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 4500 MWt. The conventional style plants that are based on dual-reactor construction have individual power ratings significantly less than that stated above, and the 4500 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 4500 MWt, with a maximum electrical capacity of about 1520 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 9000 MWt or about 3040 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.

Unit 3 would use closed-cycle, combination dry and wet cooling towers that would be placed on the ESP site in the area shown for cooling towers on Figure 3.1-3. Unit 3 dry and wet cooling towers would be less than 180 feet high. Make-up water for Unit 3 wet cooling towers would be provided from Lake Anna. To extract make-up water from the Lake, a new intake structure would be constructed near the existing Unit 1 and 2 intake structure. Unit 4 would use dry cooling towers, with finned-fan air coolers that would be placed on the ESP site in the area shown for cooling towers on Figure 3.1-3. The dry towers would be approximately 150 feet high, and would consist of a series of modules, each containing air-circulating fans. The Unit 3 and 4 cooling towers would be located with the approximately 55-acre cooling tower area.

3.1.3 **Generic Plant Parameters Envelope**

The Generic 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 Generic PPE was developed from reviews of technical data from seven designs. These designs included five water-cooled reactors: the single-unit Westinghouse AP1000; 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 Generic 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 Generic PPE.

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

Table 3.1-9, Bounding Site-Specific Plant Parameters Envelope, which contains the bounding site characteristics and design parameters for assessing the environmental impacts of constructing and operating nuclear power plants at the proposed ESP site, is described in Section 3.1.6.

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. Cooling towers for the new units would be located on a nearly 55-acre portion of the site, which has been specifically designated for them.

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

A combination of dry and wet cooling towers would provide cooling for Unit 3. Dry cooling towers use water-to-air finned-fan coolers to transfer heat through the finned tubes to the atmosphere. The dry tower would comprise fans that pass air through finned tubes and discharge the air to the atmosphere. A series of tower modules would provide the needed cooling surface area for approximately one-third of Unit 3 heat duty at design ambient conditions. The dry towers themselves do not allow circulating water evaporation since the water is fully contained inside the tubes. The wet cooling towers would remove the heat by spraying the water into a forced air or induced stream. The wet towers would have the capacity to meet all of Unit 3 condenser cooling requirements. The existing capacity of Lake Anna would allow the Unit 3 (up to 4500 MWt) wet cooling tower system to draw make-up water from the lake. Cooling capacity of the lake and operating modes of dry and wet cooling towers are presented in Section 3.4. To extract make-up water from the lake, a new intake structure would be constructed near the existing intake structure for the operating units. All cooling system discharges for both the existing units and the new Unit 3 cooling tower blowdown would be sent to the WHTF via the existing discharge canal. The new intake structure would be designed to be complementary in appearance to the existing structures.

Dry cooling towers would provide cooling for Unit 4. Dry cooling towers utilize water-to-air finned fan coolers to transfer heat through the finned tubes to the atmosphere. The tower would be comprised of fans passing air through finned tubes and discharging the air to the atmosphere. A series of tower modules would provide the needed cooling surface area for Unit 4. The towers themselves do not allow circulating water evaporation since the water is fully contained inside the tubes.

Operation of the cooling fans in the towers would create an audible noise. By using standard design techniques, the noise contribution from the dry tower and wet tower systems would produce impacts below 60 dBA at the EAB. Tower height is presented 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.

3.1.6 **Bounding Site-Specific Plant Parameters Envelope**

Table 3.1-9, Bounding Site-Specific Plant Parameters Envelope, provides a summary listing of site characteristics that have been established by analyses presented throughout the ER. This list provides a summary of bounding site characteristics that are important for assessing the environmental impacts of constructing and operating nuclear power plants at the proposed ESP site. This listing is intended to support development of Table 2, “Site Characteristics and Plant Design Parameters for the Early Site Permit,” as defined by Reference 3. Table 3.1-9 also provides a listing of design parameters and assumptions about the design of a nuclear power plant that might in the future be constructed on the ESP site. It was necessary to assume certain design parameters in order to assess site characteristics. The site-specific PPE values for radioactive liquid and gaseous effluents are based on the approach presented in SSAR Section 1.3.1.

Section 3.1 References

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

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

3. NRC letter to Dominion, J. E. Lyons to D. A. Christian, "Early Site Permit Template," June 22, 2004.

Table 3.1-1 Generic 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.
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.
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.
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.
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 Generic 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.
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.
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).
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.
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.
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.
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.
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.
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.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
1.6.5	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.
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.
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.
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.
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.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
2.1.4	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	100°F [Same for 2nd unit/group]	2, 3, 4		Design assumption for the maximum acceptable circulating water temperature at the inlet to the condenser or cooling water system heat exchangers.
2.2.2	Condenser/Heat Exchanger Duty	1.03 E10 Btu/hr [Additional 1.03 E10 Btu/hr for 2nd unit/group]	11		Design value for the waste heat rejected to the circulating water and service water systems.
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.
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.
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.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
2.3.4	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.
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 make-up water streams.
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.
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	Make-up 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.
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.
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 Generic 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.
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).
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.
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.
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.
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.
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 Generic 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 make-up water streams.
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.
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	Make-up 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.
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.
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 Generic 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
2.5.1.1 Deleted				
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
2.5.4.1 Deleted				
2.5.5 Heat Rejection Rate	1.03 E10 Btu/hr [2.06 E10 Btu/hr]	11		The expected heat rejection rate

Table 3.1-1 Generic 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. 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.
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.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
3.3.4	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 make-up water streams.
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	Make-up 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.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
3.3.13	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).
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.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
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.
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.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
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	l	The expected (and maximum) effluent flow rate from miscellaneous drains to the receiving water body.
9. Unit Vent/Airborne Effluent Release Point				
9.1 Atmospheric Dispersion (CHI/Q) (Accident)			m	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	0.61E-3 sec/m^3 [Same for 2nd unit/group]	1		
9.1.2 0–8 hr @LPZ	1.30E-4 sec/m^3 [Same for 2nd unit/group]	5		
9.1.3 8–24 hr @LPZ	1.0E-4 sec/m^3 [Same for 2nd unit/group]	1, 5		
9.1.4 1–4 day @LPZ	3.36E-5 sec/m^3 [Same for 2nd unit/group]	3		
9.1.5 4–30 day @LPZ	7.42E-6 sec/m^3 [Same for 2nd unit/group]	3		
9.2 Atmospheric Dispersion (χ/Q) (Annual Average)	1.17E-6 sec/m^3 [Same for 2nd unit/group]	3	m	The atmospheric dispersion coefficients used in the safety analysis for the dose consequences of normal airborne releases.
9.3 Dose Consequences			n	
9.3.1 Normal	10 CFR 20, 10 CFR 50 App I [Same for 2nd unit/group]	12		The estimated design radiological dose consequences due to gaseous releases from normal operation of the plant.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
9.3.2 Post-Accident	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		
9.4 Release Point			o	
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			p	
9.5.1 Gaseous (Normal)	15,000 Ci/yr [30,000 Ci/yr] See Table 5.4-7 for isotopic breakdown	12		The annual activity, by isotope, contained in routine plant airborne effluent streams, excluding tritium.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
9.5.2	Gaseous (Post-Accident)	See Chap 15 Tables RG 1.70 [Same for 2nd unit/group]	1, 3	q	The activity, by isotope, contained in post-accident airborne effluents.
9.5.3	Tritium	3500 Ci/yr [7000 Ci/yr]	5		The annual activity of tritium contained in routine plant airborne effluent streams.
10. Liquid Radwaste System					
10.1	Dose Consequences			r	
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			s	
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			t	
10.3.1	Liquid	0.37 Ci/yr [0.74 Ci/yr] See Table 5.4-6 for isotopic breakdown	13		The annual activity, by isotope, contained in routine plant liquid effluent streams, excluding tritium.
10.3.2	Tritium	3100 Ci/yr [6200 Ci/yr]	5		The annual activity of tritium contained in routine plant liquid effluent streams.

Table 3.1-1 Generic 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. Solid Radwaste System			u	
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.
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	v	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]		v	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	v	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.

Table 3.1-1 Generic 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. 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.
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.

Table 3.1-1 Generic 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. Standby Power System					
15.1 Diesels					
15.1.1	Diesel Capacity	2 × 15,000 kW [4 × 15,000 kW]	11		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	v	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]		v	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.
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	v	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]		v	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby gas-turbine generators.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section		Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
15.2.4	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	v	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	w	The weight of the heaviest expected shipment during normal plant operations and refueling.
16.2 Acreage		87 acres [174 acres]	2	x	The land area required to provide space for plant facilities.
16.2.1	Office Facilities	1.8 acres [2.18 acre (95,200 sq ft)]	2		
16.2.2	Parking Lots	3.86 acres [7.72 acres]	3		
16.2.3	Permanent Support Facilities	12 acres [8.4 acres]	2		
16.2.4	Power Block	11.64 acres [23.3 acres]	7		
16.2.5	Protected Area	40 acres [80 acres]	7		

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
16.3 Megawatts Thermal	4500 MWt [9000 MWt]	11		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	y	The operational life for which the plant is designed.
16.5 Plant Population				
16.5.1 Operation	580 people [1160 people]	5	y	The number of people required to operate and maintain the plant
16.5.2 Refueling / Major Maintenance	1000 people [Same for 2nd unit/group]	1	y	The additional number 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
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	w	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	2,200,000 lb [Same for 2nd unit/group]	2	w	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	
17.2.2 Temporary Construction Facilities	52 acres [104 acres]	3	e	
17.3 Construction				

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition
17.3.1 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	y	Peak employment during plant construction.
17.5 Site Preparation Duration	18 months [Same for 2nd unit/group]	1, 3, 7	y	Length of time required to prepare the site for construction.

Table 3.1-1 Generic Plant Parameters Envelope

PPE Section	Bounding Value [a] [Value for 2 Units in brackets] [b]	Bound Notes See Table 3.1-2	Comments	Definition

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. The atmospheric dispersion values presented in PPE Sections 9.1 and 9.2 represent typical site parameter values assumed by reactor vendors.

n. 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.

o. 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.

p. 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.

q. 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.

r. 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.

s. 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.

t. 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.

u. 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.

v. Operational impacts of non-radiological atmospheric emissions.

w. Transport requirements for component delivery.

x. Total acreage footprint for site facilities is used to estimate construction impacts on ecological resources.

y. 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 Make-up 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 make-up 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, ESBWR), with ABWR activities scaled up to 4300 MWt and ESBWR activities increased by 25 percent. These were the only reactor types with adequate information available. See Table 5.4-7.
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, ESBWR), with ABWR activities scaled up to 4300 MWt and ESBWR activities increased by 25 percent. 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 5.4-6.
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 Deleted
Table 3.1-8 Deleted

Table 3.1-9 Bounding Site-Specific Plant Parameters Envelope

Item	Single Unit/Group Value [Second Unit/Group Value]	Description and References
	Part 1 - Site Characteristics	
Atmospheric Dispersion (χ/Q) (Accident)		• Atmospheric dispersion coefficients used to estimate dose consequences of accident airborne releases. • Refer to Section 2.7.5; Tables 2.7-11 & 2.7-12.
• EAB	3.34E-5 sec/m^3 [Same for 2nd unit/group]	
• LPZ	2.17E-6 sec/m^3 [Same for 2nd unit/group]	
Gaseous Effluents Dispersion, Deposition (Annual Average)		
• Atmospheric Dispersion (χ/Q)	χ/Q values in Table 2.7-14 [Same for 2nd unit/group]	• The atmospheric dispersion coefficients used to estimate dose consequences of normal airborne releases. • Refer to Section 2.7.6; Table 2.7-14.
• Ground Deposition (D/Q)	D/Q values in Table 2.7-14 [Same for 2nd unit/group]	• The ground deposition coefficients used to estimate dose consequences of normal airborne releases. • Refer to Section 2.7.6; Table 2.7-14.
Dose Consequences		
• Normal	10 CFR 20, 10 CFR 50 Appendix I, and 40 CFR 190 dose limits [Same for 2nd unit/group]	• Radiological dose consequences due to gaseous releases from normal operation of the plant. • Refer to Section 5.4.3; Tables 5.4-7, 5.4-10 & 5.4-11.
• Post-Accident	10 CFR 50.34(a)(1) and 10 CFR 100 dose limits [Same for 2nd unit/group]	• Radiological dose consequences due to gaseous releases from postulated plant accidents. • Refer to Sections 7.1.2 & 7.1.4.
• Minimum Distance to Site Boundary	2854.9 ft [Same for 2nd unit/group]	• Minimum lateral distance from the ESP Plant Parameter Envelope boundaries to the Exclusion Area Boundary • Refer to Figure 3.1-3.
Liquid Radwaste System		
• Normal Dose Consequences	10 CFR 50 Appendix I, 10 CFR 20, and 40 CFR 190 dose limits [Same for 2nd unit/group]	• The radiological dose consequences due to liquid effluent releases from normal operation of the plant. • Refer to Section 5.4.3; Tables 5.4-6, 5.4-10 & 5.4-11.

