(*Ictalurus punctatus*), 1.35 percent; white bass, 5.56 percent; yellow bass, 11.72 percent; green sunfish (*Lepomis cyanellus*), 3.49 percent; bluegill (*L. macrochirus*), 0.04 percent; redear sunfish (*Lepomis microlophus*) 0.21 percent; and freshwater drum, 3.32 percent (TVA 1978a). The estimated number of fish that occur in Wheeler Reservoir was based on densities of fish collected in three coves. The coves are located in Second Creek near the Wheeler Dam (1.1 ha [2.7 ac] in area and 1.8 m [5.9 ft] deep), a cove at Lawrence County Park (1.4 ha [3.5 ac] in area and 1.3 m [4.3 ft] deep), and a cove on Elk River (0.6 ha [1.5 ac] in area and 1.4 m deep [4.6 ft]) (TVA 1978b).

No major or significant spawning areas, nursery grounds, feeding areas, wintering areas, or migration routes are located near BFN that would result in an increased potential for impingement (Baxter and Buchanan 1998; TVA 2003b). The intake channel at BFN is 150 m (492 ft), long from the skimmer wall to the pumping station. At normal maximum pool, the water depth along a 6.1-m (20.0-ft)-wide area in the middle of the intake channel is 10.1 m (33.1 ft). From there the sides of the channel slope at a 3-to-1 ratio. Directly in front of the pumping station the bottom slopes down an additional 1.5 m (4.9 ft) to the bottom of the intake opening, resulting in a maximum depth of 11.6 m (38.1 ft) at the intake screen at normal maximum pool (TVA 1978a). Fish have free access to the intake channel and can reside within this area without necessarily succumbing to impingement.

During original operations, the intake screens were cleaned either on a regular basis (e.g., at shift changes or daily) or when a pressure differential value is exceeded across the screens due to fouling. The often long impingement time, in addition to exposure to high-pressure spray system during the cleaning process, essentially resulted in a 100 percent mortality of impinged fish (TVA 1978a). The intake screens are now continuously backwashed as they are rotated, resulting in impingement losses of less than 100 percent. However, the survival rate has not been determined.

The paddlefish (*Polyodon spathula*) is the only State-listed fish species that has been collected in impingement samples (TVA 1978a). An estimated 168 specimens were collected between March 1974 and March 1975; 15 between March 1975 and March 1976; and 14 specimens between September 1976 and August 1977. They comprised less than 0.01 percent of the number of fish impinged in those years (TVA 1978a).

During the course of preparing this supplemental environmental impact statement (SEIS), the staff considered mitigation measures for the continued operation of BFN. Based on the assessment, the staff expects that the measures in place at BFN (e.g., shoreline intake, escape passages, and a fish return system) provide mitigation for impacts related to impingement, and no new mitigation measures are warranted. There have been no measurable changes to the fish community of Wheeler Reservoir related to the BFN, and no indications that impingement has had a destabilizing impact on fish populations (TVA 2003b). The direct and indirect effects

associated with the modification of the Tennessee River through creation of reservoirs has had the greatest influence on fish populations (see Section 2.2.5).

The staff reviewed the available information in the TVA ER (TVA 2003b), other BFN documents related to the FWPCA 316(b) permitting process, and TVA's Vital Signs Monitoring Program evaluations and other documents related to the fish community of Wheeler Reservoir. Based on the results of past impingement studies and the operating history of BFN intake structure, the staff concludes that the potential impacts of impingement of fish and shellfish are SMALL, and it is not likely that further mitigation will be warranted. Nevertheless, the TVA will evaluate the levels of impingement by monitoring under current two-unit operation and following the return of three-unit operation at 120 percent power level, which will increase intake flow rates by approximately 11 percent over those of past three-unit operation (TVA 2003b). Modeling techniques are currently being refined, which will allow more realistic analysis of the effects of impingement and allow extrapolation of impingement losses to production foregone for forage fish. These techniques or similar modeling techniques will be employed to analyze future impingement data from BFN to better quantify long-term, far-field effects of impingement to the reservoir fish community (TVA 2003b). TVA's Vital Signs Monitoring Program would also continue to assess aquatic communities in Wheeler Reservoir. If it is determined that increased impingement is resulting in unacceptable environmental impacts, TVA would assess technologies, operational measures, and restoration measures that could be undertaken to remedy the impacts, and institute appropriate mitigation measures in consultation with appropriate Federal and State of Alabama agencies (TVA 2003b).

4.1.4 Heat Shock

For plants with once-through cooling systems, the effects of heat shock are listed as a Category 2 issue and require plant-specific evaluation before license renewal. The staff made impacts on fish and shellfish resources resulting from heat shock a Category 2 issue because of continuing concerns about thermal-discharge effects and the possible need to modify thermal discharges in the future in response to changing environmental conditions (NRC 1996). Information to be considered includes (1) the type of cooling system (whether once-through or cooling pond) and (2) evidence of a FWPCA Section 316(a) variance or equivalent State documentation. To perform this evaluation, the staff reviewed the TVA ER and other TVA environmentally related documents, visited the BFN site, reviewed the facility's thermal variance monitoring and 316(a) studies, and reviewed the applicant's State of Alabama NPDES Permit No. AL0022080, which was issued on December 29, 2000, became effective on February 1, 2001, and will remain in force until January 31, 2006 (ADEM 2000).

BFN has a once-through heat dissipation system. Water is discharged back to the river through submerged diffusers located on the river bottom and oriented perpendicular to the river

flow. The diffusers for each unit have 7800 5-cm (2-in.)-diameter ports located on the downstream-facing portion of the diffuser pipe and angled to force the heated effluent up into the water column (TVA 2003a). BFN also currently has five mechanical draft cooling towers, with a sixth to be added, which can be operated to assist in heat dissipation (helper mode) primarily during summer (July and August) hot-weather periods (TVA 2003b). BFN has been able to operate at full power in the open-cycle mode while still meeting state water temperature standards under most river flow and temperature conditions. Under the original three-unit operation at 100 percent power levels, BFN used river water at the rate of 124.9 m^3/s (1.98 million gpm) and condenser cooling water was warmed a maximum of 13.9°C (25°F) above ambient temperature before being discharged to the river (Buchanan 1990). Under three-unit operation at a combined total power level of 11,856 MW(t), BFN would use river water at the rate of 139 m^3/s (2.20 million gpm) (an 11 percent increase). The maximum temperature increases above ambient temperature would be 15.9°C (28.7°F) under open mode for each unit's diffuser. Under helper mode, the diffuser discharge temperature would be 10.7°C (19.3°F) above ambient temperature for Unit 1 and 3.8°C (6.8°F) above ambient temperature for both Units 2 and 3 (Hopping 2004).

Based on results of a supplemental 316(a) demonstration for alternative thermal discharge limits for BFN (TVA 1983), the thermal limitations that have been in place for BFN since 1984 are a maximum 1-hour average of 33.9°C (93°F), a maximum 24-hour average of 32.2°C (90°F), and a maximum 24-hour average temperature increase of 5.6°C (10°F) over ambient conditions. This varies from the more stringent thermal criteria established in 1972 of a maximum temperature at the edge of the mixing zone of 30°C (86°F) and a maximum temperature increase of 2.8°C (5°F) (TVA 1983). These limitations are applied at the edges of a mixing zone with the following dimensions: (1) a maximum length of 730 m (2400 ft) downstream of the diffusers, (2) a maximum width of 600 m (2000 ft), and (3) a maximum length of 46 m (150 ft) upstream of the diffusers to the top of the diffuser pipes and extends to the bottom downstream of the diffusers (TVA 2003b). Annual ambient maximum temperatures in Wheeler Reservoir rarely exceed 31.7°C (89°F) in the main channel, but often exceed this temperature in the shallow areas of embayments and coves (TVA 2002). If the upstream 24-hour temperature exceeds 32.2°C (90°F), the 24-hour downstream temperature may equal, but not exceed, the upstream value. This type of operation is acceptable until the 1-hour average limit of 33.9°C (93°F) is obtained (TVA 2003b).

The BFN discharge diffusers are located such that fish would not become entrapped in areas of elevated temperatures. Acute thermal impacts to aquatic organisms (e.g., immediate death or disability) are unlikely (TVA 2003b). However, larval fish that pass through the mixing zone may be stunned by exposure to elevated temperatures, making them more susceptible to predation (TVA 1972). No heat-related fish kills have been reported for BFN. Thermal discharges related to the operation of BFN affect a relatively small area of Wheeler Reservoir. The required thermal mixing zone does not exceed a surface area of 47.3 ha (117 ac). This is less than 0.2 percent of the surface area of Wheeler Reservoir.

Maximum temperatures at the edge of the thermal mixing zone do not exceed the upper thermal limits for species such as bluegill; black crappie (Pomoxis nigromaculatus); white crappie; largemouth (*Micropterus salmoides*), and smallmouth (*M. dolomieu*) bass; channel catfish; and golden shiner (*Notemigonus crysoleucas*) (TVA 2002). For example, the upper temperature avoided by fish acclimated to 30°C (86°F) were 35°C (95°F) for spotfin shiner (*Cyprinella spiloptera*), 35°C (95°F) for bluegill, 33°C (91.4°F) for green sunfish, 33°C (91.4°F) for smallmouth bass, 34.0°C (93.2°F) for spotted bass (*Micropterus punctulatus*), and 35°C (93.2°F) for channel catfish (Cherry et al. 1975). However, the thermal tolerance of some species such as yellow perch (*Perca flavescens*), white sucker (*Catostomus commersoni*), walleye (*Stizostedion vitreum*), sauger, and emerald shiner (*Notropis atherinoides*) could be exceeded during annual extreme water temperatures (TVA 2002). Nevertheless, species such as sauger are reported to disperse throughout the reservoir and are not found in the vicinity of the BFN during extreme ambient water temperatures (Baxter and Buchanan 1998).

Although individual fish may occasionally be found in thermal effluents at lethal temperatures, populations as a whole avoid such conditions (Talmage and Opresko 1981). The thermal preference for relatively large numbers of species common to Wheeler Reservoir (e.g., shad, bass, crappie, sunfish, freshwater drum, and some minnows) have been found to be in the range of 28 to 32°C (82.4 to 89.6°F); while some fish such as gar, carp, catfish, and minnows have been observed in thermal effluents in summer that range from 32 to 36°C (89.6 to 96.8°F) (Talmage and Opresko 1981). Young fish generally have a higher thermal preference and greater tolerance to elevated temperatures than older fish (Talmage and Opresko 1981). Therefore, although younger fish may not be as capable of avoiding the thermal plume as older fish, they may not experience thermal shock during passage through the plume.

Thermal releases from BFN have not had a significant impact on the aquatic community of Wheeler Reservoir (TVA 1983; Baxter and Buchanan 1998; Buchanan 1990; Lowery and Poppe 1992). From 1985 through 1992, a biological monitoring program was conducted to evaluate the effects of thermal discharges from BFN on phytoplankton and on total standing stocks and selected fish species in Wheeler Reservoir. Algal surveys were conducted in 1989 (during plant shutdown) and in 1991 (during plant operation). The only consistent observation was that the planktonic community varied on a daily basis regardless of location and habitat type. There was no indication that operation of BFN, even with the revised thermal limits, had influenced the phytoplankton community in Wheeler Reservoir (Lowery and Poppe 1992). Special attention was focused on sauger and yellow perch for BFN thermal variance studies because these cool water species would be more susceptible to elevated water temperatures than would most of the warmwater fish species that occur in the reservoir. Survey results indicated that BFN had no adverse impact on the reproductive success of either species nor on the movement of sauger past BFN (Baxter and Buchanan 1998). The tailwaters of Guntersville Dam are the primary spawning location for sauger in Wheeler Reservoir (Buchanan 1990) and, therefore, are not influenced by thermal discharges from BFN. Overfishing for sauger in

Wheeler Reservoir and drought conditions (e.g., low flows and decreased turbidity) in the Tennessee Valley from 1985 through 1988 had adverse impacts on sauger spawning success (Maceina et al. 1998; Baxter and Buchanan 1998).

Currently, TVA operates cooling towers at BFN only when the water temperature of discharges approaches and presents the potential for exceeding the NPDES thermal limit. When this situation occurs, not all cooling towers are necessarily placed in service. To maximize the net generation of the plant, only those towers necessary to keep the water temperature below the thermal limits are operated. Thus, as long as derating is part of the operational strategy for maintaining the NPDES limits, there is no significant difference in the hottest average thermal discharge for any of the cooling tower options. Additionally, TVA is working toward improving its methods of predicting water temperatures in Wheeler Reservoir and optimizing the operation of the cooling system provided at BFN. Computer simulations indicate that the combination of using existing cooling towers, the addition of a new cooling tower, and derating the plant, when necessary, would allow compliance with the current NPDES permit when all three units are operating at 120 percent of OLTP power (TVA 2003b). In-stream temperatures at the end of the mixing zone would remain within NPDES-permitted limits; thus, heat shock impacts would not be expected (TVA 2003b). To maintain temperatures within thermal limitation requirements, BFN would use its cooling towers, on average, about 5.3 percent of the time, and derating would be required approximately 0.1 percent of the time when Units 2 and 3 were operating at 120 percent power levels. When all three units were operating at 120 percent power levels, on average the cooling towers would be required about 7.2 percent of the time, and derating would occur approximately 0.29 percent of the time (TVA 2003b).

The staff reviewed the available information, including that provided by TVA, the staff's site visit, the State of Alabama NPDES permit, the thermal variance monitoring and 316(a) studies, and other public sources. The staff evaluated the potential impacts to aquatic resources caused by heat shock when all three are operating at 120 percent power levels. Discharge temperatures would remain within the NPDES limits; thus, heat shock impacts are not anticipated (TVA 2003b). It is the staff's conclusion that the potential impacts to fish and shellfish due to heat shock during the license renewal term are SMALL and further mitigation measures are not warranted.

4.1.5 Microbiological Organisms (Public Health)

The effects of microbiological organisms on human health are listed as a Category 2 issue and require plant-specific evaluation before license renewal. The average annual flow of Wheeler Reservoir near the BFN site is 4.16×10^{10} m^3/yr (1.47×10^{12} ft^3/yr), which is less than the 9×10^{10} m^3/yr (3.15×10^{12} ft^3/yr) threshold value in 10 CFR 51.53(c)(3)(ii)(G) for thermal discharge to a small river. Thus, the effects of its discharge on microbiological organisms must be addressed for BFN.

The Category 2 designation is based on the magnitude of the potential public-health impacts associated with thermal enhancement of the enteric pathogens *Salmonella* spp. and *Shigella* spp., the bacterium *Pseudomonas aeruginos*, thermophilic fungi, a number of species from the Genus *Legionella*, and pathogenic strains of the free-living amoebae *Naegleria* spp. and *Acanthamoeba* spp. (NRC 1996). The BFN diffuser discharge temperatures would not exceed 44.4°C (112°F) under three-unit operation at 120 percent power level. Because two units can be run at slightly higher ambient river temperatures, the maximum diffuser discharge temperature would be 44.61°C (112.3°F) with just Units 2 and 3 in operation at 120 percent power level (Hopping 2004). Except under rare, extreme ambient water temperatures, the discharge temperatures at the edge of the thermal discharge plume would not exceed the maximum 1-hour average of 33.9°C (93°F) or the maximum 24-hour average of 32.2°C (90°F). The annual ambient maximum temperature in Wheeler Reservoir seldom exceeds 31.7°C (89°F).

Thermophilic microorganisms can have optimum growth temperatures of 50°C (122°F) or more, a maximum temperature tolerance of up to 70°C (158°F), and a minimum tolerance of about 20°C (68°F) (Deacon 2004). However, thermal preferences and tolerances vary among the various microorganisms and environmental conditions. *P. aeruginosa* has an optimum temperature for growth of 37°C (98.6°F) and can tolerate a temperature as high as 42°C (107.6°F) (Todar 2002). A water temperature range of 32.2 to 40.6°C (90 to 105°F) provide ideal conditions for *Legionella* spp. bacterial growth (CDC 2004). *Salmonella* spp. can thrive at temperatures between 4.4 to 60°C (40 to 140°F) (Kendall 2003), whereas *Acanthamoeba* spp. and *Naegleria* spp. were not found to colonize hot water systems of 40°C (104°F) or higher (Rohr et al. 1998).

Based on maximum temperatures at the diffusers and the edge of the permitted thermal plume, coupled with the dilution provided by Wheeler Reservoir and the short period of time for water to pass through the cooling system (i.e., 7 to 11 minutes, with 5 to 9 minutes of this spent in heated water), the thermophilic microorganisms are not expected to cause any appreciable public health risk (TVA 2003b). The Alabama Department of Public Health (Lofgren 2003) agreed that there is no significant threat to the public from thermophilic microorganisms attributable to operation of BFN (see Appendix E). Disinfection of the BFN sewage treatment plant effluent and NPDES permit requirements to monitor fecal coliforms in this effluent (ADEM 2000) further reduces the potential for the heated discharge to be a seed source or inoculant for pathogenic microorganisms.

The staff independently reviewed the TVA ER (TVA 2003b), visited the BFN site, and reviewed TVA's State of Alabama NPDES Permit AL0022080 (ADEM 2000). Based on its review of this information, coupled with the fact that BFN operations and cooling systems are not expected to change significantly over the license renewal term, the staff concludes that the potential

impacts to public health from microbiological organisms resulting from the BFN cooling-water discharges are SMALL. Therefore, additional mitigation is not warranted.

4.2 Transmission Lines

BFN is connected into the TVA system network by seven 500-kV lines via the 500-kV switchyard. One line is to the Madison substation; two lines are to the Trinity substation; one line each is to the West Point, Maury, and Union, Mississippi substations, and one line is to the Limestone 500-kV substation (TVA 2003b). In addition, there are two 161-kV lines, one to the Athens substation and one to the Trinity substation. All lines occupy portions of four rights-of-way: one to Maury substation, one to the Trinity substation, one to the Athens substation, and one to the Union, Mississippi, substation. There are portions of transmission lines within these rights-of-way that were not constructed specifically to connect BFN to the TVA power system. However, for the sake of simplicity and a comprehensive analysis, the entire right-of-way is included in this assessment. The 260 km (160 mi) of transmission line rights-of-way cross 10 counties in Alabama and Mississippi.

Continued maintenance activities on the transmission line rights-of-way used to connect BFN to the electric power grid will be required whether or not the proposed action is adopted. The TVA Transmission and Power Supply-Transmission Operations and Maintenance organization conducts maintenance activities on transmission lines and rights-of-way in the TVA system. These activities include, but are not restricted to, maintenance of vegetation in each right-of-way, replacement of poles or towers, installation of lightning arresters and counterpoise, and upgrading of existing equipment. Regular maintenance activities are conducted on a 3-to-5-year cycle (Muncy et al. 1999).

Transmission line maintenance activities are reviewed for potential resource issues by technical specialists in the TVA Regional Natural Heritage and Cultural Resources programs (Muncy et al. 1999). A 1.6-km (1.0-mi) buffer area is reviewed for the presence of terrestrial species, while a 16.1-km (10-mi) buffer area is used for aquatic species (TVA 2003b). The TVA Regional Natural Heritage program maintains a database of some 27,000-plus occurrence records for protected plants, animals, caves, National Wetland Inventory wetlands, cultural resources, and areas of management concern for the entire TVA Power Service Area. TVA also conducts fieldwork to inventory and protect threatened and endangered species and environmentally sensitive areas on public lands that it administers. Activities carried out by project staff members include monitoring species populations, educating the public, and managing and maintaining habitats (including caves) at TVA-managed sites.

Transmission line rights-of-way are regularly surveyed and video taped from helicopters. Video tapes can be used to search for sensitive habitat types before field crews are dispatched. Access routes and restrictions for maintenance activities are determined based on knowledge

of the species or resources to be protected. Areas identified as sensitive are placed in different classes depending on the nature of the species or resources. In the most restricted areas (Class 2), vehicles and equipment are restricted from the site when habitat/sensitive resources are present, and all vegetation clearing is done by hand. In Class 1 sensitive areas, hand or mechanical clearing and herbicide use for vegetation control on transmission line rights-of-way is allowed. There is no broadcast application of herbicides in Class 1 sensitive areas. Herbicide application is carefully controlled, and personnel are trained, licensed, and follow manufacturer's guidelines, EPA guidance, and State regulations.

The streamside management zone is maintained to slow and spread surface water flow, to trap and filter suspended particulates before they reach the stream channel, protect stream bank integrity, and protect stream water temperature.

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1 that are applicable to transmission lines from BFN are listed in Table 4-5. The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, consultation with the U.S. Fish and Wildlife Service (FWS) and the Alabama Division of Wildlife and Freshwater Fisheries (ADWFF), or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of these issues, the staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff's review and GEIS conclusions, as codified in Table B-1, for each of these issues follows:

- Power line right-of-way management (cutting and herbicide application). Based on information in the GEIS, the Commission found that

  > The impacts of right-of-way maintenance on wildlife are expected to be of small significance at all sites.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, consultation with the FWS and ADWFF, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of transmission line rights-of-way maintenance during the license renewal term beyond those discussed in the GEIS.

Table 4-5. Category 1 Issues Applicable to the Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Transmission Lines During the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
TERRESTRIAL RESOURCES	
Power line right-of-way management (cutting and herbicide application)	4.5.6.1
Bird collisions with power lines	4.5.6.2
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.5.6.3
Floodplains and wetlands on power line right-of-way	4.5.7
AIR QUALITY	
Air-quality effects of transmission lines	4.5.2
LAND USE	
Onsite land use	4.5.3
Power line right-of-ways	4.5.3

- Bird collisions with power lines. Based on information in the GEIS, the Commission found that

  > Impacts are expected to be of small significance at all sites.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, consultation with the FWS and ADWFF, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of bird collisions with power lines during the license renewal term beyond those discussed in the GEIS.

- Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock). Based on information in the GEIS, the Commission found that

  > No significant impacts of electromagnetic fields on terrestrial flora and fauna have been identified. Such effects are not expected to be a problem during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, consultation with the FWS and ADWFF, or its evaluation of other available information, such as operation at a

combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of electromagnetic fields on flora and fauna during the license renewal term beyond those discussed in the GEIS.

- Flood plains and wetlands on power line right-of-way. Based on information in the GEIS, the Commission found that

  > Periodic vegetation control is necessary in forested wetlands underneath power lines and can be achieved with minimal damage to the wetland. No significant impact is expected at any nuclear power plant during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, consultation with the FWS and ADWFF, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of transmission line rights-of-way on flood plains and wetlands during the license renewal term beyond those discussed in the GEIS.

- Air-quality effects of transmission lines. Based on information in the GEIS, the Commission found that

  > Production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no air-quality impacts of transmission lines during the license renewal term beyond those discussed in the GEIS.

- Onsite land use. Based on information in the GEIS, the Commission found that

  > Projected onsite land use changes required during ... the renewal period would be a small fraction of any nuclear power plant site and would involve land that is controlled by the applicant.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no onsite land-use impacts during the license renewal term beyond those discussed in the GEIS.

- Power line right-of-way. Based on information in the GEIS, the Commission found that

  > Ongoing use of power line right of ways would continue with no change in restrictions. The effects of these restrictions are of small significance.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of power line rights-of-way on land use during the license renewal term beyond those discussed in the GEIS.

Category 2 and uncategorized issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to transmission lines from BFN are listed in Table 4-6, and are discussed in Sections 4.2.1 and 4.2.2.

Table 4-6. Category 2 and Uncategorized Issues Applicable to the Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Transmission Lines During the License Renewal Term

ISSUE – 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
	HUMAN HEALTH		
Electromagnetic fields, acute effects (electric shock)	4.5.4.1	H	4.2.1
Electromagnetic fields, chronic effects	4.5.4.2	NA	4.2.2

4.2.1 Electromagnetic Fields – Acute Effects

In the GEIS (NRC 1996), the staff found that without a review of the conformance of each nuclear plant transmission line with National Electrical Safety Code (NESC) (IEEE 1997) criteria, it was not possible to determine the significance of the electric shock potential. Evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For other plants, land use in the vicinity of transmission lines may have changed, or power distribution companies may have chosen to upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), an applicant must provide an assessment of the potential shock hazard if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the NESC standard of 5 mA for preventing electric shock from induced currents.

The BFN site is connected to the TVA power system via seven 500-kV lines and two 161-kV lines. A study was completed by TVA to evaluate the transmission system against current NESC requirements (IEEE 2002). That study included evaluation of both the vertical clearance requirements and potential for shock from steady-state current caused by electrostatic effects for the largest equipment under the lines that could be short-circuited to ground. Drawings for each transmission line were reviewed and wire elevations were noted for road crossings under each line. Two types of roadways that passed under the lines were evaluated: (1) unpaved roadways where harvesting equipment might travel and (2) paved roadways (city, county, State, and Federal). The reference vehicles evaluated for electromagnetic field effects included a standard trailer, a cotton harvester, and an automobile. The electromagnetic field calculations were made using Version 3.1 of ENVIRO, which is a module of the Electric Power Research Institute (EPRI) electromagnetic field workstation. Steady-state current calculations were then made using procedures outlined in the EPRI Transmission Line Reference Book. The staff reviewed this study by the applicant, and concludes that the maximum steady-state current is less than the 2002 NESC standard of 5 mA. Therefore, the applicant completed the assessment required by 10 CFR 51.53. The staff concludes that the impact of the potential shock is SMALL, and additional mitigation measures are not warranted.

4.2.2 Electromagnetic Fields – Chronic Effects

In the GEIS, the chronic effects of 60-Hz electromagnetic fields from power lines were not designated as Category 1 or 2, and will not be until a scientific consensus is reached on the health implications of these fields.

The potential for chronic effects from these fields continues to be studied and is not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy (DOE). A NIEHS report (NIEHS 1999) contains the following conclusion:

> The NIEHS concludes that ELF-EMF [extremely low frequency-electromagnetic field] exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the staff to change its position with respect to the chronic effects of electromagnetic fields. The staff considers the GEIS finding of "not applicable" still appropriate and will continue to follow developments on this issue.

4.3 Radiological Impacts of Normal Operations

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to BFN in regard to radiological impacts are listed in Table 4-7. TVA stated in its ER (TVA 2003b) that it is not aware of any new and significant information associated with renewal of the BFN operating licenses (OLs).

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-7. Category 1 Issues Applicable to Radiological Impacts of Normal Operations During the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
HUMAN HEALTH	
Radiation exposures to public (license renewal term)	4.6.2
Occupational radiation exposures (license renewal term)	4.6.3

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, for each of these issues follows:

- Radiation exposures to public (license renewal term). Based on information in the GEIS, the Commission found that

  > Radiation doses to the public will continue at current levels associated with normal operations.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Any increases in radioactive effluents associated with plant operation at a combined total

power level of 11,856 MW(t) for an additional 20 years would result in radiation doses to the public that would remain well within regulatory limits. These doses are not expected to result in health impacts to individuals or populations near the plant. Therefore, the staff concludes that there are no impacts of radiation exposures to the public during the license renewal term beyond those discussed in the GEIS.

- Occupational radiation exposures (license renewal term). Based on information in the GEIS, the Commission found that

  > Projected maximum occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages, and would be well below regulatory limits.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Additional staff will be required to operate BFN at a combined total power level of 11,856 MW(t); however, the doses to individual plant workers would remain within regulatory limits. Therefore, the staff concludes that there are no impacts of occupational radiation exposures during the license renewal term beyond those discussed in the GEIS.

There are no Category 2 issues related to radiological impacts of routine operations.

4.4 Socioeconomic Impacts of Plant Operations During the License Renewal Term

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to socioeconomic impacts during the license renewal term are listed in Table 4-8. In its ER (TVA 2003b), TVA stated that it is not aware of any new and significant information associated with the license renewal of the BFN OLs. The staff has not identified any new and significant information during its independent review of the ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t).

Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS (NRC 1996). For these issues, the staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-8. Category 1 Issues Applicable to Socioeconomics During the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
SOCIOECONOMIC	
Public services: public safety, social services, and tourism and recreation	4.7.3; 4.7.3.3; 4.7.3.4; 4.7.3.6
Public services: education (license renewal term)	4.7.3.1
Aesthetic impacts (license renewal term)	4.7.6
Aesthetic impacts of transmission lines (license renewal term)	4.5.8

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, for each of these issues follows:

- Public services – public safety, social services, and tourism and recreation. Based on information in the GEIS, the Commission found that

  > Impacts to public safety, social services, and tourism and recreation are expected to be of small significance at all sites.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts on public safety, social services, and tourism and recreation during the license renewal term beyond those discussed in the GEIS.

- Public services – education (license renewal term). Based on information in the GEIS, the Commission found that

  > Only impacts of small significance are expected.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts on education during the license renewal term beyond those discussed in the GEIS.

- Aesthetic impacts (license renewal term). Based on information in the GEIS, the Commission found that

  > No significant impacts are expected during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no aesthetic impacts during the license renewal term beyond those discussed in the GEIS.

- Aesthetic impacts of transmission lines (license renewal term). Based on information in the GEIS, the Commission found that

  No significant impacts are expected during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no aesthetic impacts of transmission lines during the license renewal term beyond those discussed in the GEIS.

Table 4-9 lists the Category 2 socioeconomic issues that require plant-specific analysis and environmental justice, which was not addressed in the GEIS. These issues are discussed in Sections 4.4.1 through 4.4.6.

Table 4-9. Environmental Justice and GEIS Category 2 Issues Applicable to Socioeconomics During the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
	SOCIOECONOMIC		
Housing impacts	4.7.1	I	4.4.1
Public services: public utilities	4.7.3.5	I	4.4.2
Offsite land use (license renewal term)	4.7.4	I	4.4.3
Public services: transportation	4.7.3.2	J	4.4.4
Historic and archaeological resources	4.7.7	K	4.4.5
Environmental justice[a]	Not addressed	Not addressed	4.4.6

(a) Guidance related to environmental justice was not in place at the time the GEIS and the associated revision to 10 CFR Part 51 were prepared. Therefore, environmental justice must be addressed in the licensee's ER and the staff's environmental impact statement (EIS).

4.4.1 Housing Impacts

Impacts on housing are considered SMALL when a small or not easily discernible change in housing availability occurs. Impacts are considered MODERATE when there is discernible but

short-lived reduction in available housing units because of project-induced migration. Impacts are considered LARGE when project-related housing demands result in very limited housing availability and would increase rental rates and housing values well above normal inflation (NRC 1996).

In determining housing impacts, TVA chose to follow Appendix C of the GEIS (NRC 1996), which presents a population characterization method that is based on two factors, "sparseness" and "proximity." Sparseness measures population density within 32 km (20 mi) of the site, and proximity measures population density and city size within 80 km (50 mi). Each factor has categories of density and size (NRC 1996, Table C.1), and a matrix is used to rank the population category as low, medium, or high (NRC 1996, Figure C.1).

In 2000, the population living within 32 km (20 mi) of BFN was estimated to be approximately 164,936 (TVA 2003b). This total converts to a population density of about 52 persons/km^2 (136 persons/mi^2) living within a 32-km (20-mi) radius of BFN. This concentration falls into the GEIS sparseness Category 4 (i.e., having greater than or equal to 46 persons/km^2 [120 persons/mi^2]).

An estimated 872,478 people live within 80 km (50 mi) of the BFN site (TVA 2003b), equating to a population density of around 43 persons/km^2 (112 persons/mi^2). In addition, the City of Huntsville, which has a population of 158,216, is located about 48 km (30 miles) to the east of the site (TVA 2003b). Applying the GEIS proximity measures (NRC 1996), BFN is classified as Category 3 (i.e., having one or more cities with 100,000 or more persons and less than 73 persons/km^2 [190 persons/mi^2] within 80 km [50 mi] of the site). According to the GEIS, these sparseness and proximity scores identify the BFN nuclear units as being located in a high-population area.

10 CFR Part 51, Subpart A, Appendix B, Table B-1, states that impacts on housing availability are expected to be of SMALL significance at plants located in a high-population area where growth-control measures are not in effect. The BFN site is located in a high-population area. There are no restrictive growth-control measures that would limit housing development in Limestone County or any of its neighboring counties (Lawrence, Lauderdale, Madison, or Morgan Counties) (TVA 2003b).

SMALL impacts result when no discernible change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion is required to meet new demand (NRC 1996). The GEIS assumes that an additional staff of 60 permanent per-unit workers might be needed during the license renewal term to perform routine maintenance and other activities.

TVA plans no refurbishment activities as part of the license renewal process; therefore, employment will not change significantly in the area as a result of the license renewal of the

plant. Activities related to the replacement of a cooling tower are outside the scope of license renewal because they are related to current operations and the restart of Unit 1.

The staff reviewed the available information relative to housing impacts and TVA's conclusions. Based on this review, including interviews with local real estate agents, the staff concludes that the impact on housing during the license renewal term would be SMALL, and additional mitigation is not warranted.

4.4.2 Public Services: Public Utilities

Impacts on public utility services are considered SMALL if there is little or no change in the ability of the system to respond to the level of demand, and thus there is no need to add capital facilities. Impacts are considered MODERATE if overtaxing of service capabilities occurs during periods of peak demand. Impacts are considered LARGE if existing levels of service (e.g., water or sewer services) are substantially degraded and additional capacity is needed to meet ongoing demands for services. The GEIS indicates that, in the absence of new and significant information to the contrary, the only impacts on public utilities that could be significant are impacts on public water supplies (NRC 1996).

Analysis of impacts on the public water supply system considered both plant demand and plant-related population growth. Section 2.2.2 describes the BFN-permitted withdrawal rate and actual use of water. TVA plans no refurbishment activities at BFN so plant demand would not change beyond current demands (TVA 2004a).

For the sake of evaluation, the staff uses the employment projections for Unit 1 operation (150 new jobs), and an overall population increase of approximately 374 as a result of those jobs.[(a)] The plant-related population increase would require an additional 72 to 102 m^3/d (0.019 to 0.027 MGD) of water. This amount is within the total residual capacity of the water treatment plants serving BFN (Table 2-9). Thus, the staff concludes that the impact of increased water use resulting from the potential increase in employment is SMALL, and mitigation is not warranted.

4.4.3 Offsite Land Use

Offsite land use during the license renewal term is a Category 2 issue. Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, notes that "significant changes in land use may be associated with population and tax revenue changes resulting from license renewal."

