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BROWNS FERRY NUCLEAR PLANT SUBSEQUENT LICENSE RENEWAL PROJECT DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Limestone County, Alabama

Prepared for:
TENNESSEE VALLEY AUTHORITY
Athens, AL 35611

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COVER SHEET

Browns Ferry Nuclear Plant Subsequent License Renewal

Proposed action: The current operating licenses for Browns Ferry Nuclear Plant (BFN) expire on December 20, 2033, for Unit 1, June 28, 2034, for Unit 2, and July 2, 2036, for Unit 3. The purpose of the proposed action is to help provide continued generation of baseload power from the BFN site between 2033 and 2056 by obtaining subsequent license renewals from the Nuclear Regulatory Commission (NRC) to operate all three BFN units.

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Abstract: TVA proposes to submit a subsequent license renewal (SLR) application to the NRC for Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3, in Limestone County, Alabama. SLR would permit operation for an additional 20 years past the current operating license terms that expire in 2033, 2034, and 2036 for Units 1, 2, and 3 respectively. SLR would involve continuation of normal operations, maintenance, and refueling. The SLR program would not require major new construction, alternations, or refurbishment to BFN to maintain consistency with the current licensing basis. The purpose of the proposed action is to continue to generate baseload power at the BFN site between 2033 and 2056. BFN's current baseload generation supports future forecasted baseload power needs, as outlined in the TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. In addition to continuing to operate BFN, TVA evaluated alternative methods for supplying electrical power. Relative to BFN, the No Action Alternative would involve ceasing operation of BFN when the current operating licenses expire and using other methods to provide necessary capacity and energy. Feasible alternatives evaluated in more detail include natural gas, solar, storage, and nuclear SMRs. TVA has prepared this supplemental environmental impact statement to inform decision makers and the public about the potential environmental impacts that would result from renewing BFN operating licenses. This document supplements the original 1972 *Final Environmental Statement, BFN Units 1, 2, and 3* and the 2002 *Final Environmental Impact Statement for Operating License Renewal of the BFN in Athens, Alabama* that TVA prepared to evaluate the impacts from license renewal. TVA will use this information in addition to input provided by reviewing agencies, tribes, and the public to make an informed decision about renewing BFN operating licenses.

SUMMARY

Purpose and Need for Action

The current operating licenses for Browns Ferry Nuclear Plant (BFN) expire on December 20, 2033, for Unit 1, June 28, 2034, for Unit 2, and July 2, 2036, for Unit 3. The Tennessee Valley Authority (TVA) must decide whether to submit a subsequent license renewal (SLR) application (SLRA) to the Nuclear Regulatory Commission (NRC) to renew the operating licenses of the three BFN units for an additional 20 years beyond their current license expiration dates.

As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation capacity. Renewal of the current operating licenses would allow BFN to continue supplying approximately 3,900 megawatts electric (MWe) capacity of safe, clean, reliable, and cost-effective baseload power for an additional 20 years. BFN has two onsite independent spent fuel storage installations (ISFSIs) using dry cask storage. Expansion of the onsite ISFSI capacity will be required by 2036 to support BFN operations during the period of SLR if the U.S. Department of Energy (DOE) does not provide for permanent storage and disposal of the onsite spent fuel as planned. Otherwise, the SLR program would not require major new construction, alterations, or refurbishment to BFN to maintain consistency with the current licensing basis. Furthermore, BFN SLR is a key component of meeting TVA's goal of a net-zero carbon emissions generating system by 2050.

The purpose of the proposed action is to continue to generate baseload power at the BFN site between 2033 and 2056 through obtaining SLRs from the NRC to continue operation of all three BFN units. BFN's current baseload generation supports future forecasted baseload power needs, as outlined in the TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix.

TVA operates BFN Units 1, 2, and 3 in Limestone County, Alabama. Unit 1 began commercial operation in 1974, Unit 2 in 1975, and Unit 3 in 1977. The BFN site is located on an approximately 880-acre tract on the north shore of Wheeler Reservoir at Tennessee River Mile 294, approximately 30 miles west of Huntsville, Alabama, 10 miles northwest of Decatur, Alabama, and 10 miles southwest of Athens, Alabama.

This Supplemental Environmental Impact Statement (SEIS) supplements the original *Final Environmental Statement, BFN Units 1, 2, and 3* that TVA prepared in 1972 to evaluate the impacts of constructing and operating BFN and the *Final Environmental Impact Statement for Operating License Renewal of the BFN in Athens, Alabama* that TVA prepared to evaluate the impacts from license renewal. Information from the 1974 final environmental statement and final environmental impact statement (EIS) was analyzed and updated where needed to develop this SEIS. Additionally, information from other related environmental reviews was used to facilitate the development of this SEIS. This SEIS also updates the need for power analysis based upon the current TVA power system, TVA forecasted economic conditions, costs of fuel and technology, and other contributing factors. In TVA's IRP released in June 2019, the analysis included existing nuclear power plants such as BFN to be a main component of TVA's power supply in the future. This SEIS uses information and analyses from the IRP EIS process, particularly for load forecasting and evaluation of energy generation portfolios designed to meet forecasted needs.

Alternatives

Alternatives were analyzed in addition to the continuing operation of BFN by SLR and the proposed subsequent period of extended operation. TVA considered alternatives for the generating capacity and energy needed to provide approximately 3,900 MWe of baseload power between 2033 and 2056. TVA's IRP identified potential options for meeting TVA's purpose and need, including the range of supply-side and demand-side actions. TVA reviewed combinations of options that would, and would not require new generating capacity.

The Action Alternative for BFN is to continue operation by completing SLR. Taking no action to renew the BFN operating licenses would result in ceasing operation of BFN Unit 1 in 2033, Unit 2 in 2034, and Unit 3 in 2036. Subsequently, TVA would need to rely on alternate means to meet the demand for power that BFN provides. Therefore, in this SEIS, implementing an alternate way to provide the capacity and energy otherwise generated at BFN is described as part of the No Action Alternative.

Eventual decommissioning of BFN would be necessary regardless of TVA's decision to pursue SLR. BFN would undergo decommissioning at the end of the current licenses, or at the end of the proposed subsequent period of extended operation. BFN would be placed in a safe condition and all fuel removed from the reactor. Decommissioning activities would begin after the permanent and safe shutdown of the units is achieved and after the formal decommissioning plans are approved by the NRC.

Safe storage of spent fuel would also be necessary whether the BFN operating licenses are renewed or not. BFN has two ISFSI used to safely store spent fuel in licensed and approved dry cask storage containers on site. These ISFSI are licensed separately from the BFN operating units and would remain in place until the DOE takes possession of the spent fuel and removes it from the site for permanent disposal or processing.

In-scope transmission lines potentially affected by the proposed action include those lines connecting BFN to the onsite switchyards. All in-scope transmission lines are located completely within the BFN site boundary. Each BFN unit is connected into the existing TVA 500-kilovolt (kV) transmission system by three 500-kV transmission lines via an onsite 500-kV switchyard. BFN is also connected to the 161-kV switchyard through two 161-kV transmission lines. Transmission lines connecting the BFN switchyard to the electric power grid would be operated whether BFN is operated or shut down. Operation and maintenance of these transmission lines connecting the switchyard to the grid does not depend upon the decision to renew BFN operating licenses; proposed maintenance would be identical regardless of the decision to pursue SLR. Therefore, operation of out-of-scope transmission lines and maintenance of rights-of-way are not addressed in this SEIS.

Alternative A – BFN Units 1, 2, and 3 Shutdown - No Action Alternative

If no action were taken by TVA, the operating licenses for BFN would expire on December 20, 2033 for Unit 1, June 28, 2034 for Unit 2, and July 2, 2036 for Unit 3. If the operating licenses expire, BFN would shut down and enter decommissioning. The TVA power service area would be shorted approximately 3,900 MWe of reliable base load generation and electric service could be disrupted during periods of peak demand on the TVA system if alternate generations sources were not available.

Therefore, if BFN were shut down at the end of the current license period, TVA would need to rely on alternate means to provide adequate capacity and energy in the absence of BFN. Alternatives sufficient to meet the project purpose and need include the construction of a combination of new generating capacity (i.e., natural gas-fired combined cycle generation, natural gas-fired combustion turbine generation, solar generation, energy storage, and nuclear-powered generation in the form of small modular reactors).

Alternative B – BFN Units 1, 2, and 3 Subsequent License Renewal – Proposed Action
The proposed action is for TVA to submit a SLR application to extend the expiration dates for BFN's operating licenses. Subsequent renewal of the current operating licenses would permit operation for an additional 20 years past the current operating license terms that expire on December 20, 2033, for Unit 1, June 28, 2034, for Unit 2, and July 2, 2036, for Unit 3. The NRC would evaluate TVA's SLRA and the potential environmental impacts of granting SLRs. If SLR is granted, BFN would be available as a base load generation plant until 2053 for Unit 1, 2054 for Unit 2, and 2056 for Unit 3.

The proposed subsequent period of extended operation would not require major new construction, alterations, or refurbishment to BFN to maintain consistency with the current licensing base. Nor would it require changes to the programs, processes, or procedures currently in use. No changes to operational limits or permit requirements would be necessary to comply with current regulations. Other than the continued normal operations, refueling, and maintenance for an additional 20 years, no refurbishments or plant modifications would be needed during the proposed subsequent period of extended operation to continue current operation of BFN Units 1, 2, and 3. Expansion of the onsite ISFSI capacity will be required by 2036 to support BFN operations during the proposed subsequent period of extended operation if the DOE does not provide for permanent storage and disposal of the onsite spent fuel as planned. The current ISFSI storage pads are projected to be filled on or before year 2036. Under the existing licenses, and assuming decommissioning at the end of the current license periods, additional dry fuel storage cask will be needed to support operations and decommissioning. The addition of a third ISFSI storage pad to further increase storage capacity needed for the proposed subsequent period of extended operation is under consideration, but plans are in the conceptual stage and no installation schedule has been established. The BFN site has adequate space onsite to accommodate the construction of an additional ISFSI pad if necessary. Should this be necessary, the impacts associated with this expansion would be assessed under a licensing process separate from that of BFN Units 1, 2, and 3 Renewed Facility Operating Licenses, consequently it would also be reviewed under a separate NEPA evaluation.

Summary of Environmental Consequences
Potential environmental impacts of the proposed project and the power generation alternatives are briefly summarized in Table S-1.