Table 3.1-9 Bounding Site-Specific Plant Parameters Envelope

Item	Single Unit/Group Value [Second Unit/Group Value]	Description and References
	Part 1 - Site Characteristics (continued)	
Population Density		
• Population density at the time of initial site approval and within about 5 years thereafter	Population density meets the guidance of RS-002, Section 2.1.3 for RG 4.7, Regulatory Position C.4 [Both units/groups]	• At the time of initial site approval and within about 5 years hereafter, the population densities, including weighted transient population, averaged over any radial distance out to 20 miles (cumulative population at a distance divided by the circular area at that distance), would not exceed 500 persons per square mile. • Refer to Section 2.5.1.5; Figure 2.5-13.
• Population density at the time of initial operation	Population density meets the guidance of RS-002, Section 2.1.3 [Both units/groups]	• The population densities, including weighted transient population, averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), would not exceed 500 persons per square mile at the time of initial operation. • Refer to Section 2.5.1.5; Figure 2.5-13.
• Population density over the lifetime of the new units until 2065	Population density meets the guidance of RS-002, Section 2.1.3 [Both units/groups]	• The population densities, including weighted transient population, averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), would not exceed 1000 persons per square mile over the lifetime of new units. • Refer to Section 2.5.1.5; Figure 2.5-13.
Population Center Distance	10 CFR 100.21(b) Meets requirement [Both units/groups]	• The distance from the ESP plant parameter envelope to the nearest boundary of a densely populated center containing more than about 25,000 residents is not less than one and one-third times the distance from the ESP plant parameter envelope to the outer boundary of the LPZ. • Refer to Section 2.5.1.2.
Exclusion Area Boundary (EAB)	10 CFR 100.21(a) Meets requirement [Both units/groups]	• The exclusion area boundary is the perimeter of a 5000-ft-radius circle from the center of the abandoned Unit 3 containment. • Refer to Sections 2.7.5, 2.7.6, 3.1.5, 4.1.1, 4.4.1.3, 5.1.1, 5.3.3.2.3, 5.3.4, 5.3.4.2, 5.4.1.3, 5.4.2.2, 5.5.1.3, 5.8.1.1, 5.8.1.2, 5.8.1.4, 5.8.3.1, 7.1.2, 7.1.4; Tables 2.7-10, 2.7-11, 2.7-14, 4.4-2, 7.1-1, 7.1-2, 7.1-4, 7.1-6, 7.1-8, 7.1-10, 7.1-11, 7.1-13, 7.1-15, 7.1-17, 7.1-19, 7.1-20, 7.1-22, 7.1-24, 7.1-26, & 7.1-28; Figures 1.1-1 & 2.1-2.
Low Population Zone (LPZ)	10 CFR 100.21(a) Meets requirement [Both units/groups]	• The LPZ is a 6-mile-radius circle centered at the Unit 1 containment building. • Refer to Sections 2.7.5, 2.7.6, 5.8.3.1, 7.1.2, 7.1.4; Tables 2.7-12, 7.1-1, 7.1-2, 7.1-4, 7.1-6, 7.1-8, 7.1-10, 7.1-11, 7.1-13, 7.1-15, 7.1-17, 7.1-19, 7.1-20, 7.1-22, 7.1-24, 7.1-26, & 7.1-28.

Table 3.1-9 Bounding Site-Specific Plant Parameters Envelope

Item	Single Unit/Group Value [Second Unit/Group Value]	Description and References
	Part 2 - Design Parameters	
Structure Height	≤ 234 ft [Same for 2nd unit/group]	• The height from finished grade to the top of the tallest power block structure, excluding cooling towers • Refer to Sections 2.7.5, 3.1.2.2, & 6.4.1.1.
Structure Foundation Embedment	≤ 140 ft [Same for 2nd unit/group]	• The depth from finished grade to the bottom of the basemat for the most deeply embedded power block structure • Refer to Section 4.2.1.2.
Normal Plant Heat Sink		
• Condenser/Heat Exchanger Duty	≤1.03 E10 Btu/hr [Additional 1.03 E10 Btu/hr for 2nd unit/group]	• Waste heat rejected from the main condenser and the auxiliary heat exchangers during normal plant operation at full station load • Refer to Sections 3.4.1.1, 3.4.1.3, 3.4.2.3, 5.3.2.1, & 5.3.2.1.2.
• Maximum Inlet Temperature Condenser/ Heat Exchanger	100°F [Same for 2nd unit/group]	• Maximum water temperature at condenser and heat exchanger inlet • Refer to Section 3.4.1.3.2.
• Unit 3 Closed-Cycle, Dry and Wet Tower		
Height	≤180 ft	• The height above finished grade of the cooling towers • Refer to Sections 3.1.2.2, 5.3.3.2.4, & 5.8.1.5.
Make-Up Flow Rate	15,384 gpm, maximum (MWC mode) 22,268 gpm, maximum (EC mode)	• The expected rate of removal of water from Lake Anna to replace water losses from the closed-cycle cooling water system • Refer to Sections 3.4.1.1, 3.4.2.1, 3.4.2.2, 5.2.1.1, 5.2.2.1.2, 5.3.1, 5.3.1.1, 5.3.1.1.2, 5.3.2.1.2, & 5.3.2.1.3; Table 3.3-1; Figure 3.3-1.
Evaporation Rate	8707 gpm, average (96% plant capacity factor with wet tower cooling) 11,532 gpm, maximum (MWC mode) 16,695 gpm, maximum (EC mode)	• Expected rates at which water is lost by evaporation resulting from operation of the plant cooling towers. • Refer to Section 5.2.1.1; Tables 3.3-1 & 5.2-1; Figure 3.3-1.
Drift Rate	8 gpm, maximum (MWC mode) 8 gpm, maximum (EC mode)	• Expected rates at which water is lost by drift resulting from operation of the plant cooling towers based on 0.001% of cooling water flow. • Refer to Table 3.3-1; Figure 3.3-1.

Table 3.1-9 Bounding Site-Specific Plant Parameters Envelope

Item	Single Unit/Group Value [Second Unit/Group Value]	Description and References
Part 2 - Design Parameters (continued)		
Normal Plant Heat Sink (continued)		
• Unit 3 Closed-Cycle, Dry and Wet Tower (continued)		
Blowdown Flow Rate	3844 gpm, maximum (MWC mode) 5565 gpm, maximum (EC mode)	• Flow rate of the blowdown stream from the closed-cycle cooling water system to the WHTF • Refer to Sections 3.4.1.1, 3.4.2.1, 3.4.2.2, 5.2.1.1, 5.2.2.1.2, 5.3.1, 5.3.1.1, 5.3.1.1.2, 5.3.2.1.2, & 5.3.2.1.3; Table 3.3-1; Figure 3.3-1.
Blowdown Temperature	100°F	• The maximum expected temperature of the cooling tower blowdown stream to the WHTF • Refer to Sections 3.4.1.1 & 5.3.2.2.2
Blowdown Constituents and Concentrations		• The maximum expected concentrations for anticipated constituents in the cooling water system blowdown to the WHTF • Refer to Section 5.5.1.1.
• Free Available Chlorine	<0.3 ppm	
• Copper	<1 ppm	
• Iron	<1 ppm	
• Sulfate	<300 ppm	
• Total Dissolved Solids	<3000 ppm	
Heat Rejection Rate	≤1.03 E10 Btu/hr	• The expected maximum heat rejection rate to the atmosphere during normal operation at full station load • Refer to Sections 3.4.1.1, 3.4.1.3.1, 3.4.2.3, 5.3.2.1 & 5.3.2.1.2.
Noise	<65 dbA at EAB	• Maximum expected sound level produced by operation of the cooling towers • Refer to Sections 3.1.5, 5.3.3.2.3, 5.3.4.2, & 5.8.1.2.
• Unit 4 Dry Cooling Towers		
Evaporation Rate	None or negligible (on the order of 1 gpm, average)	• The expected rate at which water is lost by evaporation from the cooling water system • Refer to Sections 1.1.4, 2.3.1.1, 3.1.5, 3.3.1, 3.4.1.1, 5.2.1, 5.2.2.1.2, 5.3.3.1, & 5.3.3.2.1; Table 3.3-2; Figure 3.3-2.
Height	≤150 ft	• The vertical height above finished grade of the cooling towers • Refer to Sections 3.1.2.2, 5.3.3.2.4, & 5.8.1.5.
Make-Up Flow Rate	None or negligible (on the order of 1 gpm, average)	• The expected rate of removal of water from Lake Anna to replace evaporative water losses from the cooling water system • Refer to Sections 2.3.1.1, 2.3.3.1, 3.3.1, 3.4.1.1, 3.4.2.1, 5.2.1, 5.2.1.1, 5.2.1.4, 5.3.1, 5.3.1.1, 5.3.1.2.2 & 5.3.3.1; Table 3.3-2; Figure 3.3-2.

Table 3.1-9 Bounding Site-Specific Plant Parameters Envelope

Item	Single Unit/Group Value [Second Unit/Group Value]	Description and References
	Part 2 - Design Parameters (continued)	
Normal Plant Heat Sink (continued)		
• Unit 4 Dry Cooling Towers (continued)		
Noise	<60 dbA at EAB	• Maximum expected sound level produced by operation of the cooling towers • Refer to Sections 3.1.5, 5.3.3.2.3, 5.3.4.2 & 5.8.1.2.
Heat Rejection Rate	≤1.03 E10 Btu/hr	• Waste heat rejected to the atmosphere from the cooling water system, during normal plant operation at full station load • Refer to Sections 3.4.1.1, 3.4.1.3.1, & 3.4.2.3.
Ultimate Heat Sink Mechanical Draft Cooling Towers		
• Blowdown Constituents and Concentrations	[Values same for both units/group]	• The maximum expected concentrations for anticipated constituents in the UHS blowdown to the WHTF • Refer to Section 5.5.1.1.
• Free Available Chlorine	<0.3 ppm	
• Copper	<1 ppm	
• Iron	<1 ppm	
• Sulfate	<300 ppm	
• Total Dissolved Solids	<3000 ppm	
• Blowdown Flow Rate	144 gpm expected, 850 gpm maximum [288 gpm expected, 1700 gpm maximum]	• The normal expected and maximum flow rate of the blowdown stream from the UHS system to the WHTF • Refer to Sections 3.4.1.2, 3.4.2.2, & 5.3.2.1; Tables 3.3-1 & 3.3-2; Figures 3.3-1 & 3.3-2.
• Evaporation Rate	411 gpm normal, 850 gpm shutdown [822 gpm normal, 1700 gpm shutdown]	• The expected (and maximum) rate at which water is lost by evaporation from the UHS system • Refer to Section 3.4.1.2; Tables 3.3-1 & 3.3-2; Figures 3.3-1 & 3.3-2.
• Height	≤60 ft [Same for 2nd unit/group]	• The vertical height above finished grade of mechanical draft cooling towers associated with the UHS system. • Refer to Section 3.1.5.
• Maximum Consumption of Raw Water	850 gpm, nominal [1700 gpm]	• The expected maximum short-term consumptive use of water from Lake Anna by the UHS system (evaporation and drift losses) • Refer to Tables 3.3-1 & 3.3-2; Figures 3.3-1 & 3.3-2.
• Monthly Average Consumption of Raw Water	411 gpm [822 gpm]	• The expected normal operating consumption of water from Lake Anna by the UHS system (evaporation and drift losses) • Refer to Tables 3.3-1 & 3.3-2; Figures 3.3-1 & 3.3-2.

Table 3.1-9 Bounding Site-Specific Plant Parameters Envelope

Item	Single Unit/Group Value [Second Unit/Group Value]	Description and References
	Part 2 - Design Parameters (continued)	
Release Point		
▪ Elevation	Ground Level	• The elevation above finished grade of the release point for routine operational and accident sequence releases
Source Term		
• Gaseous (Normal)	Values in Table 5.4-7 (maximum values) [Double values in Table 5.4-7]	• The annual activity, by isotope, contained in routine plant airborne effluent streams • Refer to Section 5.4.2.2; Table 5.4-7.
• Gaseous (Post-Accident)	Values in Section 7.1 tables (maximum values) [Same for 2nd unit/group]	• The activity, by isotope, contained in post-accident airborne effluents • Refer to Section 7.1.4; Tables 7.1-3, 7.1-5, 7.1-7, 7.1-9, 7.1-12, 7.1-14, 7.1-16, 7.1-18, 7.1-21, 7.1-23, 7.1-25, & 7.1-27.
▪ Tritium	3500 Ci/y [7000 Ci/yr] (maximum values)	• The annual activity of tritium contained in routine plant airborne effluent streams • Refer to Section 5.4.2.2; Table 5.4-7.
Liquid Radwaste System		
• Release Point Dilution Factor	1000 (minimum) [Same for 2nd unit/group]	• The ratio of liquid potentially radioactive effluent streams discharged at 100 gpm to liquid non-radioactive effluent streams from plant systems to the WHTF through the discharge canal used for NAPS Units 1 and 2 • Refer to Section 5.4.1.1; Table 5.4-1.
• Liquid	Values in Table 5.4-6 (maximum values) [Double the values in Table 5.4-6]	• The annual activity, by isotope, contained in routine plant liquid effluent streams • Refer to Section 5.4.2.1; Table 5.4-6.
• Tritium	≤ 850 Ci/yr [≤ 1700 Ci/yr]	• The annual activity of tritium contained in routine plant liquid effluent streams • Refer to Section 5.4.2.1; Table 5.4-6.
Solid Radwaste System		
• Activity	≤ 2700 Ci/yr [≤ 5400 Ci/yr]	• The annual activity contained in solid radioactive wastes generated during routine plant operations • Refer to Section 3.5.3.
• Volume	≤ 9041 cu ft/yr [≤18,646 cu ft/yr]	• The expected volume of solid radioactive wastes generated during routine plant operations • Refer to Section 3.5.3.

