9.4 ALTERNATIVE PLANT AND TRANSMISSION SYSTEMS

The information presented in this section describes the evaluation of the alternative plant and transmission systems for heat dissipation, circulating water, and power transmission associated with the 1,600 MWe Bell Bend Nuclear Power Plant (BBNPP) facility. The information provided in this section is consistent with the items identified NUREG-1555 (NRC, 2007).

Throughout this chapter, environmental impacts of the alternatives will be assessed based on the significance of impacts, with the impacts characterized as being SMALL, MODERATE, or LARGE. This standard of significance was developed using the guidelines set forth in the footnotes to Table B-1 of 10 CFR 51, Appendix B to Subpart A (NRC, 2001):

> SMALL. Environmental effects are not detectable or are so minor they will neither destabilize, nor noticeably alter, any important attribute of the resource.
>
> MODERATE. Environmental effects are sufficient to alter noticeably but not to destabilize important attributes of the resource.
>
> LARGE. Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The impact categories evaluated in this chapter are the same as those used in the "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (GEIS), NUREG-1437, (NRC, 1996).

Section 9.4.1 discusses alternative heat dissipation systems. Section 9.4.2 discusses alternative circulating water systems. Section 9.4.3 discusses the transmission systems.

9.4.1 Heat Dissipation Systems

This section discusses alternatives to the proposed heat dissipation system that was described in Section 3.4, and is presented using the format provided in NUREG 1555 (NRC, 2007), i.e., Environmental Standard Review Plan (ESRP) 9.4.1.

These alternatives are generally included in the broad categories of "once-through" and "closed-loop" systems. The once-through method involves the use of a large quantity of cooling water, withdrawn from a water source and returned to that source (receiving water body) following its circulation through the normal heat sink (i.e., main condenser). Generally, closed-loop cooling systems require the intake of significantly less water than the volume required by once-through cooling systems because the water performing the cooling is continually recirculated through the normal heat sink (i.e., the main condenser), and normally only makeup water for evaporative losses, drift, and blowdown is required.

In closed-loop systems, two pumping stations are usually required-a makeup water system and a cooling water circulation system. Closed-loop systems include cooling towers and a cooling pond or spray pond. As a result of the evaporation process, the concentration of chemicals in the water will increase. To maintain acceptable water chemistry, water must be discharged at a small rate (blowdown) and compensated by a makeup water source.

Heat dissipation systems are also categorized as wet or dry, and the use of either system depends on the site characteristics. Both wet and dry cooling systems use water as the heat exchange medium. Wet heat dissipation systems cool water by circulating it through a cooling tower. Heat from the water is dissipated by direct contact with air circulating through the tower. The heat transfer takes place primarily by evaporation of some of the water into the air stream (latent heat transfer).

Generally, a relatively minor amount of sensible heat transfer (heating of the air and cooling of the water) also occurs. During very cold weather, the amount of sensible heat transfer can be fairly substantial. On the other hand, during a warm, dry summer day, the amount of sensible heat transfer may be nil or even negative (when negative, the air discharged from the tower is cooler than the ambient dry bulb). This does not adversely affect the cold water performance of mechanical draft towers, but does affect evaporation rate. The wet cooling tower is used widely in the industry and is considered a mature technology.

Because wet cooling towers provide direct contact between the cooling water and the air passing through the tower, some of the liquid water may be entrained in the air stream and be carried out of the tower as "drift" droplets. The magnitude of drift loss is influenced by the number and size of the droplets produced within the cooling tower, which in turn are influenced by the fill design, the air and water patterns, and other interrelated factors. Tower maintenance and operation levels can influence the formation of drift droplets. For example, excessive water flow, excessive air flow, and water bypassing the tower drift eliminators can promote and/or increase drift emission.

To reduce the drift from cooling towers, drift eliminators are usually incorporated into the tower design to remove as many droplets as practical from the air stream before exiting the tower. The drift eliminators rely on inertial separation of the droplets, caused by direction changes, while passing through the eliminators. Types of drift eliminator configurations include herringbone, wave form, and cellular (or honeycomb) designs. The cellular units are generally the most efficient. Drift eliminators may include various materials, such as ceramics, fiber-reinforced cement, fiberglass, metal, plastic, and wood installed or formed into closely spaced slats, sheets, honeycomb assemblies, or tiles. The materials may include other features, such as corrugations and water removal channels, to enhance the drift removal further (USEPA, 1995).

Dry cooling systems transfer heat to the atmosphere without the evaporative loss of water. There are two types of dry cooling systems: direct dry cooling and indirect dry cooling. Direct dry cooling systems use air to directly condense steam, while indirect dry cooling systems use a closed-loop water cooling system to condense steam and air to cool the heated water.

The most common type of direct dry cooling system is a recirculated cooling system with mechanical draft towers. For dry cooling towers, the turbine exhaust steam exits directly to an air-cooled, finned-tube condenser. Because dry cooling systems do not evaporate water for heat transfer, dry cooling towers are quite large in comparison to similarly sized wet cooling towers. Also, because dry cooling towers rely on sensible heat transfer, a large quantity of air must be forced across the finned tubes by fans to improve heat rejection. This results in a larger number of fans being required for a mechanical draft dry cooling tower than would be needed for a mechanical draft wet cooling tower.

The key feature of dry cooling systems is that no evaporative cooling or release of heat to the surface water occurs. As a result, water consumption rates are very low compared to wet cooling. Because the unit does not rely in principle on evaporative cooling like the wet cooling tower, large volumes of air must be passed through the system compared to the volume of air used in wet cooling towers. As a result, dry cooling towers need larger heat transfer surfaces and therefore tend to be larger than comparable wet cooling towers.

Dry cooling towers require high capital and operating and maintenance costs that are sufficient to pose a barrier to entry to the marketplace for some facilities (USEPA, 2001). Dry cooling technology has a detrimental effect on electricity production by reducing the energy efficiency of steam turbines. Dry cooling requires the facility to use more energy than would be required with wet cooling towers to produce the same electricity. The energy penalty would result in an increase in environmental impacts because replacement generating capacity would be needed to offset the loss in efficiency from dry cooling.