Preferred Alternative
Based upon the evaluations presented in this SEIS, and considering environmental impacts, costs, electrical generation needs of the TVA system, and TVA goals and policies, TVA has identified Alternative B – BFN Units 1, 2, and 3 SLR as the preferred alternative. Implementing the preferred alternative would provide the Tennessee Valley with an additional 20 years of reliable base load power while promoting TVA's efforts to reduce carbon emissions, make beneficial use of existing assets, and deliver power at the lowest feasible cost.

Public Review of the Draft SEIS
On June 1, 2021, TVA published a Notice of Intent (NOI) in the Federal Register announcing plans to prepare a SEIS to address the potential environmental effects associated with extending the operation of BFN Units 1, 2, and 3 for an additional 20 years. The NOI initiated a

30-day public scoping period, which concluded on July 1, 2021. In addition to the NOI in the Federal Register, TVA published notices regarding this effort in two local newspapers: The Decatur Daily which serves the Decatur and the Tennessee Valley in northern Alabama and the News Courier which serves Limestone County. TVA also issued a news release to media and posted the news release on the TVA Web site.

TVA also created a virtual meeting room that remains available for the duration of the NEPA analysis. The URL link to the virtual meeting room was included in the NOI and can be accessed through TVA's website (https://www.tva.com/environment/environmental-stewardship/environmental-reviews/nepa-detail/browns-ferry-nuclear-plant-subsequent-license-renewal). The virtual scoping meeting room contains information on the NEPA process and the proposed action, as well as links to TVA and NRC websites related to the project.

The draft SEIS will be available for public comment for 45 days following publication of the notice of availability (NOA) in the Federal Register. At the close of the public comment period, TVA will respond to the substantive comments received and incorporate any necessary changes into the final SEIS. The completed final SEIS will be transmitted to the U.S. Environmental Protection Agency (USEPA), which will publish another NOA in the Federal Register. TVA will make a decision on the proposed action no sooner than 30 days after the USEPA's NOA of the final SEIS is published in the Federal Register. This decision will be based on the project purpose and need, anticipated environmental impacts as documented in the final SEIS, and cost, schedule, technological, and other considerations. To document the decision, TVA will issue a formal record of decision (ROD).

Table S-1. Summary of the Environmental Impacts of the No Action and Action Alternatives

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Land Use	Changes in land use, land acquisition, or land conversion.	*Impacts of BFN shutdown:* No changes in onsite land use patterns. Potential decrease in offsite land-use impacts from decreased uranium mining demand. *Impacts due to new generation assets:* Alternative sources for energy include a combination of natural gas-fired combined cycle (CC) generation, natural gas combustion turbine (CT) generation, solar photovoltaic (PV) facilities, energy storage facilities, and small modular reactors (SMRs). Some of these alternative sources could be sited on the nearly 880-acre BFN site and some would be sited offsite. Impacts to land use associated with construction of these new sources for energy would be small to moderate.	No changes to offsite or onsite land use Impacts associated with expansion of ISFSI would be assessed under a licensing process separate from that of the BFN SLR. Incremental contribution to cumulative impacts to land uses would be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Geology and Soils	Seismic adequacy	*Impacts of BFN shutdown:* No impacts from potential minor seismic event(s) would be expected during shutdown activities. *Impacts due new generation assets:* The site chosen for any replacement generation facility would be evaluated for geologic conditions and potential seismic impacts during the site-selection process Impacts would largely be associated with ground-disturbing activities associated with the new construction and would be expected to be small.	No changes or new impacts.
	Changes or use of geological resources	*Impacts of BFN shutdown:* Anticipated impacts to soils from decommissioning would be small. *Impacts due new generation assets:* Potential effects from construction could include excavation, grading, and blasting. Impacts could range from small to moderate and would depend on the type and extent of soil disturbance activities.	No changes or new impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Surface Water	Surface water hydrology and water quality.	*Impacts of BFN shutdown:* Impacts to surface water quality would be small, and potentially beneficial. *Impacts due to new generation assets:* The characteristics of the surface water impacts would be expected to be small because they would be controlled under an NPDES permit that would be regulated by the state in which the plant(s) is located. There is a potential that some erosion and sedimentation may occur during construction; however, construction would be temporary, and the implementation of best management practices (BMP) should limit any potential impacts to surface water quality. Depending on the water source, the impacts on water quality caused by plant discharge could have noticeable impacts. The plant would have to maintain compliance with the plant's NPDES permit. Impacts would be expected to be small.	All releases to surface water would be controlled as per NPDES permits and impacts would remain small. BFN complies with current NRC regulations. No change is anticipated regarding potential impacts from the current level of small impacts anticipated.
	Surface water use and trends.	*Impacts of BFN shutdown:* Impacts to surface water use would be small, and potentially beneficial. *Impacts due new generation assets:* Surface water use impacts would depend on the volume of water withdrawn for makeup water for each new generation source relative to the amount available from the intake source and the characteristics of the surface water. The overall impacts could be small for water use impacts during normal flows and possibly large impacts during extreme low-flow conditions. Potential impacts can be mitigated by derating (reducing the thermal output of the plant by reducing its electrical power rating) during periods of thermal sensitivity.	Direct, indirect, and cumulative effects of chemical and thermal discharges would be small. No changes in current level of small impacts to water supply. No cumulative effects to water supply are expected.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Surface Water (continued)	Hydrothermal effects of plant operation.	*Impacts of BFN shutdown:* Impacts would be small, and potentially beneficial. *Impacts due new generation assets:* Hydrothermal impacts on surface water from an SMR or gas-fired plant would be site specific, and dependent on the volume and temperature of water discharged. The use of cooling towers and compliance with the NPDES permit should minimize impacts which could range from small to large.	BFN would continue to operate within the thermal limits set by BFN's NPDES permit and without measurable adverse impact. BFN is in compliance with current NRC and ADEM regulations related to thermal discharge evaluation requirements; therefore, no change regarding any potential impact from the current level of small impact would be anticipated, including to cumulative impacts.
	Chemical additives for plant operation.	*Impacts from BFN shutdown:* The use of chemical additives would decrease and eventually end resulting in small and potentially beneficial impacts. *Impacts due new generation assets:* Plant discharges would be regulated by the state in which the plant is located. An NPDES permit would be required, and the plant would comply with applicable water quality standards and criteria. Therefore, when the new generation source commences operation, the direct, indirect, and cumulative effects of chemical discharges would be expected to be small.	Current use and discharge of chemical additives is expected to remain the same during the proposed subsequent period of extended operation. There would be no change in impact from the current level of small impact.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Groundwater	Chemical and radiological impacts to groundwater.	*Impacts from BFN shutdown:* No effects to the groundwater hydrology, groundwater use, or groundwater quality.	No change from current level of small impact.
	Groundwater use.	*Impacts due new generation assets:* Groundwater impacts for new generation resources would depend on the use of groundwater and construction activities required to build the plant, aquifer conditions, and other withdrawals and on the type of plant constructed. With compliance with all permits and regulations and use of BMPs, chemical and radiological impacts to groundwater would be anticipated to be small. Although it is unlikely that groundwater would be used for makeup and/or cooling water, it would depend on site-specific conditions and therefore the impacts could be moderate to large.	No groundwater use at BFN. No impact anticipated.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Floodplains and Flood Risk	Construction or modification of the floodplain.	*Impacts from BFN shutdown:* No impact is anticipated on any floodplain or flood risk since a majority of the site is located outside of the floodplain. Negligible beneficial impacts would occur if facilities within the 100-year floodplain were removed upon shutdown. *Impacts due to new generation assets:* Construction and operation of a new plant(s) would introduce construction impacts and new incremental operational impacts. All proposed construction would be evaluated to ensure consistency with EO 11988. Proper standard erosion-control measures would be followed to minimize the potential for adverse impacts on floodplains. Therefore, impacts would be anticipated to be small.	No increase in flood risk and no new impacts to floodplains in the Wheeler Reservoir watershed.
Wetlands	Destruction of wetlands or degradation of wetland functions.	*Impacts from BFN shutdown:* No impacts to wetland resources on or in the vicinity of BFN would be anticipated. *Impacts due to new generation assets:* Construction of new generating sources for energy would result in small to large impacts depending on the physical location of the plant structures and footprint.	Impacts would be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Aquatic Ecology	Destruction of aquatic organisms; degradation or destruction of aquatic habitat.	*Impacts due to BFN shutdown:* Elimination of impingement and entrainment, thermal effects, non-cooling water discharge, maintenance dredging, and other operational effects generally would be expected to be small and beneficial for aquatic resources. *Impacts due to new generation assets:* Construction and operation of new SMR plant(s) could range from small to large depending on plant design, organisms present, source water, and receiving water. Construction and operation of other generating sources would range from small to large depending on location of the plant and supporting structures. Impacts would be mitigated through use of BMPs and adherence to permit and regulatory requirements.	Impacts from impingement and entrainment, thermal effects, non-cooling water discharge, maintenance dredging, and other operational effects would be small.
Terrestrial Ecology	Removal or degradation of terrestrial vegetation, wildlife habitat, and/or wildlife.	*Impacts due to BFN shutdown:* The elimination of operational effects would be expected to be small and beneficial for terrestrial resources. *Impacts due to new generation assets:* In association with construction of a new generation facility, impacts would occur to terrestrial plants cleared to accommodate the new plant site. Wildlife in the vicinity may be able to relocate and would have lesser impacts due to displacement, habitat loss, and fragmentation. Direct and indirect impacts from construction of these new sources for energy would range from small to moderate. Small cumulative impacts to terrestrial vegetation and wildlife.	No change from current BFN operations and impacts would be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Endangered and Threatened Species	Mortality, harm, or harassment of federally listed or state-listed species including impacts to their critical habitat.	*Impacts due to BFN shutdown:* The elimination of operational effects would be expected to be small and beneficial for threatened and endangered species. *Impacts due to new generation assets:* Possible alternative sources could be sited onsite or offsite. Small to large indirect and direct impacts from alterations in land use patterns and human population density and growth rates that could alter habitats. Construction of generating sources could have small to large cumulative impacts from potential habitat loss, habitat fragmentation, and loss of biodiversity.	No effect on the gray bat, Indiana bat, northern long-eared bat, and tricolored bat. BFN operations that could result in tree removal would be assessed in separate environmental reviews and Section 7 Consultation would occur as appropriate to address potential impacts. Small impacts on monarch populations, bald eagles, migratory birds, aquatic species.
Managed and Natural Areas	Degradation of the value or quality of natural areas.	*Impacts due to BFN shutdown:* No impacts to managed and natural areas in the vicinity would be expected. *Impacts due to new generation assets:* Avoidance planning would likely place any potential new generation plants at a safe distance from most natural areas, therefore impacts would be small. However, over time there could be small to large cumulative impacts resulting from additional development.	Impacts would remain small. Cumulative impacts would be small.
Recreation	Degradation or elimination of recreational facilities or opportunities.	*Impacts due to BFN shutdown:* No impacts are anticipated. *Impacts due to new generation assets:* Alternative generation facility locations would be assessed for potential adverse impacts. If a potential facility were sited near a recreational, scenic, or culturally significant area, then noise, dust, viewshed, and watershed impacts could range from small to moderate.	No impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Meteorology, Air Quality, Climate Change and Greenhouse Gasses	Local meteorology and meteorological conditions.	*Impacts due to BFN shutdown:* No impact to meteorology and impact to air quality would be slightly beneficial. *Impacts due to new generation assets:* Prior to construction of a new generating plant, local meteorological conditions would be evaluated to model dispersion characteristics as well as the potential impact on the local air quality from the operation of the new facility.	No impact.
	Emissions resulting in increases of air pollutants.	*Impacts due to BFN shutdown:* Once the destruction and recycling of site structures and facilities began, there would be a brief period of increased pollutant emissions from construction-type activities resulting in temporary adverse air quality impacts. These would be minimized through use of BMPs and adherence to all applicable regulations. *Impacts due to new generation assets:* Construction of alternative generation sources would result in a temporary increase in fugitive dust emissions, vehicular traffic emissions, heavy equipment emissions, and concrete batch plant emissions. BMPs would be used to control the sources of emissions, and the impacts would be small and of short duration. Depending on alternative power generation methods, adverse operational impacts to air quality would be small to moderate.	BFN is not a significant source of pollutants, and the impact of operation for an additional 20-year period would be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Meteorology, Air Quality, Climate Change and Greenhouse Gasses (continued)	Climatology and effects due to climate change.	*Impacts due to BFN shutdown:* Small impacts on GHGs as a result of emissions during decommissioning. These impacts would be temporary and would not be expected to contribute to climate change. *Impacts due to new generation assets:* Small impacts on GHGs from the construction of alternative generation sources. These impacts would be temporary and would not be expected to contribute to climate change. Operation of a new SMR or solar plant(s) would not create a significant source of pollutants including GHG, because those facilities produce considerably less air pollutants when compared to fossil-fueled generation sources. Therefore, the environmental impact of a new SMR or solar plant(s) would be small. Operation of a new natural gas fired turbine plant would increase some GHGs and impacts would be small to moderate.	The impacts of BFN on global climate change and greenhouse gas emissions would be expected to be small.
	Gasoline and diesel emissions from vehicles and equipment.	*Impacts due to BFN shutdown:* Vehicle and equipment emissions would initially increase during decommissioning of BFN which would result in small temporary impacts on GHG emissions. *Impacts due to new generation assets:* Vehicle and equipment emissions would initially increase during construction of any alternative generation resources which would result in small temporary impacts on GHG emissions.	No changes or new impacts would occur.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Transportation	Elevated levels of traffic from construction work force and deliveries.	*Impacts due to BFN shutdown:* Any decline in traffic due to plant closure would likely be partially offset by future development. *Impacts due to new generation assets:* Construction and operation of a new generation facility would potentially impact the transportation infrastructure and traffic load on the roadways associated with a site. Mitigation of potential transportation impacts due to the location of a facility may be necessary because of expected increases in construction and operation traffic. Therefore, impacts could range from small to moderate.	No changes or new impacts expected.
Visual Resources	Effects on scenic quality, degradation of visual resources.	*Impacts due to BFN shutdown:* No adverse impacts. *Impacts due to new generation assets:* The impact on the visual resources of an area would be dependent upon the physical, biological, and cultural characteristics of the potential new generation site. The level of impact anticipated during construction and operation would range from small to moderate and vary depending upon viewer distance from the site, the abundance of trees, hilly terrain, and mitigation measures used, such as utilizing landscape materials on site, and painting techniques applied to facility structures.	No new impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Noise and Vibration	Generation of noise at levels causing a nuisance to the community.	*Impacts due to BFN shutdown:* A drop in industrial noise would result in a small beneficial impact long-term. *Impacts due to new generation assets:* Noise impacts for a new generation facility and transmission systems are dependent on the distance to the nearest critical receptor. Noise for the construction of a new generation plant is expected to be small to moderate (depending on location and type of sensitive receptor) because most noise-producing construction activities are of short duration and the construction is temporary, and there are numerous mitigation methods that can be implemented to limit the impact of noise. Operational noise would also be anticipated to be small.	Impacts would be small. No change from the current condition.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Socioeconomics	Changes in local populations, employment, and incomes.	*Impacts due to BFN shutdown:* Impacts related to loss of jobs and income would be short-term and small. *Impacts due to new generation assets:* Potential effects from construction and operation of new assets could help offset the loss of jobs from BFN shutdown, it could also result in a small shift in population both during construction and operation. Therefore, impacts could range from small to moderate, depending on site specific site conditions.	No changes in operating employment levels. No new impacts to population, local employment, or income.
	Changes in availability of housing.	*Impacts due to BFN shutdown:* May cause housing costs to slightly decrease which would result in short-term and small impacts. *Impacts due to new generation assets:* Population shifts related to construction of new generation sources could place pressures on the housing market during both construction and operations. impacts could range from small to large depending on available housing surrounding the potential site areas.	No changes or new impacts.
	Local government revenues.	*Impacts due to BFN shutdown:* Small impact on local government revenues as a result in potential changes in TVA's payment in lieu of taxes. *Impacts due to new generation assets:* Construction and operation of replacement generation sources would result in a beneficial impact if the total amount of TVA-managed land in any individual county increased. Revenue increases would be proportionally small. Impacts from construction and operation would be beneficial.	No changes or new impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Socioeconomics (continued)	Police, fire, and medical services.	*Impacts due to BFN shutdown:* Phased reduction in the need for public safety services and emergency personnel. These changes would likely be offset by continued growth in the counties in the vicinity of BFN. *Impacts due to new generation assets:* Depending on the proximity to population centers and the availability of emergency services in the vicinity of these generation resources, the influx of construction workers could impact the ability of an area's police, fire, and medical facilities to provide support requiring additional resources. The expansion of public safety services would support incoming operational staff and families expected to permanently move to the area, as well as other further county population growth. Therefore, impacts could range from small to moderate.	No changes or new impacts.
	Schools and education.	*Impacts due to BFN shutdown:* The loss of operational jobs could result in a loss of population and result in reduced school enrollment. Impacts would likely be small. *Impacts due to new generation assets:* The arrival of workers and the facility would bring new monies to a region through direct and indirect spending, and in the long run, the costs of providing education for additional students should be offset by the increase in tax revenues and plant equivalent payments, therefore impacts should be small.	No changes or new impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Environmental Justice	Disproportionate effects on low-income and/or minority populations.	*Impacts due to BFN shutdown:* impact is expected to be short-term and small with no disproportionate impacts to potential environmental justice communities of concern. *Impacts due to new generation assets:* Environmental justice issues would depend on the proposed location of the new generation assets and impacts could range from small to moderate based on pressure on food and housing process, or increases in road congestion or noise near residential communities	No disproportionate effects on low-income or minority populations. No incremental contribution of the continued operation of BFN to the cumulative environmental justice conditions in the region during the proposed subsequent period of extended operation