Table 3.1-9 Bounding Site-Specific Plant Parameters Envelope

Item	Single Unit/Group Value [Second Unit/Group Value]	Description and References
	Part 2 - Design Parameters (continued)	
Plant Characteristics		
• Acreage	Approximately 128.5 acres [Both units/groups]	• Approximate area on the NAPS site that would be affected on a long-term basis as a result of additional permanent facilities • Refer to Section 4.1.1.4.
• Megawatts Thermal	≤4500 MWt [≤9000 MWt]	• The thermal power generated by one unit (may be the total of several modules) • Refer to Sections 1.1.3, 3.1.2.2, 3.1.5, 3.2.1, 3.8.1, 5.7.1, 7.1.3 & 7.1.4; Tables 3.8-1, 5.4-6, & 5.4-7.
• Plant Population – Operation	Approximately 720 permanent employees [Both units/groups]	• Anticipated number of new employees that would be required for operation of the new units • Refer to Sections 2.5.2, 5.8.2, & 5.8.2.2.
• Plant Population – Refueling / Major Maintenance	Approximately 700–1,000 temporary workers during planned outages [Same for 2nd unit/group]	• Anticipated number of additional workers onsite during planned outages of the new units • Refer to Sections 2.5.2 & 5.8.2.1.2.
• Plant Population – Construction	5,000 people maximum [simultaneous construction]	• Peak workforce of 5,000 for construction of both new units/groups • Refer to Sections 2.5.2, 4.4.2, 4.4.2.2.1, 4.5.4, 5.8.2.2, & 5.8.2.2.2.
• Maximum Fuel Enrichment for Light-Water-Cooled Reactors	5% [Same for 2nd unit/group]	• Concentration of U-235 in fuel • Refer to Sections 3.2.1 & 3.8; Table 3.8-1.
• Maximum Fuel Burn-up for Light-Water-Cooled Reactors	62,000 MWd/MTU [Same for 2nd unit/group]	• The value derived by calculating the reactor thermal power multiplied by the time of irradiation divided by fuel mass (expressed as megawatt-days per metric ton of irradiated fuel) • Refer to Sections 3.2.1 & 3.8; Table 3.8-1.
• Maximum Fuel Enrichment for Gas-Cooled Reactors	19.8% [Same for 2nd unit/group]	• Concentration of U-235 in fuel • Refer to Sections 3.2.1 & 3.8; Table 3.8-2.
• Maximum Fuel Burn-up for Gas-Cooled Reactors	133,000 MWd/MTU [Same for 2nd unit/group]	• The value derived by calculating the reactor thermal power multiplied by the time of irradiation divided by fuel mass (expressed as megawatt-days per metric ton of irradiated fuel) • Refer to Sections 3.2.1 & 3.8; Table 3.8-2.

Figure 3.1-1 Existing North Anna Power Station Site

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

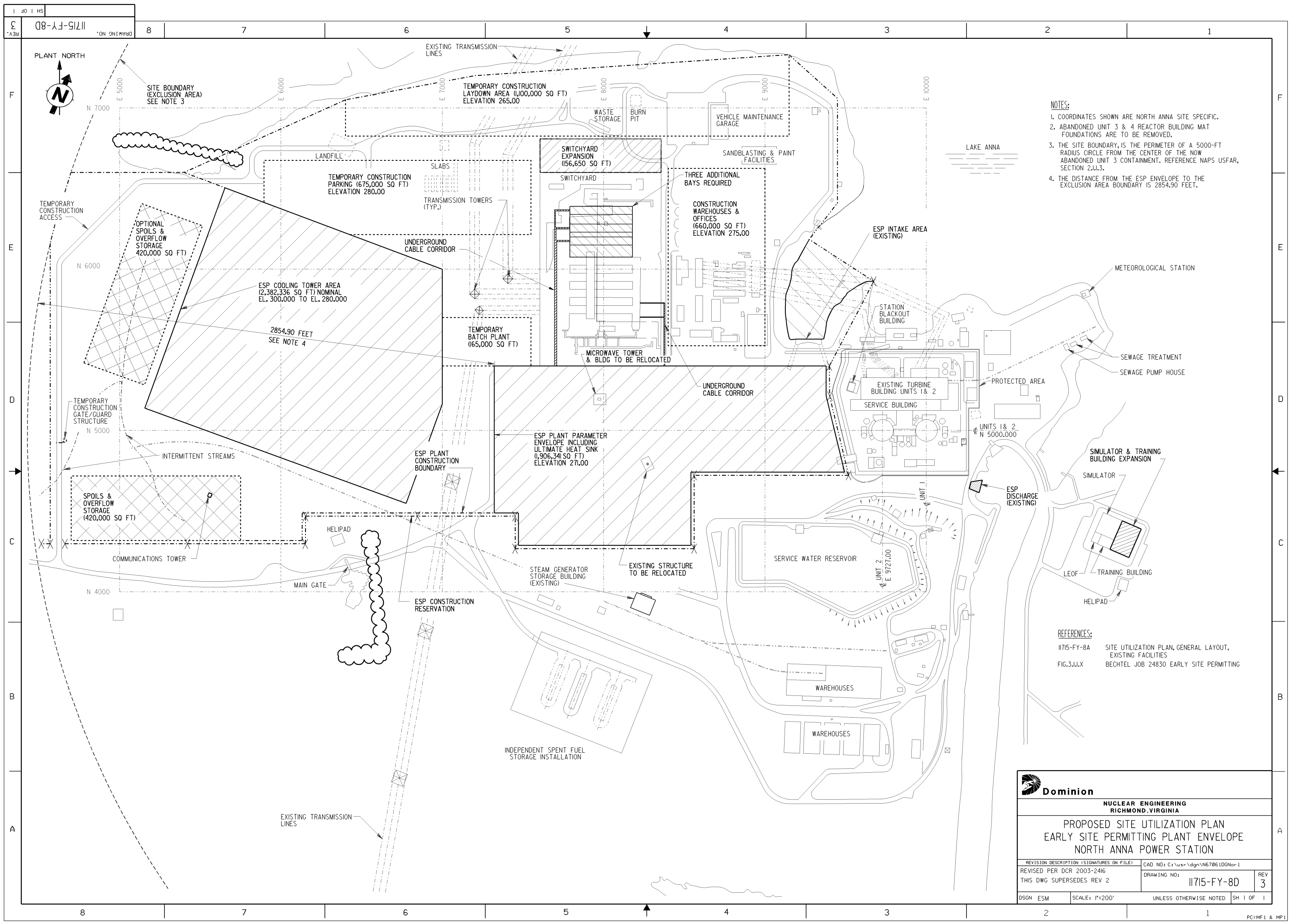


Figure 3.1-3 ESP Site Utilization Plan

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, Generic PPE was developed to describe the maximum potential impacts. This Generic PPE is described in Section 3.1.3. The site has a potential development of up to approximately 3040 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 4500 MWt reactor(s) and associated turbines and power conversion equipment. The gross electrical output of each unit of approximately 1520 MWe is dependent on circulating water inlet temperature and condenser design. Plant and site equipment would require approximately 30–100 MWe, resulting in an approximate maximum net 1420–1490 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 19.8 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). The enrichment limits for light-water-cooled reactors and gas-cooled reactors are 5 percent and 19.8 percent U-235, respectively. The burn-up limits for light-water-cooled reactors and gas-cooled reactors are 62,000 MWd/MTU and 133,000 MWd/MTU, respectively.

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 closed-cycle, combination dry and wet cooling towers and from Unit 4 to dry 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 Generic PPE information from Section 3.1.3. This Generic PPE describes a bounding plant design that is intended to accommodate current and future plants. This Generic 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 closed-cycle, combination dry and wet cooling towers. The second unit would use dry cooling towers. Cooling tower make-up water necessary to replace the water lost to evaporation would be obtained from the North Anna Reservoir. Plant water sources would come from two sources—Lake Anna and local wells—depending on the quantity and quality of make-up 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 closed-cycle, combination dry and wet cooling towers with make-up water from the North Anna Reservoir. Unit 4 would use dry cooling towers, with make-up from the North Anna Reservoir, if needed. Dry cooling towers prevent evaporation of the cooling water and significantly reduce the need for make-up water. In the event that the cooling water loop would use an open sump pump configuration with a free surface, a small amount of evaporation loss would occur, estimated to be on the order of 1 gpm. This small quantity of make-up water would be drawn from Lake Anna. 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 Generic PPE and on site-specific parameters. Evaporation estimates for Unit 3 wet cooling towers and the Unit 4 dry cooling tower collection basin 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 make-up water for the cooling towers, 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. Except as noted for plant cooling towers, the normal values listed are expected limiting values for normal plant operation. Except as noted for plant cooling towers, 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**

Cooling tower make-up water for Unit 3 would be from the North Anna Reservoir. Make-up water necessary for Unit 3 cooling towers would need treatment for biofouling, scaling, and suspended matter, with acceptable biocides, antiscalants, and dispersants, respectively.

Raw water from the North Anna Reservoir that could be used to provide make-up for various station secondary systems would also require treatment.

Any make-up water necessary for cooling towers, 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 **Make-up Water**

Make-up water from the North Anna Reservoir for other systems 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 make-up 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

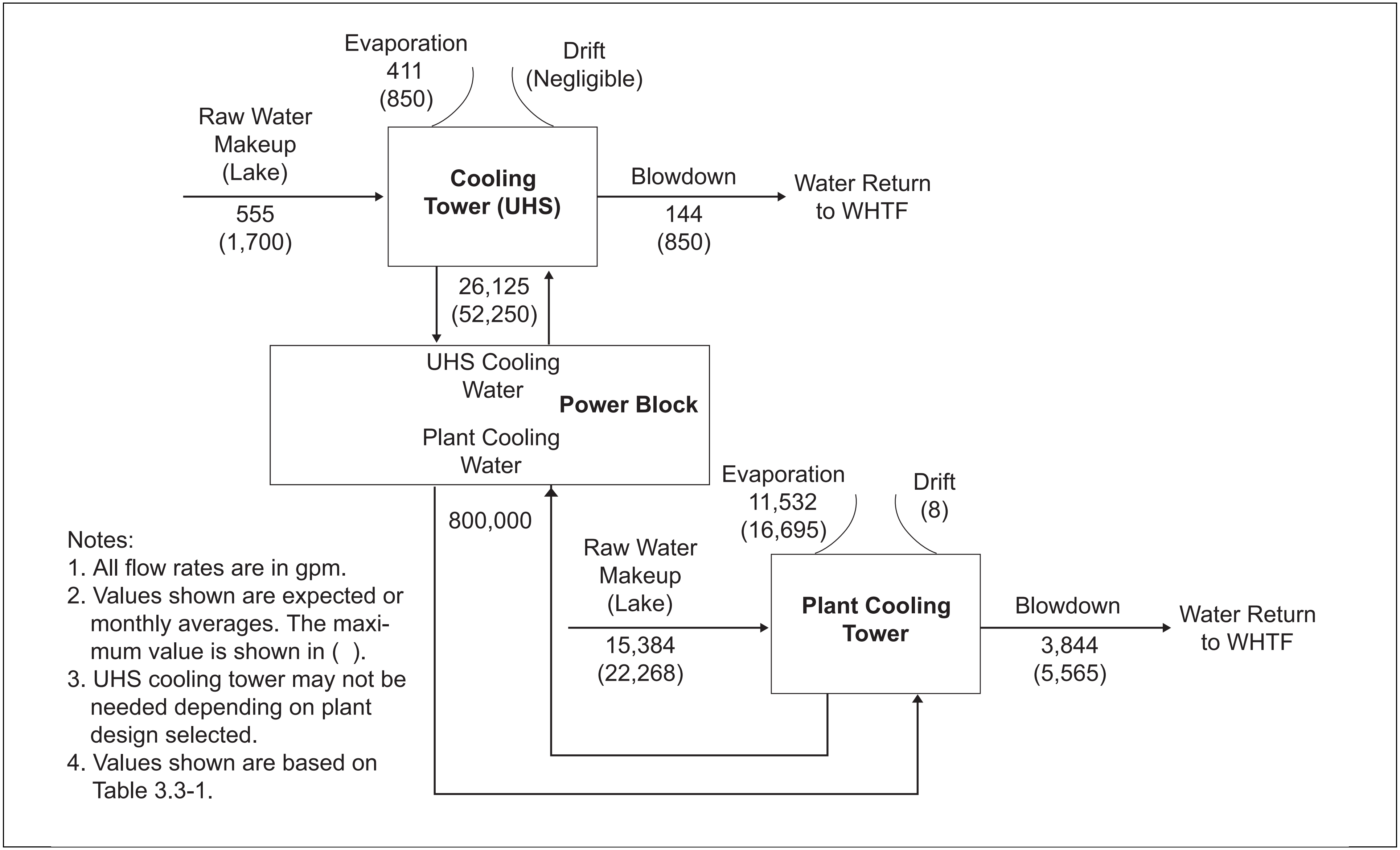
Service	Normal (gpm/cfs)[a]	Maximum (gpm/cfs)[a]	Reference (PPE Section)[b]
Water Supplies[c]			
Plant Cooling Tower Make-Up[d,e]	15,384/34.3	22,268/49.6	
UHS Cooling Tower Make-Up	555/1.24	1700/3.79	3.3.9
Potable Water Supply	90/0.2	120/0.27	5.2.1 and 5.2.2
Demineralized Water Supply	550/1.23	720/1.60	6.2.1 and 6.2.2
Fire Protection Water Supply	15/0.03	2500/5.57	7.1.1 and 7.1.2
Water Releases			
Evaporation Rate[e]			
Plant Cooling Tower[d,e]	11,532/25.7	16,695/37.2	
UHS Tower	411/0.92	850/1.89	3.3.7
Blowdown			
Plant Cooling Tower[d,e]	3844/8.57	5565/12.4	
UHS Tower	144/0.32	850/1.89	3.3.4
Drift Rate			
UHS Tower	negligible	negligible	
Plant Cooling Tower[d,e]	<8.0/0.018	<8.0/0.018	
Sanitary Waste Discharge	60/0.13	105/0.23	5.1.1
Radwaste Discharge	100/0.22	--	10.2.1
Misc. Drains Discharge	100/0.22	150/0.33	8.1.1
Demineralized Water Discharge	110/0.25	150/0.33	6.1.1

a. Flow rates were converted from gpm to cfs.
b. Reference refers to the line entry on the Generic PPE, Table 3.1-1.
c. Make-up water for Plant Cooling Towers, UHS Tower, Demineralized Water, and Fire Protection Water would be from Lake Anna. The potable water supply would be from area wells.
d. Normal for Plant Cooling Tower Make-Up, Evaporation, Drift, and Blowdown is “Maximum Water Conservation” (MWC) mode (two-thirds heat dissipated in wet cooling towers and one-third heat dissipated in dry cooling towers) and Maximum is “Energy Conservation” (EC) mode (all heat dissipated in the wet cooling towers).
e. The “Plant Cooling Tower” reference has contributions from circulating water wet and dry cooling towers and service water wet towers. Values are expected maximums at design 0.4% exceedance atmospheric conditions.