9.4.1.1 Evaluation of Alternative Heat Dissipation Systems

Heat dissipation system alternatives were identified and evaluated. The alternatives considered were those generally included in the broad categories of "once- through" and "closed-loop" systems. The evaluation includes the following types of heat dissipation systems:

- Other heat dissipation systems
  - Cooling Ponds
  - Spray Ponds
- Once-through cooling
- Natural draft cooling tower
- Mechanical draft cooling tower
- Hybrid (plume abated) cooling towers
- Dry cooling systems (closed-loop cooling system)

An initial evaluation of the once-through cooling alternative and the closed-loop alternative designs was performed to eliminate systems that are unsuitable for use at the BBNPP site. The evaluation criteria included aesthetics, public perception, space requirements, environmental effects, noise impacts, fog and drift, water requirements, capital and operating costs, and legislative restrictions that might preclude the use of any of the alternatives.

The screening process identified two natural draft cooling towers as the preferred closed loop heat dissipation system for the BBNPP site. The analysis of this alternative is discussed in Section 9.4.1.3. The discussion of non preferred alternatives that were considered is provided below. Selection of the preferred heat dissipation alternative was supported by detailed net present value (NPV) analysis.

Table 9.4-1 and the following sections provide a discussion of the heat dissipation alternatives, and Table 9.4-2 provides a summary of the environmental impacts of the alternatives.

Cooling Ponds and Spray Ponds

Cooling ponds are usually man-made water bodies that are used by power plants and large industrial facilities for heat dissipation. In a conventional static type cooling pond, warmed cooling water exiting the main condenser and other plant heat loads would be routed to the cooling pond where some of the water would evaporate, and the remaining water would be cooled and recirculated to the plant. The primary heat transfer mechanism in a cooling pond is evaporation. If there is no vertical mixing in the pond, layers (or thermoclines) of warm and cold water can form causing horizontal flows which in turn can restrict the movement of warmer water to the surface for evaporation and cooling. This can result in only portions of the pond cooling capacity being used.

Although the conventional static type cooling pond is probably the oldest form of water cooling it is not preferred for several reasons. The modern spray pond offers the following advantages over a conventional cooling pond: (1) a spray pond requires less than 10% of the land area required for a conventional pond, and (2) they provide over 30 times the cooling capacity of a conventional pond on a BTU/ft^2 basis.

A spray pond is typically a bentonite-lined structure in the ground, and is typically long and narrow to improve efficiency. The spray pond structure contains a volume of water and consists of an intake structure that houses pumps to transfer the water from the pond through their respective loops and back to the pond through a network of sprays located in the pond. The spray pond size depends on the number of nozzles required. It is important that the long, narrow spray pond have its long side perpendicular to the prevailing summer wind direction in order to benefit from a better spray droplet surface area and air contact interface. Generally, a spray pond long side dimension would be in the range of two to four times that of the narrow side dimension.

The area of the pond is determined by the quantity of water which it can treat per hour per unit area of the pond. Accepted industry practice for sizing spray ponds is based on values that are typically between 120 lb/ft^2/hr (585 kg/m^2/hr) and 150 lb/ft^2/hr (732 kg/m^2/hr). In actual practice, a spray pond will only cool the water to a point approximately midway between the hot water and wet bulb temperatures. Because of the various factors in spray pond applications, it is virtually impossible to accurately calculate the expected cooled water temperature. The 50% design efficiency factor (cooling to halfway point between hot water and wet bulb temperature) is considered to be a reasonable value for a well designed and located, long and narrow, spray pond.

Due to evaporation loss of water from the pond, the water levels in cooling and spray ponds are usually maintained by rainfall or augmented by a makeup water system operating on pond level.

Cooling ponds require a relatively large amount of land. For example, for a 1,300 MW power plant, a cooling pond with a surface area of approximately 2,470 ac (10 km^2) is required to be able to maintain a cooling water temperature of 70°F (21°C) with a dry air temperature of 54°F (12°C) and relative humidity of 57% (ENS, 2008). Given the relatively large amount of land that would be required for a cooling pond or spray pond option, which is not available at the BBNPP site, and expected thermal performance, neither the spray pond nor the cooling pond alternative is suitable for the BBNPP.

<u>Once-through Cooling System Using Susquehanna River Water</u>

In a once-through cooling system, water is withdrawn from a water body, passes through the heat exchanger, and is discharged back to the same water body. The discharged water temperature is higher than the intake by the temperature gained when passing through the heat exchanger. For BBNPP, a once-through cooling system would require approximately 2.5 million gpm (9.5 million lpm) considering a 10°F (5.6°C) temperature rise across the condenser. Because this exceeds 36% of the average annual flow of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (SSES) Units 1 and 2, which is approximately 6.87 million gpm (NRC, 2008), this option was not considered feasible for BBNPP.

Once-through cooling systems are required to comply with Federal and State regulations for thermal discharges into the Susquehanna River. Additionally, U.S. Environmental Protection Agency (USEPA) regulations governing cooling water intake structures under Section 316(b) of the Title 33 United States Code (USC) Part 1326, Federal Water Pollution Control Act (USC, 2007) make it difficult for steam electric generating plants to use once through cooling systems (FR, 2004).

Natural Draft Cooling Tower

Wet cooling towers predominantly rely on the latent heat of water evaporation to exchange heat between the water and the air passing through the tower. In a natural draft cooling tower, warm water is brought into direct contact with cooler air. When the air enters the cooling tower, its moisture content is generally less than saturation. When the air exits, it emerges at a higher temperature and with moisture content at or near saturation.

Even at saturation, cooling can take place because a temperature increase results in an increase in heat capacity, which allows more sensible heat to be absorbed. A natural draft cooling tower receives its air supply from natural wind currents that result in a convective flow up the tower. This air convection cools the water on contact.

Because of the significant size of natural draft cooling towers (typically 500 ft (152 m) high, 400 ft (122 m) in diameter at the base), their use is generally reserved for use at flow rates above 200,000 gpm (757,000 lpm) (Young, 2000). They are typically sized to be loaded at about 2 to 4 gpm/ft^2 (1.4 to 2.7 lps/m^2). Natural draft cooling towers were evaluated in the heat dissipation optimization study. As discussed in Section 9.4.1.3, two round natural draft cooling towers with a 16°F approach temperature were selected as the preferred heat dissipation system for the BBNPP. The towers will have concrete shells and heights of approximately 475 ft, with basin diameters of 350 ft and tower diameters of 222 ft. The recommended flow rate of cooling water through the two natural draft towers at the BBNPP is 720,000 gpm. The footprint for the two towers is 8.8 acres.

Mechanical Draft Cooling Tower

A wet mechanical draft cooling tower system, operated completely as a wet type cooling tower, would consist of multi-cell cooling tower banks, and associated intake/discharge, pumping, and piping systems. This closed-loop system would receive makeup water from the Susquehanna River and transfer heat to the environment via evaporation and conduction. These towers would have a relatively low profile of approximately 80 ft (24 m). Mechanical draft towers use fans to produce air movement.