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Archaeological and Historic Resources	Damage to archaeological sites or historic structures.	*Impacts due to BFN shutdown:* Any decommissioning activities, including but not limited to demolition could result in adverse effects to the National Register of Historic Places-eligible BFN historic district and contributing structures Should any activity related to decommissioning be proposed that would modify BFN or affect any of the potentially-eligible archaeological sites, TVA will follow the steps of §800.5 for assessing adverse effects and, if required, the steps of §800.6 for resolving adverse effects. *Impacts due to new generation assets:* All lands involved in the undertaking would likely need an inventory and evaluation of cultural resources to identify historic properties and may require avoidance plans or other actions to mitigate adverse effects from proposed ground-disturbing actions and/or visual effects related to physical activities at the proposed site. The effects on cultural resources could, depending on the site, range from small to large. The anticipated NHPA Section 106 process would ensure that any historic properties would be properly identified and managed and that potential impacts would be considered and mitigation developed as appropriate.	No effect to archaeological and historic resources within BFN site or vicinity are expected. Should any activity related to SLR be proposed that would modify BFN or affect any of the potentially-eligible archaeological sites, TVA will follow the steps of §800.5 for assessing adverse effects and, if required, the steps of §800.6 for resolving adverse effects.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Hazardous, Solid, and Low-Level Radioactive Wastes	Generation and disposal of hazardous, sold, and low-level radioactive wastes.	*Impacts due to BFN shutdown:* Impact on the environment from waste generated during the period of decommissioning would be small. *Impacts due to new generation assets:* The quantities and types of solid waste generated by the construction and operation of replacement generation resources would be determined primarily by the number of acres, the initial condition of the selected site(s), and the location and type of technology chosen. Any construction and demolition wastes generated during the building and renovation process would be managed through the TVA waste disposal contracts to access the permitted disposal capacity or recycling facilities, as needed. Construction of new transmission lines has a potential to produce large volumes of solid waste. TVA-established management practices would ensure impacts to the public and the environment are small.	Waste would continue to be handled according to TVA approves procedures and federal regulations. Impacts would continue to be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Radiological Effects of Normal Operations	Effects to humans and nonhuman biota from normal radiological releases.	*Impacts due to BFN shutdown:* Decommissioning effluent releases would be small. *Impacts due to new generation assets:* There would be no radioactive effects during the construction of a new SMR plant(s) unless the construction takes place at the location of another operating nuclear plant, or there are multiple units being built and one unit becomes operational before the other(s). The radiological impacts from the construction of a new nuclear plant would be of minor significance to the construction workers. There would be no expected observable impacts from radioactive liquid or gaseous releases from a new SMR plant(s) during normal operations. The REMP would be set up for the new SMR plant(s) to ensure there are no measurable indirect or cumulative effects to the environment offsite of the new location or to the public. There would be no radioactive impacts from the construction and operation of other potential generation resources.	Annual doses to the public are well within regulatory limits; no observable health impacts are expected. No changes or new impacts are expected. Doses to nonhuman biota would be well below regulatory limits; no noticeable effects are expected and impacts are expected to remain small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Uranium Fuel Cycle Effects	Radioactive waste volumes and disposal.	*Impacts due to BFN shutdown:* Impacts associated with radioactive waste handling, storage, and transportation for decommissioning activities would be expected to be small. *Impacts due to new generation assets:* If new SMR generation were selected, the approved design would be subject to the same requirements for handling and processing radioactive waste at BFN. Similar to BFN, the environmental impacts associated with radioactive waste handling, storage, and transportation would be expected to be small and potentially less than BFN. There would be no environmental impact related to radioactive waste during the construction or operation of any non-nuclear power generation facility.	Impacts to the public and the environment resulting from processing, storage, and transportation of solid radwaste, including cumulative effects of waste storage from BFN would remain small. During decommissioning, the plant would ship all stored radioactive material to be processed or to its final disposal. Transportation impacts of all types of radioactive waste would be expected to be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Uranium Fuel Cycle Effect (continued)	Radioactive waste transportation.	*Impacts due to BFN shutdown:* Generation of routine operational radioactive waste would cease. However, decommissioning of active components would generate waste and result in in small impacts. *Impacts due to new generation assets:* Impacts associated with radioactive material transportation at any new SMR facility would be small.	The impact to members of the public resulting from processing, storage, and transportation of solid low-level radioactive waste would be small.
	Spent fuel.	*Impacts due to BFN shutdown:* No additional spend fuel would be generated after BFN is shutdown. Small impacts as it is operated under a separate license. *Impacts due to new generation assets:* Impacts associated with spent fuel storage at any new SMR generation facility would be expected to be small. There would be no environmental impact related to spent nuclear fuel during construction or operation of any non-nuclear power generation facility. Potential effects from construction and operation of any replacement generation resource would be evaluated in separate analyses	Small impacts from the operation of the ISFSI, as it is operated in accordance with all applicable regulations. Additional ISFSI storage capacity would be required before 2036 if DOE does not take possession of spent fuel. Impacts from the construction and operation of an additional storage pad would be assessed in a separate evaluation and would be expected to have small cumulative impacts including small direct impacts from radiation doses from the ISFSI for onsite workers and people in the surrounding area.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Nuclear Plant Safety and Security	Postulated design-basis accidents.	*Impacts due to BFN shutdown:* All equipment and facilities would be properly maintained to ensure high integrity and safety of all systems through the end of operation and decommissioning. *Impacts due to new generation assets:* Impacts at any new SMR facility would be expected to be small. For any non-nuclear electrical power generation facility, there would be no applicable environmental impact related to DBAs.	In all cases, the doses to an assumed individual at the exclusion area boundary and low population zone are a fraction of the regulatory dose limits. Environmental risks due to postulated radiological accidents are small.
	Severe accidents.	*Impacts due to BFN shutdown:* Impacts would no longer be applicable. *Impacts due to new generation assets:* Impacts at any new SMR facility would be expected to be small and of no significance. For any non-nuclear electrical power generation facility, there would be no applicable environmental impact related to severe radiological accidents.	Severe accident analysis indicates that the risk is small and meets all safety goals.
	Plant security.	*Impacts due to BFN shutdown:* Small impacts and bound by the server accident scenarios. *Impacts due to new generation assets:* Impacts for an SMR facility would be bound by the severe accident scenarios and would be expected to remain small. For any non-nuclear electrical power generation facility, nuclear plant security regulations are not applicable.	TVA is in compliance with all regulations on plant security and plant security related impacts would remain small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Nonradiological Public Health and Safety	Electric shock and microbiological hazards.	*Impacts from BFN shutdown:* Electric shock hazards from in-scope transmission lines would be nullified. Impacts to public health would be small and beneficial from the reduced heating of waters for thermophilic organisms. *Impacts due to new generation assets:* Potential effects from construction and operation of new generation assets would be evaluated in separate analyses and impacts could range from small to moderate.	The public is precluded from accessing the site and from direct contact with transmission lines, therefore, possible shock hazard is small. No new impacts to public health from thermophilic organisms are anticipated.
Decommissioning	Environmental, cultural, and socioeconomic impacts.	Impacts would be similar to Alternative B and small.	Delaying decommissioning of the BFN reactors as a result of SLR would have small beneficial and negative impacts.