(a) Calculated by assuming that the average number of persons per household is 2.49 in the state of Alabama (150 jobs x 2.49 = 373.5) (USCB 2000).

Section 4.7.4 of the GEIS defines the magnitude of land-use changes as a result of plant operation during the license renewal term as follows:

SMALL – Little new development and minimal changes to an area's land-use pattern

MODERATE – Considerable new development and some changes to the land-use pattern

LARGE – Large-scale new development and major changes in the land-use pattern.

The current OLs for Units 1, 2, and 3 expire in 2013, 2014, and 2016, respectively. Unit 1 is currently not operating; however, TVA projects that operation will resume in 2007 (TVA 2003b). When Unit 1 resumes operation, the total permanent employment at the BFN site is expected to increase by 150 workers (TVA 2003b). TVA determined that no additional plant workers will be required during the license renewal term (TVA 2003b). Section 3.7.5 of the GEIS states that if plant-related population growth is less than 5 percent of the study area's total population, offsite land use changes would be small, especially if the study area has established patterns of residential and commercial development, a population density of at least 23 persons/km^2 (60 persons/mi^2), and at least one urban area with a population of 100,000 or more within 80 km (50 mi). For BFN, there is no expected population growth as a result of renewal of the three OLs. Consequently, the staff concludes that population changes resulting from license renewal are likely to result in minimal change to the land-use pattern in the area.

Tax revenue can affect land use because it enables local jurisdictions to be able to provide the public services (e.g., transportation and utilities) necessary to support development. Section 4.7.4.1 of the GEIS states that the assessment of tax-driven, land-use impacts during the license renewal term should consider (1) the size of the plant's payments relative to the community's total revenues, (2) the nature of the community's existing land-use pattern, and (3) the extent to which the community already has public services in place to support and guide development. If the plant's tax payments are projected to be small relative to the community's total revenue, tax-driven, land-use changes during the plant's license renewal term would be small, especially where the community has pre-established patterns of development and has provided adequate public services to support and guide development. Section 4.7.2.1 of the GEIS states that if tax payments by the plant owner are less than 10 percent of the taxing jurisdiction's revenue, the significance level would be small. If the plant's tax payments are projected to be medium to large (10 to 20 percent) relative to the community's total revenue, new tax-driven, land-use changes would be moderate. This is most likely to be true where the community has no pre-established patterns of development (i.e., land-use plans or controls) or has not provided adequate public services to support and guide development in the past, especially infrastructure that would allow industrial development. If the plant's tax payments are projected to be a dominant source of the community's total revenue, new tax-driven, land-use changes would be large. This impact would be especially true where the community has no

pre-established pattern of development or has not provided adequate public services to support and guide development in the past.

TVA makes tax-equivalent payments to the State of Alabama and local governments in eight states. These payments are redistributed by the state to the counties that are served by TVA power. See Section 2.2.8.5 for a discussion on the distribution of tax-equivalent payments to affected counties. A certain amount of this revenue is used for development and infrastructure within local communities. The portion of revenue in Limestone County and its subdivisons that is attributable to TVA payments for BFN is shown in Table 2-12. It is not expected that the percentages shown in Table 2-12 will vary significantly in the future (TVA 2003b). Consequently, the staff concludes that tax-driven, land-use impacts resulting from license renewal are likely to be minimal. Overall, changes in land use associated with population and tax revenue changes resulting from renewal of the BFN OLs are likely to be SMALL.

4.4.4 Public Services: Transportation

On October 4, 1999, 10 CFR 51.53(c)(3)(ii)(J) and 10 CFR Part 51, Subpart A, Appendix B, Table B-1, were revised to state that "Public Services: Transportation Impacts During Operations" is a Category 2 issue (see NRC 1999 for more discussion of this clarification). The issue is treated as such in this SEIS.

As noted in Section 2.2.8.2, BFN is approximately 16 km (10 mi) southwest of Athens in Limestone County and is located just south of U.S. Highway 72. The site is directly accessible from County Road 25. One portion of County Road 25 (Shaw Road) serves as a primary north-south corridor in the vicinity of the plant and intersects U.S. Highway 31 approximately 14.4 km (9 mi) east of the site. Browns Ferry Road, which intersects County Road 25 just east of the site, runs northeast from BFN and provides a direct route to BFN from Athens. The latest available 1998 average daily traffic counts in proximity to BFN indicate approximately 13,440 vehicles per day on U.S. Highway 72 north of the site and 16,260 vehicles per day on U.S. Highway 31 south of U.S. Highway 72. There are no available traffic counts on the county roads; however, TVA estimates approximately 1600 vehicles per day on Shaw Road, Browns Ferry Road, and Nuclear Plant Road. BFN is currently a primary source of traffic on these county roads (TVA 2003b).

The GEIS assumes that an additional 60 permanent workers per unit might be needed during the license renewal term to perform routine maintenance and other activities. This bounding scenario of 120 additional staff (60 workers each at Units 2 and 3) plus an additional 150 staff for operation of Unit 1 represents approximately 2 percent of the traffic volume on U.S. Highways 72 and 31. The total average daily traffic on Shaw Road, Nuclear Plant Road, and Browns Ferry Road would increase from approximately 1600 to 1870 (assuming no carpooling), which represents a 17 percent increase in average daily traffic.

To alleviate peak congestion and degradation of county roads in the vicinity of BFN, TVA identified specific site mitigation measures to improve the local roadway during peak periods. These mitigation measures include flexible working hours to reduce peak hours, delayed shift changes, restrictions for trucks traveling during peak hours, roadway improvements, which would include lane widening, realignment and lane addition, and repaving (TVA 2003b).

The staff reviewed the available information, including that provided by TVA, the scoping process, the staff's site visit, discussions with other agencies, and other public sources. Using this information, the staff evaluated the potential impacts to transportation service resulting from operation of BFN. It is the staff's conclusion that the potential impacts to transportation service degradation during the license renewal term are SMALL, considering that no additional staff are expected for renewal refurbishment activities. During the course of preparing this SEIS, the staff considered mitigation measures for the continued operation of BFN. When continued operation for an additional 20 years is considered as a whole, all the specific effects on the environment (whether or not "significant") were considered. Based on this assessment, the staff expects that the measures identified by BFN provide mitigation for all impacts related to transportation, and no new mitigation measures are warranted.

4.4.5 Historic and Archaeological Resources

The National Historic Preservation Act of 1966 (NHPA), as amended, requires Federal agencies to take into account the effects of their undertakings on historic properties. The historic preservation review process mandated by Section 106 of NHPA is outlined in regulations issued by the Advisory Council on Historic Preservation at 36 CFR Part 800. Operation of a nuclear power plant during the license renewal term could affect historic properties that may be located at the site. Therefore, in accordance with NHPA, NRC must make a reasonable effort to identify historic properties in the areas of potential effects. If no historic properties are present or affected, NRC is required to notify the State Historic Preservation Officer (SHPO) before proceeding. If it is determined that historic properties are present, NRC is required to assess and resolve possible adverse effects of the undertaking.

In 1972, TVA consulted with the Alabama Historical Commission for the construction of BFN as required by NHPA. In a letter dated March 16, 1972, the Alabama Historical Commission concluded that in the area of BFN nothing was found that would be adversely affected by the addition of the plant (AHC 1972). The original construction of the plant required the relocation of the Cox Cemetery. It was the opinion of the SHPO that the relocation of the cemetery occurred with considerable care.

In 2002, TVA prepared an SEIS for renewal of the BFN OLs (TVA 2002). In addition to the SEIS, TVA consulted with the Alabama SHPO regarding renewal of the BFN OLs. On April 24, 2002, the Alabama SHPO concurred with TVA that the project activities associated

with license renewal at BFN would have no effect on significant cultural resources provided that site 1Li535 and the Cox Cemetery were avoided (SHPO 2002).

The NRC sent a letter to the Alabama SHPO, dated March 8, 2004 (NRC 2004b), and stated that in accordance with 36 CFR 800.8, the SEIS would include analyses of potential impacts to historic and archaeological resources. In the context of the NHPA, the NRC staff determined that the area of potential effect for a license renewal action is the area at the power plant site and its immediate environs, which may be impacted by post-license renewal land-disturbing operation or by projected refurbishment activities associated with the proposed action.

Seventeen Native American Tribes were sent letters on March 23, 2004, providing them with an opportunity to provide input regarding cultural resource issues in the vicinity of BFN and inviting them to participate in the National Environmental Policy Act of 1969 (NEPA) process. Several Federal and State agencies were contacted to identify tribes that may have a potential interest in the lands at BFN including the Alabama SHPO, the Advisory Council on Historic Preservation, the Bureau of Indian Affairs, the Alabama Department of Transportation, and the U.S. Forest Service. The Tribes contacted were the Poarch Creek Indians, Miccosukee Indian Tribe, Seminole Indian Tribe, Coushatta Indian Tribe, Jena Band of Choctaw Indians, Mississippi Band of Choctaw Indians, Eastern Band of Cherokee Indians, Alabama-Coushatta Tribe of Texas, Alabama-Quassarte Tribal Town, Cherokee Nation of Oklahoma, Chickasaw Nation, Choctaw Nation of Oklahoma, Kialegee Tribal Town, Muscogee (Creek) Nation, Seminole Nation of Oklahoma, Thlopthlocco Tribal Town, and United Keetoowah Band of Cherokee Indians. An example of one of the letters sent to the Tribes is included in Appendix E.

Operation of BFN, as planned under the application for license renewal, would protect undiscovered historic or archaeological resources on the site because the undeveloped natural landscape and vegetation would remain undisturbed, and access to the site would remain restricted.

TVA operating procedures take into account the inadvertent discovery of historic and archaeological remains at BFN. However, care should be taken during normal operational and maintenance conditions to ensure that historic resources are not inadvertently impacted. These activities may include not only operation of BFN itself but also land management-related actions such as recreation, wildlife habitat enhancement, and maintaining/upgrading BFN access roads through the site and on transmission line rights-of-way.

TVA recently conducted a study to determine if changes in the operating policies for TVA's reservoirs would produce greater overall public value. TVA prepared a programmatic EIS for the Reservoirs Operation Study (TVA 2004b). Consultations with seven SHPOs, including the Alabama Historical Commission, and other consulting parties under the requirements of

Section 106 of NHPA, have resulted in agreement(s) stipulating the actions TVA will take to avoid or reduce the adverse effects of the selected alternative on historic properties. The factors that were analyzed by TVA include shoreline erosion, exposure by elevation fluctuations, land development, and visual impacts. The agreement(s) developed can be found in the programmatic EIS for the Reservoirs Operation Study (TVA 2004b).

Based on the staff's archaeological and historic resources analysis and the consultation that has occurred, TVA's commitment that 1Li535 and the Cox Cemetery will be avoided, and the fact that operation will continue within the bounds of station operations as evaluated in the final EIS (TVA 1972), the staff concludes that the potential impacts on historic and archaeological resources are expected to be SMALL, and mitigation is not warranted.

4.4.6 Environmental Justice

Environmental justice refers to a Federal policy that requires Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its actions on minority[a] or low-income populations. The memorandum accompanying Executive Order 12898 (59 FR 7629) directs Federal executive branch agencies to consider environmental justice under NEPA. The Commission's "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions" contains guidance and information for addressing environmental justice (69 FR 52040). Although the Executive Order is not mandatory for independent agencies, NRC has voluntarily committed to undertake environmental justice reviews. Specific guidance is provided in NRC Office of Nuclear Reactor Regulation Office Instruction LIC-203, Rev. 1 "Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues" (NRC 2004b).

The staff examined the geographic distribution of minority and low-income populations within 80 km (50 mi) of the BFN site, employing the 2000 census (USCB 2000) for minority and low-income populations. The populations within an 80-km (50-mi) radius of BFN encompassed all or parts of 19 counties. The staff supplemented its analysis through the scoping process and by field inquiries to county planning departments, social service agencies, and local real estate agents.

For purposes of the staff's review, a minority population is defined to exist if the percentage of each minority, or aggregated minority category within the census tract or block group[b]

(a) The NRC Guidance for performing environmental justice reviews defines "minority" as American Indian or Alaskan Native, Asian or Pacific Islander, Black not of Hispanic Origin, or Hispanic (NRC 2004b).

(b) A census block group is a combination of census blocks, which are statistical subdivisions of a census tract. A census block is the smallest geographic entity for which the U.S. Census Bureau (USCB)

potentially affected by the license renewal of BFN, exceeds the corresponding percentage of minorities in the entire state by 20 percent, or if the corresponding percentage of minorities within the census tract or block group is at least 50 percent. A low-income population is defined to exist if the percentage of low-income population within a census tract or block group exceeds the corresponding percentage of low-income population in the entire state by 20 percent, or if the corresponding percentage of low-income population within a census tract or block group is at least 50 percent. The minority population in the State of Alabama makes up 30 percent of the population and the low-income population makes up 16 percent of the total population in the state. The minority population in the State of Tennessee makes up 20 percent of the population and the low-income population makes up 14 percent of the total population in the state.

TVA used 2000 census data for identifying minority and low-income populations within the 80-km (50-mi) radius of the BFN site. TVA also followed the convention of employing census tracts within the 80-km (50-mi) radius of BFN (TVA 2003b), and the staff confirmed these results by examining the minority and low-income populations by census block group within the 80-km (50-mi) radius of the site. If the census tract or block group minority or low-income percentage exceeded the state by 20 percent then the census tract or block group was counted (TVA 2003b). Using this convention, the 80-km (50-mi) radius includes 74 census block groups for minority populations and 27 census block groups for low-income populations. Figure 4-1 shows the distribution of minority populations within the 80-km (50-mi) radius. The shaded areas in Figure 4-1 indicate census block groups where the aggregate percentage of minorities is at least 20 percentage points above the percentage of minorities in the States of Alabama and Tennessee or greater than 50 percent.

Minority population concentrations are present in eight counties within the 80-km (50-mi) radius of the BFN site. Minority populations are primarily concentrated in the urban center of Huntsville. Madison County contains 43 of the 74 block groups containing significant minority populations. The next greatest concentration of minority populations lives in Colbert and Morgan counties, which each have six block groups with significant minority populations. Lauderdale and Lawrence, Alabama each have five minority block groups. Limestone County, where BFN is located, has four minority block groups. The minority block groups in Morgan County are predominantly composed of black/African-American concentrations and are within the 16-km (10-mi) radius evacuation zone of BFN (USCB 2000; CDD 2004).

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collects and tabulates decennial census information. A census tract is a small, relatively permanent statistical subdivision of counties delineated by local committees of census data users in accordance with USCB guidelines for the purpose of collecting and presenting decennial census data. Census block groups are subsets of census tracts (USCB 2001).

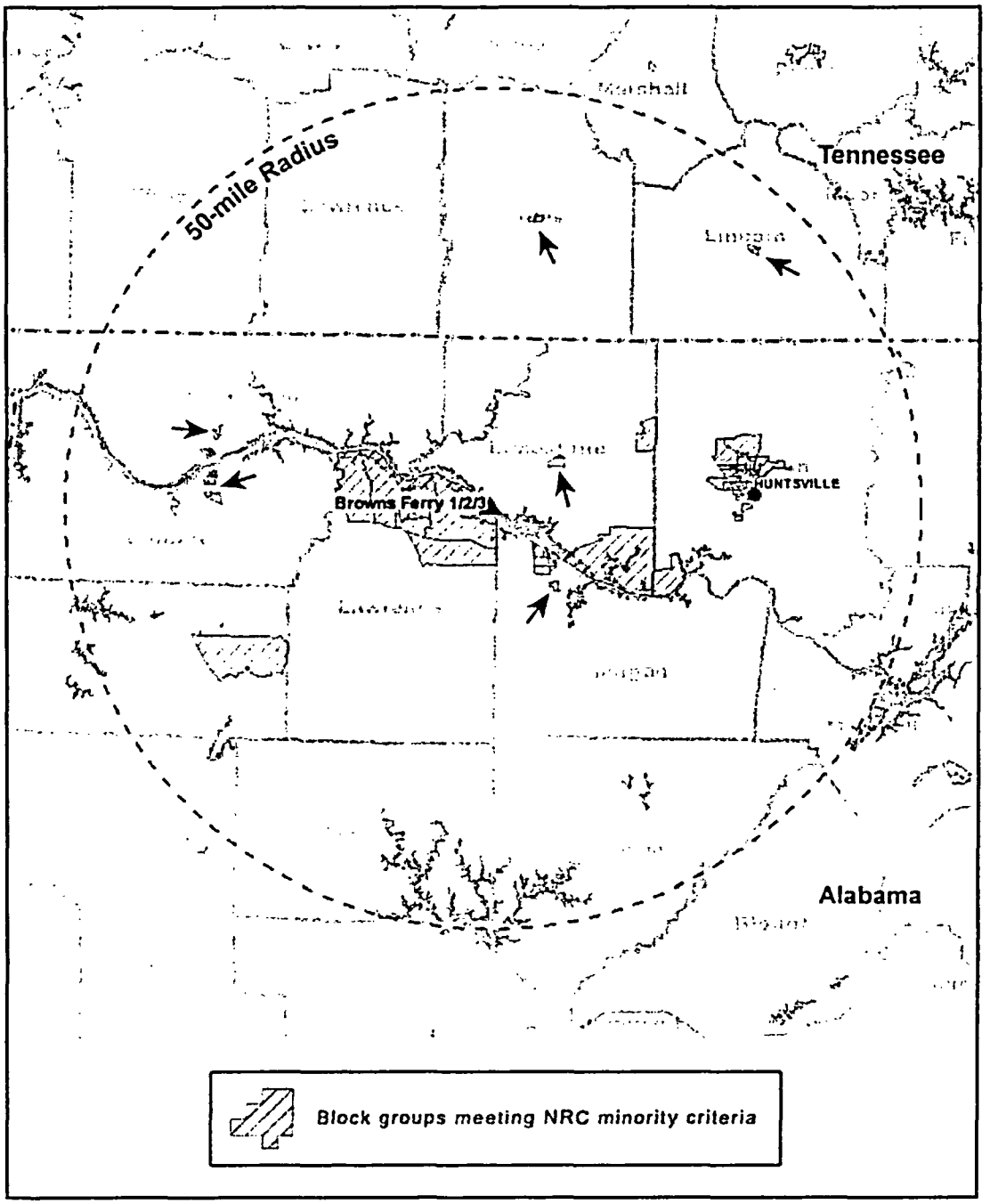

Figure 4-1. Geographic Distribution of Minority Populations (shaded areas) Within 80 km (50 mi) of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Based on 2000 Census Block Group Data

Data from the 2000 census characterize low-income populations within the 80-km (50-mi) radius of the BFN site (USCB 2000). Applying the NRC criterion of "more than 20 percent greater" than the state average or "greater than 50 percent," the census block groups containing low-income populations were identified. Figure 4-2 shows the locations of the low-income populations within an 80-km (50-mi) radius of the BFN site. The low-income populations are concentrated around the urban center of Huntsville, where 11 of the 27 low-income block groups are found. Lauderdale County has seven additional low-income block groups, while Colbert County has four block groups. Franklin, Morgan, and Winston counties in Alabama, and Lawrence and Lincoln counties in Tennessee only have 1 low-income block group each.

With the locations of minority and low-income populations identified, the staff proceeded to evaluate whether any of the environmental impacts of the proposed action could affect these populations in a disproportionately high and adverse manner. Based on staff guidance (NRC 2004b), air, land, and water resources within about 80 km (50 mi) of the BFN site were examined. Within that area, a few potential environmental impacts could affect human populations; all of these impacts were considered minimal for the general population.

The environmental impacts associated with BFN license renewal that could affect human populations are discussed in each associated section. The staff found no unusual resource dependencies or practices such as subsistence agriculture, hunting, or fishing through which minority and/or low-income populations could be disproportionately highly and adversely affected. In addition, the staff did not identify any location-dependent disproportionately high and adverse impacts affecting these minority and low-income populations. The staff concludes that offsite impacts from BFN to minority and low-income populations are SMALL, and no special mitigation actions are warranted.

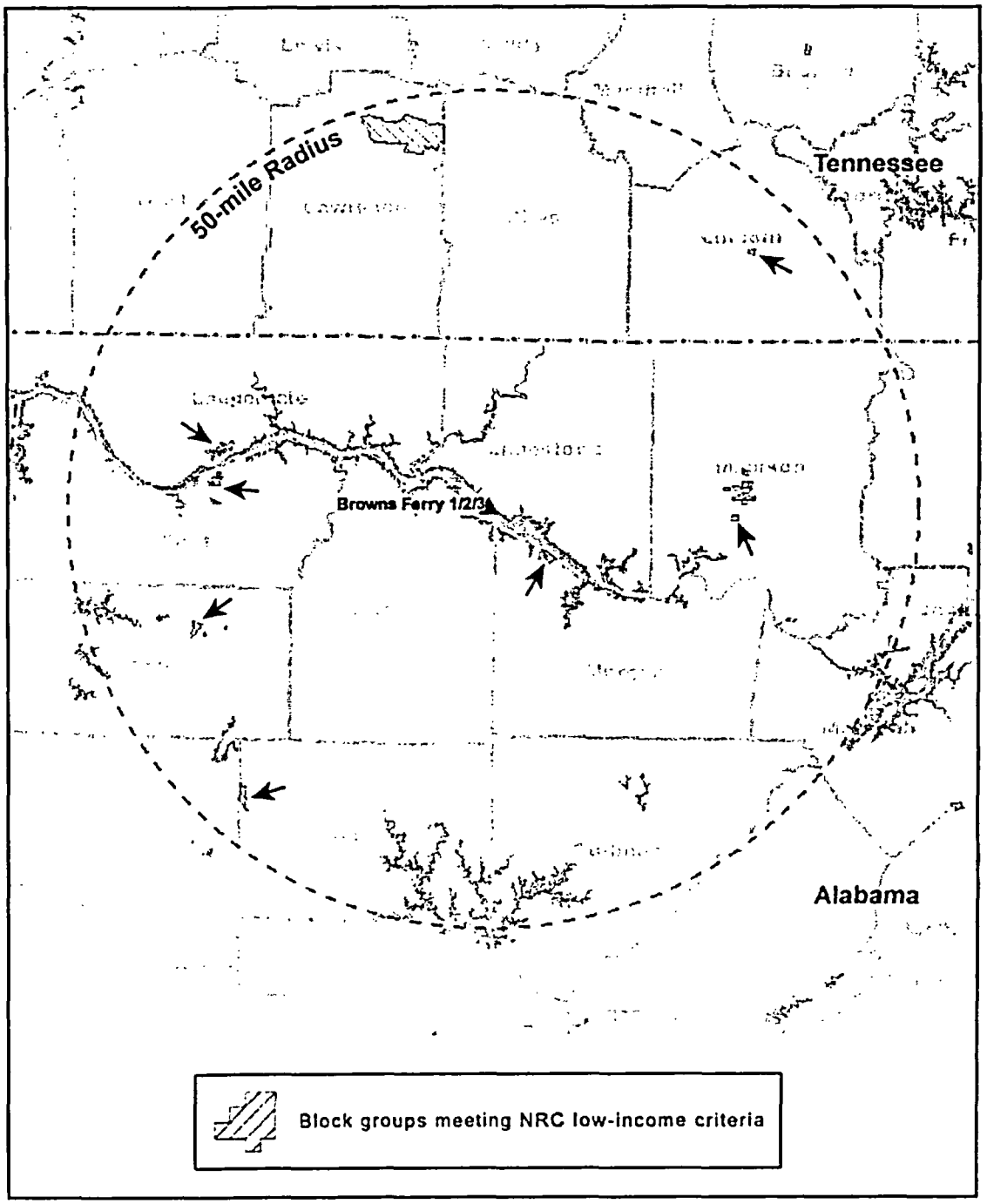

Figure 4-2. Geographic Distribution of Low-Income Populations (shaded areas) Within 80 km (50 mi) of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Based on 2000 Census Block Group Data

4.5 Groundwater Use and Quality

The Category 1 issues related to groundwater use conflicts during the license renewal term that are applicable to BFN are discussed in the section that follows, and are listed in Table 4-10.

Table 4-10. Category 1 Issues Applicable to Groundwater Use Conflicts of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 During the License Renewal Term

ISSUE 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
(FOR POTABLE AND SERVICE WATER PLANTS USING < 100 GPM)	
Groundwater use conflicts (potable and service water plants that use <100 gpm)	4.8.1.1

- Groundwater use conflicts (potable and service water plants using < 100 gpm). Based on information in the GEIS, the Commission found that

  > Groundwater use conflicts related to potable and service water plants using <100 gpm have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

BFN does not withdraw groundwater for potable or service water use. The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of groundwater use conflicts related to potable and service water plants using less than 6.3 L/sec (100 gpm) during the license renewal term beyond those discussed in the GEIS.

The Category 2 issues related to groundwater-use conflicts during the license renewal term that are applicable to BFN are listed in Table 4-11 and are discussed in Section 4.5.1.

Table 4-11. Category 2 Issue Applicable to Groundwater Use Conflicts of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 During the License Renewal Term

ISSUE 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
AQUATIC ECOLOGY			
(FOR PLANTS WITH COOLING TOWERS WITHDRAWING MAKEUP WATER FROM A SMALL RIVER)			
Groundwater use conflicts (plants using cooling towers and withdrawing makeup water from a small river)	4.8.1.3	B	4.5.1

4.5.1 Groundwater Use Conflicts (plants using cooling towers and withdrawing make-up water from a small river)

For plants using makeup water from a small river, potential use conflicts is a Category 2 issue, which requires a site-specific assessment prior to license renewal. The Tennessee River average annual flow at BFN for the period from 1976 through 2002 was 1320 m^3/s (46,606 ft^3/s) or 4.16 x 10^{10} m^3/yr (1.47 x 10^{12} ft^3/yr). This is less than the 9 x 10^{10} m^3/yr (3.15 x 10^{12} ft^3/yr) criterion stated by NRC in 10 CFR 51.53(c)(3)(ii)(A) as the value beneath which an assessment of the impact of the proposed action must be provided.

NRC has determined that indirect groundwater-use conflicts can result from surface water withdrawal from a small river (NRC 1996). It is a potentially important concern that has been designated a Category 2 issue. Rivers often supply alluvial aquifers, and large-scale withdrawals of makeup water for evaporative loss could impact an alluvial aquifer during periods of low flow. This does not occur at BFN as described below.

BFN uses cooling towers and withdraws makeup water from the Tennessee River; however, there are no existing or proposed offsite or onsite groundwater supply wells. Rights to "use" of groundwater at BFN were acquired by ownership of property overlying aquifers. There are no future water rights to groundwater underlying BFN (including Native American tribal rights).

Although shallow groundwater at BFN can occur within unconsolidated terrace deposits of alluvial origin, the terrace deposits are not recognized as an aquifer at the site. This is primarily because of the limited permeability and spatial extent of the terrace deposits. Therefore, groundwater-use conflicts associated with surface water withdrawals are small and may only occur during low flow conditions, which may affect aquifer recharge.

A total of 18 environmental monitoring wells have been installed at the BFN site since 1980, and groundwater level measurements were monitored on a monthly basis through 1989. The water levels in those wells have fluctuated throughout the year; however, there is no decreasing trend (Julian 2004). This indicates that site surface water consumption had not indirectly lowered groundwater levels or created conflicts through 1989.

The water levels in Wheeler Reservoir throughout 2003 and for the period from 1991 to 1997 were consistent with those from 1972 to 1990 (Julian 2004). This indicates that reservoir levels have had consistent annual profiles since routine site groundwater monitoring ceased in 1989. Furthermore, because the lake levels have not dropped since 1991, site surface water consumption has not indirectly lowered groundwater levels or created groundwater conflicts since site monitoring ceased in 1989.

An offsite well survey was conducted in May 1995 to identify groundwater supplies within a 3.2-km (2-mi) radius of the BFN site (TVA 1999). The closest known public groundwater supply (Limestone County Water System, Well G-1) resides approximately 3.2 km (2 mi) north of BFN (Bohac 2004). There is no groundwater use by BFN, and site dewatering wells have been inactive since the 1980s. All wells at the site are used for environmental monitoring purposes only.

The staff independently reviewed the TVA ER (TVA 2003b) and visited the site. Also, the potential for water-use conflicts was reviewed directly with respect to surface water withdrawals in Section 4.1.1 and was found to be SMALL. Because no groundwater is used at the plant, and the terrace deposits are characterized by limited permeability, the indirect use of groundwater by surface water withdrawal is even more remote. Surface water withdrawals for cooling system makeup water is not expected to affect groundwater levels. Therefore, the staff concludes that groundwater use conflicts would be SMALL.

4.6 Threatened or Endangered Species

Threatened or endangered species are listed as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. This issue is listed in Table 4-12.

This issue requires consultation with appropriate agencies to determine whether threatened or endangered species are present and whether they would be adversely affected by continued operation of the nuclear plant during the license renewal term. The presence of threatened or endangered species in the vicinity of the BFN site is discussed in Sections 2.2.5 and 2.2.6. On March 4, 2004, the staff contacted the FWS to request information on threatened and endangered species and the impacts of license renewal (NRC 2004c). In response, on May 19, 2004, the FWS provided additional information regarding Federally listed species that have been observed or may occur in the vicinity of the BFN site and its associated transmission lines, as well as the concerns that the FWS have regarding those species (Goldman 2004). On October 25, 2004 the staff sent (NRC 2004d) a biological assessment (BA) (see Appendix E) to the FWS for concurrence.

Table 4-12. Category 2 Issue Applicable to Threatened or Endangered Species in the Vicinity of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 During the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
THREATENED OR ENDANGERED SPECIES (FOR ALL PLANTS)			
Threatened or endangered species	4.1	E	4.6

4.6.1 Aquatic Species

As described in Section 2.2.5, there are 38 Federally listed aquatic species (including three candidate species) that occur or historically have occurred in either Wheeler Reservoir or its tributaries or in other streams, rivers, or caves within the counties of Alabama and Mississippi through which the BFN transmission lines pass. The species that occur in Wheeler Reservoir and its tributaries are not impacted by plant operations. During BFN's thermal variance monitoring (1985 to 1998) and current Vital Signs Monitoring Programs, no threatened or endangered aquatic species were found within the area that would be affected by operational changes at BFN (TVA 2003b). Additionally, cooling water intake and discharge are closely monitored under the NPDES program, and permit limits are reviewed on a regular basis by State regulatory agencies to ensure the protection of aquatic biota.

A number of listed species occur in the counties crossed by the BFN transmission lines; however, this does not imply that they occur under or near the transmission lines. The TVA Regional Natural Heritage Program keeps track of Federally and State-protected species. Aquatic animal occurrence records are maintained and updated by TVA staff on a regular basis. Each proposed transmission line vegetation management project is reviewed for the known or likely occurrence of protected aquatic species in streams in or adjacent to the transmission line rights-of-way. A 16-km (10-mi) buffer area around the transmission line being reviewed is examined to determine the likely occurrence of protected aquatic animals. Once an occurrence is located, appropriate class restrictions are applied (see Section 4.2). Furthermore, best management practices, outlined by Muncy et al. (1999), are employed to protect listed species and their habitats while carrying out vegetation management activities along the transmission lines (TVA 2003b).

The staff concluded in its BA (NRC 2004d) that continued operation of BFN, including return to three-unit operation at a total combined power level of 11,856 MW(t) and the associated transmission line rights-of-way maintenance activities during the license renewal term, will have no effect, or is not likely to adversely affect any Federally listed aquatic species, nor will it adversely impact any designated critical habitat. Thus, the staff concludes that the impact on threatened or endangered aquatic species from an additional 20 years of operation would be SMALL, and additional mitigation is not warranted.

4.6.2 Terrestrial Species

No Federally listed species are known to occur within 5 km (3 mi) of the BFN site (TVA 2003b). Although no Federally or State-listed species have been reported from areas within 5 km (3 mi) of BFN, a total of 11 Federally listed species have been identified from counties traversed by transmission line rights-of-way along with over 200 State-listed species. Federally listed species reported to occur from Limestone, Morgan, Lawrence, Colbert, and Franklin counties in Alabama and Tishomingo, Itawamba, Lee, and Union Counties in Mississippi are the bald

eagle, red-cockaded woodpecker, gray bat, Indiana bat, Price's potato-bean, American hart's tongue fern, leafy prairie clover, Eggert's sunflower, fleshy-fruited gladecress, lyrate bladderpod, and the Tennessee yellow-eyed grass.

Habitat for some of the Federally listed species and some of the State-listed species could be found within or traversed by BFN transmission line rights-of-way. Two wildlife management areas occur within 5 km (3 mi) of the BFN site – Swan Creek State Wildlife Management Area and Mallard-Fox Creek State Wildlife Management Area (TVA 2003b). Approximately 5.6 km (3.5 mi) upstream of BFN is the Round Island Recreation Area. The BFN-to-Maury, Alabama, transmission line right-of-way is near the Philadelphia Glade and the Swan Creek State Wildlife Management Area. The BFN-to-Union, Mississippi, transmission line right-of-way crosses the John Bell Williams State Wildlife Management Area, the Natchez Trace National Parkway, the Tennessee-Tombigbee Waterway, the Foxtrap Creek Ravine Potential National Natural Landmark, the Canal Section Wildlife Management Area, East Fork Tombigbee Macrosite, Bear Creek Unit 2 proposed critical habitat, and is near the Lake Lamar Bruce State Fishing Area. The BFN-to-Trinity and BFN to Athens transmission line rights-of-way do not cross any natural areas. The BFN-to-Trinity transmission right-of-way does pass near the Mallard-Fox Creek State Wildlife Management Area.

TVA monitors and tracks populations of Federally and State-sensitive terrestrial species on the BFN site and within transmission line rights-of-way. In addition, TVA works with appropriate Federal and State agencies to develop and establish guidelines and safeguards for their contract personnel to follow to protect threatened and endangered species and their habitats during maintenance of transmission line rights-of-way (Muncy et al. 1999).

The staff concluded in its BA (NRC 2004d) that continued operation of BFN, including return to three-unit operation at a total combined power level of 11,856 MW(t) and the associated transmission line rights-of-way maintenance activities during the license renewal term, will have no effect, or is not likely to adversely affect any Federally listed terrestrial species, nor will it adversely impact any designated critical habitat. Thus, the staff concludes that the impact on threatened or endangered terrestrial species from an additional 20 years of operation would be SMALL, and additional mitigation is not warranted.

