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Chapter 8

Chapter 9

Insert: 9.4-202 Screening of Alternatives to the Proposed Water Treatment System

9.4 ALTERNATIVE PLANT AND TRANSMISSION SYSTEMS

The information for this section is provided in the ESP Application Part 3 – Environmental Report, Section 9.4, and the associated alternatives analysis is not fully resolved in NUREG-1817; the following supplemental information is provided.

9.4.1 HEAT DISSIPATION SYSTEMS

NUREG-1817, Subsection 8.3.1 contains the following statement: “Based on the NRC staff's independent review, the staff concludes that wet mechanical draft cooling towers and wet natural draft cooling towers are suitable for the site. The specific cooling system design for one or more new nuclear units or units at the Grand Gulf ESP site has not been selected; therefore, system design alternatives would be discussed at the CP or COL stage if an application were submitted to build a new plant at the site.”

The selected cooling system design, as discussed in Sections 3.4 and 5.3, provides the normal heat sink through the use of a natural draft cooling tower in combination with a mechanical draft cooling tower. Although the final selection of the cooling system was not made at the time of the ESP, the conclusions made by the NRC staff resolved that wet natural draft and wet mechanical draft cooling towers are suitable for the Unit 3 site. A review of new technology revealed no new and significant information that would change the determination made in ESP ER Subsection 9.4.1 that there are no environmentally preferable alternatives to wet cooling towers for the Unit 3 normal heat sink.

9.4.2 CIRCULATING WATER SYSTEMS

The circulating water system is a closed-loop design that will use a natural draft cooling tower in combination with a mechanical draft cooling tower to provide heat dissipation. The following NUREG-1817 subsections resolved the issues dealing with the circulating water system.

NUREG-1817, Subsection 8.3.2.1, “Intake Systems” states with regard to riverbed structure intake or diversionary channel intake alternatives: “The staff found no basis to suggest that these two water intake alternatives would be environmentally preferable to SERI's proposed intake system.” The proposed Unit 3 intake structure is described in Subsection 3.4.2.1. There is no new and significant information that would change the intake selected.

NUREG-1817, Subsection 8.3.2.2, “Discharge Systems” states: “The staff found no basis to suggest that the two discharge alternatives would be environmentally preferable to SERI's proposed discharge system.” There is no new and significant information that would change the discharge selected.

The Unit 3 makeup water will be supplied by the Mississippi River. NUREG-1817, Subsection 8.3.2.3, “Water Supply” states: “The staff did not identify any other environmentally preferable water supply.” There is no new and significant information that would change the water supply selected.

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NUREG-1817, Subsection 8.3.2.4, Water Treatment, states: “At this stage, the final design of the various water systems for a new nuclear plant located at the Grand Gulf ESP site has not been specified. The water treatment requirements and water system effluents are not known. However, all chemical and thermal discharges from the water treatment systems, regardless of the methods chosen, would be regulated by the MDEQ through the NPDES process.” The following information is provided to discuss alternatives, to the proposed water treatment method selected, that were considered for Unit 3.

9.4.2.1 Water Treatment

Table 9.4-202 provides a tabularized evaluation of the selected and alternative water treatment systems evaluated. The following water treatment systems were considered for the circulating water system (CIRC) and plant service water system (PSWS); each is further discussed in the subsections below.

- Mechanical Cleaning: Periodic mechanical cleaning of CIRC and main condenser tubes
- Non-chemical Treatment: Ultraviolet light sterilization and magnetic field anti-scaling
- Chemical Water Treatment: Application would consist of adjustments to water chemistry using several chemicals including biocide, algaecide, pH adjuster, corrosion inhibitor, and scale inhibitor

9.4.2.1.1 Mechanical Cleaning - Alternative

The mechanical cleaning option was evaluated, including the environmental impacts and the technical feasibility of this alternative treatment system. Mechanical cleaning includes use of high pressure cleaning machines for cooling tower fill sections and some form of mechanical rod cleaning for condenser tubes. The mechanical cleaning process is not practical for the cooling towers or main condenser due to the large surface area to be cleaned and the likely need for chemicals to augment the mechanical cleaning. This method would not inhibit biofilm growth or scaling in the condenser or the cooling towers, which could cause damage to and reduce the efficiencies in the system as described below.