A mechanical draft cooling tower would typically consist of a continuous row of rectangular cells in a side-by-side arrangement sharing a common cold water basin. Water to be cooled is pumped to a hot water distribution system above the fill, and then falls over the fill to the cold water basin. Air is drawn through the falling water by fans, which results in the transfer of heat from the water to the air, and the evaporation of some of the water. The fill serves to increase the air-water contact surface and contact time, thereby promoting heat transfer.

A mechanical draft cooling tower employs large fans to either force or induce a draft that increases the contact time between the water and the air maximizing the heat transfer. A forced draft tower has the fan mounted at the base, forcing air in at the bottom and discharging air at low velocity through the top. An induced draft tower uses fans to create a draft that pulls air through the cooling tower fill (i.e., the internal packing that provides an expanded surface for air-water interface).

As discussed in Section 9.4.1.3, both round and rectangular mechanical draft cooling tower designs were considered feasible for BBNPP and evaluated further in the heat dissipation optimization study. Both concrete and fiberglass were considered as materials for construction of the mechanical draft cooling towers. Based on a detailed NPV analysis, the mechanical draft cooling tower options had a higher total NPV for BBNPP than the two natural draft cooling tower option.

Hybrid Plume Abatement Cooling Tower

A cooling tower plume occurs when the heated and saturated air leaving a wet cooling tower mixes with the relatively cooler ambient air under atmospheric conditions, and a supersaturated condition occurs during the process of mixing and dispersion. The excess vapor condenses (the amount in excess of saturation vapor) and becomes a visible plume.

A cooling tower plume may be visually objectionable or may result in problems of fogging or icing. A plume abatement hybrid cooling tower (i.e., combination wet-dry tower) combines dry cooling and wet cooling to reduce the cooling tower plume. The dry cooling section adds heat to the discharge air without adding moisture (sensible heat transfer). This results in a subsaturated air stream leaving the tower (less than 100% relative humidity) and therefore reduced plume potential.

Although the hybrid plume abatement cooling tower results in reduced water consumption and no visible plume, construction costs, operating and maintenance costs, and land use requirements are significantly higher. Therefore, the hybrid plume abatement cooling tower was not the preferred alternative for BBNPP.

Dry Cooling System

Dry cooling is an alternative cooling method in which heat is dissipated directly to the atmosphere using a tower without the evaporative loss of water (USEPA, 2001). This tower transfers the heat to the air by conduction and convection rather than by evaporation. The condenser coolant is enclosed within a piping network with no direct air to water interface. Heat transfer is then based on the dry bulb temperature of the air and the thermal transport properties of the piping material. Both natural and mechanical draft can be used to move the air. While water loss is less for dry cooling towers than wet cooling towers, some makeup water is typically required.

There are two types of dry cooling systems for nuclear power generating facility applications: direct dry cooling and indirect dry cooling. Direct dry cooling systems utilize air to directly condense steam, while indirect dry cooling systems utilize a closed loop water cooling system to condense steam, and the heated water is then air cooled. Indirect dry cooling generally applies to retrofit situations at existing power generating facilities because a water cooled condenser would already be in place for a once through or closed loop cooling system (USEPA, 2001).

Because there are no evaporative or drift losses in this type of system, there are no potential issues with blowdown disposal, water availability, chemical treatment, fogging, or icing when dry cooling towers are utilized. However, the dry towers have associated technical obstacles such as high turbine backpressure and possible freezing in cooling coils during periods of light load and startup.

Unfortunately, a dry cooling system affects plant performance so significantly that the net effect is an increased environmental impact. Dry cooling results in a significant reduction in plant output (approximately 25%). An objective comparison of dry versus wet cooling would therefore require the installation of a larger facility to compensate for the impact of dry cooling. The environmental impact of a larger facility far outweighs the environmental advantages of dry cooling.

Use of a dry system would also require a significant increase in dry cooling land use compared to wet cooling. An air-cooled condenser, where steam turbine exhaust is transported directly to a steam-to-air heat exchanger, has technical limitations due to its physical size. The distances from the main steam turbine condensers to the air-cooled condensers and the size of the steam ducting required would be uncommonly large and would far exceed the largest steam duct ever attempted.

Dry cooling material operation and maintenance (O&M) costs would be significantly greater than wet cooling. Dry cooling land use would increase significantly, and the system would require periods of significant unit power output reduction during periods of high ambient air temperatures. For the reasons stated above, the use of a dry tower was not considered as a feasible alternative for BBNPP.

This alternative is not considered suitable for BBNPP for the reasons discussed in the USEPA preamble to the final rule addressing circulating water intake structures for new facilities.

9.4.1.2 Analysis of Hybrid Cooling Tower without Plume Abatement Alternative

A hybrid cooling tower system without plume abatement has higher operating and maintenance costs and electric power demand than the natural draft towers. Therefore, this alternative is not preferred for proposed BBNPP.

9.4.1.3 Summary of Alternative Heat Dissipation Evaluation

As discussed earlier in this section, natural draft cooling towers provide a lower life-cycle cost due to the lower O&M costs. It is therefore the preferred alternative to transfer heat loads from the CWS to the environment.

Four cooling tower options were evaluated as part of the heat rejection system optimization study:

- Natural draft towers (one and two shells variations at two different design approach temperatures)
- Rectangular mechanical draft cooling towers (two and three tower variations)
- Round mechanical draft cooling towers (three and four shell variations)
- One round mechanical draft cooling tower (also known as fan-assisted natural draft cooling tower)

The evaluation assumed that if the predicted differences in net economic benefit were small, then other considerations might be given higher weight. Other considerations include site layout, aesthetics, corporate preferences related to O&M issues, initial cost, risk associated with tower technology or vendor capability, and associated site work for arrangement and fitting of cooling water piping fit up to tower.

A review of the cooling tower blowdown in hot months was performed. To maintain tower blowdown at temperatures below expected environmental constraints, several blowdown cooling options were reviewed. The need for such a system will depend on final permitting requirements.

