costs	Low	Low	Low	Medium	Not evaluated	High
Costs Ranking	Preferable	Equivalent	Unacceptable	Unacceptable	Not evaluated	Unacceptable
Overall Preference	X	X				

Table 9.4-4 Initial Screening of Alternative Heat Dissipation Systems - Unit 4 (Base Case & Alternatives 6–8)

Factors Affecting System Selection	Mechanical Draft Cooling Towers (Base Case)	Once-Through (Alternative 6)	Once-Through with Helper Tower (Alternative 7)	Natural Draft Cooling Towers (Alternative 8)
Land Use: Onsite Land Considerations	A MDCT system would require more land to site widely spaced towers. A MDCT system could be placed within the confines of the existing NAPS site property.	An OT system would have the smallest land requirements.	An OTHT system would require marginally more land than is required by the OT system alone, but less than other cooling tower system. The OTHT system could be placed within the confines of the existing NAPS site.	A NDCT system would require more land to accommodate large diameter hyperbolic towers. A NDCT system could be placed within the confines of the existing NAPS site.
Land Use: Terrain Considerations	MDCT systems withdraw less water than OT systems and are less affected by substantial terrain variations. Terrain features of the site are suitable for a MDCT system.	OT systems require flat or gently rolling terrain to minimize pump head requirements. Terrain features of the site would not preclude the use of an OT system.	OTHT systems require flat or gently rolling terrain situations to minimize pump head requirements. Terrain features of the site are suitable for a OTHT system.	NDCT systems withdraw less water than OT systems and are less affected by substantial terrain variations. Terrain features of the site are suitable for a NDCT system.
Water Use	Per the PPE, a OT system would require nearly 50 times more water than the MDCT system. Despite the reduced water intake requirements, the MDCT system would lose a considerable portion of the lesser water withdrawal to the atmosphere through evaporation. The overall evaporative losses are somewhat greater for closed wet cooling tower systems compared to open cooling systems.	A OT system would require nearly 50 times more water than the MDCT system. Despite this increased water intake requirement, a OT system would return most of the water withdrawn, while the MDCT system would lose a considerable portion of the lesser water withdrawal to the atmosphere through evaporation. Hydrological and thermal modeling results (Section 3.4.1) indicate that Lake Anna cannot support operation of Unit 4 with OT cooling.	A OTHT system would require less water than a pure OT system. Despite this reduction, hydrological/thermal modeling results (Section 3.4.1) indicate that Lake Anna cannot support operation of Unit 4 with this modified OT system.	A OT system would require nearly 50 times more water than a NDCT system. Despite the reduced water intake requirements, a NDCT system would lose a considerable portion of the lesser water withdrawal to the atmosphere through evaporation. The overall evaporative losses would be somewhat greater for closed wet cooling tower systems compared to open cooling systems.

Table 9.4-4 Initial Screening of Alternative Heat Dissipation Systems - Unit 4 (Base Case & Alternatives 6–8)

Factors Affecting System Selection	Mechanical Draft Cooling Towers (Base Case)	Once-Through (Alternative 6)	Once-Through with Helper Tower (Alternative 7)	Natural Draft Cooling Towers (Alternative 8)
Regulatory Restrictions	An intake structure for the MDCT system would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The VPDES discharge permit thermal discharge limitation to the WHTF would need to be modified to account for the additional small thermal load rejected by MDCT. These regulatory restrictions would not negatively impact application of this heat dissipation system.	An intake structure for OT system would meet Section 316(b) of the CWA and the implementing regulations, as applicable. Since the thermal load contribution of a Unit 4 OT system could produce undesirably high temperatures in the WHTF, it is unlikely that two additional once-through systems could be successfully permitted.	An intake structure for OTHT system would meet Section 316(b) of the CWA and the implementing regulations, as applicable. While the helper tower for Unit 4 would temper the thermal loading to the WHTF during the hottest summer season periods, it is unlikely that two additional once-through systems could be successfully permitted.	An intake structure for the NDCT systems would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The VPDES discharge permit thermal discharge limitation to the WHTF would need to be modified to account for the additional small thermal load rejected by the by NDCT system. These regulatory restrictions would not negatively impact application of this heat dissipation system.
Atmospheric Effects	The MDCT system would emit water droplets (drift) and intermittently produce a visible plume. The drift droplets would be a minor source of particulate matter and salt deposition. The water vapor plume would encourage some additional fogging (44 hours annually – per Section 5.3.3.1) and no additional icing conditions on local road systems. Visible plume aesthetic impacts are described as small in Section 5.3.3.1.	Since OT systems do not produce a visible water droplet plume and the associated pond induced fogging (steam fog) would be minimal, atmospheric effects would be none to small.	A OTHT system would emit water droplets (drift) and produce visible plumes during periods when the helper tower is in operation. The particulate, salt deposition, fogging and icing and aesthetic impacts would be significantly less than the predicted small impacts from larger, full-time operating cooling tower system (see Section 5.3.3.1)	A NDCT system would emit water droplets (drift) and may intermittently produce a visible plume. The drift droplets would be a minor source of particulate matter and salt deposition. The water vapor plume would not to encourage any additional fogging or icing conditions on local road systems per Section 5.3.3.1. Visible plume aesthetic impacts are described as small in Section 5.3.3.1.

Table 9.4-4 Initial Screening of Alternative Heat Dissipation Systems - Unit 4 (Base Case & Alternatives 6–8)

Factors Affecting System Selection	Mechanical Draft Cooling Towers (Base Case)	Once-Through (Alternative 6)	Once-Through with Helper Tower (Alternative 7)	Natural Draft Cooling Towers (Alternative 8)
Thermal and Physical Effects	The MDCT system would produce a significantly smaller thermal load on the WHTF (compared to OT systems) because 65-85 percent of the heat removal in cooling towers is associated with evaporation (Reference 2). Most of the remaining heat is dissipated directly to the atmosphere. In this case the smaller MDCT thermal load rejected to the WHTF would be additive to the existing OT thermal load. The VPDES permit thermal discharge criteria would need to be revised to reflect this minor thermal addition.	Hydrological and thermal modeling results (Section 3.4.1) indicate that Lake Anna cannot support operation of Unit 4 with an OT system.	While a OTHT system would minimize the thermal loading to the WHTF during the hottest summer season periods, hydrological/thermal modeling results (Section 3.4.1) indicate that Lake Anna cannot support operation of Unit 4 with this modified OT system.	A NDCT system would produce a significantly smaller thermal load on the WHTF (compared to OT systems) because 65-85 percent of the heat removal in cooling towers is associated with evaporation (Reference 2). Most of the remaining heat is dissipated directly to the atmosphere. In this case the smaller NDCT thermal load rejected to the WHTF would be additive to the existing OT thermal load. The VPDES permit thermal discharge criteria would need to be revised to reflect this minor thermal addition.
Noise Levels	MDCT operation would generate noise from fan and pump operation and from cascading water in the towers. Noise impacts associated with tower operation were evaluated to below the NRC-defined significance levels (65 dBA) at the EAB as described in Section 5.3.4. Construction-related noise impacts would be small.	OT system operation would generate minimal noise from pump operation. Construction-related noise impacts would be small.	OTHT operation would generate noise from fan and pump operation and from cascading water in the towers during the periods when the helper tower is needed. The associated noise impacts would be less than MDCT impacts which were already below the NRC-defined significance levels (65 dBA) at the EAB as described in Section 5.3.4. Construction-related noise impacts would be small.	A NDCT system would produce less noise than a MDCT system because of the lack of fan generated noise. Note MDCT noise levels were evaluated to be below NRC-defined significance levels (65 dBA) at the EAB (see Section 5.3.4). Construction-related noise impacts would be small.

Table 9.4-4 Initial Screening of Alternative Heat Dissipation Systems - Unit 4 (Base Case & Alternatives 6–8)

Factors Affecting System Selection	**Mechanical Draft Cooling Towers (Base Case)**	**Once-Through (Alternative 6)**	**Once-Through with Helper Tower (Alternative 7)**	**Natural Draft Cooling Towers (Alternative 8)**
Aesthetics and Recreational Benefits	The MDCT system would be wholly situated on the existing NAPS site and its primary external impact would be the discharge of heated water to the North Anna Reservoir via the WHTF. Discharges to the North Anna Reservoir, a popular recreational resource, would produce no tangible aesthetic or recreational benefits.	A OT system would be wholly situated on the existing NAPS site and its primary external impact would be the discharge of heated water to the North Anna Reservoir via the WHTF. Discharges to the North Anna Reservoir, a popular recreational resource, would produce no tangible aesthetic or recreational benefits.	A OTHT system would be wholly situated on the existing NAPS site and its primary external impact would be the discharge of heated water to the North Anna Reservoir via the WHTF. Discharges to the North Anna Reservoir, a popular recreational resource, would produce no tangible aesthetic or recreational benefits.	A NDCT system would be wholly situated on the existing NAPS site and its primary external impact would be the discharge of heated water to the North Anna Reservoir via the WHTF. Discharges to the North Anna Reservoir, a popular recreational resource, would produce no tangible aesthetic or recreational benefits.
Operating and Maintenance Experience	MDCT systems are common to power plants (both fossil and nuclear) and they are considered highly reliable.	OT systems are common to power plants (both fossil and nuclear) and they are considered highly reliable.	While OTHT systems are less common than OT systems, they do not pose any greater operating and maintenance risks than other cooling tower systems.	NDCT systems are common to power plants (both fossil and nuclear) and they are considered highly reliable.
Generating Efficiency	Using coal-fired power plants as a guide, wet cooling tower systems have a 6.9 to 8.6 percent efficiency penalty when compared to OT systems. (Reference 2)	Using coal-fired power plants as a guide, OT systems are 6.9 to 8.6 percent more energy efficient than wet cooling tower systems. (Reference 2)	The additional energy requirements associated with cooling tower operation, do no alter this system's energy efficiency advantages over wet cooling tower only systems.	Using coal-fired power plants as a guide, wet cooling tower systems have a 6.9 to 8.6 percent efficiency penalty when compared to OT systems. Natural draft tower energy requirements would be less than mechanical draft systems. (Reference 2)
Is this a suitable heat dissipation system?	Yes.	No.	No.	Yes.

Table 9.4-5 Screening of Unit 4 Alternative Heat Dissipation Systems (Alternatives 9 & 10)

Factors Affecting System Selection	Spray Pond (Alternative 9)	Air-Cooled Condenser (Alternative 10)
Land Use: Onsite Land Considerations	The spray pond cooling alternative would involve the development of significant additional surface water impoundments and consequently pose the greatest new land requirements. It is unlikely that spray ponds of sufficient size could be placed within the confines of the existing site.	An ACC system would require more land than a wet cooling tower system. Since ACCs could be situated within the confines of the existing site, impacts would be none to small.
Land Use: Terrain Considerations	Since spray pond construction involves substantial earthwork, such systems are most appropriate for flat or gently rolling terrain. Terrain features of the site are suitable for the addition of spray ponds.	ACC systems are unaffected by terrain considerations.
Water Use	Spray ponds would require large volumes of water and would likely require offsite sources of water.	ACC systems have no comparable evaporative water losses when compared with MDCTs or spray ponds. ACC systems require minimal service water.
Legislative Restrictions	Additional land would have to be obtained and developed to support a spray pond option. The development of this land would entail a substantial and lengthy federal, state, and local permit and approval process.	There are little or no permit or approval-related impacts to the ACC alternative.
Atmospheric Effects	Spray pond systems could produce a low-level visible water droplet plume and encourage formation of fog above the heated pond. These impacts would be localized and short-lived, and consequently small.	ACC systems do not produce visible plume or pose particulate emission or salt deposition impacts.
Thermal and Physical Effects	Since the thermal load would be rejected to the spray pond that would be wholly dedicated to industrial use, the thermal impacts external to the pond would be none to small.	An ACC system would direct an invisible heated plume of air into the atmosphere, and impacts would be none to small.