Table 3.3-2 Unit 4 Water Consumption

Service	Normal (gpm/cfs)[a]	Maximum (gpm/cfs)[a]	Reference (PPE Section)[b]
Water Supplies[c]			
Plant Cooling Tower Make-Up[d,e]	1.0/0.002	1.0/0.002	
UHS Cooling Tower Make-Up	555/1.24	1700/3.79	3.3.9
Potable Water Supply	90/0.2	120/0.27	5.2.1 and 5.2.2
Demineralized Water Supply	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			
Plant Cooling Towers[d,e]	1.0/0.002	1.0/0.002	See ER Section 5.2.1
UHS Tower	411/0.92	850/1.89	3.3.7
Blowdown			
Plant Cooling Towers[d,e]	0	0	See ER Section 5.2.1
UHS Tower	144/0.32	850/1.89	3.3.4
Drift Rate			
UHS Tower	negligible	negligible	
Plant Cooling Tower[d,e]	0.0/0.0	0.0/0.0	
Sanitary Waste Discharge	60/0.13	105/0.23	5.1.1
Radwaste Discharge	100/0.22	—	10.2.1
Misc. Drains Discharge	100/0.22	150/0.33	8.1.1
Demineralized Water Discharge	110/0.25	150/0.33	6.1.1

a. Flow rates were converted from gpm to cfs.
b. Reference refers to the line entry on the Generic PPE, Table 3.1-1.
c. Make-up water for Plant Cooling Towers, UHS Tower, Demineralized Water, and Fire Protection Water would be from Lake Anna. The potable water supply would be from area wells.
d. Unit 4 would use dry cooling towers. If an open sump pump configuration is used, a maximum 1 gpm evaporation rate would occur. There would be no drift loss associated with the dry cooling towers.
e. The “Plant Cooling Tower” reference has contributions from circulating water cooling tower and the service water cooling tower.



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

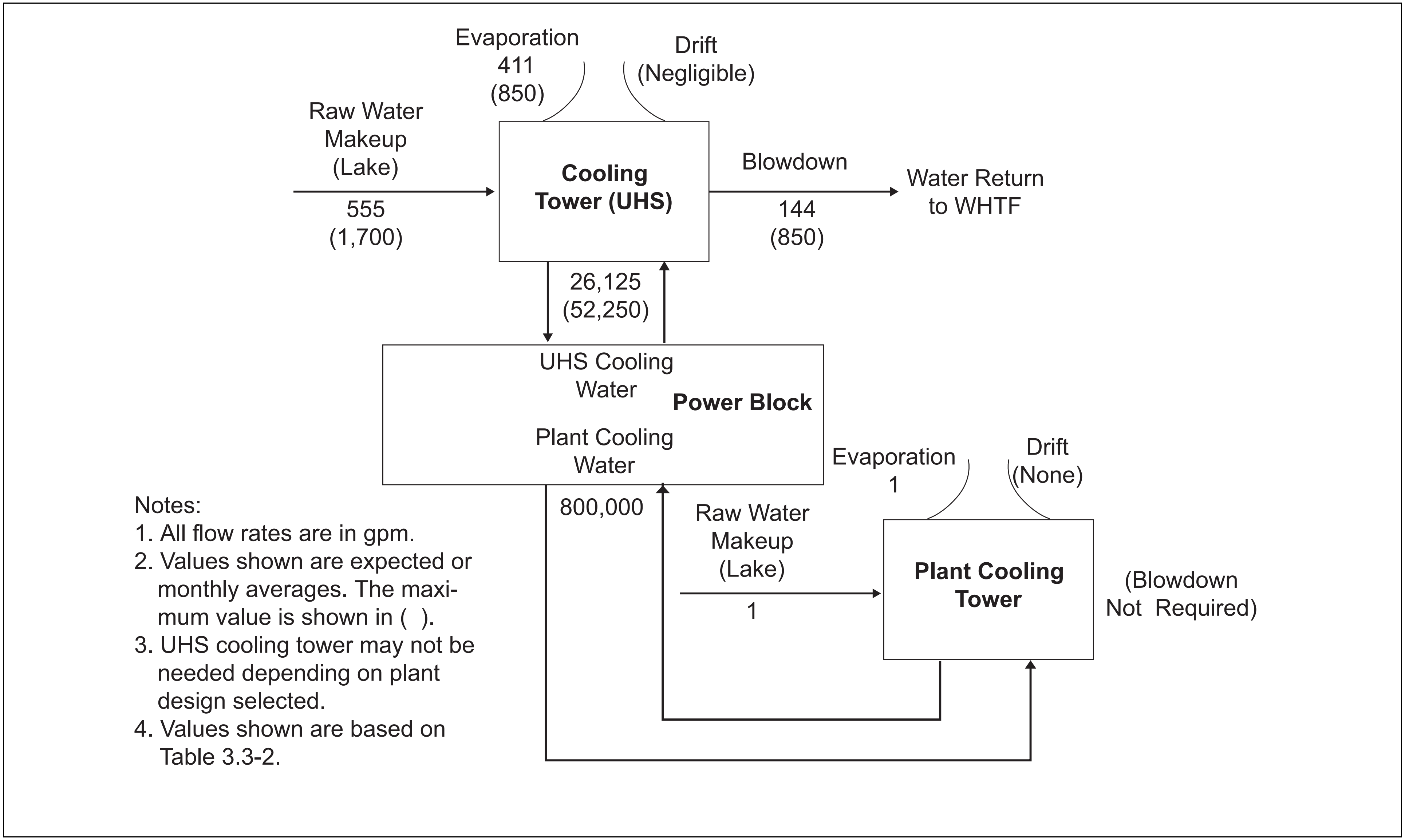


Figure 3.3-2 Unit 4 Cooling Water Use

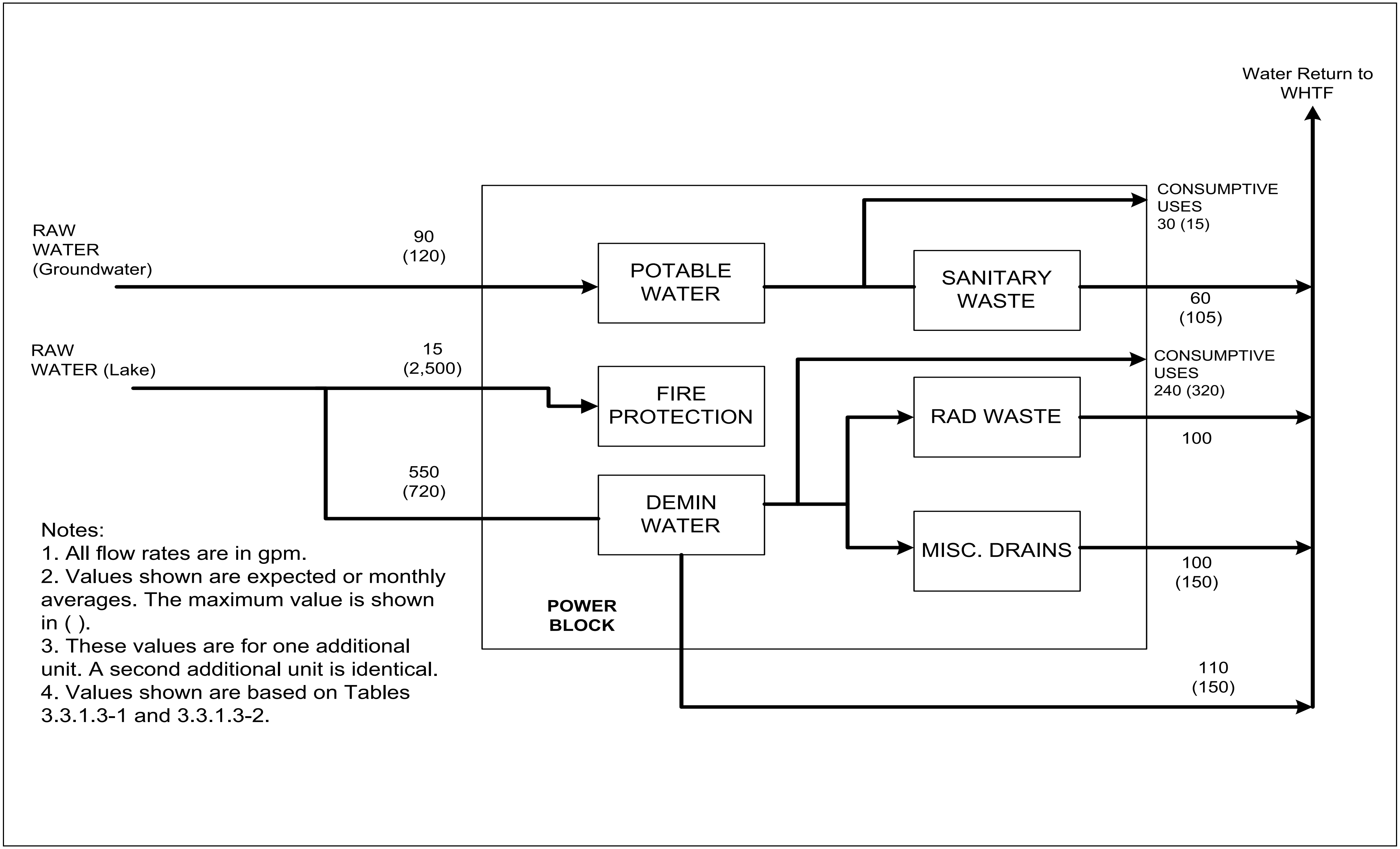


Figure 3.3-3 Power Block Water Use

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 Generic 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

Each new unit would require cooling systems to dissipate up to 1.03×10^{10} Btu/hr of waste heat rejected from the main condenser and the unit's auxiliary heat exchangers during normal plant operation at full station load. The primary normal plant cooling system, hereafter referred to as the circulating water system, would dissipate heat from the main condenser and potentially other auxiliary heat exchangers. A closed-cycle, combination dry and wet cooling tower arrangement would be used for the circulating water system of the new Unit 3, and a closed-cycle dry cooling tower would be used for the new Unit 4. Dissipation of waste heat from auxiliary heat exchangers not cooled by the plant circulating water system is typically performed by the plant service water system. The typical plant service water system water flows, heat dissipation, and losses are included in the plant cooling water system values for each unit. The service water cooling system would use a closed-cycle, wet cooling tower system for Unit 3 and a dry cooling tower system for Unit 4.

Unit 3's circulating water system would use both dry cooling towers and wet cooling towers for heat dissipation. Figure 3.4-11 shows a diagram of the conceptual closed loop system for Unit 3. Exhaust from the plant's steam turbines would be directed to a surface condenser where the heat of vaporization would be rejected to the cooling water in a closed loop. The heated cooling water would be circulated first to the finned tubes of the dry cooling towers where heat content of the cooling water would be transferred to the ambient air. To increase heat rejection to the atmosphere, electric motor-driven fans would be used to force airflow across the finned tubes. No water loss would occur in the dry cooling towers. Cooling water leaving the dry towers would then pass through the wet towers to remove the balance of condenser/heat exchanger rejected heat by spraying the water into a forced or induced air stream. The wet towers would incorporate water-saving features to help reduce evaporative water losses.

Water saving features for wet cooling towers can include incorporation of a dry cooling section in the wet tower to reduce the amount of evaporative cooling required or use of heat exchange surfaces in the upper section of the wet tower where water is condensed from the exhaust stream before it leaves the tower. Other features such as variable speed fans and pumps and adjustable louvers may also be used to more efficiently match cooling capacity to heat load and ambient conditions. Further, although the system described uses wet and dry towers, it is possible to incorporate both wet and dry cooling sections in the same tower design. The performance characteristics of the cooling towers analyzed for Unit 3 are based on considerations of a model that incorporates such features.

After passing through the cooling towers, the cooled water would be recirculated back to the surface condenser to complete the closed-cycle cooling water loop. Make-up water to the circulating water system and service water cooling system would be obtained from the North Anna Reservoir. Blowdown from the cooling systems would be discharged to the existing plant WHTF discharge canal.

The Unit 3 circulating water system would operate in either of two operating modes:

- Energy Conservation (EC) – Dry cooling would be turned off, with reliance on wet towers for heat removal.
- Maximum Water Conservation (MWC) – A minimum of one-third[1] of the heat would be removed by the dry towers. The remainder would be removed, as required, by the wet towers.

When North Anna Reservoir level is at or above 250 ft msl and adequate reservoir discharge is being maintained, the EC mode would be used. However, if reservoir level falls below 250 ft msl and if the level is not restored within a reasonable period of time, the MWC mode would be used. The period of time before switching to the MWC mode was assumed to be 7 days for analysis of

1. In the MWC mode, the dry towers would have the capacity to remove one-third of the design condenser heat duty at a design dry bulb temperature (DBT) of 95°F (the 0.4 percent exceedance DBT for the site). As the DBT decreases, the percentage of heat which can be removed by the dry towers would increase proportionately until, at some lower DBT, the dry towers would have the capability of removing the entire condenser heat duty.

water level and downstream flows. The actual time frame would be established with the appropriate State agencies at the time of permitting.