Each of the cooling tower options were evaluated at three different circulating water flow rates using two different weather profiles (the representative "hot" year and the "average" year): 1,604.16 ft^3/sec (45.43 m^3/s), or 720,000 gpm; 1,782.40 ft^3/sec (50.48 m^3/s), or 800,000 gpm; and 1,960.64 ft^3/sec (55.53 m^3/s), or 880,000 gpm. In addition, an energy rate was applied to the net production differences between the base case and each option. For this evaluation, "net power" referred to gross production less the circulating water pump and tower fan power consumed for each option. Auxiliary power serving the power block was common to all options and, therefore, was not considered for the evaluation. For the base case, the natural draft cooling tower option with a 1,782.40 ft^3/s (50.48 m^3/s) or 800,000 gpm circulating water flow rate was used.

It was determined that the environmental impacts of the four cooling tower alternatives evaluated were SMALL to MODERATE. Therefore, in considering the comparison of the various cooling tower options, three main costs and benefits were considered:

- Production - This evaluation calculated the detailed NPV for production benefits for an average and the hot single year of facility operation for each cooling tower option (summation of 8,760 hourly computations).
- Initial cost - The initial overnight cooling tower cost was based on vendor input and expected cost differences associated with procurement, support systems, and general contractor items to integrate the towers into the site.
- Maintenance - Inspection and maintenance (replacement parts) cost differences were considered over the anticipated 60 years of the facility life.

Blowdown from the towers, whether of natural or mechanical draft design, is required to maintain tower water chemistry within design limits. Blowdown will be regulated by environmental permits. It was assumed that the blowdown would be limited to a maximum temperature of 87°F (30.6°C), for purposes of the study, based on the protection of warm water fishes in the Susquehanna River.

With expected extreme wet bulb tempertatures in range of 70°F to 75°F (21.1°C to 23.9°C), and expected approach temperatures for aged towers to be in the range of 10°F to 15°F (5.6°C to 8.3°C), a potential exists that blowdown temperatures might exceed 87°F for critical production times in the hottest weather.

Two options were considered to address high blowdown temperatures: (1) a dedicated small cooling tower for blowdown and (2) blowdown cooled by makeup using a plate-and-frame heat exchanger. A makeup/blowdown system designed to cool blowdown using a plate-and-frame heat exchanger was determined to be a cost-effective option to reduce blowdown temperatures as needed to maintain environmental limits and eliminate constraints on main tower performance. This option would be common to all of the alternatives in the study and would depend on the final NPDES permit.

The cooling tower performance evaluation demonstrated that the two shell natural draft cooling tower design resulted in the largest yearly gross generation revenue for all cases considered. However, this is also the cooling tower option with the highest initial cost.

Two natural draft cooling towers with basin diameters of 350 ft (107 m), tower diameters of 222 ft (68 m), and heights of 475 ft (145 m) were selected for the proposed BBNPP based on an evaluation of the economics, siting, and risk associated with tower technology and vendor capability. Increased capital costs associated with installing natural draft towers were offset by increased net electricity generated.

9.4.2 Circulating Water Systems

In accordance with NUREG-1555 (NRC, 2007), ESRP 9.4.2, this section discusses alternatives to the following components of the CWS for the BBNPP. These components include the intake systems, discharge systems, water supply, and water treatment processes. A summary of the environmental impacts of the circulating water intake system alternatives for BBNPP is provided in Table 9.4-3.

The CWS is an integral part of the heat dissipation system. It provides the interface between (1) the normal heat sink (i.e., main steam turbine condenser) where waste heat is discharged from the steam cycle and is removed by the circulating water, and (2) the heat dissipation system where the heat energy is then dissipated or transferred to the environment.

Essentially, two types of CWSs are available for removing this waste heat: once-through (open-loop) and recycle (closed-loop) systems. In once-through cooling systems, water is withdrawn from a cooling source, passed through the condenser, and then returned to the source (receiving water body). In the recycle (closed-loop) cooling system, heat picked up from the condenser by the circulating water is dissipated through auxiliary cooling facilities, after which the cooled water is recirculated to the condenser.

As discussed in Section 9.4.1, the CWS for BBNPP will be a closed-loop system with two round natural draft cooling towers with associated pumps, piping, and cold water retention basins that will be operated as wet cooling towers year-round.

BBNPP requires water for cooling, operational, and potable and sanitary uses. The sources of water supply are the Susquehanna River and municipal water from the Berwick District of Pennsylvania American Water (PAW). Water from the Susquehanna River provides makeup water for facility cooling and power facility operations. Municipal water from PAW is used to satisfy the demands of potable, sanitary, and miscellaneous facility systems, such as the demineralized water treatment system and the fire protection system.

Water from the CWS will be pumped from the cooling tower basin through the main steam turbine condensers and turbine facility auxiliary heat exchangers, where heat transferred to the cooling water in the condenser will be dissipated to the atmosphere by evaporation, cooling the water before its return to the condenser. The water from the cooling system lost to the atmosphere through evaporation must be replaced. This evaporation would increase the level of solids in the circulating water. To control solids, a portion of the recirculated water must be removed (generating blowdown) and replaced with clean water. In addition to the blowdown and evaporative losses, a small percentage of water in the form of drift droplets will be lost from the cooling tower.

As stated in Section 3.3.1 and Section 3.4.1.1, the cooling water withdrawal rate for the CWS will normally be approximately 23,808 gpm (90,113 lpm), and maximum water withdrawal will be approximately 23,808 gpm (90,113 lpm). These withdrawals include consideration of losses due to evaporation, drift, and blowdown. A fraction of the intake water will be used to clean debris from the traveling screens. Blowdown from the CWS cooling tower will be returned to the Susquehanna River. The blowdown water will enter the discharge pipe where it will mix with the blowdown from the Essential Service Water System cooling towers during its passage to the outfall. The discharge is not likely to produce tangible aesthetic or recreational impacts.

Mechanical draft cooling towers with water storage basins (i.e., one basin for each of the four trains) comprise the Ultimate Heat Sink (UHS) System which functions to dissipate heat rejected from the Essential Service Water System (ESWS) as described in ER Section 3.3.1. The supply of the ESWS is vital for all phases of plant operation and is designed to provide cooling water during power operation and shutdown of the plant. Under normal operating and normal shutdown/cool down conditions, the UHS water storage basins will be supplied with treated non-safety related makeup water provided by the Raw Water System (RWS).

9.4.2.1 Intake and Discharge Systems

For both once-through and closed-loop cooling systems, the water intake and discharge structures can be of various configurations to accommodate the source water body and to minimize impact to the aquatic ecosystem. The intake structures are generally located along the shoreline of the body of water and are equipped with fish protection devices. The discharge structures are generally of the jet or diffuser outfall type and are designed to promote rapid mixing of the effluent stream with the receiving body of water. Biocides and other chemicals used for corrosion control and for other water treatment purposes may be mixed with the condenser cooling water and discharged from the system.