Biofilm (slime) growth in the condenser and cooling towers would provide the potential for foulants to accumulate on these biofilms, blocking condenser flow and adding weight to the cooling tower fill that could lead to failure of these components. In addition, underdeposit corrosion takes place beneath biofilms and can result in severe pitting of metal surfaces. Anaerobes are bacteria that thrive in an oxygen-free environment like that which exists under a biofilm. Anaerobes then metabolize oxygen from oxidizing radicals such as sulfate or nitrate. These reduction reactions result in the production of organic acids which lead to microbiologically induced corrosion. Additionally, biofilms provide the maximum thermal insulating characteristics of any foulant and will decrease the plant efficiency and output as the biofilms continue to grow in the system. The uncontrolled growth of biofilms could generate hazardous accumulations of infectious bacteria or viruses that could become a health hazard.

Scale crystallization would be a consequence with this treatment method; the potential scale processes are discussed as follows:

- Calcium carbonate scale is formed from ions in solution; the most common forms being calcite (the most stable) and aragonite (metastable). The conditions affecting precipitation of calcite or aragonite depend primarily upon temperature, pH, pressure and impurities present. One of the major controlling factors for calcium carbonate precipitation and the resulting predominant crystalline form is temperature. Generally, calcite forms at temperatures below 86ºF and aragonite is predominant above 122ºF. The crystal structure of the aragonite is dendritic, dense, and is reported to be more adherent than calcite. The crystalline structure, the conditions under which they form and the surface charge of small colloidal particles will come into play during the scale cleaning process.
- Silica scale formation will not be a problem at Grand Gulf due to the low concentration of silica (< 200 ppm) for the makeup water at 4 cycles of concentration.
- Magnesium silicate scale formation is also not a factor due to low silica concentration in the makeup water at 4 cycles of concentration.
- Iron scale formation will not be a factor due the low concentration of iron (< 2 ppm) for the makeup water at 4 cycles of concentration.
- Zinc scale formation will not be a concern due to the low zinc concentration in the makeup water at 4 cycles of concentration.

Allowing biofilms and scale to deposit unabated on the system internals would eventually require many hours of cleaning. Calcium scale in the condenser could completely block condenser tubes making them uncleanable. For those that can be cleaned, mild acid solutions and large amounts of water would be required. Biofilm removal would require detergents and high pressure scrubbing machines. Additional rod cleaning of the condenser tubes could damage the tubes requiring tube plugging or replacement.

Mechanical cleaning of the cooling tower would require complete disassembly of the fill section and cleaning each fill sheet individually. Cooling tower fill is designed with a special surface that allows maximum heat transfer in support of the guaranteed performance by the cooling tower vendor. Mechanical cleaning of these sheets may damage this surface reducing the cooling tower performance and voiding the cooling tower warranty.

9.4.2.1.2 Non-Chemical Treatment - Alternative

In the early 1900s, it was discovered that ultraviolet (UV) light could destroy disease-carrying microbes called pathogens. UV-C, known as short wave UV light, is the type used for water treatment. UV-C light is a successful treatment method because it can penetrate a cell's wall and cause massive damage. A basic cell is composed of a cell wall, cytoplasmic membrane and deoxyribonucleic acid (DNA). UV light targets the DNA, the life center of the cell. Exposure to even low doses of UV light scrambles the DNA, which prevents reproduction. This inability to reproduce renders the microbe harmless and, for all intents and purposes, "dead."