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Symbols, Acronyms, Abbreviations, and Glossary of Terms

°C	degrees Celsius
°F	degrees Fahrenheit
ADEM	Alabama Department of Environmental Management
ADPH	Alabama Department of Public Health
Aero	Aeroderivative
Ag	silver
ALARA	as low as reasonably achievable
APE	area of potential effects
AREOR	Annual Radiological Environmental Operating Report
BCC	birds of conservation concern
BESS	battery energy storage systems
BFARF	Browns Ferry Aquatic Research Facility
BFN	Browns Ferry Nuclear Plant
BGEPA	Bald and Golden Eagle Protection Act
BMP	best management practices
BTA	best technology available
BWR	Boiling Water Reactor
C&D	construction and demolition
CAA	Clean Air Act
CAES	compressed air energy storage
CAGR	Compound Annual Growth Rate
CC	combined cycle
CCW	condenser circulating water
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
Ci	curies
Co	cobalt
CO2	carbon dioxide
CPUE	catch per unit effort
CRP	Cummings Research Park
Cs	cesium
CST	condensate storage tank
CSX	CSX Transportation, Inc
CT	combustion turbine
CWA	Clean Water Act
CWIS	cooling water intake structure
DAW	dry active waste
dB	decibels
dBA	decibels in A-weighted scale
DBAs	Design Bias Accidents
DDT	dichlorodiphenyltrichloroethane
DNL	day/night sound level
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation

DR	demand response
EA	Environmental Assessment
EAB	Exclusion Area Boundary
EE	energy efficiency
EECW	emergency equipment cooling water
EFH	essential fish habitat
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EO	Executive Order
EPRI	Electric Power Research Institute
EPU	extended power uprate
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FICON	Federal Interagency Committee on Noise
FONSI	Finding of No Significant Impact
fps	feet per second
FR	Federal Register
FRP	Flood Risk Profile
FY	Fiscal Year
GEIS	Generic Environmental Impact Statement
GHG	greenhouse gas
GIS	geographic information system
gpm	gallons per minute
HAP	hazardous air pollutant
I&I	irreversible and irretrievable
IGCC	integrated gasification combined cycle
IPaC	Information for Planning and Consultation
IRP	Integrated Resource Plan
ISFSI	independent spent fuel storage installation
kV	kilovolt
LLRW	Low level radioactive waste
MBTA	Migratory Bird Treaty Act
MGD	million gallons per day
Mn	manganese
Mph	miles per hour
mrad	millirad
mrem	millirem
mrem/yr	millirem per year
msl	mean sea level
MW	megawatt
MWd/MTU	megawatt day/metric tons of uranium
MWe	megawatts electric
MWh	megawatt hour
MWt	megawatt thermal
NAAQS	National Ambient Air Quality Standards
NAVD 88	North American Vertical Datum of 1988

NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NESC	National Electric Safety Code
NHPA	National Historic Preservation Act
NLCD	National Land Cover Database
NOA	Notice of Availability
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
ODCM	Off-site Dose Calculation Manual
OLTP	operating license thermal power
PAM	primary amoebic meningoencephalitis
PCB	polychlorinated biphenyl
pCi/L	picocurie per liter
PFOS	perfluorooctane sulfonate
PM10	particulate matter with aerodynamic diameters of 10 microns or less
PM2.5	particulate matter with aerodynamic diameters of 2.5 microns or less
PPA	Power Purchase Agreement
PV	photovoltaic
RCRA	Resource Conservation and Recovery Act
REMP	Radiological Environmental Monitoring Program
RFAI	Reservoir Fish Assemblage Index
RHA	Rivers and Harbors Act
RHR	residual heat removal
ROD	Record of Decision
ROI	Region of Interest
ROW	right-of-way
RV	recreational vehicle
SCPC	supercritical pulverized coal
SEIS	Supplemental Environmental Impact Statement
SHPO	state historic preservation officer
SLR	subsequent license renewal
SLRA	subsequent license renewal application
SMR	small modular reactor
SND	summer net dependable capacity
SPCC	spill prevention, containment, and countermeasure
spp	species (plural)
TMDL	total maximum daily load
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
TVARAM	Tennessee valley Authority Rapid Assessment Method
TWH	terawatt hours
UFC	uranium fuel cycle
USACE	US Army Corps of Engineers

USCB	US Census Bureau
USDA	US Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
WMA	Wildlife Management Area
Zn	zinc

CHAPTER 1 – PURPOSE AND NEED FOR THE PROPOSED ACTION

The current Nuclear Regulatory Commission (NRC) operating licenses for Browns Ferry Nuclear Plant (BFN) expire on December 20, 2033, for Unit 1, June 28, 2034, for Unit 2, and July 2, 2036, for Unit 3. The purpose of the proposed action is to continue to generate baseload power at the BFN site between 2033 and 2056 through obtaining subsequent license renewals (SLRs) from the NRC to continue operation of all three BFN units. BFN's current baseload generation supports future forecasted baseload power needs, as outlined in the Tennessee Valley Authority's (TVA) 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation capacity. Renewal of the current operating licenses would allow BFN to continue supplying approximately 3,900 Megawatts electric (MWe) capacity of safe, clean, reliable, and cost-effective baseload power for an additional 20 years. The BFN SLR is a key component of meeting TVA's goal of a net-zero carbon emissions generating system by 2050.

TVA is the largest producer of public power in the United States. TVA provides wholesale power to 154 local power companies and directly sells power to 58 industrial and federal customers. TVA's power system serves nearly 10 million people in a seven-state, 80,000-square-mile region (Figure 1.1-1). In Fiscal Year (FY) 2018, TVA efficiently delivered more than 163 billion kilowatt-hours of electricity to customers from a power supply that was 39 percent nuclear, 26 percent natural gas, 21 percent coal-fired, 10 percent hydro, and 3 percent wind and solar. The remaining one percent results from TVA programmatic energy efficiency efforts (TVA 2019b).

According to forecasting and power system planning models, TVA expects annual peak load and net system power requirements to increase at a 0.3 percent compound annual growth rate (CAGR) through 2029 (TVA 2019b). TVA has a legal obligation to meet this demand while maintaining low-cost, reliable power for consumers in the power service area. Consistent with its 2020 Environmental Policy, TVA also plans to use cleaner energy options and energy efficiency initiatives to reduce the intensity of carbon emissions from its power system.

Subsequent renewal of the BFN operating licenses would involve continuation of normal operations, maintenance, and refueling. These activities would continue to be managed in accordance with TVA programs and procedures. No refurbishments are expected to occur during the proposed subsequent period of extended operation, as described in Sections 2.1.2 and generically discussed in Chapter 4 of federal guidelines, Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Power Plants (2013 GEIS).