Cooling water intake structures (CWIS) are typically regulated under Section 316(b) of the Federal CWA and its implementing regulations (FR, 2004). A federal court decision in January 2007 changed that regulatory process. The regulations that implement Section 316(b) were effectively suspended, and the USEPA recommended that all permits for Phase II facilities should include conditions under Section 316(b) developed on a best professional judgment basis (USEPA, 2007). In the Commonwealth of Pennsylvania, the 316(b) process is being managed by the Pennsylvania Department of Environmental Protection.

The Federal CWA and associated cooling water intake structures implementing regulations for Section 316(b) define acceptable levels of impingement and entrainment. Cooling water intake structure regulations require the facility to mitigate impingement loss to the extent that the costs for the mitigation are not greater than the benefits. Specifically, the location, design, construction and capacity of cooling water intake structure must reflect the best technology available (BTA) for minimizing adverse environmental impact.

Intake and discharge structures will be required for operation of BBNPP. Alternatives evaluated for BBNPP are described in the following sections.

Impacts associated with the BBNPP Intake Structure and discharge structure for BBNPP are described below (see also Table 9.4-3). No long term physical changes in land use are anticipated from construction of the BBNPP Intake Structure, the pumphouse, and the makeup water and blowdown pipeline corridor. Construction activities will cause only temporary effects to shallow pools, streams, and wetlands. The proposed BBNPP Intake Structure and discharge structure will be designed to meet applicable O&M and navigation criteria and requirements. The discharge structure will be designed to allow for an acceptable mixing zone for the thermal plume per state regulations for thermal discharges.

Long-term changes in land use from operation of BBNPP intake and discharge system will be associated primarily with the makeup water pipeline, BBNPP Intake Structure, pumphouse, and blowdown pipeline. The long term impacts on land use are expected to be SMALL to MODERATE.

Short term changes in land use from operation of BBNPP intake and discharge system will be associated primarily with impacts resulting from the increase in the stormwater due to development of BBNPP intake and discharge structures and equipment. Short-term changes in land use would be minor. More detail on short-term changes in land use is provided in Section 4.1.

Measures, such as accepted best management practices (BMPs), will be taken during construction activities at BBNPP intake and discharge system site to minimize effects to ground and surface waters. Relevant federal, state, and local permits and regulations will be followed during construction activities. Adhering to the conditions specified in the permits and regulations should minimize temporary effects. Specific erosion control measures will be implemented to minimize effects to the Susquehanna River water quality. More detail on erosion control measures to be implemented is provided in Section 4.1 though Section 4.3. In addition, BBNPP site preparation and construction activities will comply with BMPs and with federal, state, and local regulations to prevent adverse aquatic ecological effects along the Susquehanna River.

PPL is committed to conducting a Phase I cultural resource assessment for the proposed BBNPP intake and discharge system site to determine the potential to affect cultural resources (such as archeological, historical, or architectural resources). Both a Phase Ia assessment and a Phase Ib assessment have been completed. During site preparation for the proposed BBNPP intake and discharge system, construction activities, such as clearing and grading activities, will have localized noise and air quality effects. Construction noise will occur during construction activities and while installing equipment. As a result, background noise levels will increase in the short term. To minimize the increased ambient noise, mitigation measures will be implemented. Additionally, controls will be implemented to mitigate potential air emissions from construction sources. Slight but negligible increases in emissions of particulate matter (PM) and combustion byproducts might occur during proposed BBNPP intake and discharge system site preparation and construction activities.

Construction-related dust and air emissions from equipment are expected to be SMALL and will be controlled by implementing mitigation measures. More detail on construction-related impacts is provided in Chapter 4 of the BBNPP ER.

Site preparation and construction activities may result in some temporary visual aesthetic disturbance. Because these impacts will be temporary, no long term indirect or cumulative impacts to visual aesthetics are expected.

Intake System

Alternative intake systems and locations were evaluated for the BBNPP based on engineering, regulatory, and environmental factors. Key considerations in determining the intake system and location included considerations associated with the size of the intake structure, distance and routing of the pipeline to the source location, accessibility of the intake system/structure, location of the existing SSES blowdown line, and environmental impacts from construction and operation (e.g., wetlands, archeological resources, aquatic ecology, etc.). Areas to the south and north of the existing SSES intake location at the Susquehanna River were considered in the evaluation. Areas south and north present potential impacts to wetlands and archeological sites. Distance of the pipeline was also a potential issue with sites to the south of the existing SSES discharge location.

The location of the intake structure and associated pipeline was selected on PPL property along the Western bank of the Susquehanna River. Locating the intake structure on PPL property maximizes the use of previously disturbed areas and avoids impacts associated with the acquisition of additional property or easements to support the new intake line. Locating the intake structure and pipeline on PPL property also provides the added benefit of utilizing existing infrastructure, such as access roads, further reducing environmental impacts.

As stated previously, the evaluation of the intake structure location also considered wetlands located both south and north of the existing SSES intake structure. The evaluation also considered known archeological sites near the existing SSES intake structure. The area selected for the intake structure has been previously disturbed and would not impact wetlands or archeological sites.

Thermal and radiological modeling was also factored into the selection of the intake location. A key parameter in the modeling was a minimum distance between the BBNPP intake and the SSES discharge of 275 ft (84 m). The actual distance between the BBNPP intake and SSES discharge is approximately 380 ft (168 m).

Table 9.4-3 presents a comparison of the alternate intake systems and locations considered in the review.

As stated in Section 3.4.2.1, the intake structure will be located east of the BBNPP power block on the west bank of the Susquehanna River. The forebay of the intake structure is on the bank of the Susquehanna River, perpendicular to the river's flow to minimize the potential of fish entering the intake structure as shown on Figure 3.4-3. The flow velocities at the intake structure would be less than 0.5 fps (0.15 mps). The area from the river bed to the forebay is designed to allow for gradual transition without excessive turbulence. The new intake structure will be an approximately 124 ft (37.8 m) long, 90 ft (27.4 m) wide structure with individual pump bays. Three 50% capacity, vertical shaft CWS makeup pumps provide up to 26,200 gpm (99,200 lpm) of makeup water. Three 50% capacity, vertical shaft RWSS pumps provide up to 5,800 gpm (22,000 lpm) of service water. In the intake structure, one CWS makeup pump and one RWSS pump are located in each pump bay, along with one traveling screen. There are cross bay stop log slots to permit isolation of pumps on an individual bay basis. Flow through the bar grating from the river feeds the pumps. Debris collected by the bar grating and the traveling screens will be collected in a debris basin for cleanout and disposal as solid waste. The through-bar grating and through-screen mesh flow velocities will be less than 0.5 fps (0.15 mps). The dual flow type of traveling screens with a flow pattern of double entry-center exit will be used for each bay. This arrangement prevents debris carry over. The screen panels have a mesh size of 0.08 in^2 (2 mm^2). The screen mesh is mechanically rotated above the water for cleaning via spray water. The screen wash system consists of three screen wash pumps that provide a pressurized spray to remove debris from the water screens. There is no need for a fish return system since the flow velocities through the screens are less than 0.5 fps (0.15 mps) in the worst case scenario (minimum bay level with highest makeup demand flow).