The limitations of the UV light approach for mitigating bio-infection of the cooling water systems are sizing of such a large system and the high concentration of total dissolved solids, as would be the case to support the Unit 3 project. The CIRC and PSWS have large flows, with the CIRC being in excess of 700,000 gpm. UV systems are used for small cooling water systems, building air conditioning, and would be an experimental venture to apply this UV technology to a large cooling system. From reviews to support this evaluation, the largest UV bulb can only treat 500,000 gpd; therefore, it would require over 200 trains to treat 10 percent of the CIRC flow. A 10 percent portion of the flow would represent a side stream approach to treatment. The system and piping involved would be complex. In addition, there would be increased maintenance and cost of operating such a system.

General guidance is that total dissolved solids (TDS) should not exceed 500 ppm for a UV system, but there are factors where UV systems could be used at higher TDS concentrations. Factors that will affect the usefulness of the UV system are: the distance between the lamp and the wall of the UV chamber; the particular make-up of the dissolved solids and how fast they absorb the available UV energy; flow rate; and output of the lamp. At 4 cycles of concentration, the TDS would exceed 1700 ppm. This high concentration of dissolved solids and the potential of high turbidity (>1 NTU) would diminish the effectiveness of the UV system.

Magnetic technology used in the treatment of water has been cited in literature and investigated since the turn of the 19th century, when lodestones and naturally occurring magnetic mineral formations were used to decrease the formation of scale. Scale producing water contains ions, both positively and negatively charged (cations and anions, respectively). The general operating principle for the magnetic technology is a result of a moving ionized fluid through a magnetic field. When ions pass through the magnetic field, a force is exerted on each ion (Lorentz Force). This force is perpendicular to both the magnetic field and to the direction of motion and is proportional to the velocity. Since the force is at right angles to the velocity, it will not affect the magnitude of the velocity nor its kinetic energy but will merely alter its direction. The forces on ions of opposite charges are in opposite directions. The opposing redirection of the ions tends to increase the frequency with which ions of opposite charge collide and combine to form a mineral precipitate. Since this reaction takes place in a low temperature region of the system, the precipitation formed is non-adherent. This also provides calcium scale removal due to the changes in the ionic equilibrium balance in the system. This method of scale removal will generally eliminate the possibility of maintaining a thin calcium film for corrosion protection and may require the addition of a chemical corrosion inhibitor to supply this protection. This approach has only been used on a small systems with small flow applications.

Due to the ineffectiveness of the UV system and the concerns with the magnetic scale elimination process, non-chemical treatment was not considered practical for use in the large scale Unit 3 water treatment system.

9.4.2.1.3 Chemical Water Treatment – Selected Design

The proposed treatment system described in Subsection 3.3.2.2, for the circulating water system (CIRC) and plant service water system (PSWS), utilizes chemical treatment that includes injection of the following chemicals: biocide, algaecide, pH adjuster, corrosion inhibitor, and scale inhibitor. CIRC design also includes a ball cleaning system for the main condenser tubes as discussed in FSAR Section 10.4.5. Additional chemicals such as sodium bisulfite will be used in treating the CIRC/PSWS blowdown to help neutralize chemicals in the discharge.

As discussed above and in Table 9.4-202, the alternative systems would result in loss of performance, or have not been proven effective on large-scale cooling systems. As summarized in Table 9.4-202, none of the evaluated alternatives are environmentally preferable or equivalent to the selected system. Since this screening evaluation is based on environmental factors, there is no need to further consider economic factors, consistent with the guidance on NUREG-1555, Section 9.4.2 (p. 9.4.2.12). Therefore, chemical water treatment will be applied to the CIRC and PSWS. Application would consist of adjustments to water chemistry using several chemicals, including biocide, algaecide, pH adjuster, corrosion inhibitor, and scale inhibitor, and these additives would be present in the cooling tower blowdown.

The concentration of total dissolved solids in the cooling tower blowdown would be monitored in the cooling tower basin before discharge to ensure it meets the limits of the NPDES permit. Dilution of the low-volume blowdown by the receiving water also reduces water quality effects of contaminants discharged from closed-cycle cooling systems. The number of cycles that water is used before blowdown is based on inlet water quality conditions.