BFN has two onsite independent spent fuel storage installations (ISFSIs) using dry cask storage. Expansion of the onsite ISFSI capacity will be required by 2036 to support BFN operations during the proposed subsequent period of extended operation if the U.S. Department of Energy (DOE) does not provide for permanent storage and disposal of the onsite spent fuel as planned. This expansion would require the construction of an additional concrete storage pad similar to the ones used for the current ISFSIs; however, construction of an ISFSI pad, if needed, would be addressed in a separate environmental review in compliance with the National Environmental Policy Act (NEPA; 42 United States Code [U.S.C.] 4321 et seq.), associated Council on Environmental Quality (CEQ) regulations (40 CFR Part 1500), and TVA's NEPA Procedures (18 CFR 1318). Regardless, existing equipment and procedures would continue to be used to store the spent fuel at BFN until DOE provides a permanent long-term storage location.

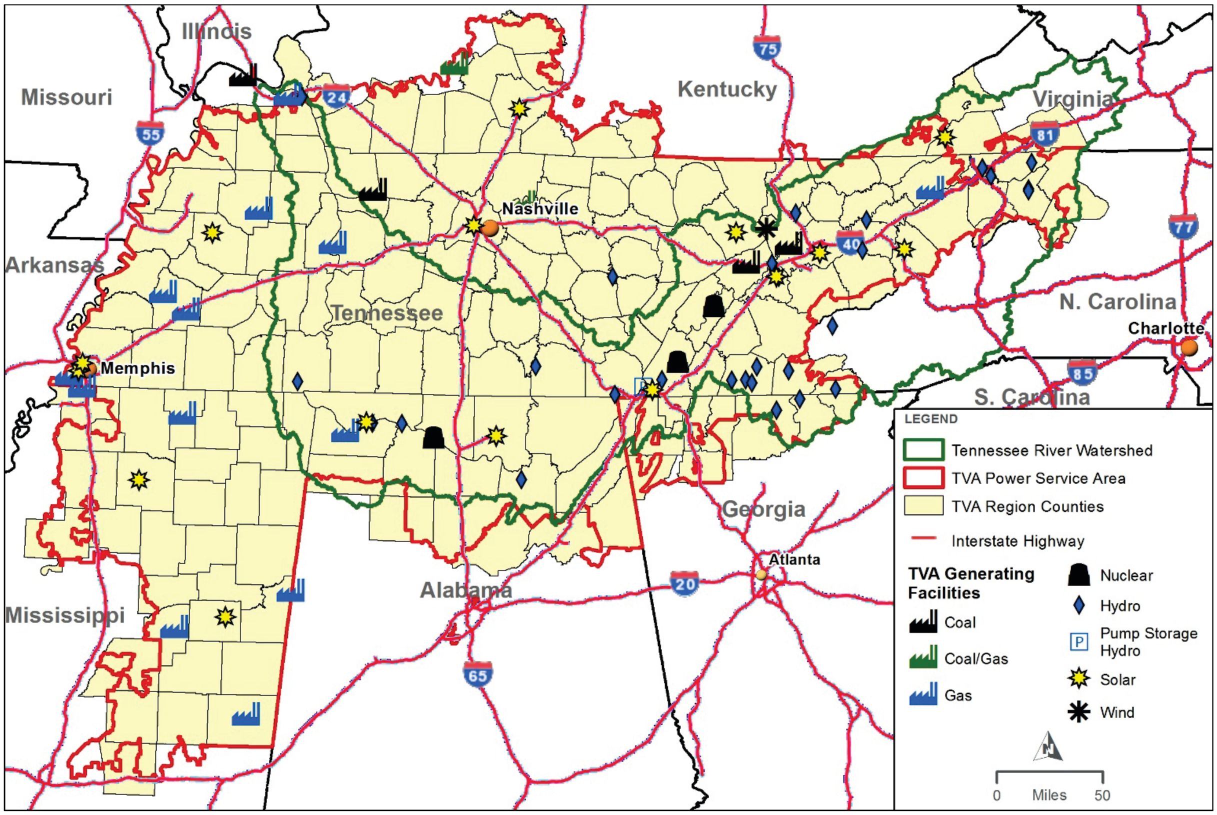


Figure 1.1-1. Power Service Area and Tennessee River Watershed in the TVA Region

1.1. Decision to be Made

TVA must decide whether to submit a subsequent license renewal application (SLRA) to the NRC to renew the operating licenses of the three BFN units for an additional 20 years beyond their current license expiration dates. Therefore, TVA has prepared this Supplemental Environmental Impact Statement (SEIS) to inform TVA decision-makers, agencies, and the public about the potential environmental impacts associated with the proposed action.

In accordance with NRC NEPA procedures, the NRC would evaluate TVA's SLRA and conduct its own environmental review to evaluate the potential environmental impacts of granting renewed operating licenses for BFN Units 1-3. As part of the SLRA, TVA would submit an environmental report to the NRC that describes the potential environmental impacts of renewing BFN's operating licenses.

1.2. Background

TVA operates BFN Units 1, 2, and 3 in Limestone County, Alabama. Unit 1 began commercial operation in 1974, Unit 2 in 1975, and Unit 3 in 1977. The BFN site is located on an approximately 880-acre tract on the north shore of Wheeler Reservoir at Tennessee River Mile (TRM) 294, approximately 30 miles west of Huntsville, Alabama, 10 miles northwest of Decatur, Alabama, and 10 miles southwest of Athens, Alabama. Figure 1.2-1 shows the 50-mile region surrounding BFN for locational context. Figure 1.2-2 shows the 6-mile vicinity around BFN which is the primary area of focus for this analysis.