Table 9.4-5 Screening of Unit 4 Alternative Heat Dissipation Systems (Alternatives 9 & 10)

Factors Affecting System Selection	Spray Pond (Alternative 9)	Air-Cooled Condenser (Alternative 10)
Noise Levels	Spray pond system operation would generate noise from the spray operations. Since the location of the spray ponds and associated receptor boundaries are presently undefined, the associated noise impacts cannot be evaluated at this time. Construction-related noise impacts would be small.	An ACC system would generate operational noise from fan operation. While noise impacts associated with operation of an ACC system have not been evaluated, the Section 5.3.4 noise evaluation for a MDCT system suggests that noise contributions from an ACC system would produce impacts below the NRC-defined significance levels (65 dBa) at the EAB. Construction-related noise impacts would be small.
Aesthetics and Recreational Benefits	The spray ponds would be at least partially situated on land outside of the NAPS site. The resulting commitment of previously undeveloped land to industrial use would produce no tangible aesthetic or recreational benefits.	An ACC system would be wholly situated on existing the NAPS site and their primary external impact would be the discharge of heated air and noise to the atmosphere. These discharges would not produce tangible aesthetic or recreational benefits.
Operating and Maintenance Experience	Spray pond systems have been used on power plant sites and they pose no operational or maintenance constraints.	ACC systems are becoming more popular at power plants. Their more limited operating experience indicates that their reliability is similar to wet cooling towers. While ACC systems are less common, they do not pose any greater operating and maintenance risks than other cooling systems.
Generating Efficiency	Spray ponds' efficiency penalty is greater than OT systems, but smaller than all the other cooling tower system based alternatives.	Using coal-fired power plants as a guide, ACC systems have the largest efficiency penalty when compared to OT systems. This penalty is also greater than wet cooling tower systems.
Is this a suitable heat dissipation system?	No.	Yes.

Table 9.4-6 Summary Comparison of Unit 4 Heat Dissipation Systems Impacts

	Base Case	Alternative 6	Alternative 7	Alternative 8	Alternative 9	Alternative 10
Criteria	**MDCT**	**OT**	**OTHT**	**NDCT**	**SP**	**ACC**
Land Use	Medium	Low	Low	Medium	High	Medium
Water Use	Medium	High	High	Medium	High	Low
Regulatory Barriers	None	High	High	None	High	None
Air Impacts	Medium	None	Low	Medium	Medium	Low
Thermal/Physical Impacts	Medium	High	High	Medium	Medium	Low
Noise Impacts	Medium	Low	Low	Low	Low	High
Aesthetics & Recreational Benefits	None	None	None	None	None	None
Operating and Maintenance Experience	High	High	Medium	High	Medium	Low
Generating Efficiency	Medium	High	High	Medium	High	Low
Overall Environmental & Operability Ranking	Preferable	Unacceptable	Unacceptable	Preferable	Unacceptable	Equivalent
Capital Costs	Medium	Not Evaluated	Not Evaluated	Medium	Not Evaluated	Medium
Operating Costs	Medium	Not Evaluated	Not Evaluated	Low	Not Evaluated	High
Costs Ranking	Preferable	--	--	Preferable	--	Equivalent
Overall Preference	X	--	--	X	--	X

Table 9.4-7 Screening of Alternatives to the Proposed Intake System (Base Case & Alternative 1)

Factors Affecting System Selection	Intake System - Base Case Addition of Shoreline Intake on Lake Anna	Intake System - Alternative 1 Offshore Intake System
Construction Impacts	Since development of the intake shoreline would result in disruptions of the littoral zone (i.e., area of more concentrated biological resources), there could be localized adverse impacts to this disturbed zone. Since previous development in this zone and the new intake would be adjacent to an operational water intake system, these impacts would be small. Experience has shown that impacts near shorelines (i.e., transportation of silt) are more readily controllable near the shoreline than offshore.	If the offsite intake system is installed using an open trench construction process, there could be large adverse impacts to both the littoral zone and to deeper areas of the lake. This process would result in greater lakebed disruptions and larger increases in the turbidity of Lake Anna water. The resulting adverse impact to the lake water quality could be large during the construction phase of work.
Aquatic Impacts	The potentially large adverse operational impacts to aquatic life could be mitigated by reducing intake velocities and using traveling screens to reduce impingement, entrapment and entrainment of aquatic life.	Situated in areas with relatively less abundant aquatic resources, submerged offsite intake systems generally pose fewer impacts to aquatic life during operation.
Land Use Impacts	Since the commitment of land for the shoreline intake is small and this development would occur on the NAPS site, land use impacts would not be an important differentiating factor for intake systems.	Through offshore intake systems have somewhat lesser land requirements then shoreline intake systems, land use impacts would not be an important differentiating factor.
Water Use Impacts	The relative position of the intake (shoreline or offshore) would have no differentiating impact on the water use requirements and therefore, it would not be an important factor.	The relative position of the intake (shoreline or offshore) would have has no differentiating impact on the water use requirements, and therefore, it would not be an important factor.
Compliance with Regulations	The intake structure for the new units at the ESP site would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The applicable VPDES permit and current Section 316(b) considerations (aquatic species entrainment-impingement-entrapment) issues would need to be modified in response to the additional intake. These regulatory restrictions would not be an important differentiating factor.	The intake structure for the new units at the ESP site would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The applicable VPDES permit and current Section 316(b) considerations (aquatic species entrainment-impingement-entrapment) issues would need to be modified in response to the additional intake. These regulatory restrictions would not be an important differentiating factor.
Environmentally preferred or equivalent? (Yes/No)	Yes	No

Table 9.4-8 Screening of Alternatives to the Proposed Intake System (Base Case & Alternatives 2 & 3)

Factors Affecting Location Selection	Intake Location - Base Case	Intake Location - Alternative 2	Intake Location - Alternative 3
	Adjacent to Existing Intake	Alternative Location on Lake Anna	Lower North Anna River
Construction Impacts	Construction impacts would be minimized if the intake structure is located adjacent to the existing NAPS site intake. Already cleared and graded in support of the original intake system development, this area has less ecological resources than other shoreline locations. Proximity to shore would allow use of best management practices to control the movement of silt and minimize impact on North Anna Reservoir waters.	Construction impacts from the disruption of shoreline environment would be larger for alternative shoreline locations along Lake Anna, since these areas have not been impacted by previous construction activities.	Construction impacts would be more significant in the lower North Anna River, since the affected body of water is smaller and more prone to turbidity impacts. The adjacent river shoreline is less developed and likely offers more diverse ecosystems.
Aquatic Impacts	The potentially large adverse operational impacts to aquatic ecosystems could be mitigated and rendered small by applying management techniques in use at the existing intake (e.g., minimized intake velocity, screens).	The potentially large adverse operational impacts to aquatic ecosystems could be mitigated and rendered small by applying management techniques in use at the existing intake (e.g., minimized intake velocity minimization, screens).	The potentially large adverse operational impacts to aquatic ecosystems could be somewhat mitigated by applying management and screening techniques in use at the existing intake. The more confined, potentially richer biological environment along the river shoreline would make it more difficult to effectively mitigate adverse impacts relative to the base case.
Land Use Impacts	Since the new intake would reside totally within the confines of the NAPS site, its location adjacent to another intake, poses the smallest land use impacts.	Land use designations outside of the NAPS site do not support the installation or operation of industrial facilities. Thus, development of intake locations in these areas would trigger potentially onerous land use amendment processes, which would make this alternative less desirable than the base case.	Land use designations along the lower North Anna River do not support the installation and operation of industrial facilities. Thus, development of intake locations in these areas would trigger potentially onerous land use amendment processes.

Table 9.4-8 Screening of Alternatives to the Proposed Intake System (Base Case & Alternatives 2 & 3)

Factors Affecting Location Selection	Intake Location - Base Case Adjacent to Existing Intake	Intake Location - Alternative 2 Alternative Location on Lake Anna	Intake Location - Alternative 3 Lower North Anna River
Water Use Impacts	Since Lake Anna represents the largest source of water for industrial use in the NAPS site area, the related water use impacts of an adjacent intake system would be small relative to other potential locations.	Since Lake Anna represents the largest source of water for industrial use in the NAPS site area, the related water use impacts of a new adjacent intake system would be small relative to potential impacts from using other locations.	The lower North Anna River does not have sufficient water capacity to supply the proposed circulating water system. The alternative is not technically viable.
Compliance with Regulations	The intake structure for the new units at the ESP site would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The applicable VPDES permit and current Section 316(b) issues (aquatic species entrainment-impingement-entrapment) issues would need to be modified in response to the additional intake. Thus, these regulatory restrictions would not be an important differentiating factor.	The intake structure for the new units at the ESP site would meet Section 316(b) of the CWA and the implementing regulations, as applicable. The applicable VPDES permit and current Section 316(b) issues (aquatic species entrainment-impingement-entrapment) issues would need to be modified in response to the additional intake. Thus, these regulatory restrictions would not be an important differentiating factor.	The intake structure for the new units at the ESP site would meet Section 316(b) of the CWA and the implementing regulations, as applicable. Since construction of the intake structure would likely impact wetland areas and other important habitats, additional federal and state-sponsored permitting processes would also be triggered. Consequently, the environmental permitting process for this intake structure location could represent a large barrier to this alternative.
Environmentally preferred or equivalent? (Yes or No)	Yes	No	No

Table 9.4-9 Screening of Alternatives to the Proposed Discharge System (Base Case & Alternative 4)