The growth of slime, algae, and other organic materials will be monitored in the intake structure and their components, as well as the accumulation of debris on the bar grating and trash rake. Cleaning will be performed, as necessary.

Discharge System

The appropriate location of the BBNPP discharge structure was evaluated based on engineering design factors and potential environmental impacts.

Careful consideration was given to potential thermal and radiological impacts during siting of the BBNPP discharge structure near the existing SSES discharge structure. Thermal and radiological modeling performed identified a minimum distance of 380 ft (116 m) for separation of the two discharge structures.

As described in Section 3.4.2.2, the discharge structure will be designed to meet all applicable navigation and maintenance criteria, and to provide an acceptable mixing zone for the thermal plume per the Commonwealth of Pennsylvania regulations for thermal discharges. Figure 3.4-6 shows details of the discharge system. The discharge point is near the southwest bank of the Susquehanna River approximately 825 ft (251m) south of the intake structure for BBNPP and extends about 310 ft (95 m) into the river through a 24 in (61 cm) discharge pipe with diffuser port holes at the end of the line. The centerline elevation of the discharge diffuser is Elevation 476 ft (145 m) msl. The seventy-two 4 in (10 cm) diameter port holes are spaced center-to-center at 1.5 ft (0.5 m). The height of the port holes above the river bed varies as the river bed elevation varies. The angle of discharge is 45 degrees to horizontal. Riprap will be placed around the discharge diffuser to resist potential erosion. Fish screens are not required on the diffuser since there will always be flow through the discharge piping, even during outages, to maintain discharge of treated liquid radioactive waste within the concentration limits of the applicable local, state, and federal requirements.

As stated in Section 5.3.2.2, the effects of the proposed BBNPP discharge are anticipated to be similar to the SSES discharge, which has been monitored for 24 years. Based on the long-term monitoring of the SSES discharge and modeling of both the SSES and BBNPP discharges, the discharge of cooling tower blowdown and wastewaters from BBNPP is predicted to have a SMALL aquatic impact on the Susquehanna River in the vicinity of BBNPP.

9.4.2.2 Water Supply (Makeup Water System Alternatives)

BBNPP will require makeup water for the CWS and ESWS cooling towers to replace water inventory lost to evaporation, drift, and blowdown. Makeup water to the ESWS is normally supplied from the plant RWSS.

Several potential source water alternatives for BBNPP were identified based on engineering, regulatory, and environmental factors. Key considerations in determining the viability of source water alternatives were considerations associated with routing the pipeline to the source location; water quantity and quality; the reliability of future water supply; and environmental impacts (e.g., previous disturbances, archeological resources).

The following makeup water system alternatives were analyzed:

- Groundwater sources
- Municipal sources
- Susquehanna River

Summary of Makeup Water Alternatives

During normal plant operations, the BBNPP will require approximately 25,729 gpm (97,384 lpm) for cooling purposes (Section 5.2.1.2). This water demand (withdrawal) will rise to approximately 28,179 gpm (106,657 lpm) during refueling outages, which occur for approximately one month every two years.

Ground water is available at the site. The primary aquifer that has the greatest capacity to provide water is the Glacial Overburden aquifer. This aquifer is composed of sand and gravel outwash, kame, kame terrace, and morainal units that were deposited during the last major Pleistocene glacial advance. Two water production wells at the SSES can produce 50 and 150 gpm (189 and 568 lpm, respectively). One pumping test of a monitoring well at the BBNPP site showed that the aquifer could yield 60 gpm (227 lpm). Thus, the maximum sustained yield for a single well in this aquifer is estimated to be approximately 60 gpm (227 lpm). To produce sufficient water for refueling outages (i.e., peak demand), approximately 470 wells would be required. The wells would have to be separated sufficiently far apart so as not to cause interference problems, thus requiring a very large area for the wellfield. The aquifer is not capable of supporting such a large demand. If groundwater were to be extracted at such a high rate, the aquifer would be greatly dewatered and would impact the SSES production wells and the wetlands surrounding the site. Overall, the aquifer is not capable of supplying such a large water demand.

The local municipal water supply company (Pennsylvania American Water Company - Berwick District) will be supplying potable water to the BBNPP for drinking water, sanitary, and other non-cooling purposes. However, the maximum estimated water usage for these purposes is 236 gpm (893 lpm), which is less than one percent of the amount needed for cooling during refueling outages. The Pennsylvania American Water Company - Berwick District well field in Berwick, Pennsylvania (located five miles southwest of the BBNPP) is the largest public water supply company in Columbia and Luzerne counties. The average production rate of this well field is 1.74 million gpd (6.58E+06 lpd), or 1,208 gpm (4,574 lpm). The maximum daily production rate is 2.48 million gpd (9.39E+06 lpd), or 1,722 gpm (6,510 lpm) (PPL, 2006). Thus, the BBNPP cooling water demand exceeds the largest municipal water supply in the area.

Because the local groundwater resources and the largest municipal water supplier in the area cannot provide a sufficiently large supply of water to the plant, the Susquehanna River was selected as a safe and reliable source of cooling water for the BBNPP. Withdrawal (demand) and consumptive use on the Susquehanna River is regulated by the Susquehanna River Basin Commission (SRBC). The SRBC is an independent agency that manages water use along the entire length of the Susquehanna River (NRC, 2008). An SRBC docket approval will be required for the operation of the BBNPP and will include water use limits and applicable mitigative measures. Section 2.3.1 provides additional description of the Susquehanna River and consumptive water use from the river. Additional information on the makeup water pumps and withdrawal rates for the CWS and RWSS are provided in Section 9.4.2 and Section 9.4.2.1.