4.7 Evaluation of Potential New and Significant Information on Impacts of Operations During the License Renewal Term

The GEIS assesses 92 environmental issues. Sixty-nine of these issues were found to be Category 1 issues, and are identified in 10 CFR Part 51 as not requiring additional plant-specific analysis in the absence of new and significant information. The staff reviewed the list and

consulted with the appropriate Federal, State, and local agencies to identify any compliance or permit issues or significant environmental issues of concern to the reviewing agencies. These agencies did not identify any new and significant environmental issues. The ER states that TVA is in compliance with applicable environmental standards and requirements for BFN. The staff has not identified any environmental issues that are both new and significant.

The staff identified one potential area that required further analysis. Category 1 issues were established by the GEIS after a review of data from existing operating nuclear plants. The analysis established an envelope of impact for each of the Category 1 issues that were based on the impacts that were identified at nuclear power plants throughout the United States at the time the GEIS was prepared. TVA has applied for extended power uprate (EPU) for the three BFN units. These EPUs would eventually increase thermal power levels from the initially licensed levels of 3293 MW(t)/unit to 3952 MW(t)/unit. This represents a total power increase of 20 percent. Once the uprate has been achieved, BFN will have a combined total power level of 11,856 MW(t), and will become the largest nuclear power plant in the United States.

For this reason, the staff determined that there is a potential that, at the uprated power level, BFN may no longer be within the envelope of impacts defined by the GEIS, as amended, for some Category 1 issues. If the potential impacts are beyond the defined envelope, the generic conclusions concerning these Category 1 issues may no longer be valid, and the power uprate could therefore represent new and significant information regarding some of the Category 1 issues. Category 2 issues are not a concern in this regard because all applicable Category 2 issues are evaluated on a site-specific basis for each facility undergoing license renewal.

To address this concern, the staff examined each of the 54 Category 1 issues applicable to BFN and determined that 34 of the Category 1 issues could be influenced by the station thermal power level. The staff then evaluated each of the 34 issues to determine if increasing the unit power level above the levels considered during the development of the GEIS would affect the specific generic conclusions. After evaluating all 34 issues the staff determined that the generic conclusions reached in the GEIS are still valid and that no additional analysis or evaluation of these issues is necessary. The 34 issues evaluated are listed in Tables 4-13 through 4-17. An explanation of why the GEIS conclusion is still valid for the uprated BFN site is provided following each table.

- Altered current patterns at intake and discharge structures

Any localized effects on current patterns would have been manifest during the initial stages of three-unit operation and would have been mitigated, if necessary, at that time. Three-unit operation at BFN, at the combined total power level of 11,856 WM (t) expected during the license renewal term, uses existing intake and discharge structures, and although re-tubing the condensers, upgrading other systems, and improving flow calibrations have increased the flow

Table 4-13. Cooling System-Related Category 1 Issues that are Potentially Affected by Proposed Extended Power Uprates at Browns Ferry Nuclear Power Plant, Units 1, 2, and 3

ISSUE 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
SURFACE WATER QUALITY, HYDROLOGY, AND USE (for all plants)	
Altered current patterns at intake and discharge structures	4.2.1.2.1; 4.3.2.2; 4.4.2
Altered thermal stratification of lakes	4.2.1.2.3; 4.4.4.2
Temperature effects on sediment transport capacity	4.2.1.2.3; 4.4.2.2
Scouring caused by discharged cooling water	4.2.1.2.3; 4.4.2.2
Eutrophication	4.2.1.2.3; 4.4.2.2
Discharge of chlorine or other biocides	4.2.1.2.4; 4.4.2.2
Discharge of other metals in wastewater	4.2.1.2.4; 4.3.2.2; 4.4.2.2
Water use conflicts (plants with once-through cooling systems)	4.2.1.3
AQUATIC ECOLOGY (for all plants)	
Accumulation of contaminants in sediments or biota	4.2.1.2.4; 4.3.3; 4.4.3; 4.4.2.2
Entrainment of phytoplankton and zooplankton	4.2.2.1.1; 4.3.3; 4.4.3
Cold shock	4.2.2.1.5; 4.3.3; 4.4.3
Thermal plume barrier to migrating fish	4.2.2.1.6; 4.4.3
Distribution of aquatic organisms	4.2.2.1.6; 4.4.3
Low dissolved oxygen in the discharge	4.2.2.1.9; 4.3.3; 4.4.3
SURFACE WATER QUALITY, HYDROLOGY, AND USE (FOR ALL PLANTS)	
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.2.2.1.10; 4.4.3
Stimulation of nuisance organisms	4.2.2.1.11; 4.4.3
Premature emergence of aquatic insects	4.2.2.1.7; 4.4.3
TERRESTRIAL RESOURCES	
Cooling tower impacts on crops and ornamental vegetation	4.3.4
Cooling tower impacts on native plants	4.3.5.1
HUMAN HEALTH	
Microbiological organisms (occupational health)	4.3.6
Noise	4.3.7

rate compared to the original three-unit operation, no increase in the total flow rate is expected as a result of the EPU operation (TVA 2002). Total intake flow is expected to be a maximum of 139 m^3/s (4907 cfs) or 12 million m^3/d (3171 MGD) (TVA 2003b). The staff concludes that the cooling system operation on current patterns is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Altered thermal stratification of lakes

TVA has modeled temperature stratification in Wheeler Reservoir with near- and far-field modeling. Three-unit operation at BFN, at the combined total power level of 11,856 MW(t) expected during the license renewal term, will increase the water discharge temperature (Hopping 2004) and presumably would affect the thermal stratification; however, discharge temperatures will not exceed temperature limits set by the NPDES permit. The licensee will be required to operate within the limits of the NPDES permit during the license renewal term. The limits impose the most severe restrictions in the late summer when thermal stratification is most pronounced at the reservoir. The staff concludes that the effect of the cooling system operation on altered thermal stratification is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Temperature effects on sediment transport capacity

Three-unit operation at BFN, at the combined total power level of 11,856 MW(t) expected during the license renewal term, will increase the water discharge temperature and theoretically could decrease viscosity and change the sediment transport capacity within the Tennessee River. The difference in the discharge temperature is not significant relative to changing the viscosity of the water, and the area of the reservoir affected by elevated temperature is small. This would not result in a detectable change in sediment transport capacity. The staff concludes that the effect of the cooling system operation on temperature effects on sediment transport capacity is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Scouring caused by discharged cooling water

Three-unit operation at BFN, even at the combined total power level of 11,856 MW(t) expected during the license renewal term, uses existing intake and discharge structures and "no changes are expected to the individual unit flow rates as a result of EPU" (TVA 2002). Total intake flow is expected to be a maximum of 139 m^3/s (4907 cfs) or 12 million m^3/d (3171 MGD) (TVA 2003b). The staff concludes that the effect of the cooling system operation on scouring is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Eutrophication

Three-unit operation at BFN, at the combined total power level of 11,856 MW(t) expected during the license renewal term, will increase water discharge temperature, but all discharges will continue to be within the thermal limits established in the NPDES permit. The licensee will be required to operate within the limits of the NPDES permit during the license renewal term. The limits impose the most severe restrictions in the late summer when thermal stratification is most pronounced in the reservoir. The staff concludes that the effect of the cooling system operation on eutrophication is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Discharge of chlorine or other biocides

BFN uses some biocides in parts of the service water system, but currently does not use chlorine or other biocides in the cooling water system. Therefore, resumption of three-unit operation at BFN, even at the 120 percent EPU expected during the license renewal term, is not likely to alter the quantity of biocides released from the station. Based on the need to stay within NPDES limits, no additional mitigation measures to reduce the discharge of biocides are necessary during the license renewal term. The effect of the cooling system operation on discharge of biocides is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Discharge of other metals in waste water

Three-unit operation at BFN at the combined total power level of 11,856 MW(t) expected during the license renewal term uses existing intake and discharge structures and "no changes are expected to the individual unit flow rates as a result of EPU" (TVA 2002). Total intake flow is expected to be a maximum of 139 m^3/s (4907 cfs) or 12 million m^3/d (3171 MGD) (TVA 2003b). Discharges of heavy metals are controlled under the NPDES permitting system administered by the State of Alabama. The current NPDES permit restricts the discharge of heavy metals. Furthermore, the main condensers of all three units will be re-tubed with stainless steel prior to the license renewal term. The staff concludes that the effect of the cooling system operation on discharge of metals in waste water is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Water-use conflicts (plants with once-through cooling systems)

Three-unit operation at BFN, at the combined total power level of 11,856 MW(t) expected during the license renewal term, uses existing intake and discharge structures and "no changes are expected to the individual unit flow rates as a result of EPU" (TVA 2002). Consumptive and off-stream water uses have not resulted in significant water-use conflicts because of the large

volume of Wheeler Reservoir water available, the high river flow rate, and the return of most of the water withdrawn (TVA 2003b). Regulatory control of withdrawal rates and NPDES permit limits for return water quality also mitigate potential conflicts. The staff concludes that the effect of water-use conflicts is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Accumulation of contaminants in sediments or biota

The three-unit operation at BFN, at the combined total power level of 11,856 WM(t) expected during the license renewal term, uses existing intake and discharge structures and "no changes are expected to the individual unit flow rates as a result of EPU" (TVA 2002). The condensers at BFN are being re-tubed with stainless steel tubing (TVA 2003b). Therefore, accumulation of contaminants associated with the condenser tubes in sediment or biota would not be expected to be a concern during the license renewal term. Furthermore, compliance with the NPDES permit, other provisions of the FWPCA (e.g., Sections 316(a) and 316(b), 401, and 404), and other regulatory requirements are expected to adequately control potential chemical effluent effects (TVA 2003b). The staff concludes that the effect of the accumulation of contaminants in sediments or biota is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Entrainment of phytoplankton and zooplankton

Because of the large numbers and short generation times of phytoplankton and zooplankton, impacts of entrainment on these organisms have rarely been documented outside the immediate vicinity of the plant and are considered to be of little consequence (NRC 1996). Algal surveys conducted in 1989 (during plant shutdown) and again in 1991 (during plant operation) did not indicate that operation of BFN under current thermal plume criteria had any impact on the phytoplankton community of Wheeler Reservoir (Lowery and Poppe 1992). Results from a two-dimensional, far-field model that included an assessment of the effects on reservoir algal biomass were essentially unchanged with all three units operating at a combined total power level of 11,856 MW(t) (TVA 2003b). The staff concludes that the effect on entrainment of phytoplankton or zooplankton is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Cold shock

It would not be expected that all three units would go off-line at the same time. Cold-shock mortalities, even at one-unit plants, are relatively rare and usually involve small numbers of fish. No population-level impacts have been observed (NRC 1996). Therefore, any fish that do occupy the thermal plume during winter conditions would still have areas of above-ambient temperatures to occupy during one- or two-unit operation. Furthermore, the high-velocity diffusers provide for rapid mixing of the heated discharge waters with ambient-temperature river

water and discourage fish from residing in the warmest portion of the plume. The staff concludes that the effect of cold shock from operation is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Thermal plume barrier to migrating fish

The impact of the thermal plume is constrained by the NPDES permit. The NPDES permit limits are designed to protect aquatic species, in particular, to prevent the establishment of a thermal plume barrier to fish migration. The licensee will be required to operate within the limits of the NPDES permit during the license renewal term. Furthermore, fish species typical of those that predominate Wheeler Reservoir have a range difference of at least 5°C (9°F) to over 10°C (18°F) between their acclimation temperature and upper avoidance temperature (Cherry et al. 1975). The staff concludes the effect of the thermal plume as a barrier to migrating fish is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Distribution of aquatic organisms

Past operations of BFN have not been shown to affect the distribution of aquatic organisms in Wheeler Reservoir (TVA 2003b). As discussed in Section 2.2.5, the aquatic biota are primarily affected by physical and chemical changes to the Tennessee River that have occurred from its modification from a free-flowing river to a series of run-of-the-river reservoirs. Within the reservoir, there are three somewhat distinct zones: the tailwaters of the upstream dam, the transition area (within which BFN is located), and the more lacustrine (lake-like) conditions in the area upstream of the reservoir dam. The distribution of aquatic biota in Wheeler Reservoir is primarily influenced by the habitats and physicochemical conditions within each zone. The staff concludes the effect of the distribution of aquatic organisms is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Premature emergence of aquatic insects

The discharge diffusers will ensure adequate mixing of the discharge flow and the receiving waters. Typically, the warmer water is buoyant and does not impinge directly on the reservoir substrate. The licensee has a considerable amount of benthic data from Wheeler Reservoir that show no impact related to premature emergence of insects. The additional heat associated with the combined total power level of 11,856 MW(t) is not expected to significantly increase the amount of benthic invertebrate habitat that is subject to elevated temperatures. The staff concludes the effect of thermal discharge on premature emergence of aquatic insects is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Low dissolved oxygen in the discharge

Current dissolved oxygen levels near the BFN site are rated "good" by TVA (TVA 2004b). Results from simulations using a two-dimensional, far-field model that included an assessment of the effects on reservoir dissolved oxygen concentrations were essentially unchanged under all three units operating at a combined total power level of 11,856 MW(t) (TVA 2003b). Thus, as long as the licensee maintains compliance with the NPDES regulatory requirements, operation of all three units at a combined total power level of 11,856 MW(t) of original power is expected to have insignificant effects on dissolved oxygen concentrations. The staff concludes the effect of low dissolved oxygen discharges is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses

Although it is likely that operation of a once-through cooling system will cause some changes in predator-prey relationships, the fact that no long-term changes in population- or community-level effects from operation of BFN have been observed (TVA 2003b) is evidence that losses from predation, parasitism, and disease are not occurring from sublethal stresses (NRC 1996). The Vital Signs Monitoring Program and other assessments of aquatic biota in Wheeler Reservoir have not demonstrated any changes to aquatic organisms related to predation, parasitism, or disease that could be attributable to sublethal stresses (thermal, physical, or chemical) caused by operations of BFN. The Vital Signs Monitoring Reservoir Fish Assemblage Index has been determined for fish in Wheeler Reservoir since the early 1990s. This index considers fish disease, lesions, parasites, and abnormalities as factors in determining the index. The index value downstream of BFN has been as good as or better than other portions of the reservoir (Section 2.2.5). No fish consumption advisories exist for mainstem Wheeler Reservoir (Section 2.2.5). Thermal and chemical discharges from BFN are governed by the NPDES permit. Thermal and chemical discharges can stress aquatic organisms leading to increased parasitism and disease. Discharge limits are established at levels that are protective of aquatic biota. As permit conditions would not change, the effects of BFN operation at a combined total power level of 11,856 MW(t) on predation, parasitism, and disease on organisms exposed to sublethal stresses would likely remain the same. The staff concludes that the effect of predation, parasitism, and disease among organisms exposed to sublethal stresses is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Stimulation of nuisance organisms

Past operations of BFN have not been shown to stimulate nuisance organisms. Water levels in Wheeler Reservoir are actively managed during the summer to limit mosquito breeding habitat (Section 2.2.5). Physical and chemical treatment of the cooling system has had a controlling

influence on the Asiatic clam (*Corbicula fluminea*) in the immediate plant area. Thermal discharges in the immediate area of the diffusers are at a level that can adversely impact Asiatic clams. When ambient reservoir temperatures are 22.4°C (72.4°F) or more, the maximum 24-hour average temperature rise of 5.6°C (10°F) would be above the optimum summer temperatures for the zebra mussel (*Dreissena polymorpha*). Therefore, increased thermal loading associated with operation of the plant at 120 percent power levels would have a further localized controlling influence over these nuisance species. The staff concludes that the effect on the stimulation of nuisance organisms is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Cooling tower impacts on crops and ornamental vegetation

Although the cooling towers are likely to be operated more frequently with three units operating at a combined total power level of 11,856 MW(t) (TVA 2003b), because they are helper towers, they will be operated less frequently than those located at plants with closed-cycle cooling systems. The staff determined in the GEIS that cooling tower impacts on crops and ornamental vegetation at plants where the cooling towers are operated continuously was not significant. The staff concludes that the impacts of cooling tower operation on crops and ornamental vegetation are within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Cooling tower impacts on native vegetation

Although the cooling towers are likely to be operated more frequently with three units operating at a combined total power level of 11,856 MW(t) (TVA 2003b), because they are helper towers, they will be operated less frequently than those located at plants with a closed-cycle cooling system. The staff determined in the GEIS that cooling tower impacts on native vegetation at plants where the cooling towers are operated continuously was not significant. The staff concludes that the impacts of cooling tower operation on native vegetation are within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Microbiological organisms (occupational health)

As discussed in Section 4.1.5, some thermophilic microbiological organisms have a range of optimum conditions within the range of temperatures that would occur at either 100 percent or 120 percent power levels. BFN was one of nine power plants that participated in a study in the early 1980s on the presence of *Legionella* spp. in power plant cooling systems. As with most locations studied, *Legionella* spp. bacteria were found in ambient-temperature (intake), pre-condenser, post-condenser, and outfall (discharge) waters, though not in concentrations sufficiently high to be a health concern. Subsequent studies determined that concentrated *Legionella* spp. aerosols could present a health concern for workers cleaning condenser tubes and cooling towers. As a precaution, BFN has adopted the practice of having workers engaged

in these activities wear appropriate respiratory protection (TVA 2003b). Therefore, even though condenser tube and cooling tower cleaning requirements for a three-unit operation may increase, the potential for occupational health risks would still be negligible, because health risks would not increase due to of the use of appropriate respiratory protection. The staff concludes the effect of microbial organisms on occupational health is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Noise

The cooling towers are likely to be operated more often when there are three units operating at a combined total power level of 11,856 MW(t) (TVA 2003b), and thus there would be more days per year when noise from tower operations could affect onsite personnel or be detected offsite. However, because these are helper towers, they will be operated intermittently, and not continuously as they are at plants with closed-cycle cooling systems. The staff determined in the GEIS that the impacts of cooling tower noise at plants with continuously operated towers are not significant. The staff concludes the effect of noise from the cooling towers is within the envelope of impacts considered in the GEIS as a Category 1 issue.

Table 4-14. Radiological Impacts of Normal Operations-Related Category 1 Issues that are Potentially Affected by Proposed Extended Power Uprates at Browns Ferry Nuclear Power Plant, Units 1, 2, and 3

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
HUMAN HEALTH	
Radiation exposures to public (license renewal term)	4.6.2
Occupational radiation exposures (license renewal term)	4.6.3

- Radiation exposures to public (license renewal term)

Some increase in radionuclide emissions might occur as a result of the combined total power level of 11,856 MW(t) (TVA 2003b); the increase would be up to a factor of 1.8 over current two-unit operations if the increase is proportional to the power level. Recent routine emissions at the site have been well below regulatory limits. Furthermore, BFN, regardless of the thermal power level, will be required to operate within the regulatory limits during the license renewal term. The staff concludes that the effects of radiation exposure to the public are within the envelope of impacts considered in the GEIS as a Category 1 issue provided that releases are maintained within the regulatory limits.

- Occupational radiation exposures (license renewal term)

Some increase in worker dose rates might occur as a result of the combined total power level of 11,856 MW(t) (TVA 2003b); the increase would be up to a factor of 1.8 over current two-unit operations if the increase is proportional to the power level. However, application of as low as reasonably achievable (ALARA) principles has reduced worker exposures relative to historic levels, and doses to individual workers at the site would be controlled to remain below regulatory limits. The staff determined in the GEIS that the dose-related impacts to workers are of small significance if doses and releases do not exceed permissible levels in the Commission's Regulations. BFN, regardless of the thermal power level, will be required to operate within the regulatory limits during the license renewal term. The staff concludes the effect of occupational radiation exposure is within the envelope of impacts considered in the GEIS as a Category 1 issue provided that the exposure to workers is maintained within the regulatory limits.

Table 4-15. Socioeconomic-Related Category 1 Issue Potentially Affected by Proposed Extended Power Uprates at Browns Ferry Nuclear Power Plant, Units 1, 2, and 3

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
SOCIOECONOMIC	
Aesthetic impacts (license renewal term)	4.7.6

- Aesthetic impacts (license renewal term)

The cooling towers are likely to be operated more often when there are three units operating at a combined total power level of 11,856 MW(t) (TVA 2003b); thus, there would be more days per year when there is a visible steam plume and when noise from tower operations could be detected offsite. However, because these are helper towers, they will be operated intermittently, and not continuously as they are located at plants with closed-cycle cooling systems. The staff determined in the GEIS that the aesthetic impacts of cooling tower plumes at plants with continuously operated towers are not significant. The staff concludes the effects of aesthetic impacts of cooling tower plumes is within the envelope of impacts considered in the GEIS as a Category 1 issue.

Table 4-16. Postulated Accident-Related Category 1 Issue Potentially Affected by Proposed Extended Power Uprates at Browns Ferry Nuclear Power Plant, Units 1, 2, and 3

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
Design basis accidents	5.3.2, 5.5.1

- Design-basis accidents

TVA is required to submit an updated Final Safety Analysis Report as part of the EPU license amendment application. NRC staff evaluates this Final Safety Analysis Report, the application, and the design of the facility prior to granting or denying the EPU application. If the EPU is granted, the staff will have evaluated design-basis accidents (DBAs) in light of the new power level, and will have determined that postulated DBA doses continue to meet NRC regulations. Therefore, the environmental impacts of DBAs will continue to be small. The staff concludes that the effect of the cooling system operation on DBAs is within the envelope of impacts considered in the GEIS as a Category 1 issue.

Table 4-17. Uranium Fuel Cycle and Waste Management-Related Category 1 Issues Potentially Affected by Proposed Extended Power Uprates at Browns Ferry Nuclear Plant, Units 1, 2, and 3

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	6.1; 6.2.1; 6.2.2.1; 6.2.2.3; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (collective effects)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (spent fuel and high-level waste)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6
Nonradiological impacts of the uranium fuel cycle	6.1; 6.2.2.6; 6.2.2.7; 6.2.2.8; 6.2.2.9; 6.2.3; 6.2.4; 6.6
Low-level waste storage and disposal	6.1; 6.2.2.2;6.4.2; 6.4.3; 6.4.3.1; 6.4.3.2; 6.4.3.3; 6.4.4; 6.4.4.1; 6.4.4.2; 6.4.4.3; 6.4.4.4; 6.4.4.5; 6.4.4.5.1; 6.4.4.5.2; 6.4.4.5.3; 6.4.4.5.4; 6.4.4.6;6.6
Mixed waste storage and disposal	6.4.5.1; 6.4.5.2; 6.4.5.3; 6.4.5.4; 6.4.5.5; 6.4.5.6; 6.4.5.6.1; 6.4.5.6.2; 6.4.5.6.3; 6.4.5.6.4; 6.6
Onsite spent fuel	6.1; 6.4.6; 6.4.6.1; 6.4.6.2; 6.4.6.3; 6.4.6.4; 6.4.6.5; 6.4.6.6; 6.4.6.7; 6.6
Nonradiological waste	6.1; 6.5; 6.5.1; 6.5.2; 6.5.3; 6.6
Transportation	6.1; 6.3.1; 6.3.2.3; 6.3.3; 6.3.4; 6.6, Addendum 1

- Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)

Offsite impacts of the uranium fuel cycle have been considered by the Commission in Table S-3 in 10 CFR 51.51(b). Based on information in the GEIS, impacts on individuals from radioactive gaseous and liquid releases including radon-222 and technetium-99 are small. There may be some local increase in radiological emissions in the immediate vicinity of the facility; however, the impact on the entire uranium fuel cycle would be negligible. Regardless of the combined total power level at BFN, the plant and fuel cycle facilities will continue to be required to operate within applicable regulatory limits. The staff concludes the effect of offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste) is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Offsite radiological impacts (collective effects)

Some increase in radionuclide emissions might occur at BFN as a result of increased fuel requirements for the combined total power level of 11,856 MW(t); the increase would be up to a factor of 1.8 over current two-unit operations if the increase is proportional to the power level. Nevertheless, releases would continue to be required to be within regulatory limits. Collective doses to the population in the vicinity of BFN have been well below levels that would result in estimated health effects; therefore, collective dose to the BFN surrounding population would remain small. Nationwide, a potential increase in annual radiation exposures to the public from BFN would be inconsequential and not substantially change the GEIS conclusions. The staff concludes that the effect of offsite radiological impacts (collective effects) is within the envelope of impacts considered in the GEIS as a Category 1 issue provided that the releases are maintained to within the regulatory limits.

- Offsite radiological impacts (spent fuel and high-level waste)

Some increase in radiation dose to members of the public might result from increased spent fuel generation during reactor operations at a combined total power level of 11,856 MW(t); the increase would be up to a factor of 1.8 over current two-unit operations if the increase is proportional to the power level. During the uprated operational period, public exposures from spent fuel disposal would be maintained within regulatory limits and are expected to remain small. The staff concludes that the effect of offsite impacts (spent fuel and high-level waste) is within the envelope of impacts considered in the GEIS as a Category 1 issue provided that exposure to the public is maintained to within the regulatory limits.

- Nonradiological impacts of the uranium fuel cycle

Uprate of the power level at BFN would result in needs for somewhat larger quantities of fuel, as well as increased need for spent fuel and waste storage and disposal. The nonradiological

impacts of these activities would be reflected in needs for additional workforce to carry out fuel manufacturing and waste and spent fuel management activities. Those activities could also result in an additional potential for industrial accidents and illnesses. However, they would not necessarily entail a higher risk than alternative occupations in which the workforce might be engaged. Other nonradiological impacts, such as land use, fugitive dust generation, air-quality impacts, erosion, sedimentation, and disturbance of ecosystems, are unlikely to increase substantially. The effect on the entire U.S. uranium fuel cycle from the additional fuel utilization at BFN would be negligible. The staff concludes that the effect of nonradiological impacts of the uranium fuel cycle is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Low-level waste storage and disposal

Some increase in radiation dose to members of the public might result from increased low-level waste (LLW) storage and disposal during reactor operations at a combined total power level of 11,856 MW(t); the increase would be up to a factor of 1.8 over current two-unit operations if the increase is proportional to the power level. During the uprated operational period, public exposures from LLW disposal would be maintained within regulatory limits and are expected to remain small. The staff concludes the effect of public exposure from LLW storage and disposal is within the envelope of impacts considered in the GEIS as a Category 1 issue provided that exposure to the public is maintained to within the regulatory limits.

- Mixed waste storage and disposal

Some increase in radiation dose to members of the public and exposure to toxic materials might result from increased mixed waste generation during reactor operations at a combined total power level of 11,856 MW(t); the increase would be up to a factor of 1.8 over current two-unit operations if the increase is proportional to the power level. During the uprated operational period, public exposures from mixed waste disposal would be maintained within regulatory limits and are expected to remain small. Any increase in mixed waste storage would be within the current BFN storage capacity, and additional impact on licensed mixed waste disposal facilities would be minimal. The staff concludes the effect of mixed waste storage and disposal is within the envelope of impacts considered in the GEIS as a Category 1 issue provided that the radiation dose to the public is maintained to within the regulatory limits.

- Onsite spent fuel

Some marginal increase in onsite storage of spent fuel is expected as a result of a combined total power level of 11,856 MW(t), The commission has made a generic determination that, if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 30 years beyond the license life for generation including any license renewal term. During the uprated operational period, occupational exposures from spent fuel management would be maintained within regulatory limits and with continuing

application of ALARA principles, are expected to remain small. The staff concludes that the effect on occupational exposure from onsite spent fuel is within the envelope of impacts considered in the GEIS as a Category 1 issue provided that the occupational exposure is maintained to within the regulatory limits during the storage period.

- Nonradiological waste

Operation of BFN at uprated power levels is not expected to substantially change the quantities of nonradiological waste generated at the facility. Any small marginal increases in routine nonradiological waste generated at the plant would be well within quantities that could be accommodated by onsite or community waste management facilities, and ongoing waste minimization and recycling programs are expected to continue to reduce the quantities of these wastes. The staff concludes the effect from nonradiological waste is within the envelope of impacts considered in the GEIS as a Category 1 issue.

- Transportation

Some increase in radiation dose to members of the public and transportation workers might result from increased transport of unirradiated fuel, spent fuel, and radiological wastes during reactor operations at a combined total power level of 11,856 MW(t); the increase would be up to a factor of 1.8 over current two-unit operations, if the increase is in proportion to the power level. Because of the regulatory requirements related to fuel shipments, the staff believes that any increase in BFN impact due to the combined total power level will be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S-4 - Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor. The staff concludes that the effect of transportation of the unirradiated fuel, spent fuel, and radiological wastes is within the envelope of impacts considered in the GEIS as a Category 1 issue provided that the dose to the public and transportation workers is maintained to within the regulatory limits during the renewal period.

4.8 Cumulative Impacts of Operations During the License Renewal Term

The staff considered the potential cumulative impacts during the evaluation of information applicable to each of the potential impacts of operations during the license renewal term identified within the GEIS. For purposes of this analysis, past actions were those related to the resources at the time of plant licensing and construction, present actions are those related to the resources at the time of current operation of the power plant, and future actions are considered to be those that are reasonably foreseeable through the end of the current license term, as well as the 20-year license renewal term. The geographical area over which past,

present, and future actions could contribute to cumulative impacts is dependent on the type of action considered, and is described below for each impact area.

The impacts of the proposed action are combined with other past, present, and reasonably foreseeable future actions at BFN, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. These combined impacts are defined as "cumulative" in 40 CFR 1508.7 and include individually minor, but collectively significant, actions taking place over time. It is possible that an impact that may be SMALL by itself could result in a MODERATE or LARGE impact when considered in combination with the impacts of other actions on the affected resource. Likewise, if a resource is regionally declining or imperiled, even a SMALL individual impact could be important if it contributes to or accelerates the overall resource decline.

4.8.1 Cumulative Impacts Resulting from Operation of the Plant Cooling System

For the purposes of this analysis, the geographic area considered for cumulative impacts resulting from operation of the BFN cooling system is primarily the Wheeler Reservoir portion of the Tennessee River. Wheeler Reservoir is located within the Lower Tennessee River Basin which extends from Chattanooga, Tennessee, to near Paducah, Kentucky. The main stem of the Tennessee River in this area is highly regulated with few free-flowing reaches. Six major reservoirs are located within the Lower Tennessee River, and three additional reservoirs are located on its major tributaries (USGS 1998). The reservoirs were created for the purpose of power generation, navigation, and flood control. They are also used extensively as sources of drinking water and for recreational activities (USGS 1998). Interbasin transfers of water occur downstream of BFN (i.e., with the Mobile River Basin via the Tennessee-Tombigbee Waterway near the Pickwick Reservoir and with the Cumberland River Basin through the Barkley-Kentucky Canal at the Kentucky Reservoir) (Kingsbury et al. 1999).

The mean annual streamflow in the Lower Tennessee River Basin ranges from about 1017 m^3/s (35,900 cfs) at Chattanooga, Tennessee, to 1858 m^3/s (65,600 cfs) at Paducah, Kentucky. The Elk and Duck Rivers, the two largest tributaries within the lower Tennessee River Basin, contribute about 26 percent of the streamflow gained between Chattanooga and Paducah (Kingsbury et al. 1999). Within the Tennessee River watershed, an average of 46.2 million m^3/d (12.2 billion gpd) were used in 2000 for public supply, industrial water supply, irrigation, and thermoelectric power generation; however, only about 5 percent (2.5 million m^3/d [649 MGD]) was used consumptively. By 2030, water withdrawals are projected to increase to nearly 53 million m^3/d (14 billion gpd) (Hutson et al. 2003). Most of the consumptive use (2.0 million m^3/d [530 MGD]) has occurred upstream of Wheeler Dam, and this is expected to increase to 2.9 million m^3/d (760 MGD) by 2030 (TVA 2003b). Within Wheeler Reservoir, there are eight potable water intakes that withdraw about 0.47 million m^3/d (124 MGD) for municipal and industrial use, while there are 11 municipal plant discharges totaling over 0.11 million m^3/d (30 MGD) and 18 industrial plants discharging more than 9.5 million m^3/d (2513 MGD) (TVA 2003b).

The main land cover in the Lower Tennessee River Basin is forest (55 percent) and row crops and pastureland (41 percent). There are numerous industries along the mainstem of the Tennessee River in northern Alabama. They manufacture and produce a variety of products (e.g., missiles and rockets, electronics, pulp and paper, synthetic fibers, chemicals, aluminum, and nickel-plated foam) (USGS 1998).

Section 2.2.5 discusses the major changes and modifications within the Tennessee River, particularly the Wheeler Reservoir area, that have had the greatest effects on aquatic resources. These include physical and chemical stresses, developments, overfishing (including commercial clam harvests), and introduction of non-native species. Physical and chemical stresses that have impacted the Tennessee River include urban, industrial, and agricultural contaminants (e.g., nutrients, toxic chemicals, sediments); stream modifications (e.g., dams and reservoirs); land use changes (e.g., residential, recreational, agricultural, and industrial development); dredging (e.g., to maintain navigation channels); shoreline modifications; wetland elimination and modification; water diversions (e.g., Tennessee-Tombigbee Waterway); and commercial and recreational boating (TVA 2003b, 2004b).

Construction of the TVA reservoir system significantly altered both the water quality and physical environment of the Tennessee River, with little regard for the subsequent effects on aquatic resources (TVA 2004b). Overall, completion of the water control system on the Tennessee River resulted in the following impacts (Barclay 2004):

- conversion of riverine habitat to reservoir pool habitat
- loss of riverine habitat and associated biota
- conversion of floodplain to reservoir pool
- loss of seasonal floodplain habitat and associated biota
- fragmentation of riverine sections
- disruption of fish migrations
- seasonal fluctuations of pool levels
- thermal stratification
- stress or mortality of organisms or sensitive life stages
- seasonal dissolved oxygen depletion in temperature stratified waters
- ammonia released by the presence of oxygen-depleted water
- disruption of sediment transport
- trapping of sediment, capture of toxic substances associated with substrates,
- toxic substance releases
- nutrient enrichment with consequent changes in habitat quality and associated species.

Within the Lower Tennessee River Basin, nutrient enrichment and pathogens have been identified as water-quality issues affecting both surface water and groundwater. Nonpoint

sources for nutrients (nitrogen and phosphorous) include urban runoff, fertilizer application, failing septic tanks, livestock waste, nitrogen fixation, sediment and rock dissolution, and atmospheric deposition (Kingsbury et al.1999).