Factors Affecting System Selection	Discharge System –Base Case Shoreline Discharge & Discharge Canal	Intake System - Alternative 4 Offshore Submerged Discharge System
Construction Impacts	Since development of the shoreline discharge would result in disruptions of the littoral zone (area of more concentrated biological resources), there could be localized moderate adverse impacts on this disturbed zone.	If the offsite discharge system is installed using an open trench system, there could be large adverse impacts on both the littoral zone and other areas of the lake. Open trench activities would result in greater lakebed disruptions and larger increases in the turbidity of Lake Anna water. The resulting adverse impact on the lake water quality could be large during the construction phase of work.
Aquatic Impacts	Situated in the more biologically important littoral zone areas, shoreline discharges would have the potential to disturb the local aquatic ecosystem. Such systems pose greater impacts than offshore discharge systems.	Situated in areas with relatively less abundant aquatic resources (outside of more ecologically abundant littoral zone), submerged offsite intake systems generally pose fewer impacts on the aquatic ecosystem.
Land Use Impacts	Since the commitment of land for the shoreline discharge is not significant, land use impacts would not be an important differentiating factor.	Through offshore discharge systems have somewhat lesser land requirements then shoreline intake systems, land use impacts would not be an important differentiating factor. Note that the submerged systems would likely be situated deep enough to avoid direct interference with recreational water uses.
Water Use Impacts	The relative position of the shoreline discharge would have little impact on the water use requirements and, therefore, it would not be an important differentiating factor.	The relative position of the discharge would have little impact on the water use requirements and, therefore, it would not be an important differentiating factor. Note that the submerged systems would likely be situated deep enough to avoid direct interference with recreational water uses.
Compliance with Regulations	The discharge system would meet the requirements of Section 316(a) of the CWA, and the implementing regulations, as applicable. The applicable VPDES permit and Section 316(a) thermal impact considerations would need to be evaluated in response to the additional discharge. These regulatory restrictions would not be an important differentiating factor.	The discharge system would meet the requirements of Section 316(a) of the CWA, and the implementing regulations, as applicable. The applicable VPDES permit and Section 316(a) thermal impact considerations would need to be evaluated in response to the additional discharge. These regulatory restrictions would not be an important differentiating factor.
Environmentally preferred or equivalent?	Yes	No

Table 9.4-10 Screening of Alternatives to the Proposed Discharge System Location (Base Case & Alternatives 5 & 6)

Factors Affecting Location Selection	Discharge Location Base Case Adjacent to Existing Discharge	Discharge Location Alternative 5 Discharge along WHTF	Discharge Location Alternative 6 Discharge on Lake Anna
Construction Impacts	Construction impacts would be minimized if the discharge structure is located adjacent to the existing discharge structure at the head of the discharge canal. Already cleared and graded in support of the original discharge system, this area boasts less ecological resources than other undeveloped areas.	Construction impacts (surface disruption and turbidity increases) would be more significant at less developed alternative discharge structure sites along the WHTF shoreline.	Construction impacts (surface disruption and turbidity increases) would be the greatest for the undeveloped or less developed alternative shoreline discharge structure sites along the shore of Lake Anna.
Aquatic Impacts	The thermal and chemical impacts of effluent discharges would be effectively mitigated (through mixing and dilution) in the discharge canal and downstream WHTF.	The thermal and chemical impacts of effluent discharges would be effectively mitigated (mixing and dilution) in the WHTF.	Effluent that is discharged directly to Lake Anna may significantly impact local aquatic resources, since the effluent would not be subject to the beneficial mixing and dilution actions from travel through the discharge canal and WHTF.
Land Use Impacts	Since the new discharge would reside totally within the confines of the NAPS site, its location adjacent to another discharge structure would pose the smallest land use impacts.	Although the new discharge would reside totally within the confines of the NAPS site, its location along a relatively undeveloped shoreline of the WHTF would require a greater commitment of land resources.	Land use designations along Lake Anna areas outside the NAPS site do not support the installation or operation of industrial facilities. The lake also offers substantial recreational benefits to the local community, which could be adversely impacted by the construction of a discharge structure. Thus, development of discharge systems in these more ecological important and community-valued areas would trigger potentially onerous land use amendment processes.

Table 9.4-10 Screening of Alternatives to the Proposed Discharge System Location (Base Case & Alternatives 5 & 6)

Factors Affecting Location Selection	Discharge Location Base Case Adjacent to Existing Discharge	Discharge Location Alternative 5 Discharge along WHTF	Discharge Location Alternative 6 Discharge on Lake Anna
Water Use Impacts	The additional circulating system effluent released through the discharge structure would pose the smallest water use and cumulative impacts since the release is consistent with current discharge practices into the WHTF; an industrial facility already designed and constructed to receive heat dissipation system discharges.	The additional circulating system effluent released to the WHTF in an alternate location would pose the smallest water use impacts, because this activity is consistent with current discharge practices into the WHTF; an industrial facility designed and constructed to receive heat dissipation system discharges.	The new discharge of circulating system effluent directly to Lake Anna could have moderate water use impacts to this receiving water body. Lake Anna is a multi-use water resource that is not compatible with direct industrial discharges. Note the thermal and chemical impacts of this discharge would not be subject to the beneficial dilution and mixing actions from travel through the discharge canal and WHTF.
Compliance with Regulations	The discharge system would meet the requirements of Section 316(a) of the CWA, and the implementing regulations, as applicable. The applicable VPDES permit and current associated 316(a) considerations would need to be modified in response to the additional discharge system. These regulatory restrictions would offer only small impacts to the design and operation of a new a discharge system sited with the existing discharge canal.	The discharge system would meet the requirements of Section 316(a) of the CWA, and the implementing regulations, as applicable. The applicable VPDES permit and current associated 316(a) considerations would need to be modified to respond to the additional discharge system. These regulatory restrictions would offer only small impacts to the design and operation of a new discharge system sited in the WHTF.	The discharge system would meet the requirements of Section 316(a) of the CWA, and the implementing regulations, as applicable. Since construction of the discharge structure is likely to impact wetland and important habitat areas, additional federal and state-sponsored permitting processes could also be triggered. The environmental permitting process for this discharge structure location could represent a barrier to development.
Environmentally preferred or equivalent?	Yes	No	No

Table 9.4-11 Screening of Alternatives to the Proposed Water Treatment System (Base Case & Alternatives 7 & 8)

Factors Affecting System Selection	Water Treatment Base Case Once-through: Mechanical Condenser Cleaning	Water Treatment System Alternative 7 Chemical Treatment: Biocide, Corrosion Inhibitor, pH Adjustment	Water Treatment System Alternative 8 Non-chemical Treatment: Ultraviolet (UV) Treatment
Chemicals Used	Mechanical cleaning would involve periodic removal of organic and inorganic residue and debris on circulating system condenser piping and related equipment. No chemicals are used.	Biocide – chlorine, sodium-hypochlorite, ozone Corrosion inhibitors (cooling tower systems only) – oxidizer (nitrates, molybates), filming (nitrogen compounds), polymer (polymeric carboxylate). pH adjustment (cooling tower systems only) – acids (sulfuric acid) and caustics (sodium hydroxide) (Reference 4)	None
Construction Impacts	Periodic mechanical cleaning of the condenser system would not require any substantial construction activities and there would be no related environmental impacts.	Installation of the chemical treatment systems would result in additional commitments of land. Associated soil erosion and sediment impacts, however, would be small.	Installation of the UV treatment systems would result in additional commitments of land. Associated soil erosion and sediment impacts, however, would be small.
Aquatic Impacts	While mechanical cleaning measures would remove biological materials from condenser system surfaces, these measures would not pose systemic impacts on aquatic resources in Lake Anna.	Residual chemicals from this treatment process could impact aquatic resources in the WHTF and downstream North Anna Reservoir. Biocides, corrosion inhibitors, and pH adjustment chemicals are potentially toxic to aquatic life. Polymeric corrosion inhibitors are proposed and would represent a much less toxic option. (Reference 4)	The UV treatment would have no residual impacts on aquatic resources in the receiving body of water. UV systems, however, have not been proven effective on large-scale cooling systems; therefore, they may prove infeasible or unreliable.
Land Use Impacts	Mechanical cleaning measures would not require any additional commitment of land.	Since the chemical treatment systems do require additional land, these systems would be wholly-confined to the existing NAPS site. There would be no appreciable land use impacts.	While these UV treatment systems do require additional land, these systems would be wholly-confined to the existing NAPS site. There would be no appreciable land use impacts.
Water Use Impacts	Mechanical cleaning would not impact water withdrawal requirements.	Chemical treatment systems would not impact water withdrawal requirements.	UV treatment systems would not impact water withdrawal requirements.

Table 9.4-11 Screening of Alternatives to the Proposed Water Treatment System (Base Case & Alternatives 7 & 8)

	Water Treatment Base Case	Water Treatment System Alternative 7	Water Treatment System Alternative 8
Factors Affecting System Selection	**Once-through: Mechanical Condenser Cleaning**	**Chemical Treatment: Biocide, Corrosion Inhibitor, pH Adjustment**	**Non-chemical Treatment: Ultraviolet (UV) Treatment**
Compliance with Regulations	Mechanical condenser cleaning is a continuation of current practice and fully compliant with the applicable regulations and existing and pending permit conditions.	The addition of chemical treatment systems would impact the current NAPS VPDES discharge permit. This permit would need to be revised in response to the revised characterization of the chemically-treated cooling system effluent.	The addition of UV treatment systems may impact the current NAPS VPDES discharge permit. This permit may need to be revised in response to the new characterization of the treated cooling system effluent.
Environmentally preferred or equivalent?	Yes	Yes	No

Chapter 10 Environmental Consequences of the Proposed Action

This chapter presents the potential environmental consequences of constructing and operating the new units at the ESP site. These potential consequences are presented in the following subsections:

Section 10.1 – Unavoidable Adverse Environmental Impacts. Unavoidable adverse environment impacts are those potential impacts of construction and operation of the new units that cannot be avoided and for which no practical means of mitigation are available.

Section 10.2 – Irreversible and Irretrievable Commitments of Resources. Irreversible commitments of resources applies to environmental resources that would be potentially impacted by the new units and that could not be altered at some later time to restore the current state of the resources. Irretrievable commitments of resources applies to material resources that would be used for the new units in such a way that they could not, by practical means, be recycled or restored for other uses.

Section 10.3 – Relationship Between Short-Term Uses and Long-Term Productivity of the Human Environment. Short-term uses and long-term productivity refer to the analyses of unavoidable adverse or beneficial environmental impacts of the construction and operation of the new units during the period of construction, operation, and through decommissioning.

Section 10.4 – Benefit -Cost Balance. This section contains a brief description explaining why cost-benefit information is not included in this ESP application.

10.1 Unavoidable Adverse Environmental Impacts

This section summarizes those adverse environmental impacts due to the construction and operation of the new units that cannot be avoided and for which no practical means of mitigation are available. Part of this summary includes identification of mitigation actions that have been proposed to reduce the impacts and would be reasonable and practical to implement. Information provided in Section 4.6 and Section 5.10 has been used in preparing this section.

10.1.1 Unavoidable Adverse Environmental Impacts During Construction

The potential adverse environmental impacts from construction of the new units are described in Chapter 4. The measures and controls to reduce or eliminate these impacts are identified in Section 4.6. The expected impacts and the mitigation measures that are practical to reduce these impacts are identified and summarized in Table 10.1-1. Those instances where adverse environmental impacts would remain after all reasonable means have been taken to avoid or mitigate them are also identified in Table 10.1-1, under the column labeled “Unavoidable Adverse Impacts”, where “Y” means there are such impacts and “N” means the specified mitigation measures are sufficient to reduce the impacts to insignificant or small. For many of the impacts related to construction activities, mitigation measures that would be applied are referred to as “best

management practices." Typically, their use is determined by the types of activities that are to be performed, and frequently, they are implemented through plans and procedures developed at the time of construction.