9.4.2.3 Water Treatment

Evaporation of water from cooling towers leads to an increase in chemical and solids concentrations in the circulating water, which in turn increases scaling tendencies of the cooling water. The RWSS supplies filtered water from the Susquehanna River to the demineralized water treatment system, fire protection, and essential service water (except under emergency operating conditions) systems during the periods of normal power operation, shutdown, maintenance, and construction. The RWSS also supplies unfiltered water from the Susquehanna River to the ESWEMS Retention Pond during all modes of normal operation. The emergency make up to the essential service water system is provided by a dedicated, safety related system.

An automatic self cleaning strainer is located at the discharge of each raw water pump to remove particulate material from the river water prior to filtration by the media filters. The strainers are set to backwash based on the pressure differential exceeding a preset limit, or a timed backwash cycle based on a preset service time. The strainers can backwash while on line without interruption of raw water flow. The backwash water from the strainers is discharged to the Susquehanna River.

Media filters are provided to remove suspended solids from the raw water before it is distributed for use, with the exception of makeup flow to the ESWEMS Retention Pond. The filters use a dual media potentially comprised of silica sand and anthracite. The use of dual media improves the effectiveness of the filters in removing suspended solids and lengthening the time between backwashes.

The media filters are backwashed to remove collected solids and the backwash water is discharged to the retention pond. Four media filters are provided; each nominally sized for the continuous makeup flow requirements during facility power operation. The media filter vessels are located in the Water Treatment Building. The final dimensions and number of media filter vessels, depths of the media layers, and media particle size distributions will be determined during the detailed design.

Compressed air is supplied to the bottoms of the filter vessels to augment the reverse water flow and improve the backwash effectiveness by air scouring of the media.

The Susquehanna River is the source of water supplied to the CWS cooling towers and RWSS. This water is characterized as a moderately hard, alkaline water with a low dissolved solids content averaging 143 mg/l.

There have been sightings of zebra mussels along the Susquehanna River, as shown in the most recent U.S. Geological Survey (USGS) distribution map, so treatment may be required at the intake structure for control of zebra mussels.

Treatment will be required to control microbial growth in the RWSS piping to control biofouling, microbiological deposits, and microbially induced corrosion, especially in the smaller pipes. An oxidizing biocide was selected as the treatment. Sodium hypochlorite solution (also referred to as bleach) will be injected intermittently. Facilities for sodium hypochlorite storage and injection will be located near the intake structure and chemical will be injected near the RWSS pumps.

Chemical treatment system pumps, valves, tanks, instrumentation, and controls provide the means of monitoring water chemistry. Monitoring will be consistent with chemical vendor recommendations required for chemical dosage and performance. The NPDES permit may require additional environmental compliance monitoring at point sources, such as pump discharges to an oil/water separator. Residual chlorine is measured to monitor the effectiveness of biocide treatment. Conductivity and pH are also monitored.

The discharge from the retention basin will consist primarily of blowdown from the CWS and from the ESWS cooling towers. The combined water composition will depend on the cycles of concentration and on the specific cooling water chemistry control strategy used for deposit control. Alternative deposit control strategies using higher pH levels with lower acid dosages and more aggressive deposit control chemical programs would have similar compositions but with higher pH levels, higher alkalinities, and lower sulfate levels.

9.4.3 Transmission systems

Section 9.4.3 of NUREG-1555 (NRC, 2007) provides guidelines for the preparation of the summary discussion that identifies the feasible and legislatively compliant alternative transmission systems.

As discussed in Section 3.7, the existing 500 kV transmission system in close proximity to BBNPP consists of the Susquehanna 500 kV Yard adjacent to SSES and two 500 kV circuits (Sunbury, Wescosville). Additionally, the Susquehanna 500 kV Yard is connencted to the Susquehanna 230 kV Yard via a 500 kV / 230 kV transformer.

In addition to this existing transmission infrastructure, PPL Electric Utilities Corporation (PPL EU) is developing a new 500 kV transmission line from Susquehanna to the Roseland substation (New Jersey). This expansion effort is a PJM regional Transmission Expansion Plan (RTEP) initiative. PJM has determined that this new 500 kV line is required for grid reliability in the region without considering whether BBNPP is constructed. The in-service date of the Susquehanna-Roseland RTEP project is planned for the year 2012.

No additional transmission corridors or other offsite land use will be required to connect BBNPP to the existing transmission system or to upgrades to the transmission system that are in process. The following facilities will be constructed to support BBNPP:

- One new BBNPP 500 kV Switchyard located in close proximity to the Turbine Building.
- One new switchyard named Susquehanna 500 kV Yard 2.
- Expansion of the existing Susquehanna 500 kV Yard.
- Two new 500 kV, 4,260 MVA (normal rating) circuits connecting the BBNPP 500 kV Switchyard to the expansion of the existing Susquehanna 500 kV Yard and to the new Susquehanna 500 kV Yard 2.

Aditionally, the 230 kV transmission lines currently passing through the BBNPP site will be relocated to run along the northern boundary of the project area.

The new transmission facilities to support BBNPP will be constructed within the BBNPP project area. Thus, environmental impacts are limited to the project area.

No new corridors, widening of existing corridors or crossings over main highways, primary roads waterways or railroad lines, will be required. Therefore, there would be no impacts from land use changes. Operational impacts from the new transmission facilities needed to support BBNPP are discussed in Section 5.6.

The power transmission needs of BBNPP can be satisfied with relatively minimal changes to the existing 500 kV transmission system. Based on this conclusion and on the small expected impact to the environment from utilizing the existing transmission facilities and independent upgrades that are in progress, no other alternatives were considered since they were less preferable.