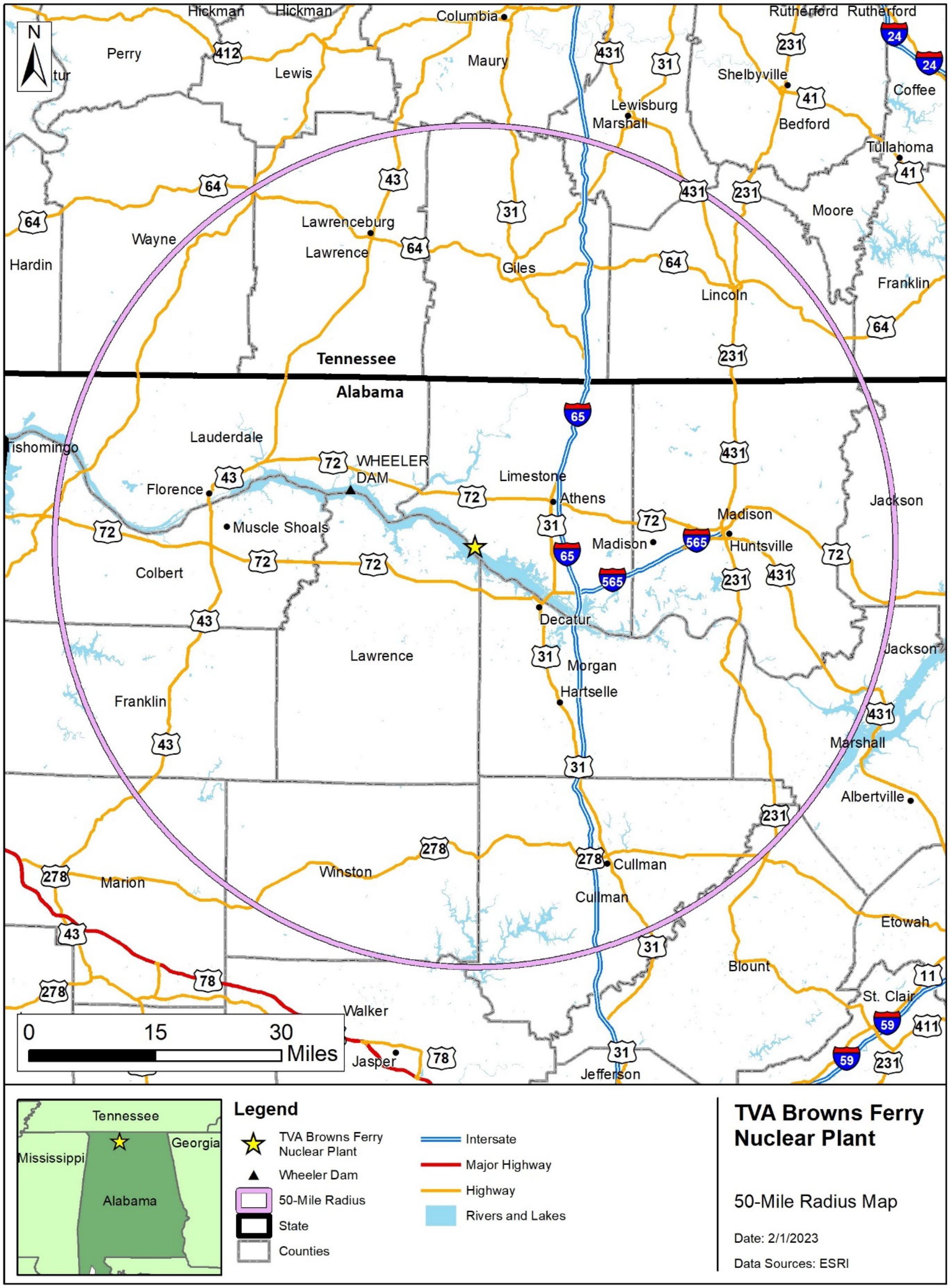


Figure 1.2-1. Regional Location Map for Browns Ferry Nuclear Plant

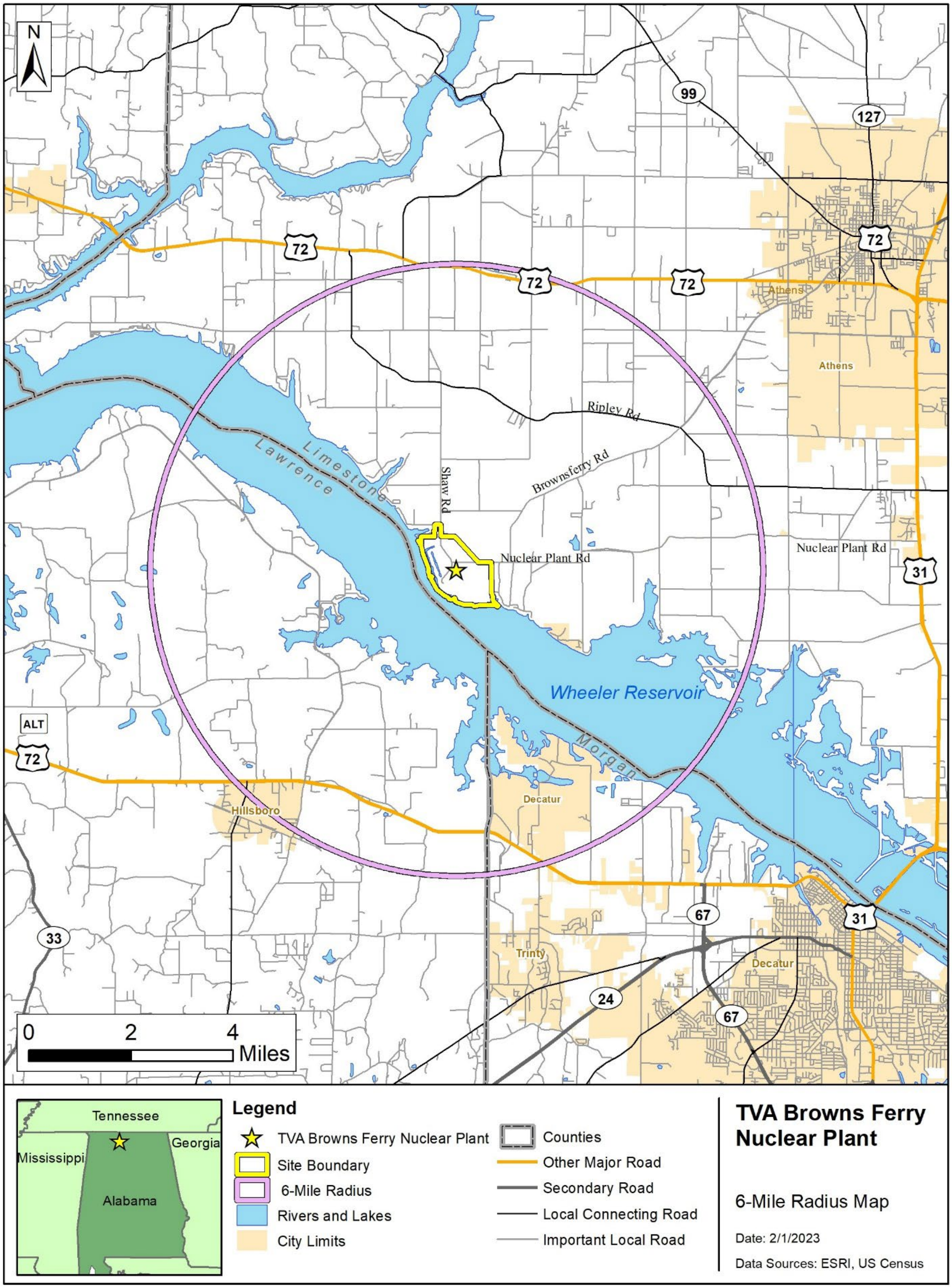


Figure 1.2-2. 6-Mile Vicinity Map for Browns Ferry Nuclear Plant

1.2.1. General Plant Information

The BFN facility consists of a reactor building, a turbine building, a service building, a maintenance building, two diesel generator buildings (one for Units 1 and 2 and one for Unit 3), a radioactive waste building, administration buildings, an intake pumping station, a 161-kilovolt (kV) switchyard and a 161-kV capacitor yard, a 500-kV switchyard, seven helper cooling towers, an off-gas stack, hot water and cold water discharge channels, and a meteorological tower. Additional facilities include a training center, materials and procurement complex, low -level radioactive waste and hazardous waste storage areas, wastewater lagoons, a Diverse and Flexible Coping Strategies (FLEX) equipment storage building, and ISFSI pads. Figure 1.2-3 shows the general features of the facility and the site boundary. Five of the original six helper cooling towers that serve BFN (Cooling Towers 1 and 3-6) have been replaced, Cooling Tower 2 is scheduled for replacement by 2027, and Cooling Tower 7 was constructed in May 2012 (TVA 2020b).

BFN consists of three General Electric Type 4 boiling water reactors (BWR/4) and associated turbine generators that collectively supply approximately 3,900 MWe to the TVA transmission and distribution system. Each of BFN's three nuclear reactors is connected to its own dedicated generator. BFN uses a once-through (open cycle) condenser circulating water system with seven helper cooling towers which can be used to dissipate waste heat and reduce cooling water temperature as necessary to comply with a National Pollutant Discharge Elimination System (NPDES) permit issued by the state of Alabama before cooling water is discharged back to Wheeler Reservoir.

1.2.2. Reactor and Containment System

The BWR/4 reactor systems at BFN are characterized by a reactor vessel housing a reactor core where nuclear fission within the uranium dioxide fuel pellets creates heat; thus, causing the coolant water to boil. The resultant steam and water droplets are separated by steam separators and steam dryers. The dried steam is directed to the turbine generators, which rotate and generate electricity. After exiting the turbine, steam is cooled back to coolant water in the condenser and then returned to the reactor core. Off-gases are treated through the off-gas treatment system and then released through the BFN main stack.

The primary containment system for each unit at BFN is a Mark I pressure suppression system consisting of a drywell, pressure suppression chamber, vent system, isolation valves, containment cooling system, and other service equipment.

Designed to withstand an internal pressure of 62 pounds per square inch above atmospheric pressure and coupled with its engineered safety features, each Mark I containment is designed to provide adequate radiation protection for both normal operation and postulated design-basis events, such as earthquakes or loss of coolant.

The reactor building acts as a secondary containment system by surrounding the primary containments, which, in turn, surround the reactor vessels. In addition, the reactor building houses refueling and reactor servicing equipment, new and spent fuel pools, and other reactor safety and auxiliary systems.

The containment systems and their engineered safeguards are designed to ensure that offsite doses resulting from postulated design-basis events are well below the guidelines in 10 Code of Federal Regulations (CFR) 50.67.

Figure 1.2-3. Browns Ferry Nuclear Plant Site Map

1.2.3. Fuel Enrichment, Burn-Up, and Independent Spent Fuel Storage

BFN Units 1, 2, and 3 are licensed to operate using fuel composed of uranium-dioxide pellets enriched at 2 to 5 percent by weight of uranium-235 and contained in sealed zircaloy fuel rod tubes which are assembled into individual fuel bundles. Average peak rod fuel burn-up for each unit will not exceed 62,000-megawatt day/metric tons of uranium (MWd/MTU).

Refueling of one-third of the fuel in each unit is performed approximately every 24 months. Refueling outages occur for approximately 28-35 days. The spent fuel pools for Units 1, 2, and 3 are available for storage of new fuel and spent fuel assemblies. The inventory of fuel assemblies in each pool is maintained such that enough locations are open to accommodate a full core offload at any time. However, the number of spent fuel assemblies in each fuel pool varies due to cycle-specific variations in the number of fuel assemblies discharged at the end of each cycle and the number of spent fuel assemblies removed and transferred to dry storage casks during dry cask storage campaigns.

Spent nuclear fuel from Units 1, 2, and 3 is also stored onsite in dry casks in the ISFSI. The ISFSI complies with the General License issued under 10 CFR Part 72, Subpart K (General License for Storage of Spent Fuel at Power Reactor Sites) and the conditions contained in the Certificate of Compliance for the cask system. Implementation of the ISFSI was reviewed as part of the TVA Final SEIS for operating license renewal of the three units and restart of Unit 1 at BFN (TVA 2002) and does not need to be analyzed herein.

1.2.4. Cooling and Auxiliary Water Systems

This section describes BFN’s condenser circulating water (CCW) system and residual heat removal (RHR) service water system.

1.2.4.1. Condenser Circulating Water System

BFN units operate utilizing a once-though (open cycle) CCW system. The condensers are normally cooled by pumping water from Wheeler Reservoir into the turbine-generator condensers and discharging it back to Wheeler Reservoir via three submerged diffuser pipes. The diffuser pipes are perforated to maximize uniform mixing of BFN thermal effluent into the flow stream. This straight-through flow path is known as “open cycle” or “open mode” operation. The water is withdrawn from Wheeler Reservoir by an intake structure located at about TRM 294.3. The CCW system is designed to provide a flow of approximately 675,000 gallons per minute (gpm) to the condenser during open cycle operation, and a flow of approximately 25,000 gpm to the raw cooling water system of each unit. In addition to flow through the CCW pumps and the raw cooling water system, the plant total intake also includes water for the emergency equipment cooling water system (EECW), the RHR service water system, the fire protection system, the intake screen wash system, and the raw service water system.

BFN returns nearly all of the water it withdraws back to Wheeler Reservoir, albeit at a higher temperature, through three submerged diffuser pipes (see Section 3.3.2). The diffuser pipes (17 feet, 19 feet, and 20 feet 6 inches in diameter) extend across the reservoir channel. Each has the last 600 feet perforated on the downstream side with more than 7,000 two-inch-diameter holes. Thus, approximately 22,000 holes spaced 6 inches on centers in both directions distribute the 4,400 cubic feet per second (cfs) (approximate) of warm water so that it mixes with the water in the reservoir. However, when reservoir temperatures approach one or more of the NPDES limits, the condenser circulating water from one or more units is cooled by one or more helper cooling towers before it is released to the reservoir. BFN has seven mechanical-draft helper cooling towers that can dissipate waste heat to the atmosphere. Water is pumped through the main condenser to an open channel going to the towers of the circulating water pumps for each unit. Water is pumped to each helper cooling tower by lift pumps. The amount of water treated by the helper cooling towers depends on the amount of cooling needed for the plant to remain in compliance with the NPDES permit. TVA may also derate one or more BFN generating units to ensure compliance with NPDES thermal limits.

Normally water is drawn into the circulating water pumping station forebay from Wheeler Reservoir, pumped through the main condenser, and discharged back into the reservoir through a diffuser discharge system consisting of perforated metal pipes which extend across the reservoir channel to diffuse the warmer water from the plant. When reservoir temperatures approach one or more of the NPDES limits, the water is pumped from the reservoir, through the plant, and into an open channel going to the helper cooling towers. It is then pumped through the helper cooling towers and is returned to the reservoir through the diffusers.

1.2.4.2. Residual Heat Removal Service Water

The RHR service water system consists of four pairs of pumps located on the intake structure for pumping raw river water to the heat exchangers in the RHR system and four additional pumps for supplying water to EECW system. The EECW system distributes cooling water supplied by the RHR service water system to essential equipment during normal and accident conditions.