10.1.2 **Unavoidable Adverse Environmental Impacts During Operation**

The potential adverse environmental impacts from operation of the new units are described in Chapter 5. The measures and controls to reduce or eliminate these impacts are identified in Section 5.10. The expected impacts and the mitigation measures that are practical to reduce these impacts are identified and summarized in Table 10.1-2. Those instances where adverse environmental impacts would remain after all practical means to avoid or mitigate them have been applied are also identified in Table 10.1-2, under the column labeled "Unavoidable Adverse Impacts," where "Y" means there are such impacts, and "N" means the specified mitigation measures are sufficient to reduce the impacts to insignificant or small. Again, the environmental impacts and related mitigation measures identified in this ER are based on the PPE approach. Because the type of reactor and associated ancillary equipment have not yet been selected, the impacts and mitigation measures identified in Table 10.1-2 should be considered as bounding cases.

10.1.3 **Summary of Adverse Environmental Impacts**

As can be seen from Table 10.1-1 and Table 10.1-2, most of the adverse environmental impacts are reduced to insignificance or eliminated through the application of the listed mitigation measures. Those that are not entirely eliminated are discussed further in this section.

During construction, the primary adverse environmental impacts would be related to land use. Much of the NAPS site would undergo a change from unused property to industrial use associated with operation of the new units at the site. While these changes would result in the movement of wildlife from the NAPS site, the changes are in keeping with the current industrial use zoning. Furthermore, the original selection and review of the NAPS site was based on building four units at the site. Therefore, the changes, while small, are compatible with the long-term use of the site. Furthermore, Dominion and Virginia Power have the long-term intention of continuing energy production on the NAPS site into the foreseeable future, which is compatible with the industrial use zoning and the current use of the site.

Many of the expected construction impacts on the terrestrial ecology of the site would short-term impacts. The numbers of wildlife, especially of the larger animals, and the amount of vegetation that would decrease because of the construction activities, would not fully recover, because the land used for new structures and operational activities, including parking, would effectively eliminate the possibility of restoring the acreage to its pre-construction condition. However, the conclusions of the ecological studies for this ER are that: 1) there are no important species currently on site, 2) some of the species would return to the areas of the site that are restored to their previous state, and

3) areas outside the site would be generally unaffected with regard to terrestrial wildlife and vegetation. Therefore, while there would be noticeable changes due to construction of the new units, the immediate area surrounding the site would not experience any long-term impacts due to the construction and operation of the new units.

Depending on the selected reactor design and its related ancillary equipment, especially the type of heat dissipation system (e.g., if cooling towers are used) there could be a noticeable visual change obvious to lake users and line-of-sight residences around the lake. Completion of a visual impact study once technologies and equipment are selected, however, would identify mitigation measures that could reduce visual impacts, through configuration of the structures on the ESP site. Furthermore, if cooling towers are used, it is possible to reduce plume impact to insignificant or small through plume abatement techniques. The conclusion is that visual impacts would not have any short- or long-term impacts to local residents or tourists, and are therefore small.

The use of new reactor technologies would reduce the amount of radioactive waste generated that would need to be disposed of when compared to the volume of waste currently generated at existing nuclear power plants.

10.1.4 **Irreversible and Irretrievable Commitment of Resources**

As discussed in Section 10.2, during construction there would be very little commitment of significant resources that are irreversible or irretrievable. Those that would be committed are the typical construction resources of steel, piping, and concrete. The latter, while large, is not atypical of other types of power plants such as hydroelectric and coal-fired plants, nor of many large industrial facilities (e.g., refineries and steel plants) that are constructed throughout the United States.

During operation, as discussed in Section 10.2, the main resource that is irreversibly and irretrievably committed is the uranium that is consumed in the power production process. However, the use of new, more efficient reactor technologies by the nuclear power industry would result in lower consumption of uranium in the form of enriched UF_6. This reduced demand for enriched UF_6 would result in a reduction in the amount of uranium ore that has to be mined for production of yellowcake that is subsequently converted into UF_6. Because the mining of uranium ore, the production of yellowcake and its conversion to UF_6, and the subsequent enrichment of the UF_6 so that it can be used as fuel, all require energy, a reduction in the amount of uranium ore required would also serve to reduce the amount of energy consumed in the production of the fuel.

Section 10.1 References

None

Table 10.1-1 Construction-Related Unavoidable Adverse Environmental Impacts

Category/ ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Land Use/ Section 4.1.1	Construction of new units and related parking	Comply with requirements of applicable federal, state and local construction permits/approvals and local ordinances.	Y
Section 4.1.1	Construction of power plant	Construct only in area approved by federal, state, and local agencies for installation of the power plant.	Y
Section 4.1.1	Earthmoving activities (e.g., grading, re-contouring of disturbed areas)	Restrict activities to actual construction site and construction access road from Route 700. Install fence along southern and eastern boundaries, which includes the boundary with the existing units.	N
Section 4.1.1	Construction and maintenance of soil stockpiles	Locate soil stockpiles on the construction site only.	N
Atmospheric/ Section 4.1.1	Fugitive dust and/or gaseous emissions from the operating vehicles and equipment	Apply measures from the fugitive dust control plan and maintain vehicles and equipment in good working order.	N
Historic, Cultural, and Archaeological Resources/ Section 4.1.3	Potential for destruction of archaeological, historic, or cultural resources in areas suspected or known to have artifacts	Conduct sub-surface testing prior to start of any onsite work to identify buried archaeological or cultural resources.	N
Section 4.1.3	Unanticipated discovery of archaeological or cultural resources or hazardous waste during construction	Require construction contractor and subcontractors to develop and follow procedures (or use applicable existing procedures) to handle potential unanticipated discoveries, including stopping work immediately and notifying appropriate agencies.	N
Hydrologic Alterations/ Section 4.2.1	Potential affect of dewatering on some existing NAPS potable water wells	Maintain flows required by existing units by using unaffected wells.	N

Table 10.1-1 Construction-Related Unavoidable Adverse Environmental Impacts

Category/ ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Section 4.2.1	Erosion and sedimentation impacts on Lake Anna due to storm water runoff from the construction site	Obtain Storm Water Construction General Permit, the VPDES permit. Apply Storm Water Pollution Prevention Plan developed as part of the Storm Water Construction General Permit application. Use best management practices (BMPs) described in Virginia Erosion and Sediment Control Handbook.	N
Section 4.2.1	Migration of turbid water into the lake due to removal of existing cofferdam after construction of new water intake	Design and install appropriate barrier (e.g., turbidity curtain in Lake Anna near cofferdam) to prevent migration of turbid water into Lake.	N
Section 4.2.1	Impacts to intermittent stream channel on site	Obtain and comply with VPDES permit. Adhere to seasonal restrictions for in-water work. Install erosion control measures. Install drainage controls to convey stream flow. Follow construction stormwater management requirements.	N
Water Use/ Section 4.2.2	Increased sediment loading to surface water due to dewatering activities	Limit dewatering activities to what is needed. Require application of erosion and sediment controls to such activities (e.g., bag filter, flow spreader, retention basin).	N
Section 4.2.2	Contamination of surface water or groundwater from releases of fuel, oils, or chemicals during construction.	Develop and implement a spill control and response plan in addition to the SWPPP.	N
Terrestrial Ecology/ Section 4.3.1	Removal of existing trees and vegetation	Restrict removal of trees and vegetation to the construction site. Leave greenbelt of trees along southern boundary of construction site. Avoid sensitive areas if any are protected by law, permit, or approval process.	Y
Section 4.3.1	Loss of habitat due to clearing and grading, which would result in movement of wildlife from area during construction	Re-establish areas, where possible, when construction is completed so that wildlife should return.	Y

Table 10.1-1 Construction-Related Unavoidable Adverse Environmental Impacts

Category/ ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Section 4.3.1	Migration of wildlife away from undisturbed areas onsite or close to site during time when there are high levels of noise generated by construction activities	Maintain vehicles and equipment as per manufacturer's requirements.	Y
Aquatic Ecology/ Section 4.3.2	Disturbance, or destruction, of wetlands by working in, over, or in proximity to these areas	Avoid, if possible. Otherwise minimize disturbance, and compensate for any destruction of wetlands as per VDEQ regulations. Compensation would require creation or expansion of another, larger, wetland area.	N
Section 4.3.2	Disturbance of intermittent streams by working in, over, or in proximity to these areas	Avoid, or else work in the dry season, if possible, and restore streambed. Divert stream around construction and use settling basins, as needed, to remove sediment prior to re-connecting downstream of construction. Reconnect original streambed after construction activities, if possible. Install permanent diversion to restore the streambed, if necessary. Minimize disturbance and compensate for any destruction of streambed as per VDEQ regulations. Compensating for the loss of the intermittent stream would replace the loss.	Y
Section 4.3.2	Degradation of water quality in lake during in-water and shoreline work	Design and install barrier (e.g., turbidity curtain) to prevent turbid water from entering lake.	N
Section 4.3.2	Temporary loss of benthic habitat and organisms during construction, as benthic organisms and fish should recolonize the intake channel cove after completion of construction activities	Adhere to any seasonal restrictions of working in-water if stipulated in approval of ER or of any required permits.	N

Table 10.1-1 Construction-Related Unavoidable Adverse Environmental Impacts

Category/ ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Socioeconomic/ Section 4.4.1	Relatively higher noise levels offsite in residential areas	Restrict noisier construction activities to daytime hours. Notify general public when activities with atypically loud noise levels would occur. Develop and implement a plan to manage and respond to concerns of citizens about noise.	N
Section 4.4.1	Offsite effects of gaseous emissions from vehicles and diesel -powered equipment which should be small due to distance to nearest residences	Proper maintenance of vehicles and equipment should be sufficient to avoid noticeable impacts. Respond to concerns of citizens about gaseous emissions from the construction site via the complaint management plan.	N
Section 4.4.1	Transport of high dust levels offsite into residential areas	Develop and apply dust control plan that includes the following: Speed controls for onsite vehicles, covers for truck loads; use of water or approved chemicals on soil stockpiles and disturbed areas. Stop work on dust-generating activities under high wind conditions. Respond to concerns of citizens about high dust levels via the complaint management plan.	N
Section 4.4.1, Section 4.4.2	Traffic congestion and/or accidents from increased commuting construction workers, especially on local roads	Develop and implement a construction traffic management plan to reduce the numbers of vehicles being used on the local roads through use of buses, increased carpooling and vanpooling. Post signs in the local area to make the public and passers-by aware of the high construction traffic associated with the site Perform a traffic study and implement recommendations with regard to upgrades needed to Route 700 between the NAPS and the intersection with Route 652. Coordinate work shifts so that the construction workers and the existing units personnel do not have simultaneous or overlapping shift changes.	N
Section 4.4.2	Traffic congestion due to slow moving construction equipment deliveries	Schedule such deliveries on off hours or via rail.	N

Table 10.1-1 Construction-Related Unavoidable Adverse Environmental Impacts

Category/ ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Aesthetics/ Section 4.4.2	Visual Impact	Leave a 50–100 foot greenbelt of trees along the southern boundary as a visual shield for the construction site.	N
Environmental Justice/ Section 4.4.3	No impacts predicted based on use of local workforce	None Required	N
Radiation Exposure/ Section 4.5	Increased exposure of workers to radiation from existing units	Less than the acceptable annual value for the general public, therefore, no mitigation needed.	N