9.4.4 References

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Table 9.4-1— Comparison of Cooling Tower Evaluation Criteria

Type of Cooling	Footprint per Plant Unit (1,562 MWe) (a)	Maximum Height	Materials of Construction	Plant Efficiency Impact Difference e)	Auxiliary Load Difference (e)	Water Makeup (b)	Drift Rate	Pump Head	Visible Plume	Noise (h)	Annual O&M Cost Difference (c, e)	Capital Cost(d)
	Acres	Ft(m)		%	MW	gpm(Lpm)	gpm (Lpm)	Feet H_2O		dBA @ 1m	103 USD	103 USD
Natural Draft (2 Hyperbolic Towers)	16	~600(183)	Concrete	0	0	23,808(90,123)	8(30)	60	Yes	82	0	173,727
Rectangular Mechanical Draft (3 Towers)	24	~60(18)	Fiberglass (FRP)	-0.046	6.22	23,808(90,123)	8(30)	36	Yes	88	468	130,710
Round Mechanical Draft (4 Towers)	16	~60(18)	Fiberglass	-0.044	4.05	23,808(90,123)	8(30)	36	Yes	88	374.4	143,103
One Round Mechanical Draft (aka Fan-assisted Natural Draft)	8	~164(50)	Concrete	-0.101	8.49	23,808(90,123)	8(30)	44	Yes	88	374.4	135,429
Dry Cooling (f)	7-30	39	Steel	25	13-79	139	0.0005	44	No	88	5.975	298.727
Hybrid (g)	5-6	177	Concrete	0.5	21.85	39.402	-	-	No	96.7	3.791	189.527

Notes:
(a) Footprint includes the required separation between towers, if applicable.
(b) Water total makeup includes drift, evaporation, and blowdown (at 2 cycles of concentration).
(c) O&M costs are calculated at 1% or 2% of the capital cost, based on vendor input.
(d) The cost shown includes the initial cost of the cooling tower(s) and construction cost differences.
(e) The value shown is the difference between the identified option and the Natural Draft (2 Hyperbolic Towers) option.
(f) Dry cooling case includes air cooled condenser (ACC), steam ducting from turbine to ACC and condensate return piping, auxiliary cooling tower and reduced size offsite water storage. Offsite water storage cost estimate $48 million.
(g) Hybrid case includes the same condenser and circulating water system as Natural Draft case plus hybrid cooling tower and offsite makeup water storage. The difference from base would be the incremental cost of the hybrid tower.
(h) By regulations, noise at property boundary required to be ≤ 55 dB in evening.

Table 9.4-2— Environmental Impacts of Alternative Cooling Tower Systems

Factors Affecting System Selection	Natural Draft Wet Cooling Tower (NDWCT)	Mechanical Draft Wet Cooling Tower (MDWCT)
Land Use: Onsite Land Requirements	Impacts would be SMALL.	Impacts would be SMALL.
Land Use: Terrain Considerations	Terrain features of the BBNPP site are suitable for a natural draft cooling tower system. Impacts would be SMALL.	Terrain features of the BBNPP are suitable. Impacts would be SMALL.
Water Use	Potential for SMALL to MODERATE impacts to aquatic biota. Impacts would be SMALL to MODERATE.	Potential for SMALL to MODERATE impacts to aquatic biota. Impacts would be SMALL to MODERATE.
Atmospheric Effects	Visible plume. Presents greater potential for fogging and salt deposition. Impacts would be SMALL.	Visible plume. Presents greater potential for fogging and salt deposition. Impacts would be SMALL.
Thermal and Physical Effects	Discharges would need to meet applicable water quality standards and be in compliance with applicable thermal discharge regulations. Discharge is not likely to produce tangible aesthetic or recreational impacts. Impacts would be SMALL.	Discharges would need to meet applicable water quality standards and comply with applicable thermal discharge regulations. Discharge is not likely to produce tangible aesthetic or recreational impacts. Impacts would be SMALL.
Noise Levels	Would emit broadband noise that is largely indistinguishable from background levels and would be considered unobtrusive. Impacts would be SMALL.	Would emit broadband noise that is largely indistinguishable from background levels and would be considered unobtrusive. Impacts would be SMALL.
Aesthetic and Recreational Benefits	Plumes resemble clouds and would not disrupt the viewscape. The cooling tower discharge is not likely to produce tangible aesthetic or recreational impacts; no effect on fisheries, navigation, or recreational use of the Susquehanna River is expected. Impacts would be SMALL.	Plumes resemble clouds and would not disrupt the viewscape. The cooling tower discharge is not likely to produce tangible aesthetic or recreational impacts; no effect on fisheries, navigation, or recreational use of the Susquehanna River is expected. Impacts would be SMALL.
Legislative Restrictions	An intake structure would meet Section 316(b) of the CWA and the implementing regulations, as applicable. NPDES discharge permit thermal discharge limitation would address the additional thermal load from blowdown back into the Susquehanna River. These regulatory restrictions would not negatively affect implementation of this heat dissipation system. Impacts would be SMALL to MODERATE.	An intake structure would meet Section 316(b) of the CWA and the implementing regulations, as applicable. NPDES discharge permit thermal discharge limitation would address the additional thermal load from blowdown back into the Susquehanna River. These regulatory restrictions would not negatively affect implementation of this heat dissipation system. Impacts would be SMALL to MODERATE.
Environmental impacts	SMALL to MODERATE	SMALL to MODERATE
Is this an environmentally suitable alternative heat dissipation system?	Yes	Yes

Table 9.4-3— Alternate Intake Systems

	Proposed System (closed loop)	Alternative Systems (open loop)	Alternative Intake Location (South)	Alternative Intake Location (North)
Construction Impacts	Some adverse impacts as discussed in Section 4.1, but mitigated as noted in Section 4.6. SMALL	Adverse impacts due to large intake structure required. LARGE	Additional adverse impacts would occur due to construction activities in previously undisturbed areas and requirement for additional infrastructure (e.g., roads). SMALL to MODERATE	Additional adverse impacts would occur due to construction activities in previously undisturbed areas and requirement for additional infrastructure (e.g., roads). SMALL to MODERATE
Aquatic Impacts	No expected long-term impacts; entrainment and impingement expected to be minimal. SMALL	Adverse impacts from entrainment of resident species. LARGE	No expected long-term impacts; entrainment and impingement expected to be minimal. SMALL	impacts; entrainment and impingement expected to be minimal. SMALL
Water Use Impacts	No expected long term impacts; water consumption minimal. SMALL	High water use would require large intake structure from Susquehanna River LARGE	No expected long term impacts; water consumption minimal. SMALL	No expected long term impacts; water consumption minimal. SMALL
Compliance with Regulations	Satisfies regulatory performance standards for CWA and Pennsylvania regulations. SMALL	Does not meet current CWA and Pennsylvania criteria for entrainment LARGE	Additional regulatory requirements associated with anticipated impacts to wetland and archeological sites. SMALL to MODERATE	Additional regulatory requirements associated with anticipated impacts to wetland and archeological sites. SMALL to MODERATE
Environmental Preferability	Environmentally preferable: limits entrainment and lower water use.	Cost prohibitive not compliant with regulations.	Due to additional construction impacts and regulatory requirements, this alternative is not environmentally preferable.	Due to additional construction impacts and regulatory requirements, this alternative is not environmentally preferable.