Because of the altered habitat conditions created by reservoir pools and dam tailwater, State agencies introduced numerous sport and some prey species into the Tennessee River watershed including several trout species, striped bass (*Morone saxatilus*), northern pike (*Esox lucius*), yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*), rainbow smelt (*Osmerus mordax*), and alewife (*Alosa pseudoharengus*). Some of the game species are not self-sustaining and, thus, continue to be stocked (TVA 2004b). Non-native species (e.g., common carp [*Cyprinus carpio*], grass carp [*Ctenopharyngodon idella*], Eurasian watermilfoil [*Myriophyllum spicatum*], and Asiatic clam) have impacted native aquatic species. Further spread or establishment of species such as the alewife, bighead carp (*Hypophthalmichthys nobilis*), silver carp (*H. molitrix*), zebra and quagga mussels (*Dreissena bugensis*), rusty crayfish (*Orconectes rusticus*), and the cladoceran *Daphnia lumholtzi* may also have major impacts on the aquatic community dynamics in Wheeler Reservoir.

TVA's reservoir operations policy guides the day-to-day operation of the Tennessee River system, and sets the balance of trade-offs for the sometimes competing uses of water in the system. TVA undertook a study to determine if changes in its reservoir system operating policies could produce a greater overall public value. A no-action alternative and eight alternative operating policies were evaluated. The evaluations included the assumption that the consumptive use of water above Wheeler Dam would increase by 0.87 million m^3/d (230 MGD). Reservoir operations over the 100-year hydrologic record were simulated. Under the proposed alternative, flow requirements would be used to protect water quality and aquatic resources, ensure year-round commercial navigation, and provide an adequate supply of cooling water for TVA's power plants (TVA 2004b).

Under the preferred TVA reservoir system operating policy alternative, drawdown of Wheeler Reservoir would begin on Labor Day rather than on August 1 to increase recreational opportunities. Fluctuations in reservoir levels to strand mosquito eggs and larvae would continue until Labor Day. Also, minimum winter elevations would be raised 15 cm (6 in.) to ensure that the 3.4-m (11-ft) navigation channel is maintained throughout the reservoir (TVA 2004b).

Under its regulatory programs, TVA treats waste water effluents, collects and properly disposes potential contaminants, and undertakes pollution prevention activities that comply with regulatory requirements and minimize the risk of adverse environmental impacts (TVA 2003b). The BFN NPDES permit is renewed every 5 years; this helps to ensure that no changes have been made to the facility that would alter aquatic impacts and that no significant adverse impacts have occurred. Compliance with the NPDES process, other provisions of the FWPCA (e.g., Sections 316[a], 316[b], 401, and 404), and other regulatory requirements are expected to adequately control potential chemical effluent effects. In general, under these regulatory

programs, TVA treats waste water effluents, collects and properly disposes potential contaminants, and undertakes pollution prevention activities that comply with regulatory requirements and minimize the risk of adverse environmental impacts.

Future contributions to cumulative impacts to aquatic resources within Wheeler Reservoir would generally occur from those actions that currently cause impacts (e.g., reservoir operations, human habitation, urban and industrial development, agriculture, and commercial and recreational fisheries). There is a potential for severe impacts to aquatic resources from large oil or chemical spills within Wheeler Reservoir or its tributaries, but the risk of such spills is relatively small. The probability of smaller spills is higher, but the impacts from such spills would probably be small, temporary, and additive, and unlikely to severely affect aquatic resources, especially if spill response activities are undertaken when such events occur. The potential exists for the expansion of exotic species that have already begun to occur in the Tennessee River, and for additional exotic species to become established in Wheeler Reservoir.

The reservoir water supply is adequate to meet the needs of BFN for cooling purposes under all conditions. The total BFN intake water flow of 139 m^3/s (4907 cfs) can encompass a significant fraction of the daily average river flow past the plant compared to the 7Q10 values of 250 m^3/s [8700 cfs]); however, consumptive water uses are negligible and are expected to remain so throughout the license renewal term (TVA 2003b). There are no significant cumulative impacts on water supply. The staff, while preparing this assessment, assumed that other industrial, commercial, or public installations could be located in the general vicinity of the BFN site prior to the end of BFN operations. The discharge of water to Wheeler Reservoir from these facilities would be regulated by the Alabama Department of Environmental Management (ADEM). The discharge limits are set considering the overall or cumulative impact of all of the other regulated activities in the area. Compliance with the FWPCA and its NPDES permits minimizes cumulative effects on aquatic resources.

There are also other power plants within the Tennessee River system that impact aquatic biota. Entrainment, impingement, and, for non-hydroelectric plants, thermal discharges occur at other power plants within the Tennessee River system. These include 11 coal-fired plants, 30 hydroelectric facilities, and three nuclear plants (including BFN) operated by the TVA (ScanChattanooga.Com 2001) and non-TVA plants such as the two Calpine combined-cycle plants near Decatur (TVA 2003b). Fish egg entrainment is not likely to be a serious problem at most dams because the freshwater drum and mooneye and, possibly, skipjack herring are the only species with buoyant or semibuoyant eggs. Larvae and juveniles of non-migratory species may only be incidentally susceptible to turbine entrainment, and the resultant effects are not significant to the dynamics of the reservoir's resident fish community (Cada 1990).

The staff determined that the cumulative impacts of BFN cooling system operations (including entrainment and impingement of fish and shellfish, heat shock, or any of the cooling system-

related Category 1 issues) are not contributing to an overall decline in water quality or the status of the fishery or other aquatic resources, and no additional mitigation measures are warranted.

Continued operation of BFN will require renewed discharge permits from the ADEM, which will address changing requirements so that cumulative water-quality objectives are served. Therefore, the staff concludes that the potential cumulative impacts of cooling system operation contributed by the continued operation of BFN will be SMALL, and that no further mitigation measures are warranted.

4.8.2 Cumulative Impacts Resulting from Continued Operation of the Transmission Lines

The continued operation of the BFN electrical transmission facilities was evaluated to determine if there is a potential for interactions with other past, present, and future actions that could result in adverse cumulative impacts to terrestrial resources such as wildlife populations, the size and distribution of habitat areas, aquatic resources such as wetlands and floodplains, and both the acute and chronic effects of electromagnetic fields. For purposes of this analysis, the geographic area that encompasses the past, present, and foreseeable future actions that could contribute to adverse cumulative effects is the area serviced by the transmission lines associated with the BFN (Figure 2.4).

TVA follows right-of-way management procedures that were found to be protective of sensitive ecological resources, including wildlife habitat, wetlands, and floodplains (TVA 2003b). TVA maintains maps of known sensitive resources such as wetlands, and maintains the transmission line rights-of-way to minimize impacts, with the result that no net loss of resources occurs. The maintenance procedures minimize disturbance to wildlife and, in many ways, provide greater protection relative to many of the surrounding areas with other land uses.

The staff determined that the electrical current induced by the electromagnetic fields from the BFN transmission lines is well below the NESC recommendations for preventing electrical shock from induced currents. Therefore, continued operation of the BFN transmission lines will not detectably change the overall potential for electrical shock in the future within the analysis area. With respect to chronic effects of electromagnetic fields, although the staff considers the GEIS conclusion of "not applicable" to be appropriate in regard to BFN, the BFN transmission lines are not likely to detectably contribute to the regional exposure to extremely low frequency electromagnetic fields (ELF-EMF). This conclusion is based on the fact that BFN transmission lines primarily pass through sparsely populated, rural areas, with few residences or businesses close enough to have detectable ELF-EMF.

Therefore, since the impacts from maintaining and operating the transmission system are so minor that they will neither destabilize or noticeably alter the existing aquatic or terrestrial

environment, the staff determined that the cumulative impacts of continued operation of BFN transmission lines will be SMALL, and that no additional mitigation is warranted.

4.8.3 Cumulative Radiological Impacts

The EPA and NRC established radiological dose limits for protection of the public and workers from both instanteneous and cumulative impacts of exposure to radiation and radioactive materials. These dose limits are codified in 40 CFR Part 190 and 10 CFR Part 20. For the purpose of this analysis, the area within an 80-km (50-mi) radius of the BFN site was included. As stated in Section 2.2.7, TVA has conducted a radiological environmental monitoring program (REMP) around the BFN site since 1968. The REMP measures radiation and radioactive materials from all sources, including BFN. Additionally, in Sections 2.2.7 and 4.3, the staff concluded that impacts of radiation exposure to the public and workers (occupational) from operation of BFN during the license renewal term are small. The NRC and the State of Alabama would regulate any reasonably foreseeable future actions in the vicinity of the BFN site that could contribute to cumulative radiological impacts.

Therefore, the staff concludes that cumulative radiological impacts of continued operations of BFN would be SMALL, and that no further mitigation measures are warranted.

4.8.4 Cumulative Socioeconomic Impacts

Much of the analysis of socioeconomic impacts presented in Section 4.4 of this SEIS already incorporate cumulative impact analysis, because the metrics used for quantification only make sense when placed in the total or cumulative context. For instance, the impact of the total number of additional housing units that may be needed can only be evaluated with respect to the total number of units in the impacted area. Therefore, the geographic area of the cumulative analysis varies depending on the particular impact considered, and may depend on specific boundaries, such as taxation jurisdictions, or may be distance related, as for environmental justice.

The continued operation of BFN is not likely to add to any cumulative socioeconomic impacts beyond those already evaluated in Section 4.4. In other words, the impacts of issues such as transportation or offsite land use are likely to be nondetectable beyond the regions previously evaluated and will quickly decrease with increasing distance from the site. The staff determined that the impacts on housing, public utilities, public services, offsite land use, and environmental justice would all be negligible. There are no reasonably foreseeable scenarios that would alter these conclusions in regard to cumulative impacts.

Related to historic and archeological resources, two sites at BFN that require protection have been identified. TVA has procedures in place to protect these sites, and to take into account the inadvertent discovery of historic and archaeological remains at BFN. There are no plans to

construct new facilities in areas that have not been heavily disturbed in the past, or to construct new transmission lines. Therefore, continued operation and maintenance of the BFN site and transmission line rights-of-way would not impact historic or archeological properties beyond the site or rights-of-way boundaries, and therefore, the contribution to cumulative adverse impacts would be negligible.

Based on these considerations, the staff concludes that continued operation of BFN is not likely to make a detectable contribution to the cumulative effects associated with any of the socioeconomic issues discussed in Section 4.4; therefore, the cumulative impacts will be SMALL, and no additional mitigation measures are warranted.

4.8.5 Cumulative Impacts on Groundwater Use and Quality

There are no groundwater withdrawals at BFN, and TVA imports potable water from Athens Water Services, which withdraws water from the Elk River. As described in Section 4.5.1, operation of BFN has not had a detectable impact on groundwater levels in the vicinity of the site. BFN does not discharge any waste to the groundwater. Because there are no groundwater withdrawals or discharges at BFN and none are anticipated in the future, BFN is not causing a detectable change in the regional groundwater usage or quality. Therefore, the contributions to cumulative impacts are SMALL, and no mitigation measures are warranted.

4.8.6 Cumulative Impacts on Threatened or Endangered Species

The geographic area considered in the analysis of potential cumulative impacts to threatened or endangered species includes those Alabama and Mississippi counties that contain the BFN site and its associated transmission line rights-of-way (Colbert, Franklin, Lawrence, Limestone, and Morgan Counties in Alabama, and Itawamba, Lee, Tishomingo, and Union Counties in Mississippi) and the waters of the Tennessee River, particularly Wheeler Reservoir, in the vicinity of the BFN site.[a] As discussed in Sections 2.2.5 and 2.2.6, there are a number of threatened or endangered species that could occur within this area. The staff's findings, presented in the October 25, 2004 (NRC 2004d) BA and in Section 4.6, are that continued operation of BFN, including return to three-unit operation at a total combined power level of 11,856 MW(t) and associated transmission line rights-of-way maintenance during the license renewal term, will have no effect, or is not likely to adversely affect any Federally listed species, nor will it adversely impact any designated critical habitat. Therefore, the BFN contribution to cumulative impacts to Federally protected species or designated critical habitat is SMALL and no mitigation is warranted.

(a) Prentiss County, Mississippi not included. Species accounted for in adjacent counties.

- **Aquatic Species**

Thirty-eight Federally listed aquatic species (including three candidate species) occur (or historically occurred) in either Wheeler Reservoir or its tributaries or in other streams, rivers, or caves within the counties of Alabama and Mississippi within which the BFN transmission lines pass. As mentioned in Section 2.2.5, past actions that have adversely affected these species have included siltation, impoundments, in-stream-habitat disturbance, contaminants, pearl button and cultured pearl industries (for mussel species), and introduced species. As discussed in Section 4.6.1, best management practices are used for transmission line maintenance, which reduces the likelihood of adverse impacts to aquatic habitats and any protected species that may be present within them.

The combination of nonpoint-source pollution (primarily from siltation) and alteration of flow regimes (primarily from impoundments) are anthropogenic factors responsible for about 72 percent of fish imperilment problems in the Southeast (Etnier 2002). These factors are also the major contributor to the endangerment of most of the listed mussel species, while habitat loss, modification, and fragmentation caused by impoundments have impacted the aquatic snail species (Neves et al. 2002). Because some mussels can live to be more than 100 years old, population declines resulting from poor reproductive success may continue for decades. Therefore, extirpation of some species may be a prolonged event, lagging behind the factors directly responsible for attrition of the fauna (Neves et al. 2002). An oil or chemical spill, especially in a tributary stream, could be significant for a listed species that has a limited distribution (e.g., Anthony's riversnail [*Athearnia anthonyi*], slender campeloma [*Campeloma decampi*], and boulder darter [*Etheostoma boschungi*]).

The Asiatic clam competitively interacts with native mussels for food and space. Invasion of the Tennessee River basin by the zebra mussel and the quagga mussel could also be detrimental to native mussels (Neves et al. 2002). The zebra mussel may ultimately cause extinction to several Federally protected mussels or cause other mussel species to become endangered or threatened (Neves et al. 2002). If the black carp (*Mylopharyngodon piceus*) becomes established in the Tennessee River, it could pose a serious threat to the listed mussel and snail species because it feeds almost exclusively upon molluscs (Chick 2002; Jernigan 2003).

The staff determined that the contribution to cumulative impacts to aquatic threatened or endangered species due to continued operation of BFN and its transmission lines would be inconsequential, and that no further mitigation measures are warranted.

- **Terrestrial Species**

There are no Federally listed threatened or endangered species known to occur within at least 5 km (3 mi) of the BFN site. Operation of BFN is not likely to have a detectable effect on terrestrial species located 5 km (3 mi) away from the site. Therefore, operations at the plant

site will not have a detectable contribution to the cumulative, regional impacts on threatened or endangered species.

Habitat for some of the Federally listed species could be found within the rights-of-way of BFN transmission lines. However, TVA monitors and tracks populations of Federally listed species on the BFN site and within transmission line rights-of-way. In addition, TVA works with appropriate Federal and State agencies to develop and establish guidelines and safeguards for their contract personnel to follow to protect threatened or endangered species and their habitats during maintenance of transmission line rights-of-way (Muncy et al. 1999). In some cases, the rights-of-way and the maintenance practices may provide for habitat that is not found in surrounding areas with other land uses.

Therefore, the staff determined that the contributions to cumulative impacts to threatened or endangered terrestrial species due to the continued operation of the BFN and associated transmission lines will be inconsequential, and that additional mitigation measures would not be warranted.

4.9 Summary of Impacts of Operations During the License Renewal Term

TVA and the staff discovered no new and significant information related to any of the applicable Category 1 issues associated with BFN operation during the license renewal term. Therefore, the staff concludes that the environmental impacts associated with the Category 1 issues are bounded by the impacts described in the GEIS. For each of the issues, the GEIS concluded that the impacts would be SMALL and that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

Plant-specific environmental evaluations were conducted for 13 Category 2 issues applicable to BFN operation during the license renewal term and for environmental justice and chronic effects of electromagnetic fields. For all 13 issues and environmental justice, the staff's conclusion is that the potential environmental impact of license renewal-term operations of BFN would be of SMALL significance in the context of the standards set forth in the GEIS and that further mitigation is not warranted. In addition, the staff determined that a consensus has not been reached by appropriate Federal health agencies regarding chronic adverse effects from electromagnetic fields. Therefore, no evaluation of this issue is required.

Cumulative impacts of past, present, and reasonably foreseeable future actions were considered, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. For purposes of analysis, where BFN license renewal impacts are deemed to be SMALL, the staff concluded that these impacts would not result in significant cumulative impacts on potentially affected resources.

4.10 References

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10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

36 CFR Part 800. Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties."

40 CFR Part 190. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 190, "Environmental Protection Standards for Nuclear Power Operations."

40 CFR Part 1508. Code of Federal Regulation, Title 40, *Protection of Environment*, Part 1508, "Terminology and Index."

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5.0 Environmental Impacts of Postulated Accidents

Environmental issues associated with postulated accidents are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999).[a] The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic.

(2) Single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and therefore, additional plant-specific review of these issues is required.

This chapter describes the environmental impacts from postulated accidents that might occur during the license renewal term.

5.1 Postulated Plant Accidents

Two classes of accidents are evaluated in the GEIS. These are design-basis accidents (DBAs) and severe accidents, as discussed below.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and Addendum 1.

5.1.1 Design-Basis Accidents

To receive U.S. Nuclear Regulatory Commission (NRC) approval to operate a nuclear power facility, an applicant must submit a safety analysis report (SAR) as part of the application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that are provided to prevent and mitigate accidents. The NRC staff reviews the application to determine whether the plant design meets the Commission's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

DBAs are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents without undue hazard to the health and safety of the public. A number of these postulated accidents are not expected to occur during the life of the plant but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility. The acceptance criteria for DBAs are described in Title 10 of the Code of Federal Regulations (CFR) Part 50 and 10 CFR Part 100.

The environmental impacts of DBAs are evaluated during the initial licensing process, and the ability of the plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license (OL). The results of these evaluations are found in license documentation such as the staff's safety evaluation report (SER), the licensee's updated final safety analysis report (UFSAR), and Section 5.1 of this supplemental environmental impact statement (SEIS). The licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant, including any extended-life operation. The consequences for these events are evaluated for the hypothetical maximally exposed individual; as such, changes in the plant environment will not affect these evaluations. Because of the requirements that continuous acceptability of the consequences and aging management programs be in effect for license renewal, the environmental impacts as calculated for DBAs should not differ significantly from initial licensing assessments over the life of the plant, including the license renewal period. Accordingly, the design of the plant relative to DBAs during the extended period is considered to remain acceptable, and the environmental impacts of those accidents were not examined further in the GEIS.

The Commission has determined that the environmental impacts of DBAs are of SMALL significance for all plants because the plants were designed to successfully withstand these accidents. Therefore, for the purposes of license renewal, DBAs are designated as a Category 1 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The early resolution of

the DBAs make them a part of the current licensing basis of the plant; the current licensing basis of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, is not subject to review under license renewal. This issue, applicable to Browns Ferry Nuclear Plant, Units 1, 2, and 3 (BFN), is listed in Table 5-1.

Table 5-1. Category 1 Issue Applicable to Postulated Accidents During the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
POSTULATED ACCIDENTS	
Design-basis accidents	5.3.2; 5.5.1

- Design-basis accidents. Based on information in the GEIS, the Commission found that

  The environmental impacts of design-basis accidents are of small significance for all plants.

The Tennessee Valley Authority (TVA) stated in its Environmental Report (ER) (TVA 2003) that it is not aware of any new and significant information associated with the renewal of the BFN OLs. The staff has not identified any new and significant information during the staff's independent review of the TVA ER, the scoping process, the staff's site visit, its evaluation of other available information, and public comments. Therefore, the staff concludes that there are no impacts of DBAs during the license renewal term beyond those discussed in the GEIS.

5.1.2 Severe Accidents

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. The GEIS assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the license renewal period.

Therefore, the Commission has designated mitigation of severe accidents as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. This issue, applicable to BFN, is listed in Table 5-2.

Table 5-2. Category 2 Issue Applicable to Postulated Accidents During the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
POSTULATED ACCIDENTS			
Severe Accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	L	5.2

- Severe accidents. Based on information in the GEIS, the Commission found that

  The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.

The staff has not identified any new and significant information during the staff's independent review of the TVA ER, the scoping process, the staff's site visit, its evaluation of other available information, and public comments. Therefore, the staff concludes that there are no impacts of severe accidents beyond those discussed in the GEIS. However, in accordance with 10 CFR 51.53 (c)(3)(ii)(L), the staff has reviewed severe accident mitigation alternatives (SAMAs) for BFN. The results of the staff's review are discussed in Section 5.2.

5.2 Severe Accident Mitigation Alternatives (SAMAs)

10 CFR 51.53(c)(3)(ii)(L) requires that license renewal applicants consider alternatives to mitigate severe accidents if the staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment. The purpose of this consideration is to ensure that plant changes (i.e., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. SAMAs have not been previously considered for BFN; therefore, the remainder of Chapter 5 addresses those alternatives.

5.2.1 Introduction

This section presents a summary of the SAMA evaluation for BFN conducted by TVA and described in its ER (TVA 2003) and of the NRC's review of that evaluation. The details of the review are described in the NRC staff evaluation that was prepared by the staff with contract

assistance from Information Systems Laboratories, Inc. The entire evaluation is presented in Appendix G.

The SAMA evaluation for BFN was a four-step process. In the first step, TVA quantified the level of risk associated with potential reactor accidents using the plant-specific probabilistic safety assessment (PSA) and other risk models.

In the second step, TVA examined the major risk contributors and identified possible ways (i.e., SAMAs) of reducing that risk. Common ways of reducing risk are changes to components, systems, procedures, and training. TVA initially identified 135 potential SAMAs. TVA screened out SAMAs that were not applicable to BFN because (1) the SAMA was not applicable at BFN because of design differences, (2) the SAMA had already been implemented at BFN, (3) the SAMA was sufficiently similar to and combined with other SAMA candidates, or (4) SAMA costs more than $6 million to implement. This screening reduced the list of potential SAMAs to 43.

In the third step, TVA estimated the benefits and costs associated with each of the remaining SAMAs. Estimates were made of how much each proposed SAMA could reduce risk. Those estimates were developed in terms of dollars in accordance with NRC guidance for performing regulatory analyses (NRC 1997a). The costs of implementing the proposed SAMAs were also estimated.

Finally in the fourth step, the costs and benefits of each of the remaining SAMAs were compared to determine whether the SAMA was cost-beneficial, meaning the benefits of the SAMA were greater than the costs (a positive cost-benefit). In the final analysis, TVA concluded that none of these 43 SAMAs were cost-beneficial for BFN.

Each of these four steps is discussed in more detail in the sections that follow.

5.2.2 Estimate of Risk

TVA submitted an assessment of SAMAs for BFN as part of the ER (TVA 2003). This assessment considers all three Browns Ferry units, each operating at 120 percent of their original licensed power level. Ideally, this assessment would take advantage of a plant-specific PSA that reflects operation of all three units at 120 percent of their original licensed power. However, such a PSA is not currently available. Because of the progressive screening nature of the SAMA evaluation, TVA relied on the available PSA information, along with engineering knowledge of the plant, to form a basis for the three-unit SAMA assessment. This assessment was based on the most recent PSAs available for Units 2 and 3 at that time. A PSA for Unit 1 was not available at the time of the SAMA analysis. The assessment was also based on insights from a multiple-unit PSA performed in 1995 to bound the effects of three-unit operation,

a plant-specific offsite consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS2) computer program, and insights from the Browns Ferry Individual Plant Examination (IPE) (TVA 1992) and the Individual Plant Examination of External Events (IPEEE) (TVA 1995, 1996, 1997).

Two distinct analyses are combined to form the basis for the risk estimates used in the SAMA analysis: (1) the BFN PSA Unit 2 and Unit 3 models, and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PSA model) developed specifically for the SAMA analysis. The SAMA analysis is based on the most recent PSA models available at the time the ER was submitted, referred to as the Extended Power Uprate (EPU) PSA for Unit 2, and the EPU PSA for Unit 3. The PSAs include a Level 1 analysis to determine the core damage frequency (CDF) from internally initiated events and a Level 2 assessment of containment performance during severe accidents. The scope of the BFN PSAs does not include external events.

The baseline CDFs for the purpose of the SAMA evaluation are approximately 2.6×10^{-6} per year for Unit 2 and 3.6×10^{-6} per year for Unit 3. The CDFs are based on the risk assessment for internally initiated events at EPU conditions (i.e., 120 percent of their original licensed power level). TVA did not include the contribution to risk from external events within the BFN risk estimates. This is discussed further in Sections G.2.2 and G.6.2.

The breakdown of CDF by initiating event is provided in Table 5-3. As shown in this table, transients and loss of offsite power initiated events are dominant contributors to the CDF.

Table 5-3. BFN Core Damage Frequency

Initiating Event or Accident Class	Unit 2		Unit 3	
	CDF (Per Year)	% Contribution to CDF	CDF (Per Year)	% Contribution to CDF
Transients	1.6×10^{-6}	63	1.8×10^{-6}	52
Loss of offsite power (LOOP)	4.8×10^{-7}	19	1.1×10^{-6}	32
Support system failures	2.2×10^{-7}	8	2.3×10^{-7}	7
Internal flooding	1.0×10^{-7}	4	1.6×10^{-7}	5
Loss of coolant accidents (LOCAs)	5.3×10^{-8}	2	5.4×10^{-8}	2
Stuck open relief valves	4.7×10^{-8}	2	5.8×10^{-8}	2

Table 5-3. (contd)

Initiating Event or Accident Class	Unit 2 CDF (Per Year)	Unit 2 % Contribution to CDF	Unit 3 CDF (Per Year)	Unit 3 % Contribution to CDF
Interfacing system LOCA (ISLOCA)	4.6×10^{-8}	2	4.6×10^{-8}	1
Total CDF (from internal events)	**2.6×10^{-6}**	**100**	**3.4×10^{-6}**	**100**

Bypass events (i.e., interfacing systems loss of coolant accident) contribute 2 percent or less to the total internal events CDF. Anticipated transients without scram (ATWS) events and station blackout (SBO) events are not specifically identified in the internal events CDF breakdown. In response to a Request for Additional Information (RAI) (NRC 2004), TVA stated that the ATWS CDF is estimated to be 2.3×10^{-7} per year for each unit, and the SBO CDF is 3.7×10^{-8} per year for Unit 2 and 3.9×10^{-8} per year for Unit 3 (TVA 2004). SAMAs to address ATWS and SBO events were considered in the SAMA evaluation. TVA estimated the dose from all postulated accidents to the population within 80 km (50 mi) of the BFN site to be approximately 0.0164 person-Sv (1.64 person-rem) per year for Unit 2, and approximately 0.0195 person-Sv (1.95 person-rem) per year for Unit 3. The breakdown of the population dose by containment release mode is summarized in Table 5-4. No containment failures and early containment failures dominate the population dose. The apparent conclusion that population dose is dominated by events involving no containment failure results from the conservative assignment of key plant damage states to release categories in which containment is assumed to fail.

Table 5-4. Breakdown of Population Dose by Containment Release Mode

Containment Release Mode	Unit 2 Population Dose (Person-Rem Per Year)	Unit 2 % Contribution	Unit 3 Population Dose (Person-Rem Per Year)	Unit 3 % Contribution
Early containment failure or Containment isolation failure	0.64	39	0.71	36
Bypass	0.01	<1	0.01	<1
Late containment failure	0.11	7	0.16	8
No containment failure	0.88	54	1.07	55
Total Population Dose	**1.64**	**100**	**1.95**	**100**

The staff has reviewed TVA's data and evaluation methods and concludes that the quality of the risk analyses is adequate to support an assessment of the risk reduction potential for the candidate SAMAs. Accordingly, the staff based its assessment of offsite risk on the CDF and offsite doses provided by TVA.

5.2.3 Potential Plant Improvements

Once the dominant contributors to plant risk were identified, TVA searched for ways to reduce that risk. In identifying and evaluating potential SAMAs, TVA considered SAMA analyses performed for other operating plants that have submitted license renewal applications, as well as industry and NRC documents that discuss potential plant improvements, such as NUREG-1560 (NRC 1997b). TVA identified 135 potential risk-reducing improvements (i.e., SAMAs) to plant components, systems, procedures, and training.

All but 43 of the these SAMAs were removed from further consideration because (1) the SAMA was not applicable at BFN because of design differences, (2) the SAMA had already been addressed in the existing BFN design, (3) the SAMA was similar to and could be combined with another SAMA, or (4) the SAMA costs more than $6 million to implement, considering the effects of multiple-unit operation and uncertainties.

The staff concludes that TVA used a systematic and comprehensive process for identifying potential plant improvements for BFN and the set of potential plant improvements identified by TVA is reasonably comprehensive and therefore acceptable.

5.2.4 Evaluation of Risk Reduction and Costs of Improvements

TVA evaluated the risk-reduction potential of the remaining 43 SAMAs that were applicable to BFN. A majority of the SAMA evaluations were performed in a bounding fashion in that the SAMA was assumed to completely eliminate the risk associated with the proposed enhancement. Such bounding calculations overestimate the benefit of the risk reduction and are conservative.

TVA estimated the costs of implementing the 43 candidate SAMAs through the application of engineering judgment and review of prior BFN completed capital projects for similar improvements. The cost estimates provided in the ER accounted for inflation (3 percent per year) to arrive at year 2016 estimated costs. Cost estimates typically included changes to and implementation of procedures, training, and documentation, in addition to any hardware costs (TVA 2003).

The staff reviewed TVA's bases for calculating the risk reduction for the various plant improvements and concluded that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative. Therefore, the staff based its estimates of averted risk for the various SAMAs on TVA's risk reduction estimates. However, the staff concluded that the benefit estimates should be increased by a factor of two to account for the potential impacts of external events.

The staff reviewed the bases for TVA's cost estimates. For certain improvements, the staff also compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors and advanced light-water reactors.

The staff concludes that the risk reduction and the cost estimates provided by TVA are sufficient and appropriate for use in the SAMA evaluation.

5.2.5 Cost-Benefit Comparison

The cost-benefit analysis performed by TVA was based primarily on NUREG/BR-0184 (NRC 1997a) and was executed consistent with this guidance. The total benefit associated with each of the 43 SAMAs was evaluated by TVA. These values were determined for the various averted costs based on the estimated annual reductions in CDF and person-rem dose.

For the TVA SAMA evaluation, it is assumed that with all three units operational, the baseline CDFs and risks for Units 1 and 2 are equal and will be four times greater than the CDF from the Unit 2 EPU PSA. Because Unit 1 is more closely tied to Unit 2 than to Unit 3, it is expected that the impact of Unit 1 operation on the Unit 3 CDF and risk would be smaller than the above impact on Unit 2. Based on this reasoning, the operation of Unit 1 is assumed to result in a factor of two increase in Unit 3 CDF and risk from that indicated by the Unit 3 EPU PSA. Therefore, TVA applied a multiplier of four to the Unit 2 averted cost estimates (benefits), assumed these same benefits for Unit 1, and applied a multiplier of two to the Unit 3 averted cost estimates. Additionally, TVA accounted for analysis uncertainties by comparing the implementation costs with three times the averted cost estimates. Consequently, all SAMAs that were evaluated were eliminated because the cost was expected to exceed the estimated benefit, as adjusted to account for multiple-unit operation and uncertainties.

The staff based its evaluation on TVA's estimated benefits for a 7-percent discount rate, applied the same multipliers as TVA to account for multiple-unit operation, and applied an additional multiplier of two to the averted cost estimates for each SAMA to account for the potential impact of external events. As a result, none of the SAMAs appeared to be potentially cost-beneficial. However, four SAMAs appeared to be within a factor of three of being cost-beneficial. These

involve improving/enhancing procedures for load shedding, which would improve direct current (DC) reliability (SAMA B11); improving procedures and hardware changes for use of cross-tied component cooling or service water (SW) pumps (SAMA G04); adding redundant DC control power for the SW pumps (SAMA G12c); and developing procedure(s) to instruct operators to trip unneeded residual heat removal/core spray pumps on loss of room ventilation (SAMA G17). TVA performed a more detailed assessment of each of these SAMAs to more realistically estimate the risk reduction and/or implementation costs for each SAMA. Based on the re-assessment, none of the SAMAs are within a factor of three of being cost-beneficial.

5.2.6 Conclusions

The staff reviewed the TVA SAMA analysis and concluded that the methods used and the implementation of those methods were sound. The treatment of SAMA benefits and costs, the generally large negative net benefits, and the inherently small baseline risks support the general conclusion that the SAMA evaluations performed by TVA are reasonable and sufficient for the license renewal submittal.

The staff considered the impact if the cost and benefits were increased by a factor of three to account for uncertainties and determined that four SAMAs could be potentially cost-beneficial. TVA re-examined each of these SAMAs and provided a more realistic estimate of their benefits and/or implementation costs. As a result of this reassessment, the cost-benefit analyses showed that none of the candidate SAMAs were cost-beneficial.

The staff concludes that none of the candidate SAMAs are cost-beneficial. This conclusion is consistent with the low residual level of risk indicated in the BFN PSA and the fact that BFN has already implemented many plant improvements identified from the Individual Plant Examination (IPE) and IPEEE processes, with the exception of the removal of the transformers, which is scheduled to occur in the future.

5.3 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 54. Code of Federal Regulations, Title 10, *Energy*, Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

10 CFR Part 100. Code of Federal Regulations, Title 10, *Energy*, Part 100, "Reactor Site Criteria."

Tennessee Valley Authority (TVA). 1992. Letter from Mark O. Medford, TVA, to U.S. NRC Document Control Desk. Subject: Browns Ferry Nuclear Plant (BFN) – Response to Generic Letter (GL) 88-20 – "Individual Plant Examination for Severe Accident Vulnerabilities – 10 CFR 50.54(f)," September 1, 1992.

Tennessee Valley Authority (TVA). 1995. Letter from Pedro Salas, TVA, to U.S. NRC Document Control Desk. Subject: Browns Ferry Nuclear Plant (BFN) – Generic Letter (GL) 88-20, Supplement 4, Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities – Partial Submittal of Report, July 24, 1995.