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Land Use/ Section 5.1.1	Potential for additional waste heat to affect recreational use of Lake Anna	Design/operate cooling system to comply with VPDES permit requirements.	N
Section 5.1.1	Increased traffic could create need for changes to local road system	Effective traffic management should avoid need for changes.	N
Transmission Lines/ Section 5.1.2	Based on an initial evaluation, the existing transmission lines and corridors have sufficient capacity for the total output of the existing and new units.	None required.	N
Historic, Cultural, or Archaeological Resources/ Section 5.1.3	None expected	None required.	N
Hydrological Alterations and Water Supply/ Section 5.2.1	Potential reduction in available water released from the North Anna Dam from current values (permit limits maintained)	Assess practices to minimize the hydrologic alterations and their implementation.	Y
Section 5.2.1	Potential reduction in Lake Anna water levels from current values during periods of extended drought with existing and new units operating	Evaluate options to reduce consumptive water use in the COL application using parameters for selected reactor technology and ancillary equipment.	Y
Water-Use Impacts/ Section 5.2.2	Increased water temperature in the Waste Heat Treatment Facility and, possibly, in the North Anna Reservoir	Identify and implement measures to minimize or avoid such impacts, where feasible and practical. Further analyze and evaluate options to mitigate impacts in the COL application process using selected reactor technology and ancillary equipment.	Y

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Section 5.2.2	Discharge of dissolved solids above ambient levels	Identify and implement measures to minimize or avoid such impacts, where feasible and practical. Further analyze and evaluate options to mitigate impacts in the COL application using selected reactor technology and ancillary equipment.	Y
Cooling Water Intake System Physical Impacts/ Section 5.3.1.1	Scouring of the lake bottom and erosion of shoreline due to operation of new unit(s)' intake system	As for existing units, construct intake system utilizing a dredged channel and intake structure in a cove on the south shore of Harris Creek. Install intake system for new units in area planned for intake system of previously abandoned Units 3 and 4. Stabilize the banks of the channel to the screens and pump house during construction.	N
Cooling Water Intake System Aquatic Impacts/ Section 5.3.1.2	Increased impingement of fish and increased entrainment of larva	Predicted effects are minimal for increased impingement and small for increased entrainment due to stable, healthy, and diverse fish population in Lake Anna.	N
Cooling Water Discharge System/ Thermal Description and Physical Impacts/ Section 5.3.2.1	Installation of more than one new unit would result in high temperature increases in the North Anna Reservoir and the WHTF if each unit were to be designed with a once-through cooling system.	If more than one unit is installed, the additional units would use other types of cooling systems, namely some form of cooling tower. Selection of cooling tower system would be part of the detailed design for the new units and identified in the COL application.	N
Section 5.3.2.1	Potential for scouring of lake bed or erosion of shoreline at Dike 3 if multiple units are constructed with once-through cooling systems	Only the first new unit would use a once-through cooling system. The second unit would be designed with cooling towers as the cooling system.	N
Section 5.3.2.1	Potential increased turbidity due to increased flows from discharges of new units	Design new cooling systems such that the flow velocities are the same as those from the existing units.	N

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Aquatic Ecosystem Impacts/ Section 5.3.2.2	Scouring and sediment transport due to increased water discharge flows possible	If needed, adjust baffles at Dike 3 to accommodate increased volume and maintain acceptable discharge velocity which would limit scouring and sediment transport.	N
Section 5.3.2.2	Impacts due to increase in chemicals and other pollutants contained in discharge from new units	Maintain compliance with VPDES water quality standards and permitted discharge limits for cooling water discharges to Lake Anna.	N
Section 5.3.2.2	Impacts due to increase in thermal discharges or sudden changes in discharge temperatures	Maintain compliance with VPDES water quality standards and permitted discharge limits for cooling water discharges to Lake Anna. Small impact on overall fish population in Lake Anna. Most temperature-sensitive species, would be expected to move away from discharge area. Typical operations of a nuclear power plant would limit sudden changes in discharge temperatures as such units do not come on and off-line regularly. Increased thermal discharge may have a small beneficial impact by reducing the presence and/or density of the nuisance Asiatic clam.	N
Heat Discharge System/ Dissipation to Atmosphere/ Section 5.3.3.1	Visual impact of plume; and, ground level fogging and icing that could affect visibility at nearby airport and highway and increase riming (i.e., ice buildup) on transmission lines	Design and install a mechanical draft cooling tower with plume abatement technology which would reduce the visual impact and associated impacts from fogging and icing. Installation of a natural draft cooling tower could increase visibility impacts but reduce occurrence of ground level fogging and icing.	N
Section 5.3.3.1	Possible interaction of cooling tower plume with air emissions from other sources at the site	Other permitted air emission sources at the existing units, such as standby diesel generators and auxiliary power systems, are used for testing and emergencies which would limit the possibility of plume interactions.	N
Terrestrial Ecology/ Section 5.3.3.2	Noise from cooling tower could cause some wildlife to avoid the site	Wildlife expected to adapt to normal operating noise variations as for existing units.	N
Section 5.3.3.2	Salt deposition from cooling tower could result in dieback of vegetation	None as the impacts are rare and, there are no important species near the cooling tower.	N

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Section 5.3.3.2	Plume shadowing and increased local precipitation due to cooling tower plume	Any impacts from shadowing and increased precipitation would be localized to the NAPS site which does not contain important species.	N
Section 5.3.3.2	Avian collisions with cooling towers	Negligible impacts from collisions with mechanical draft cooling towers that would be lower in height than existing or proposed onsite structures. Studies show that such collisions with properly lighted natural draft cooling towers are negligible.	N
Impacts to Members of the Public/ Section 5.3.4	Increased thermal discharges could affect composition micro-organisms in Lake Anna, thereby also affecting recreational use of the lake	Analyses show that there would be no significant alteration of the temperature regime in the lake or the surrounding environment and that the temperature increases would be too low to support thermophilic micro-organisms.	N
Section 5.3.4	Discharge of pathogenic materials in wastewater and/or sanitary wastes	The recently upgraded onsite sewage treatment plant that includes disinfection to reduce coliform bacteria and other micro-organisms to levels that meet Virginia water quality standards, would prevent adverse impacts from sanitary wastes.	N
Section 5.3.4	Offsite noise impacts from cooling system operation	Modeled peak noise levels from operation of all of the cooling systems are below the applicable NRC-defined significance levels at the EAB	N
Radiological Impacts from Normal Operations/ Exposure Pathways/ Section 5.4.1	Direct dose to population and environment	Shielding of new units would be at least as effective of that of existing units so direct dose contribution from the new units is expected to be negligible compared to those from liquid and gaseous effluent pathways or from natural and artificial sources outside the NAPS site	N
Impacts to Members of the Public/ Section 5.4.3	Doses due to liquid effluent releases to the discharge canal and the WHTF and from gaseous pathway releases	Calculated doses to public via liquid and gaseous pathways are within the design objectives of 10 CFR 50 Appendix I and within regulatory limits of 40 CFR 190.	N

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Impacts to Biota Other Than Members of the Public/ Section 5.4.4	Doses to biota from liquid radwaste effluent releases to the discharge canal, WHTF, and the North Anna Reservoir	There are no acceptance criteria specifically for biota. However, there is no scientific evidence that chronic dose rates below 100 mrad/day are harmful to plants and animals and all biota doses are calculated to be less than 1 mrad/day. No mitigation measures or controls are proposed.	N
Environmental Impacts of Waste/ Nonradioactive Waste System Impacts/ Section 5.5.1	Potential impacts to Lake Anna and North Anna River from increased volume of effluent discharged and increased amounts of chemicals and other pollutants in the discharged effluent as well as increased storm water discharge	Comply with applicable VPDES water quality standards for discharges from Dike 3. Prepare and implement a Storm Water Pollution Prevention Plan for the operation of the existing and new units to avoid and/or minimize releases of contaminated storm water.	N
Section 5.5.1	Potential increase impacts due to increase in gaseous and particulate emissions, including particulate from cooling towers	Design and operate cooling towers with efficient drift eliminator systems to reduce drift. Operate new minor air emission sources in accordance with applicable regulations and permits.	N
Section 5.5.1	Increase in total volume of solid and sanitary wastes	Continue use of approved transporters and offsite landfills for disposal of solid wastes. Continue existing units program for reuse and recycling of non-radwastes. Modify existing sanitary waste treatment systems, as required, to accommodate increased volume.	N

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Mixed Wastes Impacts/ Section 5.5.2	Potential hazardous chemical and occupational exposure to radiological materials during handling and storage of 15-30 cubic feet of mixed liquid waste and 5-10 cubic feet of mixed solid waste generated by operation activities for new unit(s)	Limit amounts of mixed waste to be handled and disposed of through source reduction, recycling, and treatment, to the extent practical and feasible. Develop a Waste Minimization Program that includes new and existing units. Construct temporary onsite storage facilities, as needed, for mixed wastes and implement a waste management program in compliance with applicable EPA and NRC requirements. Identify a primary and an alternative offsite facilities for transportation, treatment and disposal of mixed wastes.	N
Section 5.5.2	Potential exposure of onsite workers and emergency response personnel during accidental releases and cleanup activities	Implement, or comply with existing, spill prevention and response plans and procedures that address hazards associated with managing/handling mixed wastes. Include measures for response personnel training and protective equipment.	N
Transmission System Impacts/ Terrestrial Ecosystems/ Section 5.6.1	Air emissions and noise from use of helicopter to maintain transmission corridors	No new measures are required as current maintenance activities are sufficient.	N
Aquatic Ecosystems/ Section 5.6.2	Potential impacts to mussel species from maintenance of transmission corridors	No new measures are required as current maintenance practices would continue.	N
Impacts to Members of the Public/ Section 5.6.3	Dependent on design of transmission corridors and a determination whether any changes are required.	Based on an initial evaluation, the current ESP site transmission lines and corridors have sufficient capacity for the total output of the existing and new units.	N/A

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Uranium Fuel Cycle Impacts (relative to reference LWR)/ Section 5.7	Energy required, emissions generated, and water usage during mining, yellowcake production and uranium conversion; and production of UO_2 during fuel fabrication.	Select mining techniques, where feasible and practical, that minimize impacts such as in situ leaching rather than open pit mining. Consider use of new technology that requires less UF_6. Consider use of new technologies with less fuel loading to reduce energy, emissions, and water usage	Y
Section 5.7	Emissions from fossil fuel plants supplying the gaseous diffusion plant	Consider use of new technology that requires less UF_6. Consider use of centrifuge process rather than gaseous diffusion process which significantly reduces energy requirements and environmental impacts. Fossil fuel plants must comply with air quality regulations.	N
Section 5.7	Radioactive waste to be managed from operations, and decontamination and decommissioning	Consider use of new gas-cooled reactor technologies that can result in generation of far less low-level wastes.	Y
Physical Impacts of Station Operations/ Section 5.8.1	Potential noise impact from operating plant activities	Noise from cooling towers is expected to be below NRC-defined significance levels at the NAPS site EAB and nearest residence. Perform noise study prior to selection of cooling system to confirm compliance with NRC-defined levels, and apply controls if necessary. Control noise levels in accordance with local noise regulations.	N
Section 5.8.1	Potential air quality impacts from emissions associated with diesel generators and auxiliary power systems	Comply with applicable VDEQ permit limits and regulations to install and operate such sources.	N
Section 5.8.1	Potential impacts for salt deposition, fogging, and icing due to cooling towers	Analyses of salt deposition indicates rates should be below threshold value for adverse impacts to vegetation. Mitigate fogging and icing through use of efficient drift eliminators for cooling towers.	N