Effects of cooling tower discharges are considered to be of small significance when water quality criteria (e.g., NPDES permit limits) are met. Based on review of literature and operational monitoring reports, consultations with utilities and regulatory agencies, and comments on the draft Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants, discharge of cooling tower effluents has not been a problem at existing nuclear plants. Although occasional exceedances of NPDES permit limits have occurred at operating plants (e.g., minor spills), water quality effects have been localized and temporary. Cumulative water quality impacts are small, because the low-volume discharges are readily dissipated in the receiving water bodies.

The environmental impact from the use of chemical water treatment is small for Unit 3. As discussed above, mechanical cleaning or UV or magnetic field anti-scaling treatment are not practical or effective water treatment systems for large nuclear plant cooling water applications. Therefore, no effective alternative treatment method is identified that is environmentally preferable or equivalent to the selected water treatment systems.

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Table 9.4-202 (Sheet 1 of 2)
Screening of Alternatives to the Proposed Water Treatment System

Factors Affecting System Selection	Chemical Treatment	Mechanical Cleaning	Non-Chemical Treatment (NCT) Ultraviolet (UV) Treatment Magnetic Anti-Scale Treatment
Chemicals Used	– Biocide/Sodium Hypochlorite – Algaecide/Sodium Hypochlorite – Biocide-Algaecide dispersant-PCL 401 – pH adjustment/Sulfuric Acid – Corrosion Inhibitor/Zinc Chloride – Scale Inhibitor/Phosphate (Refer to Table 3.3-201)	Mechanical cleaning would involve periodic removal of organic and inorganic residue and debris of piping systems and related equipment. Detergents and mild acids would be required for cleaning.	None
Construction Impacts	Installation of the chemical treatment systems would result in commitment of additional land. Associated soil erosion and sediment impacts, however, would be small.	Periodic mechanical cleaning of the cooling water systems would not require any substantial construction activities and there would be no related environmental impacts.	Installation of the NCT systems would result in commitment of additional land. Associated soil erosion and sediment impacts, however, would be small.
Aquatic Impacts	Residual chemicals from this treatment process could impact aquatic resources. Biocides, corrosion inhibitors, and pH adjustment chemicals are potentially toxic to aquatic life.	While mechanical cleaning measures would remove biological materials from condenser system surfaces, these measures would not pose systemic impacts on aquatic resources in the Mississippi River. Detergents and mild acids required for periodic cleaning are potentially toxic to aquatic life.	The NCT would have no residual impacts on aquatic resources in the Mississippi River.
Land Use Impacts	The chemical treatment systems do require additional land; however these systems would be wholly-confined to the existing GGNS site. There would be no appreciable land use impacts.	Mechanical cleaning would require an area to dispose of the debris removed from the plant. Biofilm could contain disease containing bacteria or viruses and would need to be handled as potentially hazardous waste.	While these NCT systems do require additional land, these systems would be wholly-confined to the existing site. There would be no appreciable land use impacts.

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New Table 9.4-202, Sh. 2

Table 9.4-202 (Sheet 2 of 2)

Factors Affecting System Selection	Chemical Treatment	Mechanical Cleaning	Non-Chemical Treatment (NCT) Ultraviolet (UV) Treatment Magnetic Anti-Scale Treatment
Water Use Impacts	Chemical treatment systems would not impact water withdrawal.	Mechanical cleaning would require additional water withdrawal for system cleaning.	NCT systems would not impact water withdrawal.
Compliance With Regulations	The addition of chemical treatment systems would impact the current NPDES permit. The permit requires modification to support the new unit prior to construction. The effects of the cooling tower discharges are considered minimal when water quality criteria are met.	Mechanical cleaning is fully compliant with the applicable regulations and existing (Unit 1) and pending (Unit 1/Unit 3 combined) permit conditions. Biological agents growing in the cooling tower or condenser could reach hazardous levels becoming a health hazard.	The addition of NCT systems may impact the NPDES permit. The permit requires modification to support the new units prior to operation.
Summary Evaluation	(Selected system)	Neither environmentally preferred nor equivalent	Neither environmentally preferred nor equivalent