Tennessee Valley Authority (TVA). 1996. Letter from Pedro Salas, TVA, to U.S. NRC Document Control Desk. Subject: Browns Ferry Nuclear Plant (BFN) – Units 2 and 3 – Generic Letter (GL) 87-02, Supplement 1, Verification of Seismic Adequacy of Mechanical and Electrical Equipment in Operating Reactors, Unresolved Safety Issue (USI) A-46 and GL 88-20, Supplement 4, Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities – Submittal of Seismic Evaluation Reports (TAC Nos. M69431, M69432, M83596 and M83597), June 28, 1996.

Tennessee Valley Authority (TVA). 1997. Letter from T.E. Abney, TVA, to U.S. NRC Document Control Desk. Subject: Browns Ferry Nuclear Plant (BFN) – Unit 3 – Generic Letter (GL) 88-20, Supplement 4, Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities – Submittal of Report Internal Fires Analysis (TAC No. M83597), July 11, 1997.

Tennessee Valley Authority (TVA). 2003. *Applicant's Environmental Report – Operating License Renewal Stage, Browns Ferry Nuclear Power Plant Units 1, 2, and 3.* Tennessee Valley Authority, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 2004. Letter from TVA to NRC, Response to Request for Additional Information (RAI) Regarding Severe Accident Mitigation Alternatives for Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3 (Accession No. ML043860076). September 30, 2004.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437, Volumes 1 and 2, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1997a. *Regulatory Analysis Technical Evaluation Handbook*. NUREG/BR-0184, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1997b. *Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance.* NUREG-1560, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report*, "Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants, Final Report." NUREG-1437, Volume 1, Addendum 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2004. Letter from Michael T. Masnik, U.S. NRC to J.A. Scalice, Tennessee Valley Authority. Subject: Request for Additional Information (RAI) Regarding Severe Accident Mitigation Alternatives for the Browns Ferry Nuclear Plant, Units 1, 2, and 3 (TAC Nos. MC1768, MC1769, and MC1770), April 28, 2004.

6.0 Environmental Impacts of the Uranium Fuel Cycle and Solid Waste Management

Environmental issues associated with the uranium fuel cycle and solid waste management are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999)[a]. The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and therefore, additional plant-specific review of these issues is required.

This chapter addresses the issues that are related to the uranium fuel cycle and solid waste management during the license renewal term that are listed in Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B, and are applicable to Browns Ferry Nuclear Plant, Units 1, 2, and 3 (BFN). The generic potential radiological and nonradiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes are described in detail in the GEIS based, in part, on the generic impacts provided in 10 CFR 51.51(b), Table S-3, "Table of Uranium Fuel Cycle Environmental Data," and in 10 CFR 51.52(c), Table S-4, "Environmental Impact of Transportation of Fuel and Waste

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

to and from One Light-Water-Cooled Nuclear Power Reactor." The GEIS also addresses the impacts from radon-222 and technetium-99. There are no Category 2 issues for the uranium fuel cycle and solid waste management.

6.1 The Uranium Fuel Cycle

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to BFN from the uranium fuel cycle and solid waste management are listed in Table 6-1.

Table 6-1. Category 1 Issues Applicable to the Uranium Fuel Cycle and Solid Waste Management During the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
URANIUM FUEL CYCLE AND WASTE MANAGEMENT	
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	6.1; 6.2.1; 6.2.2.1; 6.2.2.3; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (collective effects)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (spent fuel and high-level waste)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6
Nonradiological impacts of the uranium fuel cycle	6.1; 6.2.2.6; 6.2.2.7; 6.2.2.8; 6.2.2.9; 6.2.3; 6.2.4; 6.6
Low-level waste storage and disposal	6.1; 6.2.2.2;6.4.2; 6.4.3; 6.4.3.1; 6.4.3.2; 6.4.3.3; 6.4.4; 6.4.4.1; 6.4.4.2; 6.4.4.3; 6.4.4.4; 6.4.4.5; 6.4.4.5.1; 6.4.4.5.2; 6.4.4.5.3; 6.4.4.5.4; 6.4.4.6;6.6
Mixed waste storage and disposal	6.4.5.1; 6.4.5.2; 6.4.5.3; 6.4.5.4; 6.4.5.5; 6.4.5.6; 6.4.5.6.1; 6.4.5.6.2; 6.4.5.6.3; 6.4.5.6.4; 6.6
Onsite spent fuel	6.1; 6.4.6; 6.4.6.1; 6.4.6.2; 6.4.6.3; 6.4.6.4; 6.4.6.5; 6.4.6.6; 6.4.6.7; 6.6
Nonradiological waste	6.1; 6.5; 6.5.1; 6.5.2; 6.5.3; 6.6
Transportation	6.1; 6.3.1; 6.3.2.3; 6.3.3; 6.3.4; 6.6, Addendum 1

The Tennessee Valley Authority (TVA) stated in its Environmental Report (ER) (TVA 2003) that it is not aware of any new and significant information associated with renewal of the BFN operating licenses. The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the staff concluded in the GEIS that the impacts are SMALL except for collective offsite radiological impacts from the fuel cycle and from HLW and spent fuel disposal, as discussed below, and that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff review and the GEIS conclusions, as codified in Table B-1, 10 CFR Part 51, for each of these issues follows:

- Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high level waste). Based on information in the GEIS, the U.S. Nuclear Regulatory Commission (NRC or Commission) found that

  > Off-site impacts of the uranium fuel cycle have been considered by the Commission in Table S-3 of this part [10 CFR 51.51(b)]. Based on information in the GEIS, impacts on individuals from radioactive gaseous and liquid releases including radon-222 and technetium-99 are small.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no offsite radiological impacts of the uranium fuel cycle during the license renewal term beyond those discussed in the GEIS.

- Offsite radiological impacts (collective effects). Based on information in the GEIS, the Commission found that

  > The 100 year environmental dose commitment to the U.S. population from the fuel cycle, high level waste and spent fuel disposal excepted, is calculated to be about 14,800 person rem [148 person Sv], or 12 cancer fatalities, for each additional 20-year power reactor operating term. Much of this, especially the contribution of radon releases from mines and tailing piles, consists of tiny doses summed over large populations. This same dose calculation can theoretically be extended to include many tiny doses over additional thousands of years as well as doses outside the U.S. The result of such a calculation would be thousands of cancer fatalities from the fuel cycle, but this result assumes that even tiny

> doses have some statistical adverse health effect which will not ever be mitigated (for example no cancer cure in the next thousand years), and that these doses projected over thousands of years are meaningful. However, these assumptions are questionable. In particular, science cannot rule out the possibility that there will be no cancer fatalities from these tiny doses. For perspective, the doses are very small fractions of regulatory limits and even smaller fractions of natural background exposure to the same populations.
>
> Nevertheless, despite all the uncertainty, some judgement as to the regulatory NEPA [National Environmental Policy Act] implications of these matters should be made and it makes no sense to repeat the same judgement in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the collective effects of the fuel cycle, this issue is considered Category 1.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no offsite radiological impacts (collective effects) from the uranium fuel cycle during the license renewal term beyond those discussed in the GEIS.

- Offsite radiological impacts (spent fuel and high level waste disposal). Based on information in the GEIS, the Commission found that

  > For the high level waste and spent fuel disposal component of the fuel cycle, there are no current regulatory limits for offsite releases of radionuclides for the current candidate repository site. However, if we assume that limits are developed along the lines of the 1995 National Academy of Sciences (NAS) report [NAS 1995], "Technical Bases for Yucca Mountain Standards," and that in accordance with the Commission's Waste Confidence Decision, 10 CFR 51.23, a repository can and likely will be developed at some site which will comply with such limits, peak doses to virtually all individuals will be 100 millirem [1 mSv] per year or less. However, while the Commission has reasonable confidence that these assumptions will prove correct, there is considerable uncertainty since the limits are yet to be developed, no repository application has been completed or

reviewed, and uncertainty is inherent in the models used to evaluate possible pathways to the human environment. The NAS report indicated that 100 millirem [1 mSv] per year should be considered as a starting point for limits for individual doses, but notes that some measure of consensus exists among national and international bodies that the limits should be a fraction of the 100 millirem [1 mSv] per year. The lifetime individual risk from 100 millirem [1 mSv] annual dose limit is about 3×10^{-3}.

Estimating cumulative doses to populations over thousands of years is more problematic. The likelihood and consequences of events that could seriously compromise the integrity of a deep geologic repository were evaluated by the Department of Energy in the "Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste," October 1980 [DOE 1980]. The evaluation estimated the 70-year whole-body dose commitment to the maximum individual and to the regional population resulting from several modes of breaching a reference repository in the year of closure, after 1,000 years, after 100,000 years, and after 100,000,000 years. Subsequently, the NRC and other federal agencies have expended considerable effort to develop models for the design and for the licensing of a high level waste repository, especially for the candidate repository at Yucca Mountain. More meaningful estimates of doses to population may be possible in the future as more is understood about the performance of the proposed Yucca Mountain repository. Such estimates would involve very great uncertainty, especially with respect to cumulative population doses over thousands of years. The standard proposed by the NAS is a limit on maximum individual dose. The relationship of potential new regulatory requirements, based on the NAS report, and cumulative population impacts has not been determined, although the report articulates the view that protection of individuals will adequately protect the population for a repository at Yucca Mountain. However, EPA's generic repository standards in 40 CFR part 191 generally provide an indication of the order of magnitude of cumulative risk to population that could result from the licensing of a Yucca Mountain repository, assuming the ultimate standards will be within the range of standards now under consideration. The standards in 40 CFR part 191 protect the population by imposing "containment requirements" that limit the cumulative amount of radioactive material released over 10,000 years. Reporting performance standards that will be required by EPA are expected to result in releases and associated health consequences in the range between 10 and 100 premature cancer deaths with an upper limit of 1,000 premature cancer deaths world-wide for a 100,000 metric tonne (MT) repository.

Nevertheless, despite all the uncertainty, some judgement as to the regulatory NEPA implications of these matters should be made and it makes no sense to repeat the same judgement in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the impacts of spent fuel and high level waste disposal, this issue is considered Category 1.

On February 15, 2002, based on a recommendation by the Secretary of Energy, the President recommended the Yucca Mountain site for the development of a repository for the geologic disposal of spent nuclear fuel and high-level nuclear waste. The U.S. Congress approved this recommendation on July 9, 2002, in Joint Resolution 87, which designated Yucca Mountain as the repository for spent nuclear waste. On July 23, 2002, the President signed Joint Resolution 87 into law; Public Law 107-200, 116 Stat. 735 (2002) designates Yucca Mountain as the repository for spent nuclear waste. This development does not represent new and significant information with respect to the offsite radiological impacts from license renewal related to disposal of spent nuclear fuel and high-level nuclear waste.

The U.S. Environmental Protection Agency (EPA) developed Yucca Mountain-specific repository standards, which were subsequently adopted by the NRC in 10 CFR Part 63. In an opinion, issued July 9, 2004, the U.S. Court of Appeals for the District of Columbia Circuit (the Court) vacated EPA's radiation protection standards for the candidate repository, which required compliance with certain dose limits over a 10,000 year period. The Court's decision also vacated the compliance period in NRC's licensing criteria for the candidate repository in 10 CFR Part 63.

Therefore, for the high-level waste and spent fuel disposal component of the fuel cycle, there is some uncertainty with respect to regulatory limits for offsite releases of radioactive nuclides for the current candidate repository site. However, prior to promulgation of the affected provisions of the Commission's regulations, we assumed that limits would be developed along the lines of the 1995 National Academy of Sciences report, *Technical Bases for Yucca Mountain Standards*, and that in accordance with the Commission's Waste Confidence Decision, 10 CFR 51.23, a repository that would comply with such limits could and likely would be developed at some site. Peak doses to virtually all individuals would be 1 mSv (100 mrem) per year or less.

Despite the current uncertainty with respect to these rules, some judgment as to the regulatory NEPA implications of offsite radiological impacts of spent fuel and high-level waste disposal should be made. The staff concludes that these impacts are acceptable in

that the impacts would not be sufficiently large to require the NEPA conclusion that the option of extended operation under 10 CFR Part 54 should be eliminated.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, including operation at a combined total of 11,856 MW(t). Therefore, the staff concludes that there are no offsite radiological impacts related to spent fuel and HLW disposal during the license renewal term beyond those discussed in the GEIS.

- Nonradiological impacts of the uranium fuel cycle. Based on information in the GEIS, the Commission found that

  > The nonradiological impacts of the uranium fuel cycle resulting from the renewal of an operating license for any plant are found to be small.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no nonradiological impacts of the uranium fuel cycle during the license renewal term beyond those discussed in the GEIS.

- Low-level waste storage and disposal. Based on information in the GEIS, the Commission found that

  > The comprehensive regulatory controls that are in place and the low public doses being achieved at reactors ensure that the radiological impacts to the environment will remain small during the term of a renewed license. The maximum additional on-site land that may be required for low-level waste storage during the term of a renewed license and associated impacts will be small. Nonradiological impacts on air and water will be negligible. The radiological and nonradiological environmental impacts of long-term disposal of low-level waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient low-level waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of low-level waste storage and disposal associated with the license renewal term beyond those discussed in the GEIS.

- Mixed waste storage and disposal. Based on information in the GEIS, the Commission found that

  > The comprehensive regulatory controls and the facilities and procedures that are in place ensure proper handling and storage, as well as negligible doses and exposure to toxic materials for the public and the environment at all plants. License renewal will not increase the small, continuing risk to human health and the environment posed by mixed waste at all plants. The radiological and nonradiological environmental impacts of long-term disposal of mixed waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient mixed waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of mixed waste storage and disposal associated with the license renewal term beyond those discussed in the GEIS.

- Onsite spent fuel. Based on information in the GEIS, the Commission found that

  > The expected increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated on site with small environmental effects through dry or pool storage at all plants if a permanent repository or monitored retrievable storage is not available.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of onsite spent fuel associated with the license renewal term beyond those discussed in the GEIS.

- Nonradiological waste. Based on information in the GEIS, the Commission found that

  > No changes to generating systems are anticipated for license renewal. Facilities and procedures are in place to ensure continued proper handling and disposal at all plants.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other

available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no nonradiological waste impacts during the license renewal term beyond those discussed in the GEIS.

- Transportation. Based on information contained in the GEIS, the Commission found that

> The impacts of transporting spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC up to 62,000 MWd/MTU and the cumulative impacts of transporting high-level waste to a single repository, such as Yucca Mountain, Nevada are found to be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S-4—Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor. If fuel enrichment or burnup conditions are not met, the applicant must submit an assessment of the implications for the environmental impact values reported in § 51.52.

BFN meets the fuel-enrichment and burnup conditions set forth in Addendum 1 to the GEIS. The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of transportation associated with the license renewal term beyond those discussed in the GEIS.

6.2 References

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 54. Code of Federal Regulations, Title 10, *Energy,* Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

10 CFR Part 63. Code of Federal Regulations, Title 10, *Energy,* Part 63, "Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada."

40 CFR Part 191. Code of Federal Regulations, Title 40, *Protection of Environment,* Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste."

National Academy of Sciences (NAS). 1995. *Technical Bases for Yucca Mountain Standards.* Washington, D.C.

National Environmental Policy Act (NEPA) of 1969, as amended, 42 USC 4321, et. seq.

Tennessee Valley Authority (TVA). 2003. *Applicant's Environmental Report – Operating License Renewal Stage, Browns Ferry Units 1, 2, and 3.* Tennessee Valley Authority, Knoxville, Tennessee.

U.S. Department of Energy (DOE). 1980. *Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste.* DOE/EIS-0046F, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* NUREG-1437, Volumes 1 and 2, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report*, "Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants, Final Report." NUREG-1437, Volume 1, Addendum 1, Washington, D.C.

7.0 Environmental Impacts of Decommissioning

Environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license are evaluated in the *Generic Environmental Impact Statement for Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors*, NUREG-0586, Supplement 1 (NRC 2002). The staff's evaluation of the environmental impacts of decommissioning presented in Supplement 1 resulted in a range of impacts for each environmental issue. These results may be used by licensees as a starting point for a plant-specific evaluation of the decommissioning impacts at their facilities.

The incremental environmental impacts associated with decommissioning activities resulting from continued plant operation during the renewal term are evaluated in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999).[a] The evaluation in NUREG-1437 includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and therefore, additional plant-specific review of these issues is required. There are no Category 2 issues related to decommissioning.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

7.1 Decommissioning

Category 1 issues in Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B that are applicable to Browns Ferry Nuclear Plant, Units 1, 2, and 3 decommissioning following the renewal term are listed in Table 7-1. Tennessee Valley Authority (TVA) stated in its Environmental Report (ER) (TVA 2003) that it is aware of no new and significant information regarding the environmental impacts of Browns Ferry Nuclear Plant, Units 1, 2, and 3 license renewal. The staff has not identified any new and significant information during its independent review of the TVA ER, the staff's site visit, the scoping process, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of these issues, the staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 7-1. Category 1 Issues Applicable to the Decommissioning of Browns Ferry Nuclear Power Plant, Units 1, 2,and 3 Following the License Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
DECOMMISSIONING	
Radiation Doses	7.3.1; 7.4
Waste Management	7.3.2; 7.4
Air Quality	7.3.3; 7.4
Water Quality	7.3.4; 7.4
Ecological Resources	7.3.5; 7.4
Socioeconomic Impacts	7.3.7; 7.4

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, for each of the issues follows:

- Radiation doses. Based on information in the GEIS, the Commission found that

  > Doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem [0.01 person-Sv] caused by buildup of long-lived radionuclides during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the staff's site visit, the scoping process, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no radiation dose impacts associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Waste management. Based on information in the GEIS, the Commission found that

  > Decommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the staff's site visit, the scoping process, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts from solid waste associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Air quality. Based on information in the GEIS, the Commission found that

  > Air quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the staff's site visit, the scoping process, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts on air quality associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Water quality. Based on information in the GEIS, the Commission found that

  > The potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts on water quality associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Ecological resources. Based on information in the GEIS, the Commission found that

  > Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts on ecological resources associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Socioeconomic Impacts. Based on information in the GEIS, the Commission found that

  > Decommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth.

  The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no socioeconomic impacts associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

7.2 References

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

Tennessee Valley Authority (TVA). 2003. *Applicant's Environmental Report – Operating License Renewal Stage, Browns Ferry Units 1, 2, and 3.* Tennessee Valley Authority, Knoxville, Tennessee.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* NUREG-1437, Volumes 1 and 2, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report*, "Section 6.3 – Transportation, Table 9.1,

Summary of findings on NEPA issues for license renewal of nuclear power plants, Final Report." NUREG-1437, Volume 1, Addendum 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2002. *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities. Supplement 1 Regarding the Decommissioning of Nuclear Power Reactors. Final Report.* NUREG–0586, Supplement 1, Volumes 1 and 2. Office of Nuclear Reactor Regulation, Washington, D.C.

8.0 Environmental Impacts of Alternatives to Operating License Renewal

This chapter examines the potential environmental impacts associated with denying the renewal of the operating licenses (OLs) (i.e., the no-action alternative) for Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 (BFN); the potential environmental impacts from electric generating sources other than BFN; the possibility of purchasing electric power from other sources to replace power generated by BFN and the associated environmental impacts; the potential environmental impacts from a combination of generating and conservation measures; and other generation alternatives that were deemed unsuitable for replacement of power generated by BFN. The environmental impacts are evaluated using the U.S. Nuclear Regulatory Commission's (NRC's) three-level standard of significance – SMALL, MODERATE, or LARGE – developed using the Council on Environmental Quality guidelines and set forth in the footnotes to Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B:

SMALL – Environmental effects are not detectable or are so minor that 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, Volumes 1 and 2 (NRC 1996, 1999)[a] with the additional impact categories of environmental justice and transportation.

8.1 No-Action Alternative

NRC's regulations implementing the National Environmental Policy Act of 1969 (NEPA) specify that the no-action alternative be discussed in an NRC environmental impact statement (EIS) (10 CFR Part 51, Subpart A, Appendix A(4)). For license renewal, the no-action alternative refers to a scenario in which NRC would not renew the OLs for the three BFN units. The Tennessee Valley Authority (TVA) would then decommission the three BFN units after plant operations cease.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

TVA states in its Environmental Report (ER) (TVA 2003) that if renewal of the Unit 1 OL is denied, further work on Unit 1 recovery and restart would terminate because restart would be economically infeasible. Operation of Units 2 and 3 would cease upon expiration of their OLs in 2014 and 2016, respectively. TVA would likely concurrently decommission all three units after the expiration of the Unit 3 OL (TVA 2003).

Under the no-action alternative, replacement of BFN electricity generation capacity would be met by (1) TVA generating alternatives other than BFN, (2) power purchased from other electricity providers, (3) demand-side management (DSM) and energy conservation, or (4) some combination of these options. The environmental impacts associated with alternative generation technologies are discussed in Section 8.2.

TVA will be required to comply with NRC decommissioning requirements at 10 CFR 50.82 whether or not the BFN OLs are renewed. If the OLs are renewed, decommissioning activities may be postponed for up to an additional 20 years.

The environmental impacts associated with decommissioning under both license renewal and the no-action alternative would be bounded by the discussion of impacts in Chapter 7 of the GEIS, Chapter 7 of this supplemental environmental impact statement (SEIS), and Supplement 1 to the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002). The impacts of decommissioning after 60 years of operation are not expected to be significantly different from those occurring after 40 years of operation.

The environmental impacts resulting from the no-action alternative are summarized in Table 8-1 and are discussed in the following paragraphs. Implementation of the no-action alternative would also have certain positive impacts in that adverse environmental impacts associated with the current operation of BFN would be eliminated.

Table 8-1. Summary of Environmental Impacts of the No-Action Alternative at the Browns Ferry Nuclear Power Plant, Units 1, 2, and 3

Impact Category	Impact	Comment
Land Use	SMALL	Onsite impacts expected to be temporary. No offsite impacts expected.
Ecology	SMALL	Impacts to ecology are expected to be temporary and can be mitigated using best management practices.
Water Use and Quality	SMALL	Water use would decrease. Water quality unlikely to be adversely affected.
Air Quality	SMALL	Greatest impact is likely to be from fugitive dust; impact can be mitigated using best management practices.

Table 8-1. (contd)

Impact Category	Impact	Comment
Waste	SMALL	Low-level radioactive waste (LLW) would be disposed of in licensed facilities. High-level radioactive waste (HLW) can be safely stored until a permanent HLW repository is available.
Human Health	SMALL	Radiological doses to workers and members of the public are expected to be within regulatory limits and comparable to, or lower than, doses from operating plants. Occupational injuries are possible, but injury rates at nuclear power plants are below the U.S. average industrial rate.
Socioeconomics	MODERATE	Decrease in employment in Limestone County and surrounding counties and tax revenues in Limestone County.
Aesthetics	SMALL	Positive impact from eventual removal of buildings and structures. Some noise impact during decommissioning operations.
Historic and Archaeological Resources	SMALL	Minimal impact on land utilized during plant operations. Land occupied by BFN would likely be retained by TVA for other purposes.
Environmental Justice	SMALL	Some loss of employment opportunities and social programs is expected.

8.1.1 Land Use

Temporary changes in onsite land use could occur during decommissioning. Temporary changes may include addition or expansion of staging and laydown areas or construction of temporary buildings and parking areas. Offsite land-use impacts associated with uranium mining would no longer occur. In the GEIS, the staff estimated that approximately 400 ha (1000 ac) would be affected for mining the uranium and processing it during the operating life of a 1000-megawatt-electric (MW[e]) nuclear power plant (NRC 1996). Following decommissioning, the land occupied by BFN would likely be retained by TVA for other purposes. It is expected that the existing transmission system, including rights-of-way, would be retained. Eventual sale or transfer of the land occupied by the plant, however, could result in changes to land use. Notwithstanding this possibility, the impacts of the no-action alternative on land use are considered SMALL.

8.1.2 Ecology

Impacts on aquatic ecology could result from removal of in-water pipes and structures. Any impacts to aquatic ecology would likely be short term and could be mitigated. The aquatic environment is expected to recover naturally. Impacts on the terrestrial ecology could occur as

a result of land disturbance for additional laydown yards, stockpiles, and support facilities. Land disturbance is expected to be minimal and result in relatively short-term impacts that can be mitigated using best management practices. The land is expected to recover naturally. Overall, the ecological impacts associated with decommissioning are considered SMALL.

8.1.3 Water Use and Quality

Cessation of plant operations would result in a significant reduction in water use because reactor cooling would no longer be required. As plant staff size decreases, the demand for potable water is expected to also decrease. Onsite disposal of demolition debris could result in minimal impacts to water quality. Overall, water use and quality impacts of decommissioning are considered SMALL.

8.1.4 Air Quality

Decommissioning activities that can adversely affect air quality include dismantlement of systems and equipment, demolition of buildings and structures, and the operation of internal combustion engines. The most likely adverse impact would be the generation of fugitive dust. Best management practices, such as seeding and wetting, can be used to minimize the generation of fugitive dust. Overall, air quality impacts associated with decommissioning activities are considered SMALL.

8.1.5 Waste

Decommissioning activities would result in the generation of radioactive and nonradioactive waste. The volume of LLW is related to the type and size of the plant, the decommissioning option chosen, and the waste treatment and volume reduction procedures used. LLW must be disposed of in a facility licensed by NRC or a State with authority delegated by NRC. Recent advances in volume reduction and waste processing have significantly reduced waste volumes. A permanent repository for HLW is not currently available. The NRC has made a generic determination that, if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 30 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of that reactor at its spent fuel storage basin or at either onsite or offsite independent spent fuel storage installations (10 CFR 51.23(a)). Disposal of nonradioactive waste would be at onsite and offsite licensed disposal facilities. Overall, waste impacts associated with decommissioning activities are considered SMALL.

8.1.6 Human Health

Radiological doses to occupational workers during decommissioning activities are estimated to average approximately 5 percent of the dose limits in 10 CFR Part 20, and to be similar to, or lower than, the doses experienced by workers in operating nuclear power plants. Collective doses to members of the public and to the maximally exposed individual as a result of decommissioning activities are estimated to be well below the limits in 10 CFR Part 20, and to be similar to, or lower than, the doses received from operating nuclear power plants. Occupational injuries to workers engaged in decommissioning activities are possible. However, historical injury and fatality rates at nuclear power plants have been lower than the average U.S. industrial rates. Overall, the human health impacts associated with decommissioning activities are considered SMALL.

8.1.7 Socioeconomics

If BFN ceased operation, there would be a decrease in employment and tax revenues associated with the closure. Impacts on employment (primary and secondary) and population would occur over a wide area. BFN employees reside in a number of counties; however, approximately 75 percent of employees live in Lauderdale, Limestone, Madison, and Morgan Counties (TVA 2003).

Tax-related impacts would occur primarily in Limestone County and surrounding counties. TVA makes tax-equivalent payments to states served by TVA which in turn redistribute some of the tax payments to the counties that are served by TVA power. The distribution of those payments to political subdivisions in the vicinity of BFN is discussed in Section 2.2.8.5. The no-action alternative would result in the loss of the tax-equivalent payments attributable to BFN as well as the loss of plant payrolls 20 years earlier than if the OLs were renewed. There would also be an adverse impact on housing values and the local economy if BFN were to cease operations.

Both Chapter 7 of the GEIS and Supplement 1 to NUREG-0586 (NRC 2002) note that socioeconomic impacts would be expected as a result of the decision to close a nuclear power plant, and that the direction and extent of the overall impacts would depend on the state of the economy, the net change in workforce at the plant, and the changes in local government tax receipts. The socioeconomic impact of decommissioning activities themselves is expected to be minimal. Appendix J of Supplement 1 to NUREG-0586 (NRC 2002) shows that the overall socioeconomic impact of plant closure plus decommissioning could be greater than small.

The staff concluded that when the property tax revenue from a nuclear power plant comprises 10 percent or less of the tax revenue of a local jurisdiction, the socioeconomic impacts associated with the loss of the plant's tax revenue as a result of plant closure would likely be

minor. Because the tax payments received by Limestone County from TVA are 10 percent or less of total tax revenue (see Table 2-12), socioeconomic impacts to Limestone County resulting from loss of this revenue would be minimal.

TVA employees working at BFN contribute time and money toward community involvement, including school, churches, charities, and other civic activities. It is likely that with a reduced presence in the community following decommissioning, community involvement efforts by TVA and its employees in the region would be less.

Overall, the socioeconomic impacts associated with non-renewal of the BFN OLs and decommissioning of BFN Units 1, 2, and 3 are considered MODERATE.

8.1.8 Aesthetics

Decommissioning would result in the eventual dismantlement of buildings and structures at the BFN site resulting in a positive aesthetic impact. Noise would be generated during decommissioning operations that may be detectable offsite; however, the impact is unlikely to be of large significance. Overall, the aesthetic impacts associated with decommissioning are considered SMALL.

8.1.9 Historic and Archaeological Resources

The amount of undisturbed land needed to support the decommissioning process would be relatively small. Activities conducted within operational areas are not expected to have a detectable effect on important cultural resources because these areas have likely been impacted during the operating life of BFN. Minimal disturbance of land outside TVA's operational area for decommissioning activities is expected. Historic and archaeological resources on undisturbed portions of the plant site are not expected to be adversely affected. The site would likely be retained by TVA following decommissioning. Eventual sale or transfer of the site, however, could result in adverse impacts to cultural resources if the land-use pattern changes dramatically. Notwithstanding this possibility, the impacts of the no-action alternative on historic and archaeological resources are considered SMALL.

8.1.10 Environmental Justice

Current operations at BFN have no disproportionate adverse impacts on the minority and low-income populations of Limestone County and surrounding counties, and no environmental pathways have been identified that would cause disproportionate impacts. Closure of the plant would result in decreased employment opportunities and tax revenues in Limestone County and surrounding counties as a result of reduced in-lieu-of-tax payments from TVA. Together, these

impacts could result in secondary job losses (such as retail, services, etc.) that could have negative and disproportionate impacts on minority or low-income populations. Overall, however, the environmental justice impacts under the no-action alternative are considered SMALL.

8.2 Alternative Energy Sources

This section discusses the environmental impacts associated with alternative sources of electric power to replace the baseload[a] electric power generating capacity of BFN assuming that the OLs are not renewed.

The TVA ER states that the combined generating capacity of BFN Units 1, 2, and 3 at full uprated power will be 3840 MW(e)[b] (TVA 2003). This level of power production will make BFN among the largest, if not the largest, thermal generating station in the United States (DOE/EIA 2002). If the BFN OLs are not renewed, it is unlikely that this level of power (3840 MW[e]) would be produced from alternative generating sources at the BFN site or any other single alternative site. For purposes of the Section 8.2 analysis, it is assumed that replacement power production for the 3840 MW(e) will occur at more than one site and that the BFN site could be one site for siting new alternative power generating sources. Siting of additional energy sources at the BFN site would likely require TVA to acquire additional land beyond the current site boundary. Such acquisition would be complicated by the fact that there are nearby residential areas both upriver and downriver from the BFN site; however, the site could be expanded to the northeast.

The order of presentation of alternative energy sources in Section 8.2 does not imply which alternative would be most likely to occur or to have the least environmental impacts. The following generation alternatives are considered in detail:

- pulverized coal (Section 8.2.1)
- coal gasification (Section 8.2.2)

(a) A baseload plant normally operates to supply all or part of the minimum continuous load of a system and consequently produces electricity at an essentially constant rate. Nuclear power plants are commonly used for baseload generation; that is, these units generally run near full load continuously.
(b) One-MW(e) represents one million watts of electric capacity.

- natural gas combined-cycle (Section 8.2.3)
- new nuclear (Section 8.2.4).

Consistent with the TVA ER, the principal cooling alternative considered for each alternative energy plant is closed-cycle wet cooling using mechanical draft cooling towers. For completeness, the alternative of once-through cooling is considered, although the use of once-through cooling for newly constructed power plants is limited by the U.S. Environmental Protection Agency (EPA) requirements in 40 CFR Part 125, Subpart I, for cooling water intake structures for new facilities under Section 316(b) of the Clean Water Act.

The alternative of purchasing power from other sources to replace power generated at BFN is discussed in Section 8.2.5. Other power generation alternatives and conservation alternatives considered by the staff and found not to be reasonable replacements for the BFN generation capacity are discussed in Section 8.2.6. Section 8.2.7 discusses the environmental impacts of a combination of generation and conservation alternatives.

Each year, the Energy Information Administration (EIA), a component of the U.S. Department of Energy (DOE), issues an Annual Energy Outlook. The 2004 report projects that combined-cycle,[a] combustion turbine, or distributed generation technology fueled by natural gas is likely to account for approximately 62 percent of new electricity generating capacity added between 2002 and 2025 (DOE/EIA 2004). Combined-cycle technology can be used to meet baseload requirements. Coal-fired plants are projected by EIA to account for approximately 33 percent of new capacity during this period. Coal-fired plants are generally used to meet baseload requirements. Renewable energy sources, primarily wind and biomass units, are projected by EIA to account for the remaining 5 percent of capacity additions. EIA's projections are based on the assumption that providers of new generating capacity will seek to minimize cost while meeting applicable environmental requirements. Combined-cycle plants are projected by EIA to have the lowest adjusted generation cost for new plants in 2010 (DOE/EIA 2004). Coal-fired plants are projected to have the lowest adjusted generation cost for new plants in 2025 (DOE/EIA 2004).

EIA projects that oil-fired plants will account for no new generation capacity in the United States through the year 2025, except for limited industrial combined heat and power applications, because of higher fuel costs and lower efficiencies (DOE/EIA 2004).

(a) In the combined-cycle unit, hot combustion gases in a combustion turbine rotate the turbine to generate electricity. Waste combustion heat from the combustion turbine is routed through a heat-recovery boiler to make steam to generate additional electricity.

EIA's reference case also projects that new nuclear power plants will not account for any new generation capacity in the United States through the year 2025 because of the relative economics of competing technologies (DOE/EIA 2004). In spite of this projection, a new nuclear plant alternative for replacing power generated by BFN was considered in the TVA ER and is discussed in Section 8.2.4.

If an alternative generating technology were selected to replace power generated by BFN, Units 1, 2, and 3 would be decommissioned. Environmental impacts associated with decommissioning are discussed in Section 8.1 and are not otherwise addressed in Section 8.2.