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Section 5.8.1	Potential visual impacts to surrounding areas due to new structures and cooling tower plumes	New structures would not present a visual impact because of existing structures, distance and trees. Install plume abatement system to reduce plume visibility from mechanical draft cooling towers. Exception could be natural draft cooling tower which could represent a moderate visual impact. Perform visual impact study during final plant design.	N
Section 5.8.1	Potential traffic impacts on local roads	Existing roads are expected to have sufficient capacity to handle increased traffic due to operation of new units.	N
Socioeconomic/ Section 5.8.2	Noise impacts at residences from operation of the new units and ancillary facilities, e.g., cooling tower	Due to distance to nearest residences, no noticeable increase in noise levels. A noise study would be performed for the area once the reactor and ancillary facilities are selected. If indicated, noise mitigation measures would be designed into facility.	N
Section 5.8.2	Visual impact of new units	Selection of cooling tower, reactor. Perform visual impact assessment prior to construction to assist in facility layout.	N
Section 5.8.2	Visual impact of mechanical draft cooling tower plume	Abatement of mechanical draft cooling tower would eliminate plume.	N
Section 5.8.2	Visual impact of natural draft cooling tower plume and from size of natural draft cooling tower	No abatement of plume from natural draft cooling tower. Visual impact study could assist in reducing visual impact due to size of the natural draft cooling tower.	Y
Section 5.8.2	Impact of increased operations traffic on local road network	Operations traffic management study plus any permanent upgrades for the construction phase should eliminate any adverse impact on the local road network.	N
Environmental Justice/ Section 5.8.3	None expected	None required.	N

Table 10.1-2 Operations-Related Unavoidable Adverse Environmental Impacts

Category/ESP ER Section	Adverse Impact	Mitigation Measure	Unavoidable Adverse Environmental Impacts
Decommissioning/ Section 5.9	Potential radiation exposure related to decommissioning, including transportation of materials to authorized disposal sites	No mitigation measures are proposed at this time as this would be part of the required decommissioning plan.	N/A

10.2 Irreversible and Irretrievable Commitments of Resources

This section describes the predicted irreversible and irretrievable environmental resource commitments used in the construction and operation of the new units. These environmental resource commitments are developed from information in Chapter 4 and Chapter 5, and are summarized in Section 10.1. Those areas that were assessed and determined to have unavoidable adverse environmental impacts, even after application of all practical means to mitigate or avoid the impacts, have been used to identify resources to be evaluated in this section.

10.2.1 **Irreversible Environmental Commitments**

The following categories have been assessed for their irreversible environmental commitments and are described in this section:

- Land Use
- Hydrology and Water Use
- Ecology (Terrestrial and Aquatic)
- Socioeconomics
- Radiological Releases
- Atmospheric Releases and Meteorological Changes

10.2.1.1 **Land Use**

The ESP site is within the NAPS site. The NAPS site is zoned industrial by Louisa County. The original permitting of the NAPS site was for the installation of four units. Lake Anna was created by damming up the North Anna River for the purpose of providing cooling water to the power station. Virginia Power and ODEC own all of the land under the lake as well as the NAPS site. Structures at the NAPS site that would be used by the new units include the partial construction of an intake structure originally intended to service the abandoned Units 3 and 4.

Based on an initial evaluation, the existing transmission lines have sufficient capacity to carry the total output of the existing units and the new units.

In summary, no new property is needed for the new units and an existing partially completed intake structure for the cooling water is available to support the new units.

Currently undeveloped portions of the NAPS site would be cleared to construct the new units. A large portion of the cleared area would contain the new units and ancillary equipment. That area would not be restored after completion of the new units until the new units are decommissioned. Much of the wildlife that currently utilizes the area where the new units would be constructed would move out into the areas surrounding the ESP site. There are no known special or protected species on the site. When the units are decommissioned, both the vegetation and the wildlife are eventually

expected to return naturally to current conditions. Therefore, there are no irreversible environmental commitments associated with the land that is to house the new units and ancillary equipment.

10.2.1.2 Hydrology and Water Use

Cooling water for the new units would be taken from the North Anna Reservoir, consistent with the original permitting of the NAPS site. The amount of water that is not returned as heated discharge to the WHTF would be that evaporated, which is a small fraction of the amount of water in the lake. The evaporated water would be replaced by in-flowing water upstream of the dam. However, during extended drought conditions the second new unit, Unit 4, could require an outside water source according to the analyses presented in Section 3.4.1. Therefore, it is intended that Unit 3 would use a once-through cooling system and Unit 4 would use closed-loop system with cooling towers. Once the site is decommissioned, the balance of water in the lake would be governed by the in-flowing water, evaporation from the surface of the lake, and the amount of water flowing over the dam.

Groundwater from existing wells would be sufficient for the potable water demands during operation of the new units.

10.2.1.3 Ecology (Terrestrial and Aquatic)

As discussed in Section 10.2.1.1, there would be some anticipated loss of vegetation and relocation of terrestrial wildlife, respectively, due to construction of the new units. However, some of this would return once construction is completed and unused areas are restored. The decommissioning of the new units would eventually result in complete restoration, if left undisturbed. There would be no irreversible loss of terrestrial ecology.

Similarly, aquatic ecology in streams and wetlands on site would be affected by the construction of the new units, but there are no protected or special aquatic ecosystems on the ESP site. The discharge from the new units would not adversely affect the aquatic ecology in Lake Anna. There are no unique, special, or protected aquatic ecosystems on the ESP site or in Lake Anna. Once the new units are decommissioned, the aquatic ecology is eventually expected to return to its current levels. Therefore, there is no irreversible loss of aquatic ecology associated with installation of the new units at the ESP site.

10.2.1.4 Socioeconomics

The effect of the construction and operation of the new units would be to increase long-term employment and to provide positive input to the local community in the form of taxes and personal commitments to the community by the new employees and their families. The fact that the workforce during construction would be supplied primarily from the region means that there would not be major disruptions in the transition from construction to operation of the new units. Because the various DRI subsidiaries intend to maintain the NAPS site for power generation purposes for the

foreseeable future, there would be no irreversible commitment of resources from a socioeconomic standpoint, once the decommissioning of the new units occurs.

10.2.1.5 **Radiological Releases**

The new units would operate under the limitations imposed by the NRC with respect to radioactive releases. Decommissioning would also be performed according to the requirements of the NRC, which would ultimately be expected to result in the unrestricted use of the site. The loss of radioactive material in the form of nuclear fuel due to operation of the new units, is addressed in Section 10.2.2 under Irretrievable Resources.

10.2.1.6 **Atmospheric Releases and Meteorological Changes**

There would be no major releases of pollutants to the atmosphere from operation of the new units, because only the testing of emergency generators and occasional use of large pieces of equipment that run on diesel fuel would generate such pollutants. The operation of a cooling tower has the potential for making micro-level changes to the meteorology, but only in the immediate vicinity of the tower. Upon decommissioning of the new units, these changes would cease to be a factor. Therefore, the operation of ancillary equipment associated with the new units would not result in irreversible atmospheric or long-term meteorological changes to the area.

10.2.2 **Irretrievable Commitments of Resources**

Irretrievable commitments of resources during construction of the new units generally would be similar to that of any major, multi-year, construction project. Unlike the earlier generation of nuclear plants, asbestos and other materials considered hazardous would not be used, if possible, or would be used sparingly and in accordance with safety regulations and practices. Available information on materials used to construct earlier nuclear power plants has been reviewed and adjusted to a nominal 1000 MWe unit on the assumption that the usage is linear with energy output. That is, the usage of materials for each of the units is simply multiplied by the ratio of the actual energy output for each unit reviewed, divided by 1000. The conclusion is that each new 1000 MWe unit could require up to 200,000 cubic yards of concrete (not including cooling tower requirements) and up to 15,000 tons of structural steel.

The U.S. Defense National Stockpile centers, shut down since 1991, have been slowly selling off reserves since that time. A review by the federal government of the sources of available materials in the world, and their locations, has resulted in the determination of no material supply threat to the U. S., nor any real benefit to continuing to stockpile such materials. That is, the use of certain metals and materials on the list of strategic materials has been determined to no longer represent a significant impact on the country’s defense (Reference 1). Therefore, use of such materials in the quantities associated with those expected for a 1000 MWe nuclear power plant, while irretrievable, would not be a large or moderate impact, with respect to the availability of such resources.

The main resource that would be irretrievably lost during operation of a new 1000 MWe nuclear unit would be uranium. This is best represented by the annual consumption of yellowcake, which is not expected to exceed the normalized value for the reference plant of 293 metric tons (MT) per year for a 1000 MWe generating unit using current reactor technology as identified in Section 5.7.2.3.4, Uranium Milling. Depending on the actual reactor technology selected, this yellowcake consumption could be much lower. Studies performed by U.S. Government agencies, such as the National Defense Stockpile Impact Committee of the Bureau of Industry and Security (Reference 2), and entities such as the World Nuclear Association (Reference 3) (Reference 4), have concluded that there are easily accessible, rich deposits of uranium throughout the world and that existing stocks of highly enriched uranium (HEU) in the U.S. and Russia--formerly for military usage--could be converted to fuel for nuclear power plants. Also, the reduction in use of uranium by the newer reactors when compared to the existing reactors would serve to extend the current 50-year supply of uranium available to the nuclear power industry. Therefore, the uranium that would be used to generate power by the new units at the ESP site, while irretrievable, would not be a large or moderate impact with respect to the long-term availability of uranium worldwide.

Section 10.2 References

1. *National Defense Stockpile Market Impact Committee*, Bureau of Industry and Security, website www.bis.doc.gov/DefenseIndustrialBasePrograms/OSIES/StockpikeCommittee.html accessed 8/15/03.

2. *Effects of Imports of Uranium on the National Security* Summary, Bureau of Industry and Security, Document Number 003-009-00698-8, September 1989, website. www.bis.doc.gov/defenseindustrialbaseprograms/OSIES/2-3-2-Reports/Uranium89.html.

3. *Introduction to Nuclear Energy/Factsheets, Uranium Resources*, World Nuclear Association, website www.world-nuclear.org/factsheets/uranium.htm, accessed 8/15/03.

4. *Supply of Uranium, Information and Issue Briefs,* World Nuclear Association August 2002, website www.world-nuclear.org/info/inf75.htm, accessed 8/15/03.

10.3 Relationship Between Short-Term Uses and Long-Term Productivity of the Human Environment

This ER has focused on the analyses and resulting conclusions associated with the environmental and socioeconomic impacts arising from activities during the construction, operation, and decommissioning of new units at the ESP site. These activities are considered to be short-term uses for purposes of this section. For this section, the long-term is considered to start with the conclusion of decommissioning of the new units at the ESP site. This section includes an evaluation of the extent to which the short-term uses preclude any options for future use of the ESP site.