1.2.5. Transmission Lines

TVA is the owner and operator of the transmission lines that connect BFN to the transmission grid. Each BFN unit is connected into the existing TVA 500-kV transmission system by three 500-kV transmission lines via an onsite 500-kV switchyard (Figure 1.2-4). The 500-kV switchyard receives the output of Units 1, 2, and 3 generators and delivers this output to the 500-kV system network for transmission to system loads. BFN is also connected to the 161-kV switchyard through two 161-kV transmission lines. The 161-kV switchyard receives power from the 161-kV system network and delivers this power to station auxiliaries.

Normal BFN power is from the unit station service transformers connected between the generator breaker and main transformer of each unit. Startup power is from the TVA, 500-kV system network through the 500 to 22-kV main and 20.7- to 4.16-kV unit station service transformers. Auxiliary power is available through the two common station service transformers that are fed from two 161-kV lines supplying the 161-kV switchyard.

Continued operation of BFN would not require transmission system upgrades during the proposed subsequent period of extended operation. Any maintenance activities conducted in the transmission line rights-of-way (ROWs) would follow TVA's best management practices for construction and maintenance of transmission lines, *A Guide for Environmental Protection and Best Management Practices for TVA Construction and Maintenance Activities* (TVA 2017b) and TVA's programmatic consultation for ROW Vegetation management (TVA 2018a).

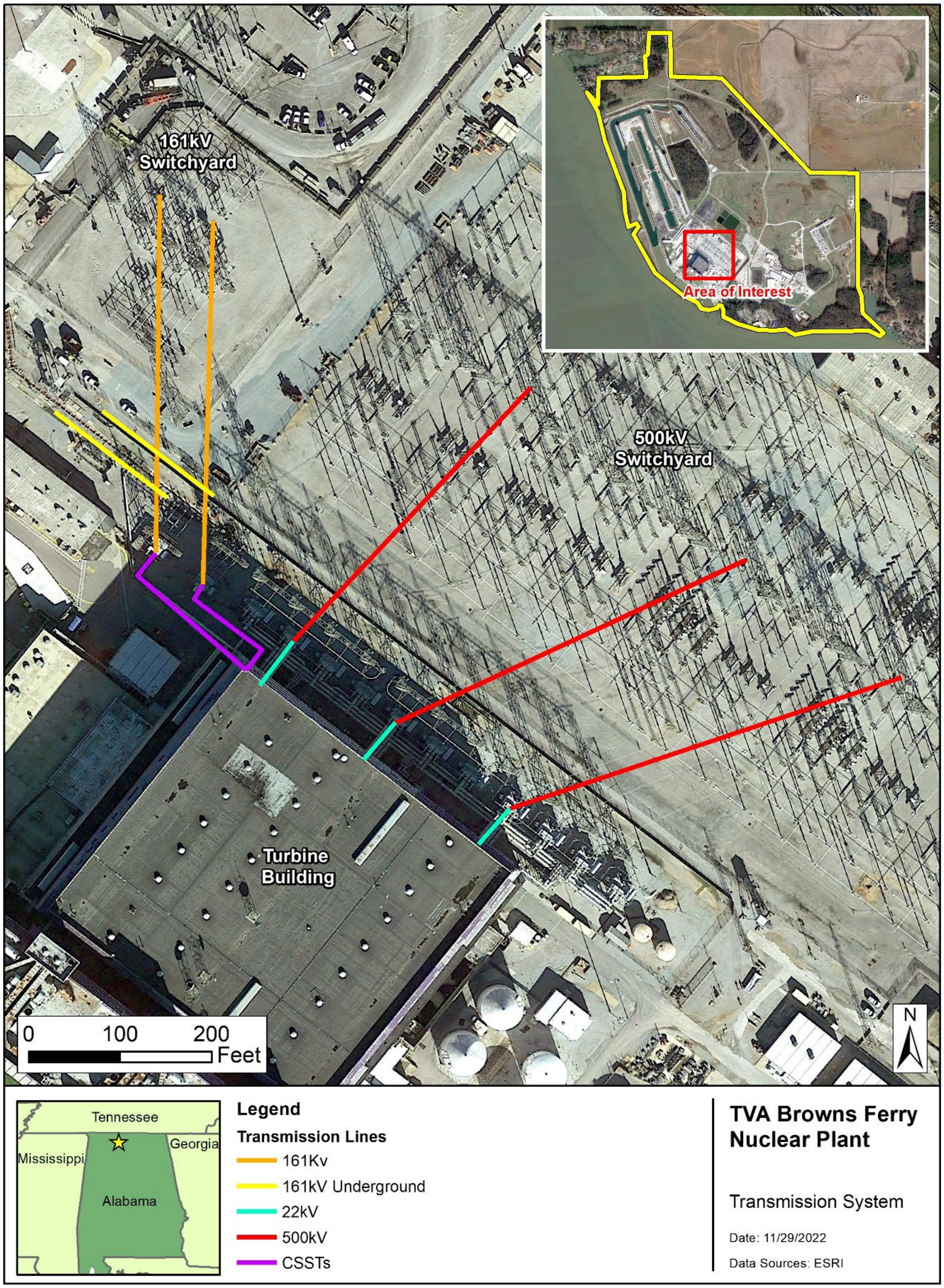


Figure 1.2-4. Browns Ferry Nuclear Plant Onsite Transmission Lines

1.3. The TVA Power System

TVA is a corporate agency and instrumentality of the United States, created by Congress and existing pursuant to the TVA Act of 1933 (16 U.S.C. Part 831) to, among other things, foster the social and economic welfare of the people of the Tennessee Valley region and promote the sustainable use and conservation of the Valley's natural resources. TVA generates and distributes electricity for business customers and local power distributors, serving more than 10 million people in parts of seven southeastern states. TVA is fully self-financed without direct Federal appropriations, and funds virtually all operations through electricity sales and power system bond financing. In addition to operating and investing its revenues in its electric system, TVA provides flood control, navigation, and management for the Tennessee River system, manages 293,000 acres of public land, and assists local power companies and state and local governments with economic development efforts.

TVA's generating assets include: five coal plants, three nuclear facilities, 29 hydroelectric dams, one pumped-storage hydroelectric plant, nine natural gas combustion turbine gas plants, eight natural gas combined cycle gas plants, one diesel generator site, and 13 solar energy sites. TVA has gas-co-firing potential at one coal-fired site as well as biomass co-firing potential at all of its coal-fired sites. TVA also purchases a portion of its power supply from third-party operators under long-term power purchase agreements (PPAs). In total, these assets constitute a portfolio of approximately 37,896 megawatts (MW). In FY 2020 about 10 percent of TVA's annual generation is from hydro; 15 percent is from coal; 21 percent is from natural gas; 41 percent is from nuclear; and the remainder is from PPAs from renewable and non-renewable resources. TVA also gains available electrical distribution capacity through its energy efficiency programs. Like other utility systems, TVA has power interchange agreements with utilities surrounding the Tennessee Valley Region, and routinely buys and sells electricity (TVA 2021g).

TVA also operates one of the largest transmission systems in the United States. It serves an area of 80,000 square miles through a network of about 16,200 miles of transmission lines, 500 substations, switchyards and switching stations, and over 1,300 individual customer connection points. The system connects to switchyards at generating facilities and transmits power from them at primarily either 161 kV or 500 kV to local power companies and directly served customers. For the past 18 years, the system has achieved 99.999 percent power reliability. It efficiently delivered nearly 163 billion kilowatt-hours of electricity to customers in FY 2018 (TVA 2019b). Additionally, the TVA transmission system has 69 interconnections with 13 neighboring utilities at interconnection voltages ranging from 69-kV to 500-kV. These interconnections allow TVA and its neighboring utilities to buy and sell electricity from each other and to wheel power through their systems to other utilities. To the extent that Federal law requires access to the TVA transmission system, the TVA transmission organization offers services to others to transmit power at wholesale in a manner that is comparable to TVA's own use of the transmission system, according to the Federal Energy Regulatory Commission (FERC) Standards of Conduct for Transmission Providers (18 CFR Part 358).

1.4. Need for Power

One of TVA's most important responsibilities is meeting the demand for electricity placed on its power system. Thousands of businesses, industries and public facilities, and millions of people, depend on TVA every day to supply their power needs reliably. That responsibility drives the purpose and need for the proposed action described in this SEIS.

1.4.1. Integrated Resource Plan

TVA's 2019 IRP provides a system-wide review on meeting projected future energy demands and the direction on potential replacement power sources that TVA is considering over the planning period from 2019-2038 (TVA 2019b). It shapes how TVA will provide low-cost, reliable, and clean electricity; support environmental stewardship; and foster economic development. Specifically, the 2019 IRP forecasted generating assets that would be added to, and removed from, TVA's fleet by 2028 and by 2038. The 2019 IRP and associated IRP Final Environmental Impact Statement (FEIS) (TVA 2019a) evaluated six scenarios or plausible futures, including No Nuclear Extension of BFN, with five strategies per scenario (potential TVA responses to those futures). Using these scenarios, TVA identified a range of potential resource additions and retirements throughout the TVA power service area based upon TVA's system-wide generation planning models. TVA estimated a capacity gap by comparing anticipated demand and current supply, and then determined the type and amount of additional generating resources or energy management services needed to fill the gap. TVA also considered whether retirements of certain resources may be economical (TVA 2019b). Because planning, permitting, and construction of new generating capacity and transmission require a long lead time, TVA must make decisions to build new generating capacity well in advance of the actual need.

This SEIS incorporates information used in the development of the 2019 IRP. The IRP FEIS (TVA 2019a) identified TVA's preferred alternative (Target Power Supply Mix) as the recommended planning direction. The implementation of the Target Power Supply Mix alternatives will result in a diverse generating portfolio and provide TVA the flexibility to make energy resource decisions consistent with least-cost planning. As the IRP is implemented, TVA will closely monitor key input variables, including changing market conditions, more stringent regulations and technology advancements to inform appropriate actions within the recommended ranges and appropriate timing for initiating the next IRP. Under the recommended planning direction, as with all but one planning strategy evaluated in the IRP, it is assumed that TVA will pursue the option for SLR of BFN Units 1, 2, and 3 for an additional 20 years (TVA 2019b).