8.2.1 Pulverized Coal-Fired Generation

In a pulverized coal-fired generation system, pieces of coal are crushed between balls or cylindrical rollers. The raw coal is then fed into the pulverizer along with air heated to about (343°C) 650°F from the boiler. As the coal is crushed by the rolling action, the hot air both dries it and moves the usable fine coal powder to a burner in the boiler where it is combusted.

In its ER, TVA considered the construction of 1200-MW(e) pulverized coal power stations, composed of two 600-MW(e) subcritical units (TVA 2003). At least three of these stations would be needed to replace the generating capacity of BFN. Each unit would have its own subcritical steam generator and condensing steam turbine generator. The subcritical steam generators would be balanced draft pulverized coal furnaces with drum type, single reheat boilers. Each unit would be an eight-heater cycle design with four low-pressure feedwater heaters, three high-pressure feedwater heaters, and a de-aerator. Ignition fuel would be No. 2 fuel oil.

Major structures for the pulverized coal-fired facility would include the boiler building, turbine and control building, and limestone preparation building. TVA assumed a single common concrete chimney for each station, with dual flues for wet stack gas (TVA 2003).

The pulverized coal-fired stations could be located near the coal supply (i.e., at the "mine mouth") or at a location with suitable cooling water that is closer to the loads to be served. For a mine-mouth plant, the impacts of coal transportation would be relatively small. However, lime or limestone, which is used in the scrubbing process for control of sulfur dioxide emissions,[a] would still need to be delivered to the plant site. Additionally, transmission line impacts would

(a) In a typical wet scrubber, lime (calcium hydroxide) or limestone (calcium carbonate) is injected as a slurry into the hot effluent combustion gases to remove entrained sulfur dioxide. The lime-based scrubbing solution reacts with sulfur dioxide to form calcium sulfite, which precipitates out and is removed in sludge form.

likely be greater for a mine-mouth plant than for a plant sited closer to the areas ultimately needing the power generated at the plant. For a plant not located at the mine mouth, coal would be delivered by railroad or barge.

Although the license renewal term is only 20 years, the impact of operating coal-fired stations for 40 years is considered (as a reasonable projection of the operating life of a coal-fired plant).

8.2.1.1 Closed-Cycle Cooling System

The overall impacts of constructing three 1200-MW(e) pulverized coal-fired power stations using closed-cycle cooling are discussed in the following sections and summarized in Table 8-2. The use of three 1200-MW(e) units is intended to be an approximation of the uprated BFN capacity; actual capacity of BFN is slightly larger – 3840 MW(e). It is unlikely that the three 1200-MW(e) stations would be located at a single site.

- **Land Use**

Approximately 400 ha (1000 ac) would be required for construction and operation of each 1200-MW(e) station. This area includes land for a barge unloading facility, the coal pile, a limestone pile, ash and scrubber solids disposal area, and plant buildings and structures, but it does not include land for an associated coal mine, transmission lines, access road, and railroad spur (TVA 2003).

In the GEIS, the staff estimated that approximately 8800 ha (34 mi^2) would be affected for mining the coal and disposing of the waste to support a 1000-MW(e) coal plant during its operational life (NRC 1996). A replacement coal-fired plant to replace the 3840-MW(e) capacity of BFN would affect proportionately more land.

Construction of each station would permanently change the land use at the site, and would most likely involve an irretrievable but moderate loss of forest land and/or farmland. Because of the use of erosion control practices during and following construction, no significant impacts to plant site soils are anticipated.

The impacts of three 1200-MW(e) pulverized coal-fired generating stations on land use is best characterized as MODERATE to LARGE. The impacts would definitely be greater than the alternative of renewing the BFN OLs.

Table 8-2. Summary of Environmental Impacts of Pulverized Coal-Fired Generation Using Closed-Cycle Cooling

Impact Category	Impact	Comment
Land Use	MODERATE to LARGE	Approximately 1200 ha (3000 ac) for power block; coal handling, storage, and transportation facilities; infrastructure facilities; and waste disposal. Mining the coal and disposal of waste could impact more than 30,000 ha (120 mi^2). Additional land impacts for limestone mining, electric power transmission lines, rail spurs, and cooling water intake and discharge pipelines.
Ecology	MODERATE to LARGE	Impacts would depend on location and ecology of the site, surface water body used for intake and discharge, and electric power transmission line route; potential habitat loss and fragmentation; reduced productivity and biological diversity; impacts to terrestrial ecology from cooling tower drift.
Water Use and Quality	SMALL to MODERATE	Impacts would depend on the volume of water withdrawn and discharged, the constituents in the discharge water, and the characteristics of the surface water body. Discharges would be regulated by the State or EPA.
Air Quality	MODERATE	Air emissions from three pulverized coal-fired plants sized to replace the uprated BFN capacity would be approximately: Sulfur oxides – 13,300 MT/yr (14,700 tons/yr) Nitrogen oxides – 15,900 MT/yr (17,500 tons/yr) PM_{10} – 3200 MT/yr (3500 tons/yr) Carbon monoxide – 4130 MT/yr (4550 tons/yr) Small amounts of mercury and other hazardous air pollutants and naturally occurring radioactive materials, mainly uranium and thorium. 40 million MT/yr (44 million tons/yr) of unregulated carbon dioxide.
Waste	MODERATE	For three 1200-MW(e) stations, potentially marketable material waste streams include 900,000 MT/yr (990,000 tons/yr) of fly ash, 224,400 MT/yr (247,500 tons/yr) of bottom ash, and 1,662,000 MT/yr (1,833,000 tons/yr) of flue gas desulfurization sludge (gypsum). Unusable waste streams would include 1695 MT/yr (1869 tons/yr) of raw water treatment sludges and 1062 MT/yr (1170 tons/yr) of general water treatment sludges.
Human Health	SMALL	Impacts are uncertain, but considered SMALL in the absence of more quantitative data.

Table 8-2. (contd)

Impact Category	Impact	Comment
Socioeconomics	MODERATE	Construction impacts depend on location and how many plants are constructed at the location. Limestone County could experience loss of BFN tax base and employment. Transportation impacts would result from commuting workers and delivery of coal and lime/limestone by rail or barge. Overall, impacts are considered MODERATE.
Aesthetics	MODERATE to LARGE	Impacts would depend on the site selected and the surrounding land features. Power block, exhaust stacks, cooling towers, and cooling tower plumes would be visible from nearby areas. If needed, new electric power transmission lines and/or a rail spur could have a significant aesthetic impact. Noise impact from plant operations and intermittent sources such as rail transportation of coal would be noticeable. Overall, visual and noise impacts are considered MODERATE to LARGE.
Historic and Archeological Resources	SMALL	New plant locations would necessitate cultural resource studies. Any potential impacts can likely be effectively managed.
Environmental Justice	SMALL to MODERATE	Impacts would vary depending on population distribution at the site. Impacts in Limestone County would be the same as those under the no-action alternative.

- **Ecology**

The coal-fired generation alternative would introduce construction impacts and new incremental operational impacts. Even assuming siting at a previously disturbed area, the impacts would alter the ecology. Impacts could include wildlife habitat loss, reduced productivity, habitat fragmentation, and a local reduction in biological diversity. Use of cooling makeup water from a nearby surface water body could have adverse aquatic resource impacts. If needed, construction and maintenance of a transmission line and a rail spur would have ecological impacts. There could be impacts to terrestrial ecology from cooling tower drift. Overall, the ecological impacts would be MODERATE to LARGE.

- **Water Use and Quality**

Construction of each power station (including transmission lines and access roads) would affect surface water hydrology, but sites could be chosen to avoid extensive site excavation, filling, or grading. New construction would disturb the land surface, which may temporarily affect surface water quality. Potential water quality impacts would consist of suspended solids from disturbed soils, biochemical oxygen demand, nutrient loading from disturbed vegetation, and oil and

grease from construction equipment. New construction activities that disturb 2 ha (5 ac) or more would require a National Pollutant Discharge Elimination System (NPDES) permit for storm water discharges from the site to ensure the implementation of best management practices and to minimize impacts to surface waters during construction. To minimize the impacts of storm water flow erosion during construction, onsite retention areas (storm water detention pond) would be designed to detain storm water from the 25-year, 24-hour rainfall event. Runoff detention ponds would be designed to detain runoff within the containment areas to allow for settling and to reduce peak discharges. Best management practices would also be required during construction to minimize water quality impacts. Construction would cause no significant consumption of surface water resources. Sanitary waste water would most likely be routed to a publicly owned treatment works, if available. If a sanitary waste treatment system was not available, one would be constructed (TVA 2003).

During operation, approximately 90.5 percent of the 908 L/s (14,400 gal/min) plant intake water requirement for each 1200-MW(e) station would be for cooling tower makeup water flow, or about 822.7 L/s (13,040 gal/min). This amount of water consumption is normally obtainable from river intake or wells with a negligible impact on water availability downstream or in the vicinity of the plant. Cooling water for the main condensers and miscellaneous components would be recirculated through the cooling towers, with the blowdown (i.e., the fraction of circulated water that is discharged to prevent the buildup of dissolved salts and minerals) and other plant operational waste water streams subsequently being discharged through diffusers. A biocide would be used to protect the cooling water system from biological growths. Cooling tower blowdown amounting to 164 L/s (2600 gal/min) is expected to be several times larger than any other waste water stream, but it would not contain any detectable amounts of priority pollutants. Plant process waste water streams would include demineralizer regeneration wastes (11.4 L/s [180 gal/min]), steam cycle blowdown (13 L/s [200 gal/min]), and service water/pre-treatment waste and chemical drains (5.80 L/s [92 gal/min]). Plant waste water outfalls would also require a National Pollutant Discharge Elimination System (NPDES) permit, with established treatment standards and discharge limits. To prevent leachate in storm water runoff from entering the surficial aquifer, the coal storage area and the runoff basin would be lined with low-permeability materials. Runoff streams from the coal pile, fly ash and bottom ash piles, and gypsum storage area would be collected in the lined recycle basin for reuse (which would be sized to exceed capacity requirements for the 25-year, 24-hour storm event), with no direct discharge to the surface water (TVA 2003).

Overall, water use and quality impacts can be characterized as SMALL to MODERATE.

- **Air Quality**

The air quality impacts of coal-fired generation vary considerably from those of nuclear generation due to emissions of sulfur oxides (SO_x), nitrogen oxides (NO_x), particulates, carbon monoxide, hazardous air pollutants such as mercury, and naturally occurring radioactive materials. Estimated emissions for SO_x, NO_x, PM_{10} (particulate matter with an aerodynamic diameter less than or equal to 10 μm), and carbon monoxide are shown in Table 8-2. The emissions are for new pulverized coal-fired plants meeting all applicable regulatory requirements with a capacity sufficient to replace the power generated at the BFN.

A new coal-fired generating plant would need to meet the new source review requirements in Title I of the Clean Air Act (42 USC 7491). The plant would need an operating permit issued under Title V of the Clean Air Act. The plant would also need to comply with the new source performance standards for new generating plants in 40 CFR Part 60, Subpart Da. The standards establish limits for particulate matter and opacity (40 CFR 60.42a), sulfur dioxide (SO_2) (40 CFR 60.43a), and NO_x (40 CFR 60.44a).

EPA has various regulatory requirements for visibility protection in 40 CFR Part 51, Subpart P, including a specific requirement for review of any new major stationary source in an area designated as attainment or unclassified under the Clean Air Act.

Section 169A of the Clean Air Act establishes a national goal of preventing future and remedying existing impairment of visibility in mandatory Class I Federal areas when impairment results from air pollution caused by human activities. In addition, EPA issued a new regional haze rule in 1999 (64 FR 35714). The rule specifies that State agencies must establish goals for reasonable progress toward achieving natural visibility conditions for each mandatory Class I Federal area located within a state. The reasonable progress goals must provide for an improvement in visibility for the most-impaired days over the period of the implementation plan and ensure no degradation in visibility for the least-impaired days over the same period (40 CFR 51.30(d)(1)). If a new coal-fired power plant were located close to a mandatory Class I area, additional air pollution control requirements could be imposed.

In 1998, EPA issued a rule requiring 22 eastern states to revise their state implementation plans to reduce NO_x emissions. Nitrogen oxide emissions contribute to violations of the national ambient air quality standard for ozone (40 CFR 50.9). The total amount of NO_x that can be emitted by each of the 22 states in the year 2007 ozone season (May 1 through September 30, 2007) is specified in 40 CFR 51.121(e). For Alabama, the amount is 108,706 MT (119,827 tons). Any new coal-fired power plant sited in Alabama would be subject to these limitations.

A new coal-fired power plant would be subject to the requirements in Title IV of the Clean Air Act. Title IV was enacted to reduce emissions of SO_2 and NO_x, the two principal precursors of acid rain, by restricting emissions of these pollutants from power plants. Title IV caps aggregate annual power plant SO_2 emissions and imposes control on SO_2 emissions through a system of marketable allowances. EPA issues one allowance for each ton of SO_2 that a unit is allowed to emit. New units do not receive allowances but are required to have allowances to cover their SO_2 emissions. Owners of new units must therefore acquire allowances from owners of other power plants by purchase or reduce SO_2 emissions at other power plants they own. Allowances can be banked for use in future years. Thus, a new coal-fired power plant would not add to net regional SO_2 emissions, although it might do so locally. Regardless, SO_2 emissions would be greater for the coal alternative than the OL renewal alternative because a nuclear power plant releases almost no SO_2 during normal operations.

Section 407 of the Clean Air Act establishes technology-based emission limitations for NO_x emissions. The market-based allowance system used for SO_2 emissions is not used for NO_x emissions. A new coal-fired power plant would be subject to the new source performance standards for such plants at 40 CFR 60.44a(d)(1). This regulation, issued on September 16, 1998 (63 FR 49453), limits the discharge of any gases that contain nitrogen oxides (expressed as NO_2) in excess of 200 ng/J of gross energy output (1.6 lb/MWh), based on a 30-day rolling average.

EPA issued the Clean Air Interstate Rule (CAIR) in 2005 (EPA 2005a). CAIR provides a Federal framework requiring certain states to reduce emissions of SO_2 and NO_x. EPA anticipates that states will achieve this reduction primarily by limiting emissions from the power generation sector. CAIR covers 28 eastern states and the District of Columbia. Any new fossil-fired power plant sited in Alabama would be subject to the CAIR limitations.

In 2005, EPA issued a final rule limiting mercury emissions from coal-fired power plants (EPA 2005b). Emissions are capped at specified, nationwide levels. A first-phase cap of 34 MT/yr (38 tons/yr) becomes effective in 2010 and a second-phase cap of 13 MT/yr (15 tons/yr) becomes effective in 2018. Plant owners must demonstrate compliance with the standard by holding one "allowance" for each ounce of mercury emitted in any given year. Allowances are transferable among regulated plants. Any new coal-fired power plant sited in Alabama would be subject to this rule.

Coal contains uranium and thorium. Uranium concentrations are generally in the range of 1 to 10 parts per million. Thorium concentrations are generally about 2.5 times greater than uranium concentrations (Gabbard 1993). One estimate is that a 1000-MW(e) coal-fired plant had an annual release of approximately 4.7 MT (5.2 tons) of uranium and 11.6 MT (12.8 tons) of thorium in 1982 (Gabbard 1993). The population dose equivalent from the uranium and

thorium releases and daughter products produced by the decay of these isotopes has been calculated to be significantly higher than that from nuclear power plants (Gabbard 1993).

A coal-fired plant would also have unregulated carbon dioxide emissions that could contribute to global warming. TVA estimates that pulverized coal-fired plants sufficient to replace the power generated at BFN would emit approximately 40 million MT/yr (44 million tons/yr) of carbon dioxide (TVA 2003).

During the construction of a coal-fired plant, fugitive dust would be generated. Exhaust emissions would come from vehicles and motorized equipment used during the construction process. In addition, coal-handling equipment would introduce fugitive particulate emissions.

The GEIS analysis did not quantify emissions from coal-fired power plants but implied that air quality impacts would be substantial. The GEIS also mentioned global warming from unregulated carbon dioxide emissions and acid rain from SO_x and NO_x emissions as potential impacts (NRC 1996). Adverse human health effects, such as cancer and emphysema, have been associated with the products of coal combustion.

Overall, the air quality impacts associated with three new 1200-MW(e) pulverized coal-fired stations to replace the power generated at BFN would be MODERATE. The impacts would be clearly noticeable, but would not destabilize air quality.

- **Waste**

Coal combustion generates waste in the form of ash, and equipment for controlling air pollution generates additional ash, spent selective catalytic reduction (SCR) catalyst, and scrubber sludge.

Pulverized coal-fired plants would produce solid material streams in significant quantities, including both potential by-products and unusable solid wastes. The potentially marketable material streams for three 1200-MW(e) units are shown in Table 8-2. All of these by-product and waste streams are classified as non-hazardous, as determined by the Resource Conservation and Recovery Act (RCRA) toxicity characteristic leaching procedure (TVA 2003). Provision would be made to store fly ash, bottom ash, and scrubber by-products onsite indefinitely. If permitted, it might be possible to inject ash into underground mine works in the future. TVA would explore the market potential and economic benefit of selling the ash and scrubber by-products to wallboard manufacturers. Water treatment sludges would be disposed at a State-approved landfill, either onsite or offsite. Spent SCR catalyst would be regenerated or disposed offsite. Waste impacts to groundwater and surface water could extend beyond the operating life of the plant if leachate and runoff from the waste storage area occurred. Disposal

of the waste could noticeably affect land use and groundwater quality, but with appropriate management and monitoring, it would not destabilize any resources. After closure of the waste site and revegetation, the land could be available for other uses.

In May 2000, EPA issued a "Notice of Regulatory Determination on Wastes from the Combustion of Fossil Fuels" (65 FR 32214). EPA concluded that some form of national regulation is warranted to address coal combustion waste products because (1) the composition of these wastes could present danger to human health and the environment under certain conditions; (2) EPA has identified 11 documented cases of proven damages to human health and the environment by improper management of these wastes in landfills and surface impoundments; (3) present disposal practices are such that, in 1995, these wastes were being managed in 40 to 70 percent of landfills and surface impoundments without reasonable control in place, particularly in the area of groundwater monitoring; and (4) EPA identified gaps in State oversight of coal combustion wastes. Accordingly, EPA announced its intention to issue regulations for disposal of coal combustion waste under subtitle D of RCRA.

Debris would be generated during construction activities for the three 1200-MW(e) units. Such debris would be disposed in landfills.

For all of the preceding reasons, the appropriate characterization of impacts from waste generated from burning pulverized coal is MODERATE; the impacts would be clearly noticeable but would not destabilize any important resource.

- **Human Health**

Coal-fired power generation introduces worker risks from coal and limestone mining, worker and public risks from coal and lime/limestone transportation, worker and public risks from disposal of coal combustion wastes, and public risks from inhalation of stack emissions. Emission impacts can be widespread and health risks are difficult to quantify. The coal alternative also introduces the risk of coal-pile fires and attendant inhalation risks.

The staff stated in the GEIS that there could be human health impacts (cancer and emphysema) from inhalation of toxins and particulates from a coal-fired plant, but did not identify the significance of these impacts (NRC 1996). In addition, the discharges of uranium and thorium from coal-fired plants can potentially produce radiological doses in excess of those arising from nuclear power plant operations (Gabbard 1993).

Regulatory agencies, including EPA and State agencies, set air emission standards and requirements based on human health impacts. These agencies also impose site-specific emission limits as needed to protect human health. As discussed previously, EPA has recently

concluded that certain segments of the U.S. population (e.g., the developing fetus and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects because of mercury exposures from sources such as coal-fired power plants. However, in the absence of more quantitative data, human health impacts from radiological doses and inhaling toxins and particulates generated by burning coal at a newly constructed coal-fired plant are characterized as SMALL.

- **Socioeconomics**

The projected construction period for a 1200-MW(e) pulverized coal-fired power plant would be 54 months, with the first unit becoming operational at 48 months (TVA 2003). The total construction workforce would ramp up to the peak of 1100 workers over the first 18 months and then remain there until beginning to decline at 30 months to 500 workers at 42 months (TVA 2003). The total number of workers would exceed 500 for approximately 30 months. The peak number of workers would noticeably affect the local workforce for most sites, but the jobs would be temporary and many of the workers would commute from surrounding areas. The influx of workers could noticeably affect local school systems and other social services.

For a mine-mouth plant, the mining process preparation would increase the local construction employment to a base of 1500 workers for 4 years, peaking at 2500 workers (TVA 2003). A construction workforce of this size would have a noticeable impact for most prospective sites.

The permanent operating staff for a 1200-MW(e) pulverized coal-fired power plant would be approximately 120 workers. If the plant were sited at a mine mouth, the projected local employment for the mining operation would be approximately 320 workers (TVA 2003).

The coal-fired plants would provide a new tax base for the local communities in which they were sited through the in-lieu-of-tax payments made by TVA. In-lieu-of-tax payments in Limestone County would likely decrease if the BFN OLs were not renewed. For all of these reasons, the nontransportation socioeconomic impacts for new pulverized coal-fired plants would be noticeable, but would be unlikely to destabilize the area.

For transportation related to commuting of plant operating personnel for a 1200-MW(e) pulverized coal-fired power plant, the impacts are considered negligible. Transportation impacts would be temporary, noticeable, but not destabilizing during plant construction.

The GEIS states that socioeconomic impacts at a rural site would be larger than at an urban site, because more of the peak construction workforce would need to move to the area to work (NRC 1996).

Coal and lime/limestone would likely be delivered by rail to each power plant, although barge delivery is feasible for a site located on a navigable body of water. Socioeconomic impacts associated with rail transportation would likely have some impact to the community. Barge delivery of coal and lime/limestone would likely have minor socioeconomic impacts.

For power plants not located at the mine mouth, socioeconomic impacts would also occur at the site of coal mining.

Overall, the staff concludes that socioeconomic impacts associated with constructing and operating three 1200-MW(e) pulverized coal-fired plants would be MODERATE.

- **Aesthetics**

The coal-fired power block could be as much as 60 m (200 ft) tall and could be visible offsite during daylight hours. The exhaust stack could be as high as 200 m (650 ft). The stack would likely be highly visible in daylight hours for distances greater than 16 km (10 mi). The plant and associated stack would also be visible at night because of outside lighting. The Federal Aviation Administration generally requires that all structures exceeding an overall height of 60 m (200 ft) above ground level have markings and/or lighting so as not to impair aviation safety (FAA 2000). Visual impacts of a new coal-fired plant could be mitigated by landscaping and color selection for buildings that is consistent with the environment. Visual impact at night could be mitigated by reduced use of lighting, provided the lighting meets Federal Aviation Administration requirements, and appropriate use of shielding. Overall, the addition of the coal-fired unit and the associated exhaust stack would likely have some aesthetic impact. There could be a significant aesthetic impact if construction of a new transmission line and/or rail spur were needed.

Coal-fired generation would introduce mechanical sources of noise that would be audible offsite. Sources contributing to total noise produced by plant operation are classified as continuous or intermittent. Continuous sources include the mechanical equipment associated with normal plant operations. Intermittent sources include the equipment related to coal handling, solid-waste disposal, transportation related to coal and lime/limestone delivery, use of outside loudspeakers, and the commuting of plant employees. The noise impacts of a coal-fired plant would be slightly greater than those of current operations at BFN. Noise impacts associated with rail delivery of coal and lime/limestone would be most significant for residents living in the vicinity of the facility and along the rail route. Although noise from passing trains significantly raises noise levels near the rail line, the short duration of the noise reduces the impact. Nevertheless, given the frequency of train transport and the fact that many people are likely to be within hearing distance of the rail route, the impacts of noise on residents in the vicinity of the facility and the rail line would be noticeable. Noise associated with barge

transportation of coal and lime/limestone would be minimal. Noise and light from the pulverized coal-fired power plants would be detectable offsite. Aesthetic impacts at the plant site would be mitigated if the plant were located in an industrial area adjacent to other power plants.

Overall, the aesthetic impacts associated with new pulverized coal-fired power plants can be categorized as MODERATE to LARGE.

- **Historic and Archaeological Resources**

Before construction at any site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on cultural resources. The studies would likely be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission lines, rail lines, or other rights-of-way). Historic and archaeological resource impacts can generally be effectively managed and as such are considered SMALL.

- **Environmental Justice**

Environmental justice impacts would depend upon the sites chosen for the pulverized coal-fired power plants and the nearby population distribution. Construction activities would offer new employment possibilities, but could have negative impacts on the availability and cost of housing, which could disproportionately affect minority and low-income populations. Impacts in Limestone County would be the same as those under the no-action alternative. Overall, environmental justice impacts are likely to be SMALL to MODERATE.

8.2.1.2 Once-Through Cooling System

The environmental impacts of constructing and operating a pulverized coal-fired power plant using a once-through cooling system are essentially the same as the impacts for a coal-fired plant using closed-cycle cooling with wet cooling towers. However, there are some environmental differences between the closed-cycle and once-through cooling systems. Table 8-3 summarizes the incremental differences.

Table 8-3. Summary of Environmental Impacts of Pulverized Coal-Fired Generation with Once-Through Cooling

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Land Use	10 to 12 ha (25 to 30 ac) less land required per 1200-MW(e) unit because cooling towers and associated infrastructure are not needed.
Ecology	Impacts would depend on ecology at the site. No impacts to terrestrial ecology from cooling tower drift. Increased water withdrawal with possible greater impacts to aquatic ecology.
Surface Water Use and Quality	No discharge of cooling tower blowdown. Increased water withdrawal and more thermal load on receiving body of water.
Groundwater Use and Quality	No change
Air Quality	No change
Waste	No change
Human Health	No change
Socioeconomics	No change
Aesthetics	Less aesthetic impact because cooling towers would not be used.
Historic and Archaeological Resources	Less land impacted.
Environmental Justice	No change

8.2.2 Coal Gasification

Coal gasification is a method of producing relatively clean, burnable gas from almost any type of coal or from petroleum coke. The basic process involves crushing the coal and partially oxidizing the carbon in the coal. Partial oxidation converts the coal into a gaseous fuel composed primarily of combustible hydrogen and carbon monoxide. The gas can be piped directly into a gas turbine to generate electricity. The exhaust from the gas turbine is ducted into a heat recovery steam generator to produce steam for a conventional steam turbine generator. To make the overall process both environmentally safe and thermally efficient, a coal gasification plant must integrate a number of different technologies. Major systems include fuel preparation, an air separation unit, a gasifier, acid gas removal, sulfur recovery, a combustion turbine generator, a heat recovery steam generator, and a steam turbine generator (TVA 2003).

In its ER TVA evaluated the construction and operation of a 2720-MW(e) coal gasification plant sited at TVA's unfinished Bellefonte nuclear plant site. Additional capacity beyond the 2720-MW(e) plant, probably sited at another location, would be needed to fully replace the 3840-MW(e) uprated capacity of BFN. The Bellefonte site comprises approximately 610 ha (1500 ac) and is located adjacent to the Tennessee River (Guntersville Lake) in Jackson County, Alabama. Construction access routes are completed at the Bellefonte site, and basic support functions (i.e., electric power, potable water, sanitary waste disposal, office buildings, parking lots, railways, and barge unloading facility) are in place (TVA 2003). Almost all of the basic site preparation work, such as grading, has been completed.

The coal gasification plant would have eight 340-MW(e) modules, each consisting of one coal gasification plant, one combustion turbine, and one heat recovery steam generator. The steam recovered from each module would be collected and routed to the two existing low-pressure steam turbine generators, four modules per steam turbine. An air separation plant would be constructed for each gasifier to supply the pressurized 95 percent (by volume) oxygen required for the oxygen-blown gasifiers (TVA 2003).

Delivery of coal and/or petroleum coke to the Bellefonte site would be needed. Approximately 21,800 MT (24,000 tons) of fuel would be shipped in daily, probably via barge (TVA 2003). If coal is used as fuel, the origin would likely be southern Illinois. If petroleum coke is used as fuel, the origin would likely be Texas or Louisiana, states with extensive refining industries. Approximately 218 MT/day (240 tons/day) of limestone would likely be required for air pollution control. Trucking would be used for limestone delivery. Fuel oil would be required for startup activities, but would not be used as a backup fuel (TVA 2003).

8.2.2.1 Closed-Cycle Cooling System

The overall impacts of constructing a coal gasification plant at the Bellefonte site are discussed in the following sections and summarized in Table 8-4. Additional impacts would occur at another location as necessary to fully replace the 3840-MW(e) capacity of BFN. The impact categorizations in Table 8-4 are based on 3840 MW(e) of coal gasification generating capacity.

- **Land Use**

TVA assumes siting of the coal gasification facility at the existing unfinished Bellefonte nuclear plant site (TVA 2003). The existing cooling towers and circulating water system at the Bellefonte site would be used. There is an existing 39.9-km (24.8-mi) 500-kV transmission line to the Bellefonte site that is not energized (TVA 2003). Approximately 77 ha (190 ac) to the southwest of the existing cooling towers would be used to construct new facilities. Construction

Table 8-4. Summary of Environmental Impacts of Coal Gasification Using Closed-Cycle Cooling

Impact Category	Impact	Comment
Land Use	MODERATE to LARGE	Impact at the Bellefonte site would be minor, but there would be offsite impacts for coal and limestone mining. At another site, several hundred acres would be impacted for the power block; fuel handling, storage, and transportation facilities; infrastructure facilities; and waste disposal. Additional land impacts for coal and limestone mining, electric power transmission lines, and cooling water intake and discharge pipelines.
Ecology	SMALL to LARGE	Impact at the Bellefonte site would be SMALL to MODERATE. Impacts at another site could be as much as LARGE and would depend on the location and the ecology of the site, the surface water body used for intake and discharge, and the electric power transmission line route; potential habitat loss and fragmentation; reduced productivity and biological diversity; impacts to terrestrial ecology from cooling tower drift.
Water Use and Quality	SMALL to MODERATE	Impact would depend on the volume of water withdrawn and discharged, the constituents in the discharge water, and the characteristics of the surface water body. Discharges at the Bellefonte site would be regulated by the Alabama Department of Environmental Management.
Air Quality	MODERATE	Air emissions from coal gasification plants sized to fully replace BFN capacity would be approximately: Sulfur oxides – 10,700 MT/yr (11,800 tons/yr) Nitrogen oxides – 4881 MT/yr (5380 tons/yr) PM_{10} – 1524 MT/yr (1680 tons/yr) Carbon monoxide – 5661 MT/yr (6240 tons/yr) Small amounts of mercury and other hazardous air pollutants would be discharged along with approximately 28 million MT/yr (31 million tons/yr) of unregulated carbon dioxide.

Table 8-4. (contd)

Impact Category	Impact	Comment
Waste	MODERATE	Waste streams from the 2720-MW(e) plant would be 457,000 MT/yr (504,000 tons/yr) of slag, 36,000 MT/yr (40,000 tons/yr) of fly ash, 180,000 MT/yr (200,000 tons/yr) of sulfur, 1161 MT/yr (1280 tons/yr) of raw water treatment sludge, 730 MT/yr (800 tons/yr) of general waste water treatment sludge, and 36 MT/yr (40 tons/yr) of sludges from the biotreatment of gasification process waste water.
Human Health	SMALL	Impacts are uncertain, but considered to be SMALL in the absence of more quantitative data.
Socioeconomics	MODERATE	Peak construction employment at the Bellefonte site would be approximately 2200 workers. The operating workforce would be approximately 530. Limestone County could experience loss of BFN tax base and employment. Transportation impacts would result from commuting workers and delivery of coal and lime/limestone. Transportation of coal to the Bellefonte site would likely be by barge with negligible socioeconomic impacts. Overall, impacts at the Bellefonte site or at an alternate site are considered MODERATE.
Aesthetics	MODERATE to LARGE	Introduction of 12 new emission stacks 99.1 m (325 ft) high and two flaring stacks 60 m (200 ft) high at the Bellefonte site. No new transmission lines or cooling towers at the Bellefonte site. If needed at an alternate site, new electric power transmission lines and/or a rail spur could have significant aesthetic impacts.
Historic and Archeological Resources	SMALL	The Bellefonte site has had previous surveys for historic and archeological resources. New plant locations would necessitate cultural resource studies. Any potential impacts can likely be effectively managed.
Environmental Justice	SMALL to MODERATE	Impacts would vary depending on population distribution and makeup water at the site. Impacts in Limestone County would be the same as those under the no-action alternative.

in this location would require the demolition or relocation of several existing buildings and underground utilities. After completion of demolition, the area would be cleared of existing vegetation, then leveled to an elevation above the 500-year floodplain (TVA 2003). Construction would include the preparation of an area for disposal of unmarketable slag. There would be offsite land impacts to supply coal and limestone for the plant.

At another site, several hundred acres would be impacted for the power block; fuel handling, storage, and transportation facilities; infrastructure facilities; and waste disposal. There would

be additional land impacts for coal and limestone mining, electric power transmission lines, and cooling water intake and discharge pipelines.

In the GEIS, the staff estimated that approximately 8800 ha (34 mi^2) would be affected for mining the coal and disposing of the waste to support a 1000-MW(e) coal plant during its operational life (NRC 1996). A replacement coal gasification plant to replace the 3840-MW(e) capacity of BFN would affect proportionately more land.

Overall, land-use impacts can be characterized as MODERATE to LARGE.

- **Ecology**

At the Bellefonte site, there are no Federally or State-listed threatened or endangered plant species (TVA 2003). Construction of barge facilities could result in some reduction in roosting and foraging sites for raptors, bats, waterfowl, and wading birds such as great egrets, green herons, and great blue herons. There are no caves at the Bellefonte site that support the Federally endangered Indiana and gray bats, but they are known to forage along the Guntersville Lake shoreline. However, areas close to the Bellefonte site have an extensive network of similar wooded shoreline and shallow lagoon habitats. Therefore, the impacts associated with new coal gasification facilities are expected to be minimal. Lowering the existing diffuser at the site and constructing the barge terminal and mooring cells would require in-stream dredging to remove approximately 115,000 m^3 (150,000 yd^3) of material, resulting in impacts on resident aquatic communities. However, surveys have found no toxic sediments and a low average density of mussels in the area, and it is expected that the dredge material would be disposed on land (TVA 2003). Because water intake demand would be small compared to the total water mass flowing past the Bellefonte site, there would be little potential for significant entrainment or impingement impacts (TVA 2003). The existing Bellefonte water intake structure would be used. The greatest impacts of entrainment and impingement would result from water withdrawn from the upstream productive overbank, although losses to the lake fish community should be minimal due to the large amounts of similar habitat near the plant and in other areas of the lake (TVA 2003). There could be impacts to terrestrial ecology from cooling tower drift.