10.3.1 Construction of New Units at ESP Site and Long-Term Productivity

Section 10.1 summarizes the potential unavoidable adverse environmental impacts of construction of the new units and the measures proposed to reduce these impacts. There are adverse environmental impacts that would remain after all practical measures to avoid or mitigate the impacts have been taken. However, none of these impacts represent a long-term effect that would preclude any options for future use of the ESP site.

The new units would be constructed on the property adjacent to the existing units. The NAPS site was originally selected and reviewed to accommodate four units. As a consequence, the size of the site, the characterization of the Lake, and the transmission capacity are generally already acceptable for the new units.

While some changes may be made to the WHTF or the existing intake area to accommodate the new units, any disturbances to these areas would be temporary and would not change the long-term productivity of the ESP site.

The acreage disturbed during construction of the new units would be much larger than that required for the actual structures and other ancillary facilities because of the need for construction laydown areas and a parking area for the construction workforce. The clearance of this acreage, plus the noise of the construction of the new units, would displace some wildlife and remove vegetation. Once the new units are completed, the disturbed areas would be restored. Wildlife is expected to return to the restored area.

Noise emitted during some construction activities would increase the ambient noise levels in the vicinity of the site. However, upon completion of these activities, the ambient levels would return to the levels associated with the operation of the existing units. Because of the nature of the vicinity about the ESP site, no long-term effects would occur. Generally, the requirements of the local ordinance would be complied with during construction of the new units so that the local residents or visitors to Lake Anna would not be unduly impacted. Also, the workforce would be protected by adherence to the OSHA requirements for noise levels that are acceptable during specified time periods or through the use of protective equipment when excessive noise levels for a given time

period are unavoidable. There would be no effects on the long-term productivity of the ESP site as a result of these impacts.

Construction traffic has the potential to cause congestion in the immediate area of the ESP site. A construction traffic management plan would be developed and implemented in cooperation with VDOT to reduce the possibility of major congestion problems. It is likely that permanent upgrades would be made at both the intersection of the construction access road with Route 700 and at the intersection of Route 700 and Route 652. These upgrades to relieve congestion problems that could arise during shift changes would remain in place after construction ends and would be a benefit to the local area throughout the life of the new units.

The construction of the new units would be beneficial to the local area through the generation of new construction-related jobs, local spending by the construction workforce, and payment of taxes to the area.

No long-term adverse environmental impacts would result from the construction of new units at the ESP site.

10.3.2 **Operation of the New Units and Long-Term Productivity**

Section 10.1 summarizes the potential unavoidable adverse environmental impacts of operation of the new units and the measures proposed to reduce or eliminate these impacts. There are some adverse environmental impacts that could remain after all practical measures to avoid or mitigate the impacts have been taken. However, none of these impacts represent long-term effects that would preclude any options for future use of the ESP site.

The NAPS site has been developed by Virginia Power as a location for major energy generation facilities. The existing units have been operating for over twenty years. The various DRI subsidiaries intend to continue the use of the NAPS site for major energy generation facilities beyond the lifetime of the existing or new units. Therefore, the operation of the new units represents a continuation of the current and planned use of the land. For the foreseeable future, any options for future use of the ESP site, including operation of new energy generation facilities, are not precluded.

The type of reactor to be installed at the ESP site has not yet been selected, nor has the ancillary equipment related to the reactor, including the type of cooling tower, if necessary. Mechanical draft and natural draft cooling towers are among the options that are being considered for use at the ESP site. Initial analyses were performed for both types of cooling towers to determine if there would be issues from salt deposition, icing, or fogging impacts. These analyses have concluded that any such offsite or onsite impacts would be small or minimal. Any such impacts generated by the use of either type of cooling tower at the site would be so small that there would be no future long-term issues with regard to future uses of the ESP site.

The cooling water discharge from the new units would be to the existing WHTF. Although there would be an increase in water temperature within the WHTF, there would be little to no increase in temperature within the North Anna Reservoir part of Lake Anna that is open to the public for recreational purposes. Additionally, the discharges to the existing WHTF are projected to remain within the limits of the wastewater discharge permit issued for the NAPS site (or, if needed, to the wastewater discharge permit as amended). Therefore, any long-term effects on the future usage of the lake, including the cessation of the heated discharge, would be small.

The daily volume of traffic on the section of Route 700 between Route 652 and the entrance to the NAPS site is expected to nearly double, once the new units become operational. However, any permanent upgrades that would be made for construction to eliminate or greatly reduce congestion, would remain in effect after construction is completed and the new units become operational. Normal maintenance of this half-mile section of road should allow the benefits of these upgrades to persist into the future.

The operation of the new units would slightly increase air emissions because of diesel engines that would be operated intermittently on site. However, these engines would be operated in accordance with applicable federal, state, and local regulations, and they would not create any noticeable impacts in the area. Additionally, no long-term impacts would result from salt deposition arising from salt drift from the cooling towers as the analysis has determined the amount deposited on a monthly basis would be minimal when compared to those levels at which ecological impacts might occur. Normal maintenance activities for the area within 300 feet of the cooling towers plus rain or snowfall would prevent the buildup of salt in the soil within this area. No future issues for the long-term uses of the site would result from the impacts of increased air emissions.

Impacts due to radiological emissions would be negligible to small, since the operation of the new units would be in accordance with the operating license and NRC regulations. Furthermore, radiological monitoring would be implemented to measure radiation levels from the operation of the new units and would initiate a timely response to reduce such emissions if elevated levels are detected. No future issues associated with the radiological emissions from operation of the new units would affect the long-term uses of the ESP site.

10.3.3 Summary of Relationship Between Short-Term Uses and Long-Term Productivity

The impacts from the local use of the human environment by the installation and operation of the proposed new units at the ESP site is presented in Section 10.1 and summarized in the preceding paragraphs in terms of the unavoidable adverse environmental impacts of construction and operation. Section 10.2 presents information on the irreversible and irretrievable commitments of resources. Except for consumption of non-renewable resources because of construction and operation of the new units, the uses may be classified as short-term. The principal short-term benefit is the production of electrical energy, and the economic productivity of the ESP site is large compared with the productivity from agriculture or other probable uses for the site. Because the site

would eventually be restored by decommissioning, there would be no significant impact on long-term productivity.

Section 10.3 References

None

10.4 Benefit – Cost Balance

In accordance with the 10 CFR 52.17(a)(2), an assessment of the benefits (need for power) of new units is not included in this report.

Section 10.4 References

None

PART 4 - PROGRAMS AND PLANS
Contents

PART 4: PROGRAMS AND PLANS

Chapter 1 Site Redress

This chapter describes early site preparation (ESP) site preparation activities that might occur after U.S. Nuclear Regulatory Commission (NRC) issuance of an early site permit. The chapter also describes the site redress plan that would be implemented if those site preparation activities were performed, but the ESP then expired before it is referenced in a combined license (COL) application.

1.1 Description of Site Preparation Activities

The Site Redress Plan in Section 1.2 is submitted by Dominion Nuclear North Anna, LLC (Dominion) pursuant to 10 CFR 52.17(c) to allow Dominion to perform, after being granted the ESP, the site preparation activities for new nuclear units at the ESP site allowed by 10 CFR 50.10(e)(1). The site preparation activities that Dominion may perform include:

- Preparation of the site for construction of the facility (including such activities as clearing, grading, construction of temporary access roads, and preparation of borrow areas);
- Installation of temporary construction support facilities (including items such as warehouse and shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and construction support buildings);
- Excavation for facility structures;
- Construction of service facilities (including items such as roadways, paving, railroad spurs, fencing, exterior utility and lighting systems, switchyard interconnects, and sanitary sewage treatment facilities);
- Construction of structures, systems and components which do not prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public, including but not limited to:
    - Cooling towers,
    - Intake and discharge structures,
    - Circulating water lines,
    - Fire protection equipment,
    - Switchyard and on-site interconnections,
    - Microwave towers,
    - Underground utilities.

Before commencing any of these activities, after the ESP is granted, Dominion would:

1. Create a record of the existing site conditions within the proposed ESP site by way of photographs, surveys, listings of existing facilities and structures, or other documentation. This record would serve as the baseline for redressing the site in the event ESP site preparation activities are terminated as a result of project cancellation or expiration of the ESP.

2. Obtain any state and local permits and authorizations necessary to perform the site preparation activities.

3. Obtain the appropriate regulatory approvals of an agreement between Virginia Power and Dominion. This agreement would authorize Dominion to conduct the pre-construction activities subject to Dominion's obligation to perform such site redress as may be required to comply with the Site Redress Plan approved by the NRC.

4. Provide to the NRC a guaranty by Dominion Resources, Inc. (DRI) of $10 million as financial assurance for Dominion's obligation to comply with the Site Redress Plan. Dominion is an indirect, wholly-owned subsidiary of DRI. DRI is the largest fully-integrated natural gas and electric provider in the United States with over $37 billion in assets, over $10 billion in annual revenue, and over $2 billion in annual operating cash flow.

1.2 Site Redress Plan

This section constitutes Dominion's plan for redress of the North Anna site in the event that activities allowed by 10 CFR 50.10(e)(1) are performed but the ESP then expires before it is referenced in an application for a combined license under 10 CFR 52, Subpart C. This Site Redress Plan provides reasonable assurance that redress carried out under the plan would achieve an environmentally stable and aesthetically acceptable site condition suitable for whatever non-nuclear use may conform with local zoning laws.

The following sections describe the objective of the Site Redress Plan and activities that would be considered to redress the site; a general description of proposed redress activities; and the procedure for NRC notification and final acceptance of the redressed site.

1.2.1 Site Redress Plan Objective and Considerations

The objective of the Site Redress Plan is to ensure that the site, should it not be fully developed for the intended purpose of new nuclear power generation, would be returned to an unattended, environmentally stable and aesthetically acceptable condition suitable for such non-nuclear use as is consistent with local zoning laws.

Site redress activities would be commensurate with the level of site modification created by the proposed site preparation activities. Redress activities would reflect applicable land use and/or zoning requirements of local, state and federal agencies. Redress activities would consider the following:

- Recontouring, revegetation, and replanting of cleared areas
- Restoration of sensitive water resource features disturbed for intake and/or discharge structures
- Habitat replacement
- Use of constructed facilities for alternative purposes, or their removal
- Remediation of contamination resulting from site preparation or site redress activities

In planning for site redress, two general categories of conceptual options would be considered:

1. Topographic approaches that accomplish the objective stated above as well as preserve the potential of the site for future industrial use
2. Completion or addition of site development features that enhance the value of the site for potential future industrial use.

Redress activities would begin (in concert with local and/or state land use agencies and industrial development authorities) either when the ESP has expired or reactor construction plans have been abandoned. The redress activities would include those actions necessary to terminate or transfer local and state permits and would identify site features or improvements that would remain and those that must be removed. A detailed redress scope and schedule consistent with this plan would

be implemented at that time. The schedule would include adequate preparation time to secure additional input from regulators and local municipalities. The redress activities would comply with applicable environmental requirements. If, prior to commencement of the redress activities, industrial or other acceptable uses for the site are identified that are consistent with its development, the redress would be performed in a manner that accommodates and is consistent with the alternative use. Dominion would carry out the Site Redress Plan to the greatest extent possible consistent with the alternative use.