The Unit 4 system would use dry cooling towers for heat dissipation in which the exhaust from the plant's steam turbines would be directed to a surface condenser where the heat of vaporization would be rejected to a closed loop of cooling water. The heated cooling water would be circulated to the finned tubes of the dry cooling towers where heat content of the cooling water would be transferred to the ambient air. To increase heat rejection to the atmosphere, electric motor driven fans would be used to force airflow across the finned tubes. After passing through the dry cooling towers, the cooled water would be recirculated back to the surface condenser to complete the closed-cycle cooling water loop. Except for the initial filling of the cooling water loop, Unit 4's circulating water and service water cooling systems would have no make-up water need since dry tower systems typically have no evaporative water losses and would have no continuous blowdown discharge to the WHTF. In the event that the cooling water loop would use an open pump sump configuration with a free surface, a small amount of evaporation losses, estimated to be on the order of 1 gpm (0.002 cfs), will occur. Any make-up water necessary to replenish the small evaporative losses for Unit 4's circulating water system and service water cooling system would be obtained from the North Anna Reservoir. Since there would be a minimal, if any, make-up water requirement and no blowdown discharge to the WHTF from the Unit 4 dry cooling systems, impacts to Lake Anna would be minimal.

In the closed-cycle, wet and dry cooling system for new Unit 3, pumps would circulate water in a closed loop of cooling water at an expected rate of about 3.355×10^8 lb/hr (approximately 1500 cfs at a maximum temperature of 100°F). The circulating water flow rate may vary depending on the final selected parameters of the unit condenser. Make-up water to the circulating water and service water cooling systems would be taken from the North Anna Reservoir by make-up water pumps at a maximum instantaneous rate of 2.23×10^4 gpm (49.6 cfs) when not operating in the MWC mode. The make-up water is required to compensate for the water lost from the closed-cycle cooling system due to evaporation, blowdown, and drift. In the EC mode, these losses would be no greater than 1.67×10^4 gpm for evaporation, 5.57×10^3 gpm for blowdown, and 8 gpm for drift. In the MWC mode, these losses would be no greater than 1.15×10^4 gpm for evaporation, 3.84×10^3 gpm for blowdown, and 8 gpm for drift. The make-up water pumps would be installed inside a new shoreline intake structure located in a cove west of the intake structure for the existing units. Blowdown from the circulating water and service water cooling systems of Unit 3 would be discharged to an outfall structure located at the head of the WHTF discharge canal at a temperature no greater than 100°F and a flow rate no greater than 5.57×10^3 gpm (12.4 cfs). At the maximum blowdown flow rate of 12.4 cfs at 100°F discharge temperature, the heat rejected from the closed cycle cooling systems of Unit 3 to the WHTF would be on the order of 4.2×10^7 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. Compared to the once-through cooling system discharge of the existing units, which have a combined maximum heat content of up to 1.35×10^{10} Btu/hr, the heat load in the blowdown discharge of Unit 3 would be about 0.3 percent of the heat load from the existing units during the summer months, when thermal impact would be most critical. Figure 2.1-1 shows the location of the cooling towers for normal plant cooling on the ESP site. 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, the blowdown discharge from Unit 3 would mix with the circulating water discharge from Units 1 and 2. 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. Because of the significantly lower flow rate and heat content, the blowdown discharge from Unit 3 would have negligible effect on the thermal structure and heat dissipation capacity of WHTF. 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 six-bay adjustable skimmer wall discharge structure at Dike 3 as described in Section 3.4.2. Upon 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 dry cooling tower system for new Unit 4 would consist of pumps that circulate cooling water in a closed loop at a rate of about 8.00×10^5 gpm (1782 cfs). The cooling water would be pumped through the main condenser and auxiliary heat exchangers, and then to the finned tubes of the dry cooling towers for heat dissipation to the atmosphere. Figure 2.1-1 shows the location of the cooling towers for normal plant cooling on the ESP site. The closed-cycle dry towers for the circulating water and service water systems would be designed to dissipate the heat load of up to 1.03×10^{10} Btu/hr anticipated during full station load operation. During the heat transfer process, no water would be lost to the atmosphere since there would be typically no evaporation losses in a dry tower system. A small amount of make-up water on the order of 1 gpm (0.002 cfs) would be needed and would be obtained from North Anna Reservoir to replenish the evaporative loss only if an open pump sump with a free surface would be used to recirculate water in the circulating water system cooling water loop or the service water cooling loop. Water use impacts to Lake Anna would therefore be minimal. Since the dry cooling system would produce no continuous blowdown discharge, new Unit 4 would have 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. 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. 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 make-up water flow at 1.2 cfs to 3.8 cfs. Water supply to the storage basin would be pumped directly from the UHS make-up water pumps or other water supply 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 9.9×10^9 Btu/hr per each new unit, that is 96 percent of the rated unit heat load of 1.03×10^{10} Btu/hr, would be dissipated to the atmosphere via wet and dry cooling towers for Unit 3 and dry 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 100°F. This temperature is higher than the maximum allowable intake water temperature of 95°F for Units 1 and 2, specified in the existing units' Technical Requirements Manual. However, as the new units' closed-loop cooling systems operate independently of lake water temperature, no mandatory shutdown of the new units would be required if intake water temperature exceeded the 95°F limit.

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, 242 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 will not drop below 242 ft msl during severe drought conditions. 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. Cooling tower make-up water for Unit 3 would come from the North Anna Reservoir and would require treatment for bio-fouling, scaling, and suspended matter, with acceptable biocides, antiscalants, and dispersants, respectively.

If an open pump sump configuration would be selected for the cooling water loop of Unit 4's dry cooling tower system, make-up water would be obtained from the North Anna Reservoir to replenish the small evaporative losses. Pre-treatment of the dry cooling tower make-up 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 site-specific estimates, if available, are used as the basis for discussion. If site-specific estimates are not available, bounding values of the parameters from the Generic PPE are used.

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 Unit 3 would withdraw make-up water for the normal plant circulating water and service water cooling systems from the North Anna Reservoir at a flow rate up to 2.23×10^4 gpm (49.6 cfs). As presented in Section 3.4.1.1, make-up water for the closed-cycle dry cooling tower system of Unit 4 would not be required normally. However, if an open pump sump configuration would be used in the closed cooling water loop, a small amount of make-up water estimated to be on the order of 1 gpm (0.002 cfs) would be needed to replace the evaporative losses through the free surface of the sump. This make-up water for Unit 4 would be obtained from the North Anna Reservoir.

The intake system of the new units would consist of a compartmented intake structure with a common screen well and separate pump bays dedicated to each unit, and a common 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. In addition to the make-up water pumps for Unit 3's closed-cycle cooling towers, 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 of make-up water for 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. Screen wash pumps with a total capacity of about 1.1 cfs per unit will be installed in the screenwell to clean the traveling water screens during operation of the intake pumps. The screen wash flow would not be a consumptive water use as it would be recirculated back to intake flow upstream of the traveling water screens. The miscellaneous water supply pumps in the Unit 4 pump bays would also supply the make-up water as needed to the closed cooling water loop of the Unit 4 dry cooling tower system. 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 new 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. To bring water from the reservoir to the new intake structure via the approach channel, the cofferdam, or a portion of it, would be removed. Because of the limited quantity of water to be supplied from the North Anna Reservoir, no major modification to the existing shoreline or dredging in the approach channel would be necessary. The approach channel has 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 is approximately 220 ft msl. At the minimum lake operating level (242 ft msl) for the future combined operation of the new and existing units, the flow velocity in the approach channel would be about 0.01 ft/sec, based on the intake flow rate of 61 cfs for Unit 3 and 11 cfs for Unit 4. If a partial opening at the cofferdam would be constructed to connect the reservoir with the approach channel of the intake structure of Units 3 and 4, the through flow velocity at the opening would be designed to be about 0.1 fps, similar to the current velocity in the reservoir, to minimize entrainment of debris, aquatic life, and sediment.

At the end of the approach channel, lake water would flow into the common screen well and the pump bays of either Unit 3 or Unit 4 at a velocity of less than 1 fps. A skimmer wall, extending to just below Elevation 242 ft msl, would be installed at the entrance of the screen well to reduce the amount of floating debris carried into the intake. The screenwell would also be equipped with automatically raking trash racks, traveling water screens, debris basin, and screen wash pumps. The traveling water screens would be designed to have the capability to operate continuously.

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 common screen well, multiple pump bays would house the make-up water pumps for Unit 3. Other smaller capacity water supply pumps and firewater pumps of Unit 3 would also share the space in some of these pump bays. The make-up water pumps and firewater pumps for Unit 4 would be located in separate pump bays dedicated to Unit 4. 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 screen well, trash racks, and traveling water screens would be less than 1 fps at the minimum operating lake level of 242 ft msl. The total width of the intake structure would be about 70 feet, with approximately 50 feet allocated for Unit 3 and 20 feet for Unit 4. A bottom sill would be installed at the entrance of the common screenwell to reduce entrainment of bed sediment. Figure 3.4-4 is a schematic section view of the arrangement of the intake structure. The shoreline area disturbed by construction of the new intake structure would be stabilized and 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**

Blowdown flow from the Unit 3 closed-cycle cooling towers would be released into the discharge channel of the WHTF via a new outfall. The temperature of the blowdown discharge would be no greater than 100°F. 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 Table 3.3-1, the maximum blowdown flow rate from the Unit 3 circulating water and service water cooling towers would be no greater than 12.4 cfs. As presented in Section 3.4.1.1, there would be no blowdown discharge from the Unit 4 closed-cycle, dry cooling tower system.

With all four units operating, the 12.4 cfs of blowdown effluent from Unit 3 would mix in the discharge channel with 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 0.8 cfs to 1.1 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 recirculating 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 presented in Section 5.3.1.1, the long-term average flow released at the dam is estimated to be 276 cfs during the operation of the existing units. The lake receives inflow estimated to be about 369 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 cooling system described in Section 3.4.1 would provide the normal heat sink for Unit 3. A closed-cycle, combination dry and wet cooling tower arrangement would be used for the circulating water system. A separate service water cooling system would use a closed-cycle, wet cooling tower for dissipation of waste heat from auxiliary heat exchangers not cooled by the plant circulating water system. Mechanical draft type dry towers with electric motor-driven fans would be used to force airflow across the finned tubes to increase heat rejection to the atmosphere. Similarly, mechanical draft type wet towers with electric motor-driven fans would be used to force or induce airflow through the sprayed water to increase heat rejection to the atmosphere. The closed-cycle cooling towers would be designed to dissipate up to 1.03×10^{10} Btu/hr of waste heat at full station load.

For the closed-cycle cooling system of Unit 4, dry cooling towers with finned tubes would be used as the normal heat sink. Mechanical draft type dry towers with electric motor-driven fans would be used to force airflow across the finned tubes to increase heat rejection to the atmosphere. The dry cooling towers would be designed to dissipate a maximum waste heat load of up to 1.03×10^{10} Btu/hr.

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.

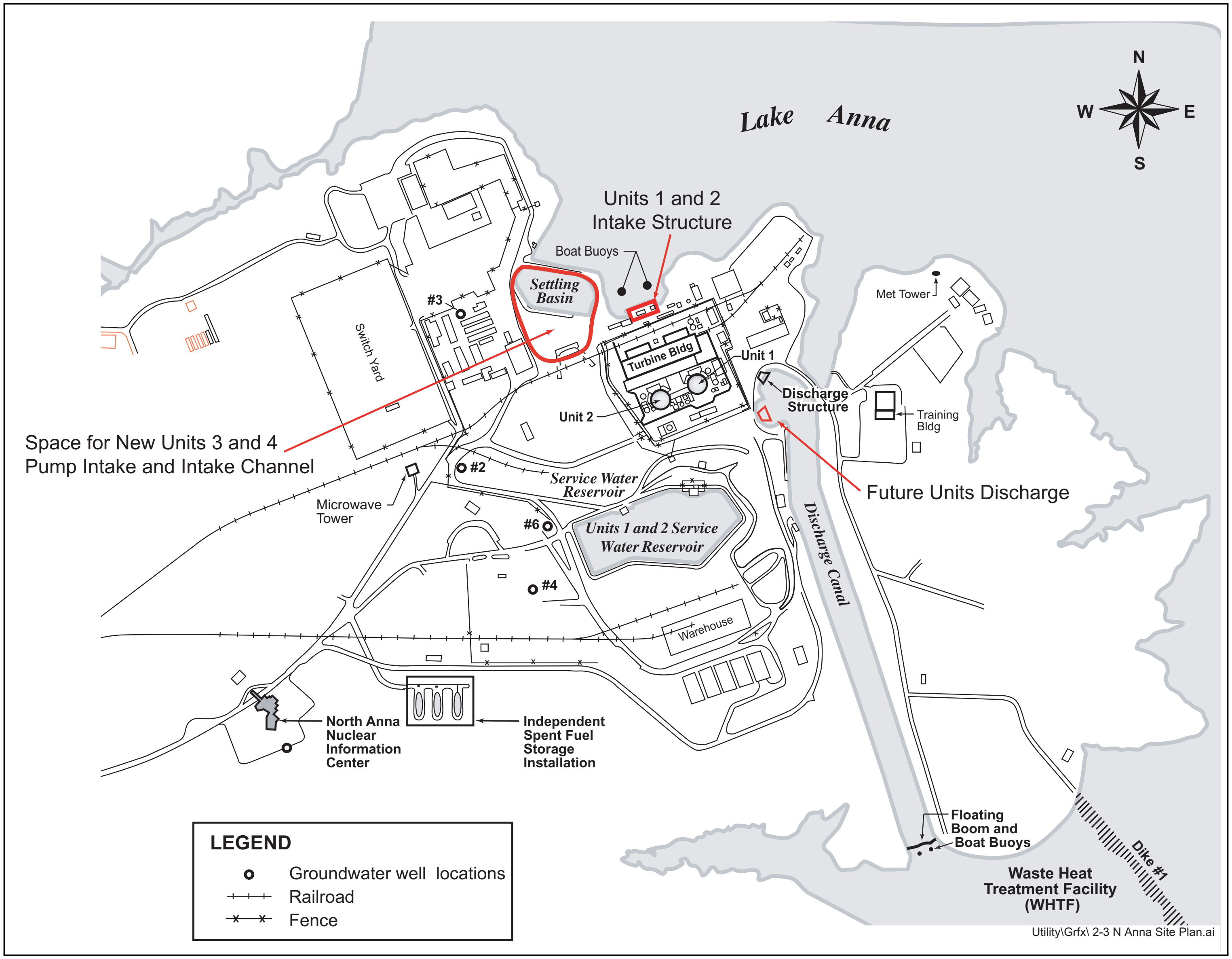


Figure 3.4-1 Proposed Location of the Intake Structure and Discharge Structures for the New Units 3 and 4