At another site, the coal gasification alternative would introduce construction impacts and new incremental operational impacts. Even assuming siting at a previously disturbed area, the impacts would alter the ecology. Impacts could include wildlife habitat loss, reduced productivity, habitat fragmentation, and a local reduction in biological diversity. Use of cooling makeup water from a nearby surface water body could have adverse aquatic resource impacts. If needed, construction and maintenance of a transmission line and a rail spur would have ecological impacts.

Overall, the ecological impacts at the Bellefonte site are considered SMALL to MODERATE and at another site SMALL to LARGE.

- **Water Use and Quality**

Raw water for construction and operation at the Bellefonte site would be obtained from the Tennessee River. The quantities needed would be unlikely to have a significant effect on the river. The highest sustained water needs during operation would be approximately 2315 L/s (36,700 gal/min), or about 0.21 percent of the average river flow. Of the 2315 L/s, 1142 L/s (18,100 gal/min) would be for cooling system makeup water. Both existing closed-cycle natural draft cooling towers on the Bellefonte site would be used (TVA 2003).

Potable water is supplied to the Bellefonte site by the City of Hollywood, which receives its water from the City of Scottsboro. The Bellefonte site is connected to the Hollywood municipal sewage system treatment plant located adjacent to the south side of the site. The sewage treatment plant serves the Bellefonte site and residential customers in the area, but currently it does not have sufficient capacity to handle the increased demand of a large construction workforce and would have to be enlarged (TVA 2003).

No significant construction-related impacts to surface water resources would be expected as a result of the project. The majority of the power plant and associated facilities would be constructed on land that has been previously disturbed due to construction activities related to the uncompleted Bellefonte nuclear plant. Construction of new facilities and overall site reclamation activities would affect surface hydrology, but extensive site excavation, filling, or grading would not be needed. The primary surface water impact during construction would be soil erosion, which could be kept low by the use of best management practices. To minimize the impacts of storm water flow during construction, a storm water retention pond would be designed to retain storm water from the 25-year, 24-hour rainfall event, in compliance with regulatory requirements (TVA 2003).

The surface water resources within the areas of the proposed development at the Bellefonte site are currently monitored under an NPDES permit issued by the Alabama Department of Environmental Management.

Any impacts to groundwater during operation would most likely be associated with storage and handling of feedstocks and the storage, handling, and disposal of wastes generated. Runoff from the coal and petroleum coke storage areas would be collected in a drainage basin and treated as needed (TVA 2003).

At another site, water use and quality impacts would depend on the volume of water withdrawn and discharged, the constituents in the discharge water, and the characteristics of the surface water body. Discharges would be regulated by the State or by EPA. Construction-related impacts at another site may be significantly greater than at the Bellefonte site; however, they would be mitigable and temporary.

Overall, water use and quality impacts at the Bellefonte site or another site can be characterized as SMALL to MODERATE.

- **Air Quality**

The air quality impacts of coal-fired generation vary considerably from those of nuclear generation emissions of SO_2, NO_x, particulates, carbon monoxide, and hazardous air pollutants such as mercury, and naturally occurring radioactive materials.

Estimated air emissions for a coal gasification plant meeting all applicable regulatory requirements and sized to fully replace the 3840-MW(e) uprated capacity of BFN are shown in Table 8-4 (TVA 2003). The estimated emissions are based on using petroleum coke as fuel. Emissions of SO_x are higher for petroleum coke than if coal is used as the fuel.

A new coal gasification generating plant would need to meet the new source review requirements in Title I of the Clean Air Act. The plant would need an operating permit issued under Title V of the Clean Air Act. The plant would also need to comply with the new source performance standards for new generating plants in 40 CFR Part 60, Subpart Da. The standards establish limits for particulate matter and opacity (40 CFR 60.42a), SO_2 (40 CFR 60.43a), and NO_x (40 CFR 60.44a).

EPA has various regulatory requirements for visibility protection in 40 CFR Part 51 Subpart P, including a specific requirement for review of any new major stationary source in an area designated as attainment or unclassified under the Clean Air Act. All of Jackson County, Alabama, the location of the Bellefonte site, is classified as attainment or unclassified for criteria pollutants under the Clean Air Act.[a]

Section 169A of the Clean Air Act establishes a national goal of preventing future and remedying existing impairment of visibility in mandatory Class I Federal areas when impairment is from air pollution resulting from human activities. In addition, EPA issued a new regional haze rule in 1999 (64 FR 35714). The rule specifies that for each mandatory Class I Federal

(a) Existing criteria pollutants under the Clean Air Act are ozone, carbon monoxide, particulates, sulfur dioxide, lead, and nitrogen oxide. Ambient air standards for criteria pollutants are set out at 40 CFR Part 50.

area located within a state, state agencies must establish goals that provide for reasonable progress towards achieving natural visibility conditions. The reasonable progress goals must provide for an improvement in visibility for the most-impaired days over the period of the implementation plan and ensure no degradation in visibility for the least-impaired days over the same period (40 CFR 51.308(d)(1)). If a new coal gasification power plant were located close to a mandatory Class I area, additional air pollution control requirements could be imposed. The nearest Class I area to the Bellefonte site is the Cohutta Wilderness, which is approximately 120 km (75 mi) distant (TVA 2003).

In 1998, the EPA issued a rule requiring 22 eastern states to revise their state implementation plans to reduce NO_x emissions. Nitrogen oxide emissions contribute to violations of the national ambient air quality standard for ozone (40 CFR 50.9). The total amount of NO_x that can be emitted by each of the 22 states in the year 2007 ozone season (May 1 through September 30) is set out at 40 CFR 51.121(e). For Alabama, the amount is 108,706 MT (119,827 tons). Any new fossil-fired power plant sited in Alabama would be subject to these limitations.

EPA issued the Clean Air Interstate Rule (CAIR) in 2005 (EPA 2005a). CAIR provides a Federal framework requiring certain states to reduce emissions of SO_2 and NO_x. EPA anticipates that states will achieve this reduction primarily by limiting emissions from the power generation sector. CAIR covers 28 eastern states and the District of Columbia. Any new fossil-fired power plant sited in Alabama would be subject to the CAIR limitations.

In 2005, EPA issued a final rule limiting mercury emissions from coal-fired power plants (EPA 2005b). Emissions are capped at specified, nationwide levels. A first-phase cap of 34 MT/yr (38 tons/yr) becomes effective in 2010 and a second-phase cap of 13 MT/yr (15 tons/yr) becomes effective in 2018. Plant owners must demonstrate compliance with the standard by holding one "allowance" for each ounce of mercury emitted in any given year. Allowances are transferable among regulated plants. Any new coal-fired power plant sited in Alabama would be subject to this rule.

A coal gasification plant would also have unregulated carbon dioxide emissions that could contribute to global warming. TVA estimates that coal gasification plants sufficient to replace the power generated at BFN would emit approximately 28 million MT/yr (31 million tons/yr) of carbon dioxide (TVA 2003).

Overall, the air quality impacts associated with new coal gasification plants to replace the power generated at BFN would be MODERATE. The impacts would be clearly noticeable, but would not destabilize air quality.

- **Waste**

The major solid waste and by-product streams would be generated by the gasifiers. Slag, fly ash, and sulfur account for more than 99 percent of the solids produced by coal gasification plants, with the remaining 1 percent consisting of spent catalysts and water treatment sludges. The generation rates in tons per year for a 2720-MW(e) plant are shown in Table 8-4 (TVA 2003). The slag produced is an inert, glass-like material that has been found in coal gasification demonstrations to be nonleachable (TVA 2003). Based on testing at gasification demonstration plants, the slag and fly ash from gasification of eastern bituminous coal is expected to be below the RCRA threshold limits for hazardous designation (TVA 2003). Most of the sulfur in the coal is converted to hydrogen sulfide in the synthetic gas. The hydrogen sulfide is removed by acid gas removal and then converted to elemental sulfur by-product in the sulfur recovery system. TVA anticipates that the slag, fly ash, and sulfur produced at a coal gasification plant would be of sufficient quality to be marketed (TVA 2003).

There would be three process solid waste streams composed of sludges from raw water or waste water treatment: raw water treatment sludge, general waste water treatment sludge, and sludge from the biotreatment of gasification process waste water. Generation amounts are shown in Table 8-4. These sludges are typically not hazardous and would be disposed of at nearby State-approved municipal disposal sites (TVA 2003).

Construction-related debris would be generated during construction activities for the coal gasification units and disposed at a landfill.

For all the preceding reasons, the appropriate characterization of waste impacts from coal gasification is MODERATE; the impacts would be clearly noticeable but would not destabilize any important resource.

- **Human Health**

Power generation from coal introduces worker risks from coal and limestone mining, worker and public risks from coal and lime/limestone transportation, worker and public risks from disposal of coal combustion wastes, and public risks from inhalation of stack emissions. Emission impacts can be widespread and health risks difficult to quantify. The coal gasification alternative also introduces the risk of coal-pile fires and attendant inhalation risks.

The staff stated in the GEIS that there could be human health impacts (cancer and emphysema) from inhalation of toxins and particulates from a coal-fired plant, but did not identify the significance of these impacts (NRC 1996). In addition, the discharges of uranium

and thorium from coal-fired plants can produce radiological doses in excess of those arising from nuclear power plant operations (Gabbard 1993).

Regulatory agencies, including EPA and State agencies, set air emission standards and requirements based on human health impacts. These agencies also impose site-specific emission limits as needed to protect human health. As discussed previously, EPA has recently concluded that certain segments of the U.S. population (e.g., the developing fetus and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects due to mercury exposures from sources such as coal-fired power plants. However, in the absence of more quantitative data, human health impacts from radiological doses and inhaling toxins, and particulates generated by burning coal at a newly constructed coal gasification plant are characterized as SMALL.

- **Socioeconomics**

Peak employment during construction at the Bellefonte site would be approximately 2200 workers (TVA 2003). The peak number of workers would noticeably affect the local workforce near the Bellefonte site, but the jobs would be temporary and many of the workers would commute from surrounding areas. The influx of workers could noticeably affect local school systems and other social services. The permanent operating staff would be approximately 530 workers (TVA 2003).

The coal gasification plants would provide a new tax base for Jackson County and any other local communities in which they were sited through the in-lieu-of tax payments made by TVA. In-lieu-of-tax payments in Limestone County would likely decrease if the BFN OLs were not renewed. For all these reasons, the nontransportation socioeconomic impacts for new coal gasification plants would be noticeable, but would be unlikely to destabilize the area.

For transportation related to commuting of plant operating personnel, the impacts are considered negligible. Transportation impacts would be noticeable, temporary, but not destabilizing during plant construction.

The GEIS states that socioeconomic impacts at a rural site would be larger than at an urban site, because more of the peak construction workforce would need to move to the area to work (NRC 1996).

Coal and lime/limestone would likely be delivered by barge to the Bellefonte site (TVA 2003). Approximately 17 barges of coal per day would be delivered (TVA 2003). Some recreational impact would result from increased barge traffic. Nevertheless, barge delivery of coal and

lime/limestone would likely have minor socioeconomic impacts. At an alternate site, rail delivery of coal and lime/limestone could be needed.

For coal gasification power plants not located at the mine mouth, socioeconomic impacts would also occur at the site of the coal mine.

Overall, the staff concludes that socioeconomic impacts associated with constructing and operating new coal gasification plants would be MODERATE.

- **Aesthetics**

The 2720-MW(e) coal gasification plant would have 12 stacks for emissions that would be approximately 99.1 m (325 ft) high (TVA 2003). In addition, the completed plant would have two flaring stacks to burn waste gas approximately 60 m (200 ft) in height. Flaring operations would generally be visible within a 5-km (3-mi) radius, particularly at night. The stacks would not rise to the height of the existing cooling towers at the Bellefonte site, but would be visible up to 10 km (6 mi) away. Vapor fog from the cooling towers and stack emissions could be visible from distances of 16 km (10 mi) or more. There is an existing 40-km (24.8-mi) 500-kV transmission line to the Bellefonte site that is not energized (TVA 2003). Consequently, there would not be a new incremental aesthetic impact associated with transmission lines. Overall, construction and operation of a new coal gasification plant at the Bellefonte site would likely have a MODERATE aesthetic impact.

At an alternate site, aesthetic impacts would be similar to those at the Bellefonte site. If needed, new electric power transmission lines and/or a rail spur could have significant aesthetic impacts. Overall, aesthetic impacts at an alternate site would be MODERATE to LARGE.

- **Historic and Archaeological Resources**

A 1972 archaeological survey of the Bellefonte site identified five historic sites, none of which are within proposed construction zones for a coal gasification plant (TVA 2003). The original Town of Bellefonte was located just offsite and determined in 1974 to be eligible for placement on the National Register of Historic Places. Prior to the initiation of construction of the uncompleted Bellefonte nuclear plant, the Alabama State Historic Preservation Office determined that no mitigation would be required. Since that time all structures have been removed by landowners (TVA 2003).

Before construction at an alternative site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on archaeological resources. The studies would likely be needed for all areas of potential disturbance at the

proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission line, rail lines, or other rights-of-way). Historic and archaeological resource impacts can generally be effectively managed and would likely be SMALL.

- **Environmental Justice**

Environmental justice impacts would depend upon the population distribution around the Bellefonte site or other alternative sites. Construction activities would offer new employment possibilities, but could have negative impacts on the availability and cost of housing, which could disproportionately affect minority and low-income populations. Impacts in Limestone County would be the same as those under the no-action alternative assuming no construction of a coal gasification plant at the BFN site. Overall, environmental justice impacts are likely to be SMALL to MODERATE.

8.2.2.2 Once-Through Cooling System

The environmental impacts of constructing and operating a coal gasification plant using a once-through cooling system are essentially the same as the impacts for a coal gasification plant using closed-cycle cooling with wet cooling towers. However, there are some environmental differences between the closed-cycle and once-through cooling systems. Table 8-5 summarizes the incremental differences.

Table 8-5. Summary of Environmental Impacts of a Coal Gasification Plant with Once-Through Cooling

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Land Use	Less land required because cooling towers and associated infrastructure are not needed.
Ecology	Impacts would depend on ecology at the site. No impacts to terrestrial ecology from cooling tower drift. Increased water withdrawal with possible greater impacts to aquatic ecology.
Surface Water Use and Quality	No discharge of cooling tower blowdown. Increased water withdrawal and more thermal load on receiving body of water.
Groundwater Use and Quality	No change
Air Quality	No change
Waste	No change

Table 8-5. (contd)

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Human Health	No change
Socioeconomics	No change
Aesthetics	Less aesthetic impact because cooling towers would not be used.
Historic and Archaeological Resources	Less land impacted.
Environmental Justice	No change

8.2.3 Natural Gas Combined-Cycle Generation

The TVA ER considers the construction of 510-MW(e) natural gas combined-cycle power plants using mechanical draft cooling towers. Seven such plants would be needed to replace most of the 3840-MW(e) uprated capacity of BFN. It is likely that multiple locations would be needed for this number of plants. At each location it is likely that a new transmission line would need to be constructed to connect to existing lines. In addition, construction or upgrade of a natural gas pipeline from the plant location to a supply point where a firm supply of gas would be available would be needed.

Although the OL renewal term is only 20 years, the impact of operating the natural gas combined-cycle alternative for 40 years is considered (as a reasonable projection of the operating life of a natural gas combined-cycle plant).

8.2.3.1 Closed-Cycle Cooling System

The overall impacts associated with the construction and operation of natural gas combined-cycle plants of sufficient capacity to replace the uprated BFN are summarized in Table 8-6 and are discussed in the following sections.

- **Land Use**

Each 510-MW(e) natural gas combined-cycle plant would require approximately 80 ha (200 ac) (TVA 2003). Additional land would be impacted for construction of a transmission line and natural gas pipeline to serve the plant. For any new natural gas combined-cycle plant, additional land would be required for natural gas wells and collection stations. In the GEIS, the staff

Table 8-6. Summary of Environmental Impacts of Natural Gas Combined-Cycle Generation Using Closed-Cycle Cooling

Impact Category	Impact	Comment
Land Use	MODERATE to LARGE	Approximately 560 ha (1400 ac) would be needed to fully replace BFN capacity. Additional site-specific impacts for natural gas pipeline, electric power transmission lines, rail spurs, and cooling water intake and discharge pipelines.
Ecology	MODERATE	Impact depends on location and ecology of the site, surface water body used for intake and discharge, and electric power transmission line and natural gas pipeline routes; potential habitat loss and fragmentation; reduced productivity and biological diversity; and impacts to terrestrial ecology from cooling tower drift.
Water Use and Quality	SMALL to MODERATE	Impact would depend on the volume of water withdrawn and discharged, the constituents in the discharge water, and the characteristics of the surface water body. Discharges would be regulated by the State or EPA.
Air Quality	MODERATE	Air emissions to fully replace BFN capacity would be approximately: Sulfur oxides – 67 MT/yr (74 tons/yr) Nitrogen oxides – 1295 MT/yr (1428 tons/yr) PM_{10} – 1188 MT/yr (1310 tons/yr) Carbon monoxide – 4941 MT/yr (5446 tons/yr) Small amounts of hazardous air pollutants would be discharged along with 17.1 million MT/yr (18.9 million tons/yr) of unregulated carbon dioxide.
Waste	SMALL	The only significant waste would be spent SCR catalyst used for control of nitrogen oxide emissions.
Human Health	SMALL	Impacts are uncertain, but considered SMALL in the absence of more quantitative data.
Socioeconomics	MODERATE	Construction impacts depend on location and how many plants are constructed at the location. Limestone County could experience loss of BFN tax base and employment. Impacts during operation of the natural gas plants would likely be SMALL. Transportation impacts would result from commuting workers.

Table 8-6. (contd)

Impact Category	Impact	Comment
Aesthetics	MODERATE to LARGE	Impact would depend on the site selected and the surrounding land features. Power block, exhaust stacks, cooling towers, and cooling tower plumes would be visible from nearby areas. If needed, new electric power transmission lines could have a significant aesthetic impact. Noise impact from plant operations and intermittent sources would be noticeable.
Historic and Archeological Resources	SMALL	New plant locations would necessitate cultural resource studies. Any potential impacts can likely be effectively managed.
Environmental Justice	SMALL to MODERATE	Impacts would vary depending on population distribution at the site. Impacts in Limestone County would be the same as those under the no-action alternative.

estimated that approximately 1500 ha (3600 ac) would be needed for a 1000-MW(e) plant (NRC 1996). Proportionately more land would be needed for a natural gas combined-cycle plant replacing the 3840-MW(e) uprated generating capacity of BFN.

Overall, land-use impacts for construction of seven 510-MW(e) natural gas combined-cycle plants are considered MODERATE to LARGE.

- **Ecology**

Ecological impacts would depend on the nature of the land converted for the plant and any new transmission lines or gas pipelines. Construction of a transmission line and a gas pipeline to serve the plant would be expected to have temporary ecological impacts. Ecological impacts to a plant site and utility easements could include impacts on threatened or endangered species, wildlife habitat loss and reduced productivity, habitat fragmentation, and a local reduction in biological diversity. Intake and discharge of makeup water for the cooling system could adversely affect aquatic resources. There could be impacts to terrestrial ecology from cooling tower drift. Overall, ecological impacts are considered MODERATE.

- **Water Use and Quality**

Construction would be expected to increase erosion and storm water runoff of suspended solids above existing levels, but this would be temporary and mitigable by the use of best management practices. Completion of a retention pond for the treatment of storm water runoff

early in the construction phase would significantly reduce potential increased solids loading to local surface drainage waterways. Application of best management practices to control erosion during construction should mitigate construction impacts of transmission lines and pipelines (natural gas supply, potable water supply, process water supply, and waste water discharge). Impacts of constructing new intake and discharge structures on nearby waterways and/or reservoirs would be minimized by construction techniques to minimize disturbance of sediments and by the use of mitigation measures such as coffer dams, turbidity curtains, and selection of a construction time window (TVA 2003).

Waste water discharges would be regulated by the State or by EPA. Approximately 90 percent of the waste water discharge flow would be cooling tower blowdown. Other sources of waste water include steam cycle blowdown, water from inlet fogging, demineralizer rinse water, and miscellaneous low-volume waste water. This water would be treated onsite as necessary to meet regulatory requirements before being discharged to local waters (TVA 2003).

Storm water runoff during plant operation would be drained to a retention pond to allow sediments to settle out prior to discharge to local waterways. Rainwater that fell in secondary containment around oil-containing equipment would drain to an oil/water separator where the oil would be removed for disposal and the water would subsequently drain to the process water pond. Excavation and grading associated with construction of the plant or any of the ancillary features, such as the transmission lines, backup power, process and potable water pipelines, waste water discharge pipelines, and natural gas pipelines, would not be expected to cause adverse effects to groundwater. Excavations that penetrated the water table might require temporary construction dewatering. Any groundwater drawdown impacts associated with construction dewatering would be temporary. The long-term impact of these activities should be negligible because of the limited depth and relatively small area of disturbance. Structural damage to aquifer areas resulting from pipeline construction would not be anticipated because aquifers are not generally located within excavation depth (TVA 2003).

The impact on the surface water would depend on the discharge volume and the characteristics of the receiving body of water. Intake from and discharge to any surface body of water would be regulated by the State or EPA.

Water quality impacts from sedimentation during construction of a natural-gas-fired plant were characterized in the GEIS as small (NRC 1996). NRC staff also noted in the GEIS that operational water quality impacts would be similar to, or less than, those from other generating technologies.

Overall, water use and quality impacts would be SMALL to MODERATE.

- **Air Quality**

Natural gas is a relatively clean-burning fuel. The natural gas combined-cycle alternative would release similar types of emissions, but in lesser quantities than the coal-fired alternative.

A new natural gas combined-cycle generating plant would likely require a permit issued under the new source review procedures in Title I, Part C, of the Clean Air Act and an operating permit issued under Title V. A new natural gas combined-cycle power plant would also be subject to the new source performance standards for such units at 40 CFR Part 60, Subparts Da and GG. These regulations establish emission limits for particulates, opacity, SO_2, and NO_x.

The EPA has various regulatory requirements for visibility protection in 40 CFR Part 51, Subpart P, including a specific requirement for review of any new major stationary source in an area designated as attainment or unclassified under the Clean Air Act.

Section 169A of the Clean Air Act establishes a national goal of preventing future impairment and remedying existing impairment of visibility in mandatory Class I Federal areas when the impairment results from air pollution caused by human activities. In addition, EPA issued a new regional haze rule in 1999 (64 FR 35714). The rule specifies that for each mandatory Class I Federal area located within a state, the State must establish goals that provide for reasonable progress towards achieving natural visibility conditions. The reasonable progress goals must provide for an improvement in visibility for the most-impaired days over the period of the implementation plan and ensure no degradation in visibility for the least-impaired days over the same period (40 CFR 51.308(d)(1)). If a new natural gas combined-cycle power plant were located close to a mandatory Class I area, additional air pollution control requirements could be imposed.

In 1998, EPA issued a rule requiring 22 eastern states, including Alabama, to revise their State implementation plans to reduce nitrogen oxide emissions. NO_x emissions contribute to violations of the national ambient air quality standard for ozone (40 CFR 50.9). The total amount of NO_x that can be emitted by each of the 22 states in the year 2007 ozone season (May 1 through September 30) is set out at 40 CFR 51.121(e). For Alabama, the amount is 156,597 MT (172,619 tons). Any new natural gas combined-cycle plant sited in Alabama would be subject to these limitations.

EPA issued the Clean Air Interstate Rule (CAIR) in 2005 (EPA 2005a). CAIR provides a Federal framework requiring certain states to reduce emissions of SO_2 and NO_x. EPA anticipates that states will achieve this reduction primarily by limiting emissions from the power generation sector. CAIR covers 28 eastern states and the District of Columbia. Any new fossil-fired power plant sited in Alabama would be subject to the CAIR limitations.

A natural gas combined-cycle power plant would also have unregulated carbon dioxide emissions that could contribute to global warming. TVA estimates that natural gas combined-cycle plants sufficient to replace the power generated at BFN would emit approximately 17.1 million MT/yr (18.9 million tons/yr) of carbon dioxide (TVA 2003).

The estimated annual emissions for natural gas combined-cycle plants sized to replace the power generated by BFN are shown in Table 8-6 (TVA 2003).

The combustion turbine portion of the combined-cycle plant would be subject to EPA's National Emission Standards for Hazardous Air Pollutants for Stationary Combustion Turbines at 40 CFR Part 63, Subpart YYYY, if the site is a major source of hazardous air pollutants. Major sources have the potential to emit 9.1 MT (10 tons) per year or more of any single hazardous air pollutant or 22.7 MT (25 tons) or more per year of any combination of hazardous air pollutants (40 CFR 63.6085(b)).

Construction activities would result in temporary fugitive dust. Exhaust emissions would also come from vehicles and motorized equipment used during the construction process.

Overall, the air quality impacts of new natural gas combined-cycle plants sized to replace the BFN capacity are estimated to be MODERATE.

- **Waste**

In the GEIS the staff concluded that waste generation from natural gas-fired technology would be minimal (NRC 1996). The only significant solid waste generated at a new natural gas combined-cycle plant would be spent SCR catalyst. The SCR catalyst is used to control NO_x emissions. The spent catalyst would be regenerated or disposed offsite. Other than spent SCR catalyst, waste generation at an operating natural gas combined-cycle plant would be largely limited to typical office wastes; impacts would be so minor that they would not noticeably alter any important resource attribute. Construction-related debris would be generated during construction activities.

Overall, the solid waste impacts associated with natural gas combined-cycle plants sized to replace the BFN capacity would likely be SMALL.

- **Human Health**

Potential accidents related to plant operations include the possible rupture of natural gas pipelines both onsite and offsite, and the possible release of ammonia (TVA 2003). Ammonia is used in the SCR process for control of NO_x emissions. Both events are considered very low probability.

In the GEIS, the staff identified cancer and emphysema as potential health risks from natural gas-fired plants (NRC 1996). The risk may be attributable to NO_x emissions that contribute to ozone formation, which in turn contributes to health risks. NO_x emissions from any plant would be regulated by the State or EPA. For a plant sited in Alabama, NO_x emissions would be regulated by the Alabama Department of Environmental Management. Human health effects are not expected to be detectable or would be sufficiently minor that they would neither destabilize nor noticeably alter any important attribute of the resource. Overall, the impacts on human health of newly constructed natural gas combined-cycle plants are considered SMALL.

- **Socioeconomics**

Construction of a 510-MW(e) natural gas combined-cycle plant would take approximately 22 months (TVA 2003). Peak employment would be approximately 420 workers. Employment would exceed 200 workers for approximately 6 months (TVA 2003). During construction, the communities immediately surrounding each plant site would experience demands on housing and public services that could have noticeable impacts. These impacts would be tempered by construction workers commuting to the sites from more distant cities. After construction, the communities would be impacted by the loss of jobs. The operating workforce at each 510-MW(e) plant would be approximately 40 persons (TVA 2003). The BFN workforce would decline through a decommissioning period to a minimal maintenance size. The new natural gas combined-cycle plants would provide a new tax base through TVA's in-lieu-of-tax payments, at their respective locations.

Jobs related to pipeline construction and to transmission/distribution line upgrades would not be centralized at one location for any significant period of time and, therefore, would have no important impact on the local economy or on community and government services.

In the GEIS, the staff concluded that socioeconomic impacts from constructing a natural gas-fired plant would not be very noticeable and that the small operational workforce would have the lowest socioeconomic impacts of any nonrenewable technology (NRC 1996). Compared to the coal-fired and nuclear alternatives, the smaller size of the construction workforce, the shorter construction time frame, and the smaller size of the operations workforce would mitigate socioeconomic impacts.

The impacts of transportation related to commuting of plant operating personnel would depend on the population density and transportation infrastructure in the vicinity of the site, but are likely to be negligible. Impacts related to the commuting of plant construction personnel would be noticeable, temporary, but not destabilizing.

Overall, socioeconomic impacts resulting from construction and operation of natural gas combined-cycle plants can be characterized as MODERATE.

- **Aesthetics**

The natural gas combined-cycle plants would alter the visual landscape character at each location. The tallest structures would be the 46-m (150-ft)-high auxiliary boiler and two heat recovery steam generator stacks, as well as the 30-m (100-ft)-high steam turbine building (TVA 2003). Some portion of these structures would likely be visible for 2 km (1 mi) or more. Cooling tower plumes would also be visible. There would be more lighting visible across the night landscape, and sky brightness would increase somewhat. Noise from the plant would be detectable offsite.

If a new electric power transmission line is needed, the aesthetic impact could be significant. The gas pipeline compressors also would be visible. Aesthetic impacts would be mitigated if the plant were located in an industrial area adjacent to other power plants. Overall, the aesthetic impacts associated with replacement natural gas combined-cycle plants are categorized as MODERATE to LARGE, with site-specific factors determining the final categorization.

- **Historic and Archaeological Resources**

Before construction at any site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on cultural resources. The studies would likely be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission lines, pipelines, or other rights-of-way). Impacts to cultural resources can be effectively managed under current laws and regulations and kept SMALL.

- **Environmental Justice**

Environmental justice impacts would depend upon the sites chosen for the natural gas combined-cycle power plants and the nearby population distribution. Construction activities would offer new employment possibilities, but could have negative impacts on the availability and cost of housing, which could disproportionately affect minority and low-income populations.

Impacts in Limestone County would be the same as those under the no-action alternative assuming no construction of natural gas combined-cycle plants at the BFN site. Overall, environmental justice impacts would likely be SMALL to MODERATE.

8.2.3.2 Once-Through Cooling System

The environmental impacts of constructing and operating a natural gas combined-cycle generating plant using a once-through cooling system are essentially the same as the impacts for a plant using closed-cycle cooling with wet cooling towers. However, there are some environmental differences between the closed-cycle and once-through cooling systems. Table 8-7 summarizes the incremental differences.

Table 8-7. Summary of Environmental Impacts of a Natural Gas Combined-Cycle Plant with Once-Through Cooling

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Land Use	Less land required because cooling towers and associated infrastructure are not needed.
Ecology	Impacts would depend on ecology at the site. No impacts to terrestrial ecology from cooling tower drift. Increased water withdrawal with possible greater impacts to aquatic ecology.
Surface Water Use and Quality	No discharge of cooling tower blowdown. Increased water withdrawal and more thermal load on receiving body of water.
Groundwater Use and Quality	No change
Air Quality	No change
Waste	No change
Human Health	No change
Socioeconomics	No change
Aesthetics	Less aesthetic impact because cooling towers would not be used.
Historic and Archaeological Resources	Less land impacted.
Environmental Justice	No change

8.2.4 Nuclear Power Generation

The TVA ER considers the feasibility of constructing and operating two Advanced Boiling Water Reactors (ABWRs) at the unfinished Bellefonte nuclear plant site (TVA 2003). The ABWR design is a light-water reactor that has been certified by the NRC (10 CFR Part 52, Appendix A).

Although construction of the original Bellefonte nuclear units has been halted, TVA still retains construction permits issued by NRC. Construction access routes are completed at the site, and basic support functions (electric power, potable water, sanitary waste disposal, office buildings, parking lots, railways, and barge unloading facility) are in place to support resumption of construction. Almost all the basic site preparation work, such as grading, has been completed, including where the ABWR units would be constructed (TVA 2003). DOE is cooperating with an industry team led by TVA to conduct a detailed study of the potential construction of a two-unit ABWR nuclear plant at the Bellefonte site (DOE 2004a).

Construction of two ABWR units at the Bellefonte site would likely make use of the existing site intake water pumping station, natural draft cooling towers, discharge water diffusers, and electrical transmission lines and switchyards, each with varying degrees of modification (TVA 2003). Some existing service facilities such as fire protection, temporary construction power, auxiliary boilers, office buildings and parking lots, environmental monitoring, outside lighting, diesel fuel storage tanks, telecommunications, and potable water and sanitary waste supply lines would be used wherever possible. Almost none of the existing unfinished nuclear units and their contiguous support systems would be used (TVA 2003). To supplement the existing natural draft cooling towers, two additional mechanical draft cooling towers might be built on land immediately adjacent to and just south of the existing cooling towers, between the existing cooling towers and the proposed ABWR plant (TVA 2003). A 3.6-ha (9-ac) cooling spray pond might also be constructed south of the ABWR plant to serve as the emergency core cooling ultimate heat sink for the two units. All this land has previously been cleared for other uses (TVA 2003).

The base or lowest expected power output is 1336 MW(e) per unit during summer, which would likely increase to 1380 MW(e) during winter months as the condenser inlet temperature (and consequently the condenser backpressure) was reduced (TVA 2003). Although some uprating of the ABWR units might be possible, an additional ABWR unit, probably constructed at another site, would likely be needed to fully replace the uprated 3840-MW(e) capacity of BFN.

NRC has summarized environmental data associated with the uranium fuel cycle in Table S–3 of 10 CFR 51.51. The impacts shown in Table S–3 are representative of the impacts that would be associated with a replacement nuclear power plant. The impacts shown in Table S–3 are for

a 1000-MW(e) reactor and would need to be adjusted to reflect replacement of the uprated 3840-MW(e) capacity of BFN. The environmental impacts associated with transporting fuel and waste to and from a light-water cooled nuclear power reactor are summarized in Table S–4 of 10 CFR 51.52. The summary of NRC's findings on NEPA issues for license renewal of nuclear power plants in Table B-1 of 10 CFR Part 51 Subpart A, Appendix B, is also relevant, although not directly applicable, for consideration of environmental impacts associated with the operation of a replacement nuclear power plant. Additional environmental impact information for a replacement nuclear power plant using closed-cycle cooling is presented in Section 8.2.4.1 and using once-through cooling in Section 8.2.4.2.

8.2.4.1 Closed-Cycle Cooling System

The overall impacts associated with the construction and operation of two ABWR generating units at the Bellefonte site are discussed in the following sections. The impacts are summarized in Table 8-8. Additional impacts would occur, probably at another site, to fully replace the 3840-MW(e) capacity at BFN. The impact categorizations for Table 8-8 are based on 3840 MW(e) of new ABWR generating capacity.