Prior to the commencement of site redress activities, environmental control of local water quality, air quality, stormwater runoff, solid waste, and the protection of critical ecological elements, if any, would be maintained in compliance with approved permits and regulatory requirements.

1.2.2 **Description of Site Redress**

This section describes the site redress actions that would be taken should pre-construction work not proceed to full construction. The overall objective of site redress is to provide an environmentally stable, self-draining, self-maintaining, esthetically acceptable site that can be left unattended. The methods by which this would be accomplished are discussed in the following subsections.

1.2.2.1 **Future Use of Constructed Facilities**

Any facilities or structures constructed as part of the site preparation activity that could have applicability to a future use of the site may be left in place to the extent that they are consistent with local zoning and provided that they pose no hazard to safety or the environment. Such facilities or structures would be evaluated at the time of site redress to assess their usefulness for potential or proposed site utilization. Should the facilities or structures be deemed to have a potential for future use, they would be preserved in a manner that would pose no threat to the environment or to activities on the site. However, should the facilities or structures be considered to be of no value to final disposition of the property, they would be removed as part of the overall site redress activities.

1.2.2.2 **Physical Restoration**

Changes to the site would be evaluated to assess their potential for future impact on the site and future site use. Any changes that are deemed to have no future value to the site and could not be dispositioned to a stable configuration would be redressed. No additional areas outside those already cleared would be disturbed. Final site redress would include regrading the area to conform with the surrounding land surface and to mitigate stormwater runoff and erosion potential. Revegetation and replanting would be performed to achieve the objective of environmental and

aesthetic site stabilization. Some or all of the following activities would be performed to redress the site to a suitable condition:

- Structures and facilities, unless deemed useful to the existing plant or for future industrial development, would be demolished and the resulting debris would be properly disposed of at the site or an approved disposal facility.
- Existing excavations would be backfilled and the areas regraded to conform with the surrounding land surface and to mitigate stormwater runoff and erosion potential. Backfill placement would be performed in accordance with specified procedures. Borrow materials to be used in the backfilling and contouring operations would be obtained from locations on the site that are within the existing cleared areas. The backfilled areas would be revegetated and/or replanted, or otherwise mitigated for erosion control.
- Perimeter fencing would be removed, unless it is considered necessary for liability and security purposes.
- Fire protection systems would be evaluated for removal or abandonment in place.
- Underground utilities and overhead lighting would be evaluated for removal or abandonment in place.
- All unneeded construction equipment would be removed from the site and dispositioned accordingly.
- If intake and discharge structures are removed, the shoreline would be restored to an acceptable long-term condition.
- If not needed, onsite transmission interconnects (towers, lines, etc.) would be deactivated at the switchyard and evaluated for removal or abandonment in place.
- Asphalt roadways would be evaluated for removal or abandonment in place. If removed, the materials would be disposed of at an approved disposal facility.
- Roadbeds would be evaluated for removal or abandonment in place. If removed, the roadbed areas would be recontoured to conform with the surrounding land surface and revegetated.
- Borrow areas would be regraded to conform with the surrounding land surface and to mitigate stormwater runoff and erosion potential, and the areas would be revegetated.
- Railroad spurs would be evaluated for removal or abandonment in place. If removed, the railbed areas would be recontoured to conform with the surrounding land surface, and the areas would be revegetated.

1.2.2.3 Restoration of Sensitive Water Resource Features

1.2.2.3.1 Lake Anna

Construction of the cooling water intake structure for the new units at the ESP site would not significantly affect the open water habitat of Lake Anna. The intake structure would be constructed in the vicinity of the existing units cooling water intake structure. The modification to open water habitat resulting from construction of the intake structure would not be considered significant in comparison to the amount of open water habitat found on Lake Anna. If the intake structure is removed as part of site redress activities, the shoreline would be redressed by grading and revegetation to control erosion. Any significant sediment deposition in the vicinity of the intake structure would be removed.

During site redress activities, erosion and sediment control best management practices would be used to contain eroded soil on the site and remove sediment from stormwater runoff prior to its leaving the site. Measures would be taken to avoid concentrated flows with a high potential to transport sediment. Visual inspections of erosion control measures would be performed to monitor the effectiveness of the control measures and to aid in determining if other mitigation measures are necessary. Where necessary, special erosion control measures would be implemented to further minimize impacts to the lake, lake users, and existing units operations. Site redress activities would include the use of appropriate stabilization methods to mitigate the long-term delivery of sediment into the lake.

1.2.2.3.2 Freshwater Streams

Portions of two small ephemeral streams that discharge to Lake Anna, designated Streams A and B on Figure 1.2-1, may be filled to level the area should the construction of cooling towers in that area become a part of the final plant design. It is estimated that about 1500 feet of stream channel would require filling. The site drainage system would be designed to incorporate the flow currently conveyed by these streams to the lake. By providing alternate drainage facilities to convey the stream flows, no short-term or long-term adverse hydrologic impacts on site drainage would result. Therefore, the need to redress the streams to their original condition, should construction be terminated, would be evaluated at that time to determine the best way to ensure long-term stability of the site. If considered necessary, the stream channels would be re-excavated and stabilized by vegetation and/or riprap to return the area to an acceptable long-term condition.

New onsite pipelines that cross freshwater streams would be constructed so that no permanent alteration to the streams occurs. Should site preparation activities be terminated, an evaluation would be made at that time regarding removal of these facilities as part of the site redress activities. Should removal be considered necessary, it would be accomplished in such a manner as to minimize disruption to the streams, and the streams would be redressed to an acceptable long-term condition.

1.2.2.3.3 Groundwater

Impacts to groundwater during site preparation activities may occur due to temporary dewatering of foundation areas or general lowering of the groundwater table in localized areas due to topographic alterations. Once the dewatering activities are terminated, the groundwater levels are expected to return to their previous levels. Groundwater levels that are altered due to topographic changes would be minor and of no significance to the overall flow of groundwater to Lake Anna. Should the topographic alterations be redressed to their original configuration, the groundwater would also likely return to its previous levels and flow direction in these areas. Therefore, no redress of groundwater levels is anticipated to be necessary.

1.2.2.4 Habitat Replacement

Site preparation activities would occur within the boundaries of the existing NAPS site, which has been designated an industrial zone. Areas outside the site would be generally unaffected with respect to habitat disturbance. The site contains no critical habitat areas that would require replacement as a result of ESP site preparation activities. Therefore, no habitat replacement would be necessary as part of the site redress activities. Some habitats would recover naturally when the site is redressed.

1.2.2.5 Contamination

Any areas on the ESP site that become contaminated as a result of site preparation or redress activities would be remediated in compliance with applicable local, state and federal regulations.

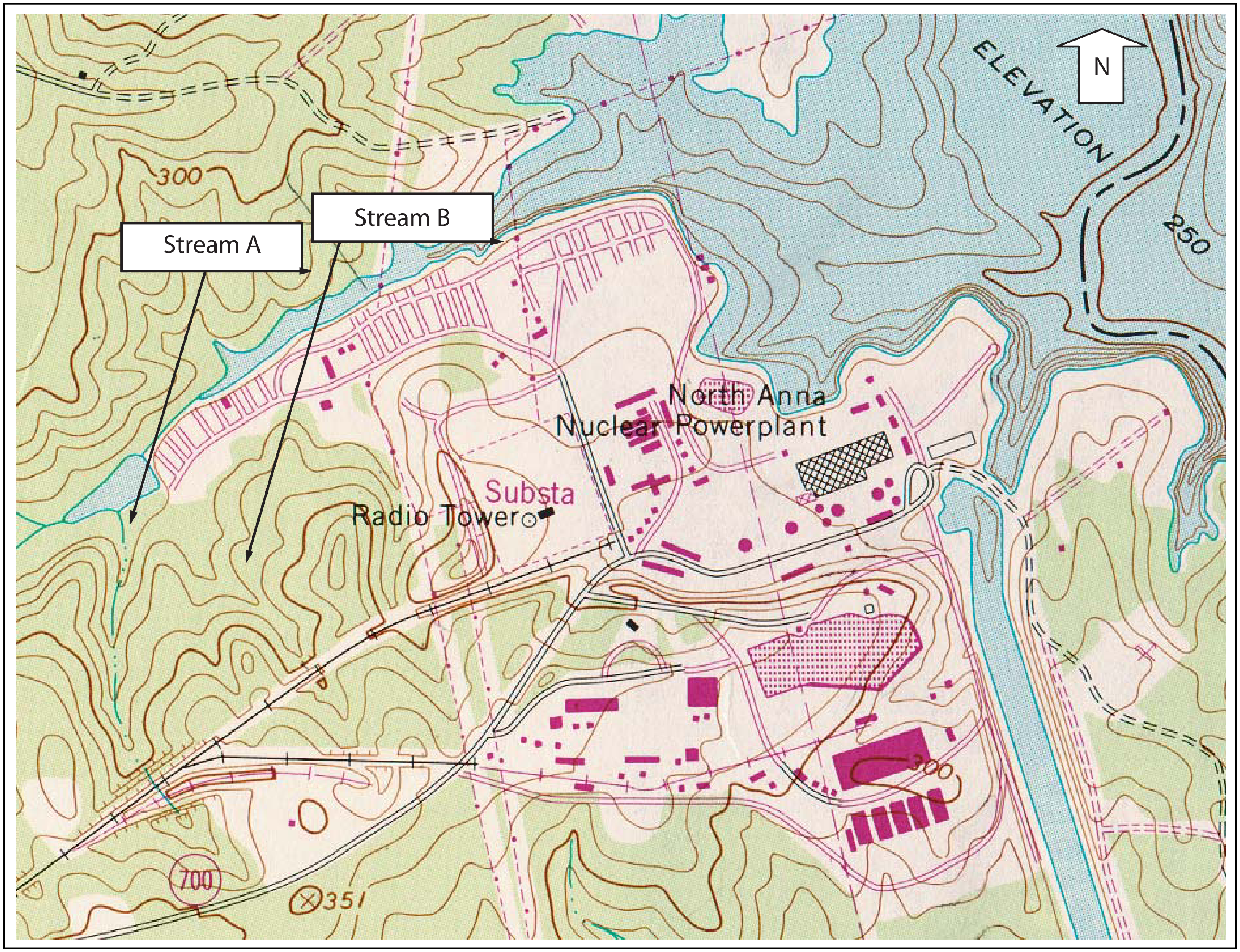

Figure 1.2-1 Ephemeral Steam Locations

Source: *Lake Anna West, VA*, USGS 7.5 Minute Topographic Map, 1983.

1.2.3 NRC Notification Upon Completion

Dominion Nuclear North Anna, LLC would notify the NRC upon completion of activities addressed by this Site Redress Plan. The site would be made available for inspection and any documentation that the NRC may require would be provided to confirm the satisfactory completion of the redress activities.