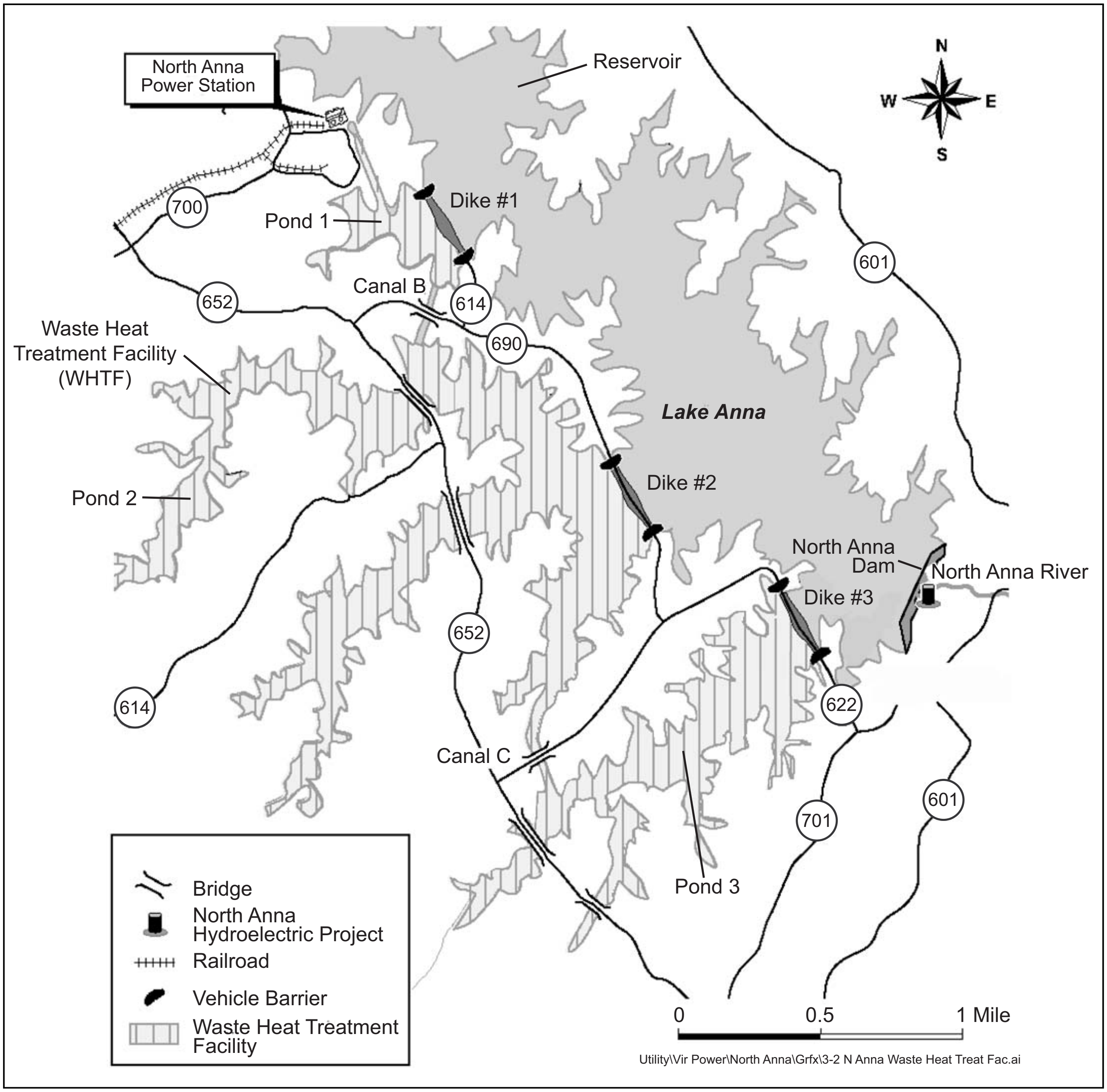


Figure 3.4-2 North Anna Plant - Reservoir and WHTF of Lake Anna

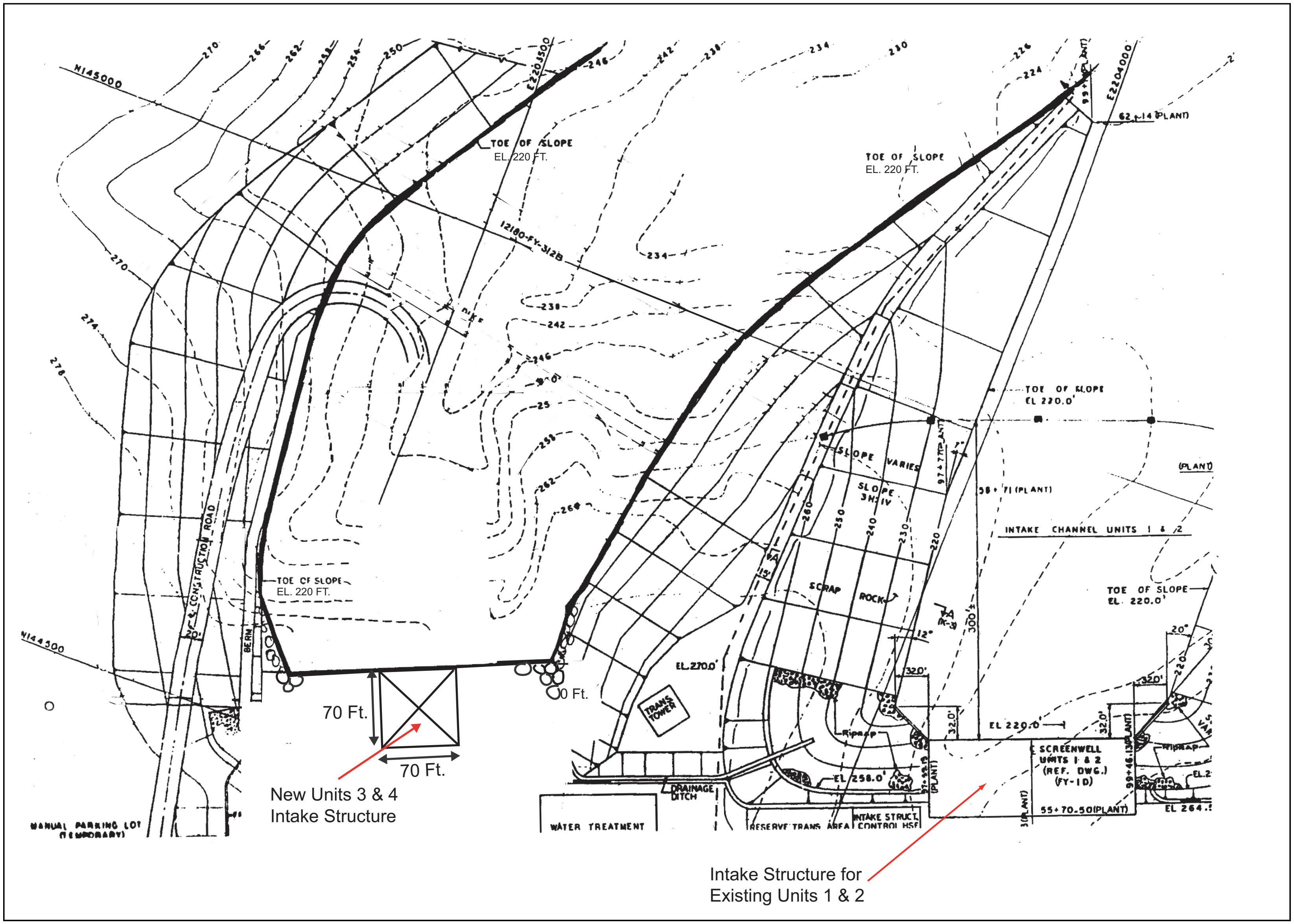


Figure 3.4-3   Layout of Screenwell/Pump Intake for New Units 3 and 4

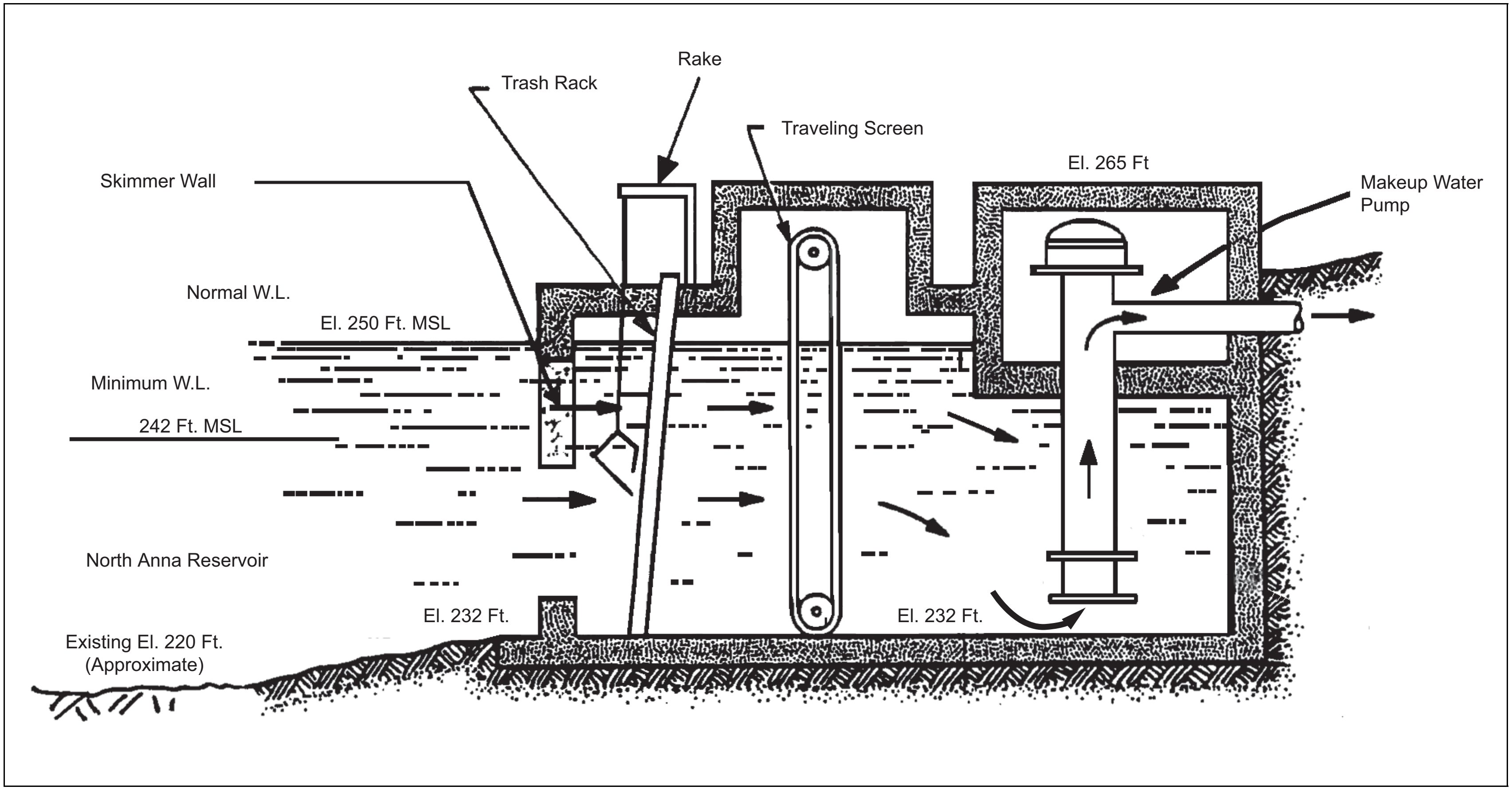


Figure 3.4-4 Schematic View of Pump Intake

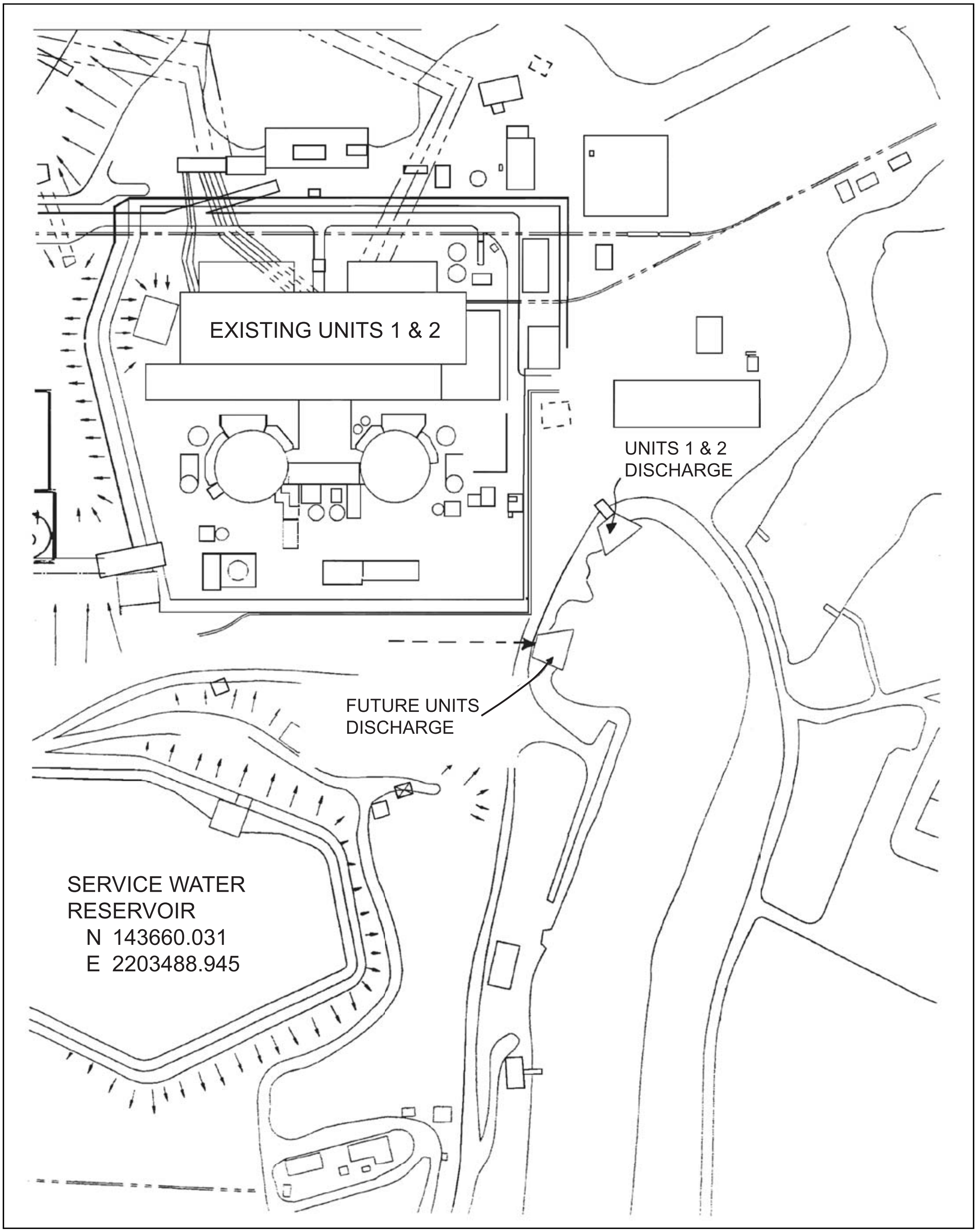