Table 8-8. Summary of Environmental Impacts of New ABWR Units Using Closed-Cycle Cooling

Impact Category	Impact	Comment
Land Use	SMALL to LARGE	Most of the construction would take place on already disturbed areas of the Bellefonte site. Construction of an ABWR at another site would require approximately 200 ha (500 ac) for the plant and possibly additional land if a new transmission line and/or rail spur were needed. Additional land-use impacts might occur for uranium mining.
Ecology	SMALL to LARGE	Impacts at the Bellefonte site would be SMALL to MODERATE. Impacts at another site could be LARGE and would depend on location and ecology of the site, surface water body used for intake and discharge, and electric power transmission line route; potential habitat loss and fragmentation; reduced productivity and biological diversity; and impacts to terrestrial ecology from cooling tower drift.
Water Use and Quality	SMALL to MODERATE	Impacts would depend on the volume of water withdrawn and discharged, the constituents in the discharge water, and the characteristics of the surface water body. Discharges at the Bellefonte site would be regulated by the State of Alabama.
Air Quality	SMALL	Air emissions from ABWR plants sized to fully replace BFN capacity would be approximately: Sulfur oxides – 12.7 MT/yr (14 tons/yr) Nitrogen oxides – 12.7 MT/yr (14 tons/yr) PM_{10} – 0.62 MT/yr (0.68 tons/yr) Carbon monoxide – 3.4 MT/yr (3.7 tons/yr)

Table 8-8. (contd)

Impact Category	Impact	Comment
		Approximately 4350 MT/yr (4800 tons/yr) of unregulated carbon dioxide would be discharged.
Waste	SMALL	Radioactive waste generated at an ABWR would be less than a conventional boiling water reactor (BWR). Debris would be generated and removed during the construction process.
Human Health	SMALL	Impacts are uncertain, but considered SMALL in the absence of more quantitative data. ABWR units are expected to have a lower human health impact than existing BWR units.
Socioeconomics	MODERATE to LARGE	Peak construction employment at the Bellefonte site would be approximately 3100 workers. The operating workforce would be approximately 900. Limestone County could experience loss of BFN tax base and employment. Impacts at an alternate rural site could be LARGE.
Aesthetics	MODERATE to LARGE	At the Bellefonte site, a new off-gas stack would be needed. Cooling tower plumes would be visible for 16 km (10 mi) or more. At an alternative site, a new transmission line might be needed, which could have a LARGE impact.
Historic and Archeological Resources	SMALL	The Bellefonte site has had previous surveys for historic and archeological resources. Any potential impacts could likely be effectively managed.
Environmental Justice	SMALL to MODERATE	Impacts would vary depending on population distribution and makeup water at the site. Impacts in Limestone County would be the same as those under the no-action alternative.

- **Land Use**

Twin ABWR units would be constructed adjacent to and directly south of the existing cooling towers (TVA 2003). A construction laydown space is planned for the area bordered by the existing cooling towers, the existing 500-kV transmission line, and the ABWR plant. Almost all the ABWR construction activities would take place on land that has already been disturbed for the original Bellefonte construction. There are no buried structures that cannot be removed or transferred (TVA 2003).

Including wind effect, the maximum flood level of the Bellefonte site is 191.3 m (627.7 ft) above mean sea level, which is higher than the 189-m (620-ft) average grade for the planned construction area. Keeping the finished grade above the maximum flood level would require adding about 3 m (10 ft) of fill soil to the construction area, increasing its elevation to 192 m (630 ft) (TVA 2003). The grading soil would most likely be taken from hills to the east or southwest of the construction area.

Compared to a fossil-fueled power plant, which would involve either long fuel pipelines or large fuel and combustion product storage areas, the impacts on land use and soils would be minimal for completing a relatively compact nuclear plant on the previously disturbed Bellefonte site.

Land-use impacts would likely be SMALL at the Bellefonte site, and MODERATE to LARGE if an additional site were needed to fully replace the power generated by BFN. At another site, approximately 200 ha (500 ac) would be needed for the plant and possibly additional land needed for construction of a transmission line and/or rail spur. Additional land-use impacts might occur for uranium mining.

- **Ecology**

At the Bellefonte site there are no Federally or State-listed threatened or endangered plant species (TVA 2003). There are no caves at the site that support the Federally endangered Indiana and gray bats, but they are known to forage along the Guntersville Lake shoreline. However, the immediate area near the site has an extensive network of similar wooded shoreline and shallow lagoon habitats.

The intake channel at the site has not been maintained and would require dredging, both initially and periodically throughout the life of the plant. Surveys have found no toxic sediments and a low average density of mussels in the area. It is expected that the dredge material would be disposed on land (TVA 2003). Because water intake demand would be small compared to the total water mass flowing past the Bellefonte site, there is little potential for significant entrainment/impingement impacts. The existing water intake structure at the site would be used; this intake system entrains water through a 7.6-m (25-ft)-wide trench connected to the original river channel and is designed such that 85 percent of the intake demand would be withdrawn from the river channel and 15 percent from the more productive upstream overbank habitat. The greatest impacts of entrainment and impingement would result from water withdrawn from the upstream productive overbank, although losses to the lake fish community should be minimal because of the large amounts of similar habitat near the plant and in other areas of the lake (TVA 2003). There could be impacts to terrestrial ecology from cooling tower drift.

Overall, siting of two ABWR units at the Bellefonte site would have a SMALL to MODERATE ecological impact.

At an alternate site, there would be construction impacts and new incremental operational impacts. Even assuming siting at a previously disturbed area, the impacts would alter the ecology. Impacts could include wildlife habitat loss, reduced productivity, habitat fragmentation, and a local reduction in biological diversity. Use of cooling water from a nearby surface water body could have adverse aquatic resource impacts. If needed, construction and maintenance of the transmission line would have ecological impacts. Overall, the ecological impacts at an alternate site would be MODERATE to LARGE.

- **Water Use and Quality**

Raw water for construction and operation would be obtained from the Tennessee River. The quantities needed would be unlikely to have a significant effect on the river. Both existing closed-cycle natural draft cooling towers on the Bellefonte site would likely be used. The existing intake channel at the site has not been periodically maintained and might require some dredging (TVA 2003).

No significant construction-related impacts to surface water resources would be expected as a result of the project. The majority of the power plant and associated facilities would be constructed on land that has been previously altered because of construction activities related to the uncompleted Bellefonte nuclear plant. Construction of new facilities and overall site reclamation activities would affect surface hydrology, but extensive site excavation, filling, or grading would not be needed. The primary surface water impact during construction would be soil erosion, which could be kept low by the use of best management practices. To minimize the impacts of storm water flow during construction, a storm water retention pond would be designed to retain storm water from the 25-year, 24-hour rainfall event, in compliance with regulatory requirements (TVA 2003).

The surface water resources within the areas of the proposed development at the Bellefonte site are currently monitored under an NPDES permit issued by the Alabama Department of Environmental Management.

Potable water is supplied to the Bellefonte site by the City of Hollywood, which receives its water from the City of Scottsboro. The Bellefonte site is connected to the Hollywood municipal sewage system treatment plant located adjacent to the south side of the site. The sewage treatment plant serves the Bellefonte site and residential customers in the area, but currently it does not have sufficient capacity to handle the increased demand of a large construction force and would have to be enlarged (TVA 2003).

It is expected that water impacts at the Bellefonte site would be sufficiently minor that they would not noticeably alter any important attribute of the resource.

For alternate sites, the impact on the surface water would depend on the discharge volume and the characteristics of the receiving body of water. Intake from and discharge to any surface body of water would be regulated by the State or by EPA.

A nuclear power plant sited at an alternate site may use groundwater. Groundwater withdrawal at an alternate site would likely require a permit.

Overall, water-use and quality impacts are estimated to be SMALL to MODERATE.

- **Air Quality**

Annual emission rate estimates for operating ABWR units sized to fully replace the power generated by BFN are shown in Table 8-8 (TVA 2003). The only combustion sources to produce carbon dioxide are the small auxiliary heating boilers, emergency power generators (usually diesel-driven but sometimes combustion turbines), service vehicles, some portable self-powered devices such as pumps and generators, and some types of welding and heat treatment gear (TVA 2003).

There would be fugitive emissions during the construction process. Exhaust emissions would also come from vehicles and motorized equipment used during the construction process.

Overall, plant emissions and associated impacts are considered SMALL.

- **Waste**

The waste impacts associated with operation of pressurized-water reactor (PWR) and boiling water reactor (BWR) nuclear power plants are set out in Table B-1 of 10 CFR 51 Subpart A, Appendix B. Similar to conventional BWRs, during operation the ABWR produces spent resins from the condensate filters and demineralizers and dry active wastes from maintenance operations, typically gloves, plastic sheeting, mops, rags, wood, paper, metal, and plastic scraps. Based on experience with LLW generated at both conventional and advanced BWRs in Japan, TVA expects that the LLW generated at the ABWR units would be less than 15 percent of the LLW currently generated at BFN BWR units (TVA 2003). The reasons for the reduction in LLW for the ABWR include lower regeneration requirements for condensate demineralizers; non-precoat, hollow-fiber filters for the condensate filters; and less required maintenance and inspection overall. As an alternative means of disposal for solid and liquid LLW waste, TVA would explore the feasibility of shipping it to offsite contractors for processing (incineration, compaction, etc.) prior to permanent disposal at a licensed facility, similar to what is currently done for radioactive wastes generated at BFN (TVA 2003).

In addition to the impacts shown in Table B-1, construction-related debris would be generated during construction activities, which would be disposed in landfills. During construction, some modifications to the existing cooling towers at the Bellefonte site might be necessary to increase their cooling capacity (TVA 2003). Modifications could include replacing the present asbestos fill. In this case, proper disposal of the asbestos fill in an offsite permitted landfill would be required. Much of the waste generated during construction would be typical construction/ demolition waste (e.g., broken concrete, rock, asphalt, scrap lumber and metal,

etc.) generated by the modification/removal of existing buildings such as old warehouses and the building of the new plant. There is enough space available on the Bellefonte site for a landfill to receive construction/demolition waste, but it may prove more economical to use any of several existing landfills within 80 km (50 mi) of Bellefonte that have adequate storage capacity and life expectancy (TVA 2003).

Waste impacts associated with construction of ABWR units at another site are unlikely to exceed those associated with construction at the Bellefonte site. Overall, waste impacts are considered SMALL.

- **Human Health**

Human health impacts for operating PWR and BWR nuclear power plants are set out in 10 CFR 51 Subpart A, Appendix B, Table B-1.

The total worker radiation exposure for an operating two-unit ABWR is projected to be about 0.62 man-Sieverts/yr, based on experience from the first 5 years of commercial operation for two comparable ABWR units in Japan and adjusted to projected steady-state conditions (TVA 2003). For three ABWR units to fully replace BFN capacity, total worker radiation exposure would be about 0.93 man-Sieverts/yr. For comparison, the median U.S. annual exposure for (two-unit) BWRs is 2.88 man-Sieverts/yr (TVA 2003). The reasons for the reduced occupational exposure include less piping, particularly in containment, and therefore less in-service inspection; larger maneuvering space for maintenance work inside containment; improved design requiring less maintenance of reactor components such as control rod drives; and shortened durations of refueling and maintenance outages due to expanded use of automated systems and design improvements such as split-type control rod drive housings. Approximately half of the radiation exposure is accumulated during outages. Experience with the prototype ABWR plants in Japan has shown that radiation exposure during outages has decreased steadily with time, reflecting lessons learned through operating experience (TVA 2003).

Overall, human health impacts for siting of new ABWR units at the Bellefonte site or at alternative sites are considered SMALL.

- **Socioeconomics**

Based on Japanese ABWR construction experience, TVA expects that the construction period for two new ABWR units at the Bellefonte site would be 34 months (TVA 2003). This abbreviated schedule reflects a high degree of modularization, requiring the use of large cranes; expansion of the work scope, which can proceed in parallel; and a number of

improvements in field productivity through innovations such as increased use of automatic welding machines. Peak employment during construction of the two units is estimated to be 3115 workers, of which 2885 workers would be craft workers and craft work supervisors (TVA 2003). Approximately 230 workers would be construction and pre-operational turnover engineers and technical advisors supplied by an architectural/engineering company with ABWR construction experience. TVA estimates that approximately one-third of the crafts workers would move into the local area, with the rest commuting from longer distances. TVA expects that less than half of those moving into the local area would buy or rent houses. Of those workers who do move to the area, TVA estimates that more than two-thirds would bring their families. TVA expects that few, if any, of the architectural/engineering personnel would buy houses in the local area (TVA 2003). TVA estimates that approximately 720 new students would attend the Scottsboro and Jackson county schools temporarily during the construction period (TVA 2003).

The total projected employment during operation for the two-unit ABWR plant is 906 workers (TVA 2003). For comparison, there are currently 1297 workers at BFN Units 2 and 3 (TVA 2003). TVA projects that the total population impact on Jackson County attributable to the new ABWR units would be approximately 1200 to 1400 workers. The total annual employment generated in Jackson County is estimated by TVA to be approximately 1600 workers, and the total annual income generated to be more than $78 million (TVA 2003). The impacts from plant operation on housing, schools, and services such as fire protection would be less than those of peak construction and should, therefore, be accommodated without difficulty.

The new ABWR units would likely provide an increase in the in-lieu-of-tax payments received by Jackson County or any other county where new units are constructed by TVA. In-lieu-of-tax payments in Limestone County would likely decrease if the BFN OLs are not renewed. Employment in Limestone County would decrease if the BFN OLs are not renewed.

Construction of new ABWR units at a site other than Bellefonte would relocate some socioeconomic impacts, but would not eliminate them. Assuming the new units were not built at the BFN site, the communities around the BFN site would experience the impact of operational job loss and the loss of tax base. The communities around the new site would have to absorb the impacts of a large, temporary workforce and a permanent operating workforce. In the GEIS, the staff noted that socioeconomic impacts at a rural site would be larger than at an urban site because more of the peak construction workforce would need to move to the area to work (NRC 1996). Alternate sites would need to be analyzed on a case-by-case basis. Socioeconomic impacts at a rural site could be LARGE. Transportation-related impacts associated with commuting construction workers at an alternate site are site dependent. Transportation impacts related to commuting of plant operating personnel would also be site-dependent.

Overall, the socioeconomic impacts associated with constructing and operating new ABWR units sized to replace BFN capacity are considered MODERATE to LARGE.

- **Aesthetics**

The Bellefonte site is seen most frequently by passing motorists from various points along U.S. Highway 72. The on-ground plant facilities such as roads, parking lots, and office buildings are screened for the most part by low rolling terrain in the foreground. The Bellefonte site is buffered from the main Tennessee River channel by a wooded ridgeline, which rises approximately 60 m (200 ft) above the lake surface. Distant views of the 145-m (477-ft)-high cooling towers and the reactor domes can be seen in excess of 8 km (5 mi) away. The only new ABWR construction that would rise to a height comparable to the existing cooling towers would be an off-gas stack, which would have no associated visible plume (TVA 2003). Vapor fog from the cooling towers could be visible from distances of 16 km (10 mi) or more. There is an existing 39.9-km (24.8-mi) 500-kV transmission line to the Bellefonte site that is not energized (TVA 2003).

Noise from operation of a replacement nuclear power plant would potentially be audible offsite in calm wind conditions or when the wind was blowing in the direction of the listener. Mitigation measures, such as reduced or no use of outside loudspeakers, could be employed to reduce noise level.

At an alternate site, there would be an aesthetic impact from the buildings. There would also be a significant aesthetic impact if a new transmission line were needed. Noise and light from the plant would be detectable offsite. The impact of noise and light would be mitigated if the plant was located in an industrial area adjacent to other power plants. Overall, the aesthetic impacts associated with locating new ABWR units at Bellefonte or at an alternative site can be categorized as MODERATE to LARGE.

- **Historic and Archaeological Resources**

A 1972 archaeological survey of the Bellefonte site identified five historic sites, none of which are within proposed construction zones (TVA 2003). The original Town of Bellefonte was located just offsite and determined in 1974 to be eligible for placement on the National Register of Historic Places. Prior to the initiation of construction of the uncompleted Bellefonte nuclear plant, the Alabama State Historic Preservation Office determined that no mitigation would be required. Since that time all structures have been removed by landowners (TVA 2003).

Before construction at an alternative site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on cultural resources.

The studies would likely be needed for all areas of potential disturbance at the proposed plant site and along associated rights-of-way where new construction would occur (e.g., roads, transmission lines, rail lines, or other rights-of-way). Historic and archaeological resource impacts can generally be effectively managed and would likely be SMALL at either the Bellefonte or an alternative site.

- **Environmental Justice**

Environmental justice impacts would depend upon the population distribution around the Bellefonte site or other alternate sites. Construction activities would offer new employment possibilities, but could have negative impacts on the availability and cost of housing, which could disproportionately affect minority and low-income populations. Impacts in Limestone County would be the same as those under the no-action alternative. Overall, environmental justice impacts would likely be SMALL to MODERATE.

8.2.4.2 Once-Through Cooling System

The environmental impacts of constructing and operating new ABWR units using once-through cooling are essentially the same as the impacts for a plant using closed cycle-cooling with wet cooling towers. However, there are some environmental differences between the closed-cycle and once-through cooling systems. Table 8-9 summarizes the incremental differences.

Table 8-9. Summary of Environmental Impacts of a New Nuclear Plant with Once-Through Cooling

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Land Use	Less land required because cooling towers and associated infrastructure are not needed.
Ecology	Impacts would depend on ecology at the site. No impacts to terrestrial ecology from cooling tower drift. Increased water withdrawal with possible greater impact to aquatic ecology.
Surface Water Use and Quality	No discharge of cooling tower blowdown. Increased water withdrawal and more thermal load on receiving body of water.
Groundwater Use and Quality	No change
Air Quality	No change
Waste	No change
Human Health	No change

Table 8-9. (contd)

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Socioeconomics	No change
Aesthetics	Less aesthetic impact because cooling towers would not be used.
Historic and Archaeological Resources	Less land impacted.
Environmental Justice	No change

8.2.5 Purchased Electrical Power

If available, purchased power from other sources could obviate the need to renew the BFN OLs. TVA currently purchases electric power from other generators (TVA 2003). However, some power purchase activities implemented by TVA have not performed as intended in delivering reliable power to TVA customers. TVA has issued several requests for proposals in recent years with the goal of obtaining additional peaking and baseload power (TVA 2003). Some of the responses have either not met stated conditions and requirements, or the entities submitting the proposals could not deliver power by the needed dates. Consequently, the projected power hoped for from the requests for proposals has not fully materialized (TVA 2003).

Current regional reserve margins[(a)] in the TVA service area are estimated to be approximately 30 percent; however, projections suggest that this surplus will be exhausted before the current BFN OLs expire (TVA 2003).

If power to replace the capacity of BFN were to be purchased from sources within the United States or from a foreign country, the generating technology likely would be one of those described in this SEIS and in the GEIS (probably coal, natural gas, or nuclear). The descriptions of the environmental impacts of other technologies in Chapter 8 of the GEIS and in Chapter 8 of this SEIS are representative of the environmental impacts associated with the purchased electrical power alternative to renewal of the BFN OLs. Under the purchased power alternative, the environmental impacts of imported power would still occur, but would be located elsewhere within the region, the United States, or another country.

(a) Reserve margin is the amount of unused available capability of an electric power system (at peak load) as a percentage of total capability.

8.2.6 Other Alternatives

Other generation technologies are discussed in the following subsections.

8.2.6.1 Oil-Fired Generation

EIA projects that oil-fired plants will account for no new generation capacity in the United States through the year 2025, except for limited industrial combined heat and power applications, because of higher fuel costs and lower efficiencies (DOE/EIA 2004). Oil-fired operation is more expensive than nuclear or coal-fired operation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly more expensive than coal-fired generation. The high cost of oil has resulted in a decline in its use for electricity generation. In Section 8.3.11 of the GEIS, the staff estimated that construction of a 1000-MW(e) oil-fired plant would require about 49 ha (120 ac) (NRC 1996). Operation of oil-fired plants would have environmental impacts (including impacts on the aquatic environment and air) that would be similar to those from a coal-fired plant.

8.2.6.2 Wind Power

Most of Alabama, Mississippi, and western Tennessee are in a wind power Class 1 region (average wind speeds less than 5.6 m/s) (DOE 2004b). Class 1 has the lowest potential for wind energy generation (DOE 2004b). Alabama does not have sufficient wind resources to use large-scale wind turbines (DOE 2004c).

Aside from the coastal areas and exposed mountains and ridges of the Appalachian Mountains, there is little wind energy potential in the East Central region of the United States for current wind turbine applications (Elliott et al. 1987). Moreover, wind turbines typically operate at a 25 to 35 percent capacity factor compared to 90 to 95 percent for a baseload plant (NWPPC 2000).

Therefore, the staff concludes that locating a wind-energy facility on or near BFN or offshore as a replacement for BFN generating capacity would not be economically feasible given the current state of wind-energy generation technology.

8.2.6.3 Solar Power

Solar technologies use the sun's energy to provide heat and cooling, light, hot water, and electricity for homes, businesses, and industry. Solar power technologies (both photovoltaic and thermal) cannot currently compete with conventional nuclear and fossil-fueled technologies in grid-connected applications because of higher capital costs per kilowatt of capacity. Energy

storage requirements also limit the use of solar-energy systems as baseload electricity supply. The average capacity factor of photovoltaic cells is about 25 percent (NRC 1996), and the capacity factor for solar thermal systems is about 25 to 40 percent (NRC 1996).

There are substantial impacts to natural resources (wildlife habitat, land use, and aesthetic impacts) from construction of solar-generating facilities. As stated in the GEIS, land requirements are high – 142 km^2 (55 mi^2) per 1000 MW(e) for photovoltaic (NRC 1996) and approximately 57 km^2 (22 mi^2) per 1000 MW(e) for solar thermal systems (NRC 1996). Neither type of solar electric system would fit at the BFN site, and both would have large environmental impacts at an alternate site.

The BFN site receives approximately 4500 to 5000 Wh/m^2 per day that can be used for flat-plate solar systems and 3500 to 4000 Wh/m^2 per day that can be used for solar concentrating systems. This is in comparison to areas in the southwestern United States that receive up to 7500 Wh/m^2 per day (DOE 2004d). For solar concentrating collectors, Alabama only has a useful resource in the southeastern portion of the state. The solar resource in Alabama can be used for water heating or photovoltaic systems, but not large concentrating solar thermal utility systems (DOE 2004d).

Because of the natural resource impacts (land and ecological), the area's relatively low rate of solar radiation, and high cost, solar power is not deemed a feasible baseload alternative to renewal of the BFN OLs. Some onsite generated solar power (e.g., from rooftop photovoltaic applications) may substitute for electric power from the grid. Implementation of solar generation on a scale large enough to replace BFN would likely result in LARGE environmental impacts.

8.2.6.4 Hydropower

Alabama has an estimated 363 MW[(a)] of developable hydroelectric resources (INEEL 1998). Tennessee has an estimated 138 MW of developable hydroelectric resources (INEEL 1997). This total amount is significantly less than needed to replace the 3840-MW(e) uprated capacity of BFN. As stated in Section 8.3.4 of the GEIS, hydropower's percentage of U.S. generating capacity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern about flooding, destruction of natural habitat, and alteration of natural river courses. In the GEIS, the staff estimated that land requirements for hydroelectric power are approximately 400,000 ha (1 million ac) per 1000 MW(e) (NRC 1996). Because of the relatively low amount of undeveloped hydropower resource in Alabama and Tennessee and the large land-use and related environmental and ecological resource impacts associated with

(a) One megawatt (MW) represents one million watts of electricity.

siting hydroelectric facilities large enough to replace BFN, the staff concludes that local hydropower is not a feasible alternative to renewal of the BFN OLs. Any attempts to site hydroelectric facilities large enough to replace the BFN would result in LARGE environmental impacts.

8.2.6.5 Geothermal Energy

Geothermal energy technologies have an average capacity factor of 90 percent and can be used for baseload power where available. However, geothermal technology is not widely used for baseload generation due to the limited geographical availability of the resource and immature status of the technology (NRC 1996). As illustrated by Figure 8.4 in the GEIS, geothermal plants are most likely to be sited in the western continental United States, Alaska, and Hawaii, where hydrothermal reservoirs are prevalent. Alabama has low-to-moderate geothermal resources that can be tapped for direct heat or for geothermal heat pumps. However, electrical generation is not possible with these resources (DOE 2004e). There is no practical eastern location for geothermal capacity to serve as an alternative to BFN. The staff concludes that geothermal energy is not a feasible alternative to renewal of the BFN OLs.

8.2.6.6 Wood Waste

A wood-burning facility can provide baseload power and operate with an average annual capacity factor of around 70 to 80 percent and with 20 to 25 percent efficiency (NRC 1996). The fuels required are variable and site-specific. A significant barrier to the use of wood waste to generate electricity is the high delivered-fuel cost and high construction cost per MW of generating capacity. The larger wood-waste power plants are only 40 to 50 MW(e) in size. Estimates in the GEIS suggest that the overall level of construction impact per MW of installed capacity should be approximately the same as that for a coal-fired plant, although facilities using wood waste for fuel would be built at smaller scales (NRC 1996). Like coal-fired plants, wood-waste plants require large areas for fuel storage and processing and involve the same type of combustion equipment.

Because of uncertainties associated with obtaining sufficient wood and wood waste to fuel a baseload generating facility, ecological impacts of large-scale timber cutting (e.g., soil erosion and loss of wildlife habitat), and low efficiency, the staff determined that wood waste is not a feasible alternative to renewing the BFN OLs.

8.2.6.7 Municipal Solid Waste

Municipal waste combustors incinerate the waste and use the resultant heat to generate steam, hot water, or electricity. The combustion process can reduce the volume of waste by up to

90 percent and the weight of the waste by up to 75 percent (EPA 2004). Municipal waste combustors use three basic types of technologies: mass burn, modular, and refuse-derived fuel (DOE/EIA 2001). Mass burning technologies are most commonly used in the United States. This group of technologies process raw municipal solid waste "as is," with little or no sizing, shredding, or separation before combustion. The initial capital costs for municipal solid-waste plants are greater than for comparable steam-turbine technology at wood-waste facilities. This is caused by the need for specialized waste-separation/handling equipment for municipal solid waste (NRC 1996).

Growth in the municipal waste combustion industry slowed dramatically during the 1990s after rapid growth during the 1980s. The slower growth was due to three primary factors: (1) the Tax Reform Act of 1986, which made capital-intensive projects such as municipal waste combustion facilities more expensive relative to less capital-intensive waste disposal alternative such as landfills; (2) the 1994 Supreme Court decision (*C&A Carbone, Inc. v. Town of Clarkstown*, 511 U.S. 383(1994)), which struck down local flow control ordinances that required waste to be delivered to specific municipal waste combustion facilities rather than landfills that may have had lower fees; and (3) increasingly stringent environmental regulations that increased the capital cost necessary to construct, operate, and maintain municipal waste combustion facilities (DOE/EIA 2001).

Municipal solid waste combustors generate an ash residue that is buried in landfills. The ash residue is composed of bottom ash and fly ash. Bottom ash refers to that portion of the unburned waste that falls to the bottom of the grate or furnace. Fly ash represents the small particles that rise from the furnace during the combustion process. Fly ash is generally removed from flue gases using fabric filters and/or scrubbers (DOE/EIA 2001).

Currently there are approximately 89 waste-to-energy plants operating in the United States. These plants generate approximately 2500 MW(e), or an average of approximately 28 MW(e) per plant (Integrated Waste Services Association 2004). The staff concludes that generating electricity from municipal solid waste would not be a feasible alternative to replace the uprated 3840-MW(e) baseload capacity of BFN and, consequently, would not be a feasible alternative to renewal of the BFN OLs.

8.2.6.8 Other Biomass-Derived Fuels

In addition to wood and municipal solid waste fuels, there are several other concepts for fueling electric generators, including burning crops, converting crops to a liquid fuel such as ethanol, and gasifying crops (including wood waste). In the GEIS, the staff stated that none of these

technologies has progressed to the point of being competitive on a large scale or of being reliable enough to replace a large baseload plant such as BFN (NRC 1996). For these reasons, such fuels do not offer a feasible alternative to renewal of the BFN OLs.

8.2.6.9 Fuel Cells

Fuel cells work without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air over a cathode. Activated by a catalyst, hydrogen atoms separate into protons and electrons, which take different paths to the cathode. The electrons go through an external circuit, creating a flow of electricity. The only by-products are heat, water, and carbon dioxide. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam under pressure. Natural gas is typically used as the source of hydrogen.

Phosphoric acid fuel cells are generally considered first-generation technology. Higher temperature second-generation fuel cells achieve higher fuel-to-electricity conversions and thermal efficiencies. The higher temperatures contribute to improved efficiencies and give the second-generation fuel cells the capability to generate steam for cogeneration and combined-cycle operations.

During the past three decades, significant efforts have been made to develop more practical and affordable fuel cell designs for stationary power applications, but progress has been slow (DOE 2004e). Today, the most widely marketed fuel cells cost about $4500 per kW of installed capacity; by contrast, a diesel generator costs $800 to $1500 per kilowatt, and a natural gas turbine can be even less (DOE 2004f).

DOE has launched an initiative – the Solid State Energy Conversion Alliance – to bring about dramatic reductions in fuel cell costs. DOE's goal is to cut costs to as low as $400 per kW of installed capacity by the end of this decade, which would make fuel cells competitive for virtually every type of power application (DOE 2004f).

The staff concludes that at the present time fuel cells are not economically or technologically competitive with other alternatives for baseload electricity generation. Future gains in cost competitiveness for fuels cells compared to other fuels are speculative. Fuel cells are, consequently, currently not a feasible alternative to renewal of the BFN OLs.

8.2.6.10 Delayed Retirement

It is conceptually possible that delayed retirement of other TVA generating units could replace the power generated by BFN. At the present time, however, TVA has no plans for retiring any

of its generating units. TVA is adding environmental controls and maintaining existing generating units as necessary to keep them operational and in compliance with environmental requirements. The staff therefore concluded that delayed retirement of other TVA generating units could not replace the power supplied by BFN Units 1, 2, and 3 and would not be a feasible alternative to renewing the OLs for BFN Units 1, 2, and 3.

8.2.6.11 Utility-Sponsored Conservation

The utility-sponsored conservation alternative refers to a situation with the following three conditions: (1) BFN ceases to operate, (2) no new generation is brought online to meet the lost generation, and (3) the lost generation is instead replaced by more efficient use of electricity brought about by DSM programs.

DSM programs consist of the planning, implementing, and monitoring activities of electric utilities that are designed to encourage consumers to modify their level and pattern of electricity usage. DSM programs have been part of TVA's energy portfolio since the 1970s. They were initiated in response to the rising cost of energy and the rising cost of building new electric generating units that began in the mid 1970s. By 1988, TVA DSM programs were credited with saving more than 2.3 billion kilowatt-hours per year and cutting system demand by 1200 MW (TVA 2003). Of these savings, 960 MW came from the residential sector after weatherization measures were installed in 631,000 homes in the Tennessee Valley. DSM initiatives (such as energy-right home electrical efficiency, direct load control, industrial customer products and services, and firm buy-back agreements) continue to be implemented through TVA power distributors with an estimated 154 MW of capacity added from 1995 through 1999, and an additional 264 MW from 2000 to 2002 (TVA 2003). TVA's energy savings attributable to DSM are part of its long-range plan for meeting projected demand, and thus are not available offsets for the generating capacity of BFN.

Current residential DSM programs offered by TVA include a new homes plan, a heat pump plan, a water heater plan, and a new manufactured home plan. Current commercial DSM programs offered by TVA include onsite operations support to aid the achievement of energy savings, support to industrial power users to improve energy efficiency, and an initiative to encourage use of groundwater heat pumps.

Although DSM programs are an important part of TVA's energy portfolio, the staff concludes that additional DSM, by itself, would not be sufficient to replace the uprated 3840-MW(e) capacity of BFN and that it is not a reasonable substitute for renewing the OLs.

8.2.7 Combination of Alternatives

Even though individual alternatives might not be sufficient on their own to replace the BFN generating capacity because of the small size of the resource or lack of cost-effective opportunities, it is conceivable that a combination of alternatives might be cost-effective.

BFN is projected to have an uprated capacity of 3840 MW(e). There are many possible combinations of alternatives to replace this capacity. Table 8-10 contains a summary of the environmental impacts of an assumed combination of alternatives consisting of 3060-MW(e) (six 510-MW[e]) plants of natural gas combined-cycle generation using mechanical draft cooling towers, 400 MW purchased from other generators, and 380 MW gained from additional DSM measures. The impacts associated with the natural gas combined-cycle units are based on the discussion in Section 8.2.3, adjusted for the reduced generating capacity. While the DSM measures would have few environmental impacts, operation of the new natural gas combined-cycle plants would result in increased emissions and other environmental impacts. The environmental impacts associated with power purchased from other generators would still occur, but would be located elsewhere within the region as discussed in Section 8.2.4. The environmental impacts associated with purchased power are not shown in Table 8-10. The staff concludes that it is very unlikely that the environmental impacts of any reasonable combination of generating and conservation options could be reduced to the level of impacts associated with renewal of the BFN OLs.

Table 8-10. Summary of Environmental Impacts of an Assumed Combination of Generation and Acquisition Alternatives

Impact Category	Impact	Comment
Land Use	MODERATE to LARGE	Approximately 80 ha (200 ac) for each 510-MW(e) plant. Additional site-specific impacts for natural gas pipeline, electric power transmission lines, rail spurs, and cooling water intake and discharge pipelines.
Ecology	MODERATE	Impacts depend on location and ecology of the site, surface water body used for intake and discharge, and electric power transmission line and natural gas pipeline routes; potential habitat loss and fragmentation; reduced productivity and biological diversity; and impacts to terrestrial ecology from cooling tower drift.
Water Use and Quality	SMALL to MODERATE	Impacts would depend on the volume of water withdrawn and discharged, the constituents in the discharge water, and the characteristics of the surface water body. Discharges would be regulated by the State or EPA.