Figure 3.4-5 Discharge Outfall at Head of the Discharge Canal for New Units 3 and 4

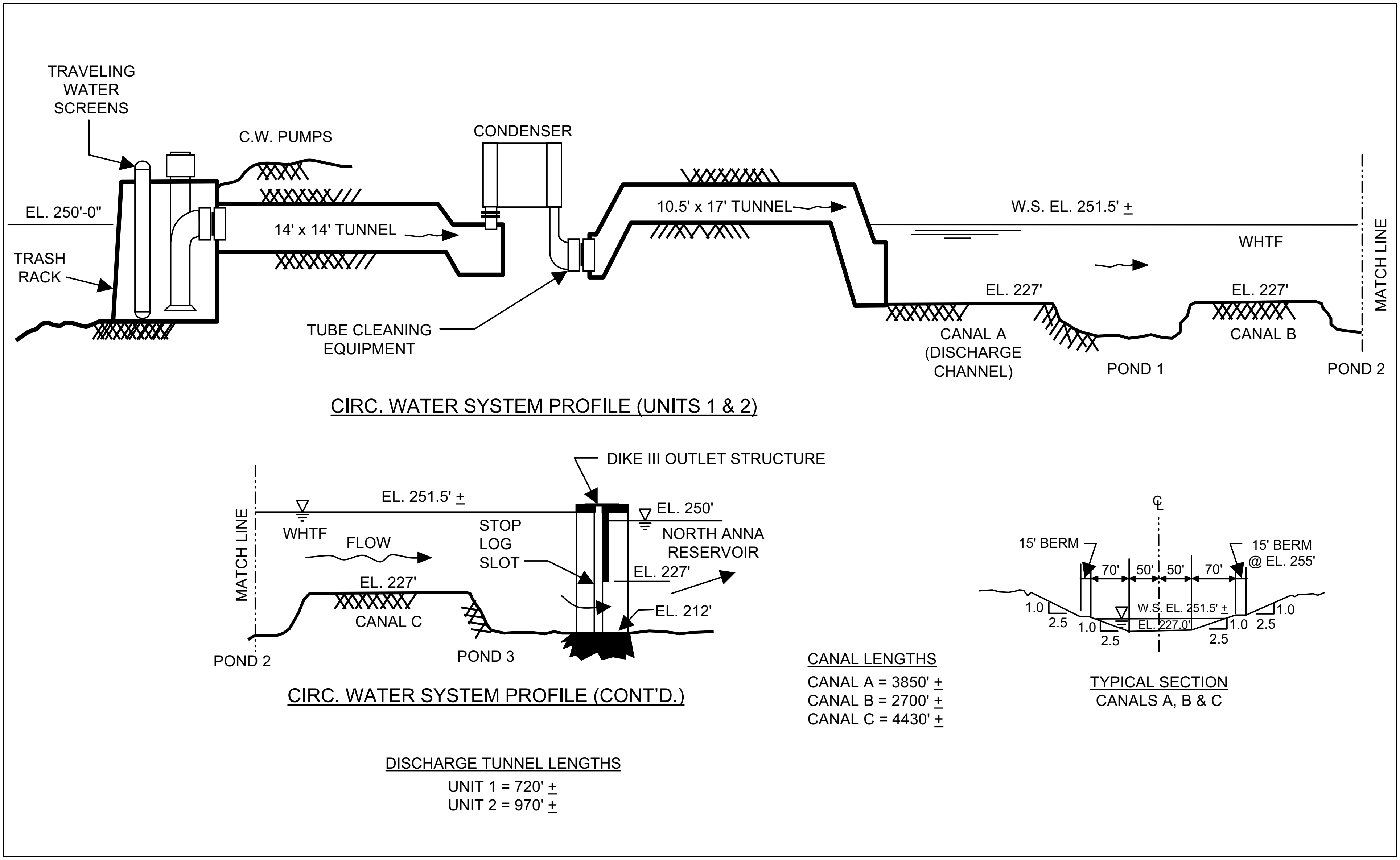


Figure 3.4-6 Discharge Channel and Dike 3 Outlet Structure

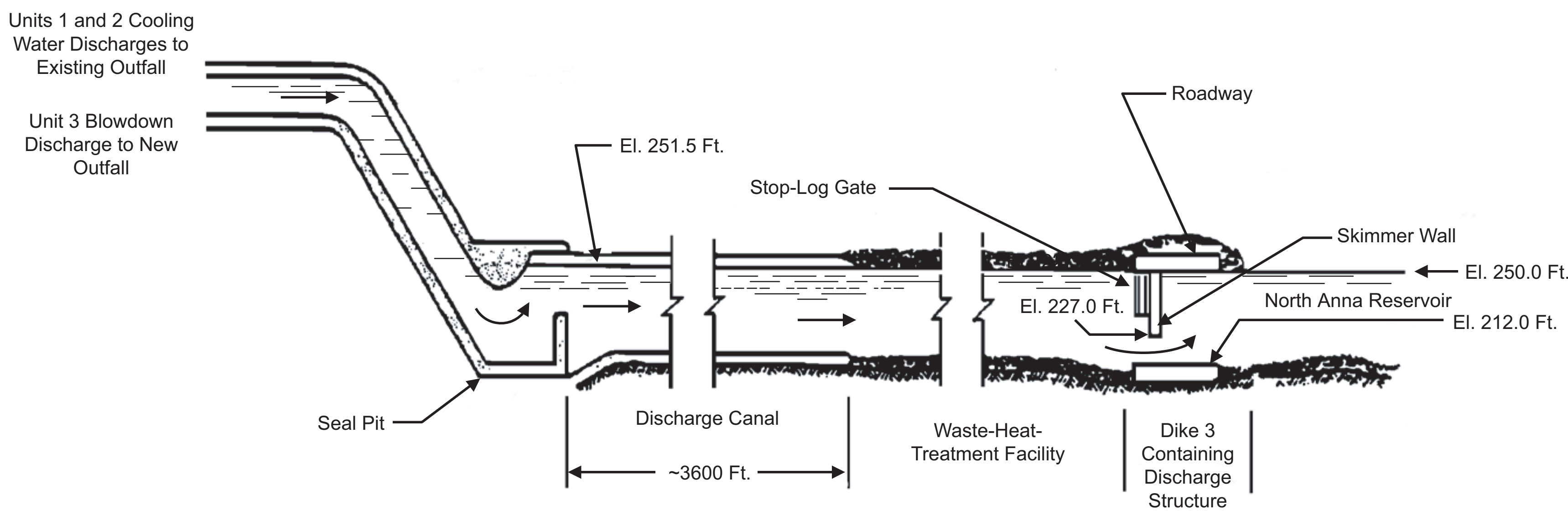


Figure 3.4-7 Schematic Diagram of the Discharge System

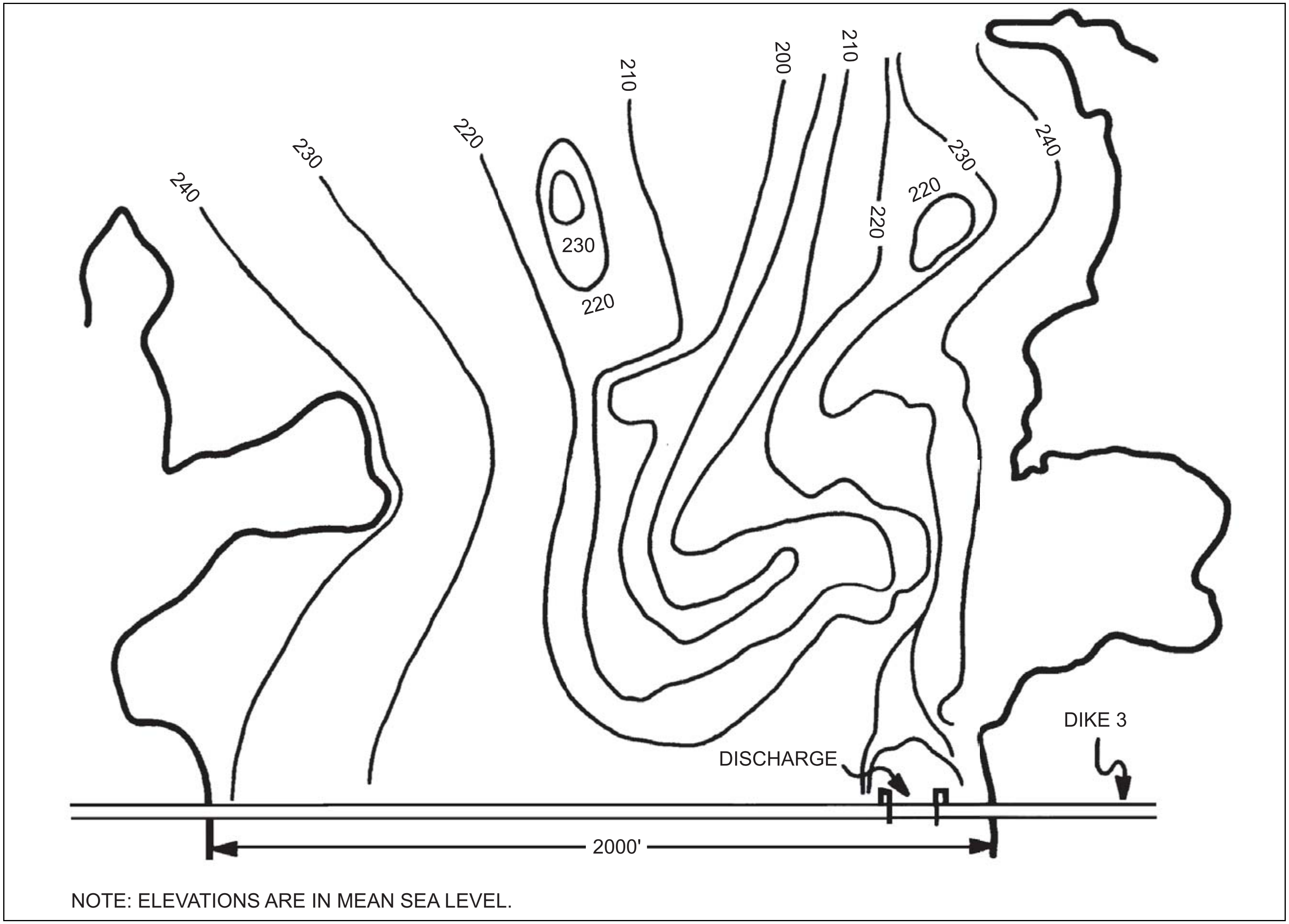


Figure 3.4-8 Location of Discharge Structure in Dike 3 and Bottom Topography of the North Anna Reservoir

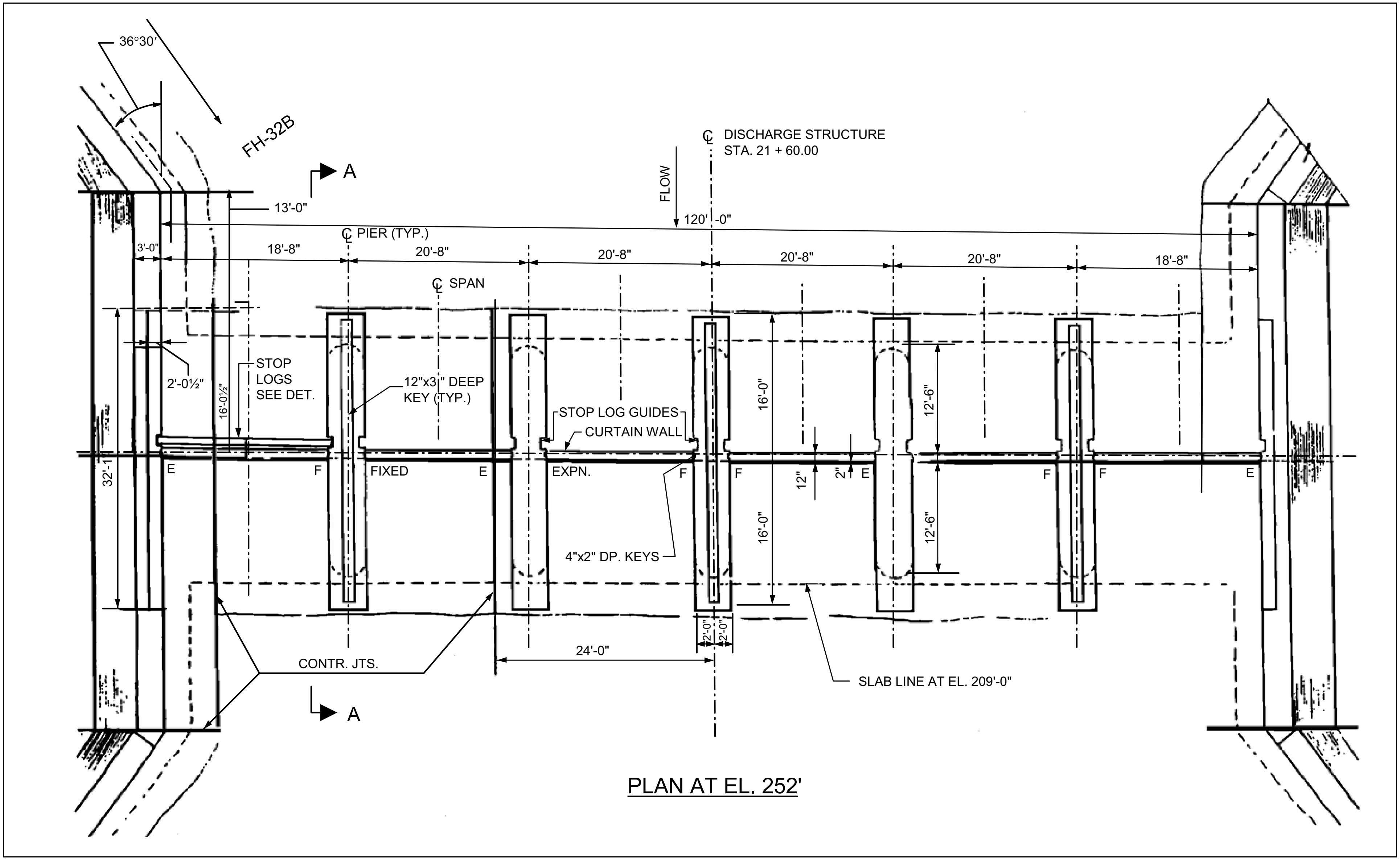


Figure 3.4-9 Water Discharge System from WHTF to North Anna Reservoir

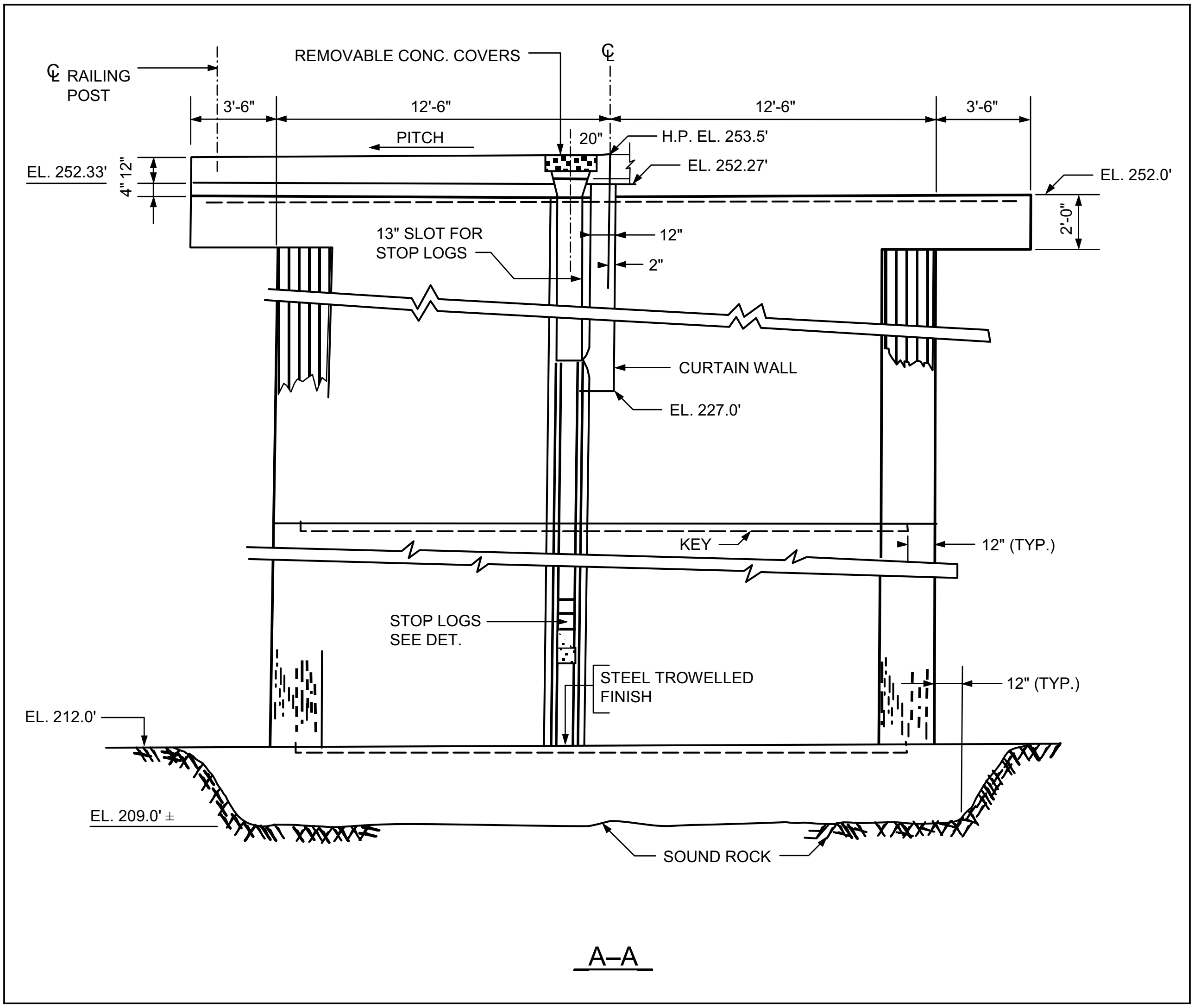


Figure 3.4-10 Water Discharge System from WHTF to North Anna Reservoir

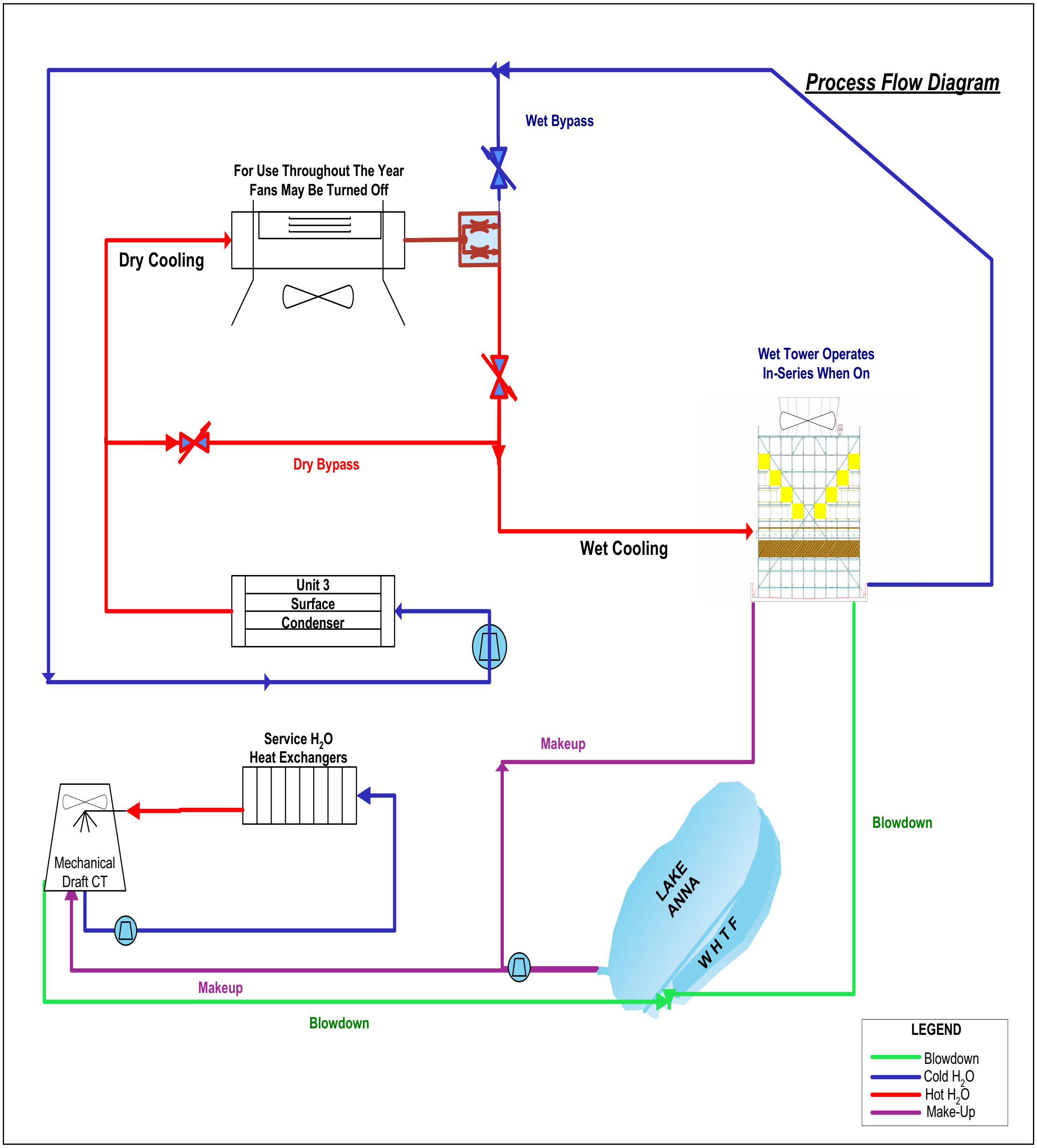


Figure 3.4-11 Conceptual Closed Loop Cooling Water Diagram

3.5 Radioactive Waste Management System

Because a reactor design has not been chosen for the ESP site, a Generic PPE was developed to characterize the generic bounding conditions for which the ESP site is suitable for development (See Section 3.1.3 and Table 3.1-1).

From the Generic PPE, a Bounding Site-Specific PPE was developed (Table 3.1-9). This site-specific 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 5.4-6 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 5.4-6 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.

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 5.4-7 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 Bounding Site-Specific PPE, Table 3.1-9.

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 be treated, but might still contain some low-level 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 chemicals that may be present in the plant’s permitted discharge:

- Iron
- Chlorides
- Ammonia or Amines
- Hydrazine
- Chlorine (sodium hypochlorite)
- Phosphates or dispersants used in cooling towers
- Low levels of oil and grease
- Corrosion inhibitors used in cooling systems
- Suspended solids

Discharges would occur from domestic water treatment, dry and wet cooling tower 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 approximately 3040 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 net electrical output of the new units is estimated to be 3040 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 output of the existing units and the new units would be:

$$1884 \text{ MWe} + 3040 \text{ MWe} = 4924 \text{ MWe}$$

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 flow 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 51.52 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 presented 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 AP1000 (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, 4500 MWt, nominal 1520 MWe. The AP1000 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 4500 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 34 MTU. In fact, the annual MTU of fuel normalized to equivalent electrical generation is significantly less that of the reference LWR, 21.9 for ABWR and 22.4 for the ESBWR versus 35 MTU per year for the reference case. 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 for thermal rating. The ESBWR deviates slightly from the maximum listed electrical

output due to a higher thermal efficiency. This higher thermal efficiency has no impact on the analysis.

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 U-235 enrichment not exceeding 4 percent by weight. The NRC has subsequently concluded that enrichment up to 5 percent is also bounding 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. The enrichment limit for LWRs at the ESP site is 5 percent U-235.

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. The burnup limit for LWRs at the ESP site is 62,000 MWd/MTU.

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 presented 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.

The enrichment and burnup limits for the gas-cooled reactors analyzed in this section are 19.8 percent U-235 and 133,000 MWd/MTU, respectively.

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 was 20 for both the PBMR and GT-MHR. The number of shipments normalized to the electrical generation changes to 14 for the PBMR and 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 113 based on a 40-year period, while the normalized number of truck shipments for the gas-cooled reactor technologies would require as few as 31 for the PBMR and only 53 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 60 to 82 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 presented 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 presented 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) (4500 MWt) (1520 MWe)	**ABWR** (Single unit) (4300 MWt) (1500 MWe)	**AP1000** (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	4500	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	45,000–55,000	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) (4500 MWt) (1520 MWe)	ABWR (Single unit) (4300 MWt) (1500 MWe)	AP1000 (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 $\times$ 4 modules; 80 elements per truck)	44 shipments (260,000 fuel spheres per module $\times$ 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 $\times$ 4 modules; 80 elements per truck)	20 shipments (120,000 fuel spheres per module $\times$ 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 $\times$ 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 $\times$ 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.