1.4.2. Power Demand

TVA's long-term demand forecast is developed from individual forecasts of residential, commercial, and industrial sales. These forecasts serve as the basis for planning the TVA power system, budgeting, and financial planning. TVA considers forecasts based upon several potential future conditions, including scenarios for the high and low load growth. A description of TVA's load forecasting methodology is presented in Chapter 4 of the IRP. Figures 1.4-1 and 1.4-2 show the range of forecasts for system peak load and energy requirements forecasts as developed for the IRP. Both include modeling results of the Current Outlook scenario and the highest and lowest growth scenarios. Annual peak load growth over the 2019 through 2038 time period is 0.3 percent in the Current Outlook scenario and varies from a -0.7 percent CAGR in the lowest peak scenario to a 1.7 percent CAGR in the highest growth scenario. System energy requirements are flat in the Current Outlook scenario with energy declining annually 1.5 percent in the lowest scenario and going as high as 2.0 percent annually in the highest growth scenario. The planning period for the IRP was through 2038, so to arrive at the forecast through 2056, average annual growth through 2038 was assumed to remain constant through 2056. It would be highly unlikely that the actual load would exceed the high forecast or fall below the low forecast, given the range of possible outcomes used in the forecast modeling.

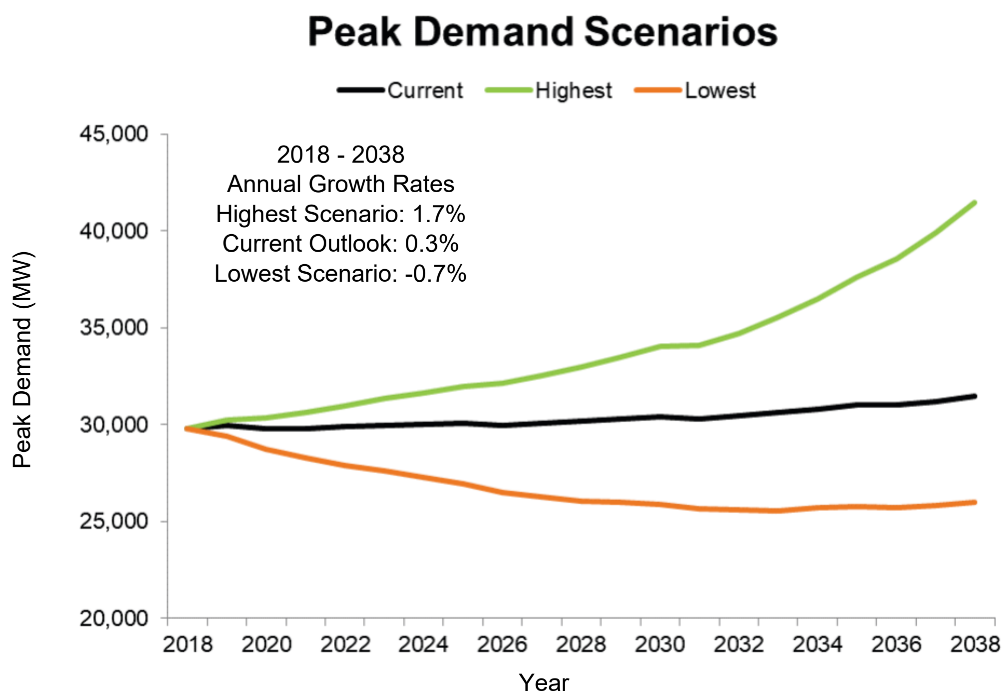


Figure 1.4-1. Peak Demand (MW) Forecast

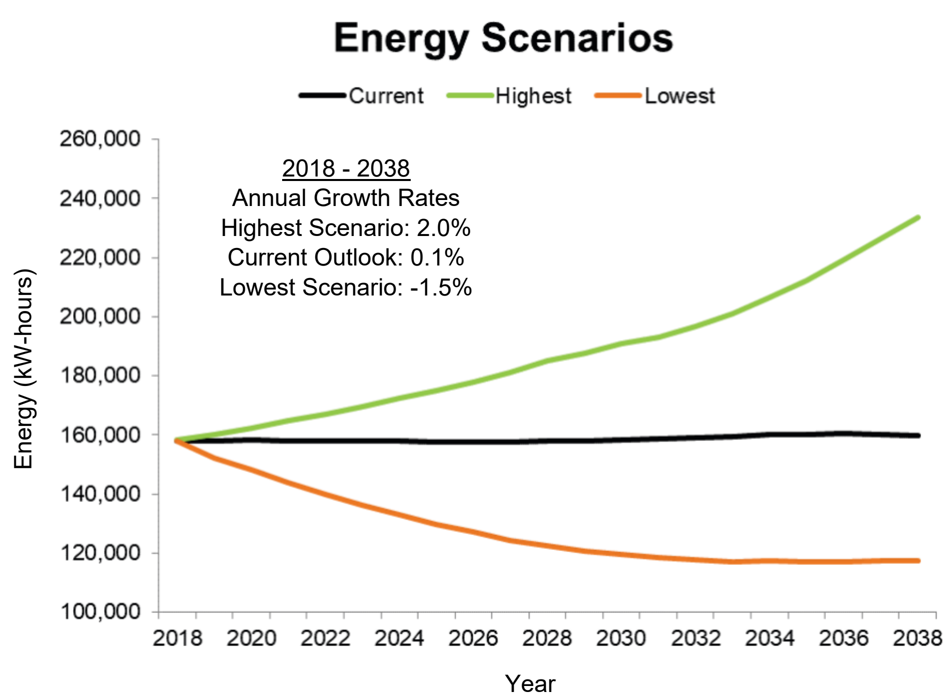


Figure 1.4-2. Energy (kilowatt-hours) Forecast

1.4.3. Power Supply

TVA's generation supply consists of a combination of existing TVA-owned resources, budgeted and approved projects such as new plant additions and updates to existing assets, and existing PPAs. Generating assets can be categorized both by whether the power they produce is used to meet base, intermediate or peak demand or used for storage, and by capacity type or energy/fuel source.

Baseload Resources: Due to their lower operating costs and high availability, baseload resources are used primarily to provide continuous, reliable power over long periods of uniform demand. They typically have higher construction costs than other energy sources, but may have lower fuel and variable costs, especially when fixed costs are expressed on a unit basis (e.g., dollars per megawatt hour [MWh]). An example of a baseload resource is a nuclear power plant. Some energy providers also use larger coal units and natural gas-fired combined cycle plants as incremental baseload generators (TVA 2019b).

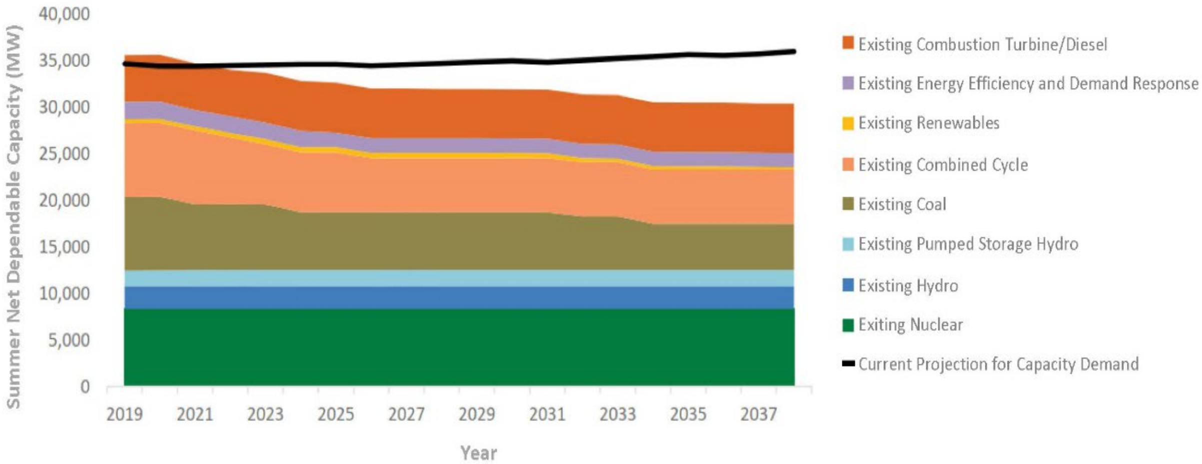
Intermediate Resources: Intermediate resources are used primarily to fill the gap in generation between baseload and peaking needs and provide backup and balance the supply of energy from intermittent wind and solar generation. These units are required to produce varying power loads in response to fluctuations in energy demand both during the course of a day and seasonally. Given current fuel prices and relative generating efficiencies, these units are typically more costly to operate than baseload units but less expensive than peaking units. Intermediate generation comes from natural gas-fired combined cycle plants, smaller coal units, and wind and solar generation. Solar and wind energy profiles align more closely with summer and winter load shapes, respectively. Hydro generating assets can also generally be categorized as intermediate resources, but their flexibility allows them to operate the full range from baseload to peaking. Hydro generation capacity is restrained by water availability and the various needs of the river system such as navigation, flood control and recreation (TVA 2019b).

Peaking Resources: Peaking units are expected to operate infrequently during short-duration, high demand periods. Their purpose is to help meet system reliability requirements, as they can start up and shut down quickly in response to sudden changes in either demand or supply. Typical peaking resources are natural gas-fired frame combustion turbines, aeroderivative combustion turbines, reciprocating internal combustion engines, and conventional hydro generation (TVA 2019b).

Storage Resources: Storage units usually serve the same power supply function as peaking units but use low-cost, off-peak electricity to store energy for generation during peak demand. An example of a storage unit is a hydro pumped-storage plant. These plants pump water to a reservoir during periods of low demand and release it to generate electricity during periods of high demand. Consequently, a storage unit is both a power supply source and an electricity user. Lithium-ion batteries are another example of a storage resource (TVA 2019b).

TVA uses a wide range of technologies to meet the power needs of the Valley residents, businesses, and industries. Figure 1.4-3 shows the current projection for capacity demand and for capacity supply from existing resources and PPAs, highlighting the capacity gap. This figure includes both owned and purchased resources, in megawatts of summer net dependable capacity, and is divided into fuel-type (i.e., nuclear, hydro, coal). The chart builds up from the bottom generally in a baseload, intermediate and peaking order, as some assets can serve dual roles. Figure 1.4-3 shows how TVA's existing capacity portfolio is expected to change through 2038, and this projection serves as the baseline firm capacity for optimizing all portfolios. The existing assets only include resources that currently exist, assets that are under contract, TVA

Board-approved changes to existing resources such as refurbishment projects, and TVA Board-approved additions. Existing resources decrease through 2038 primarily because of the retirement of coal-fired units and the expiration of existing PPAs. The renewable component of the existing portfolio is primarily composed of wind PPAs that expire in the early 2030s. Because the power generated from wind and other renewable resources is intermittent, the firm capacity (or the amount of capacity that can be applied to firm requirements) for these assets is lower than the nameplate capacity (TVA 2019b).



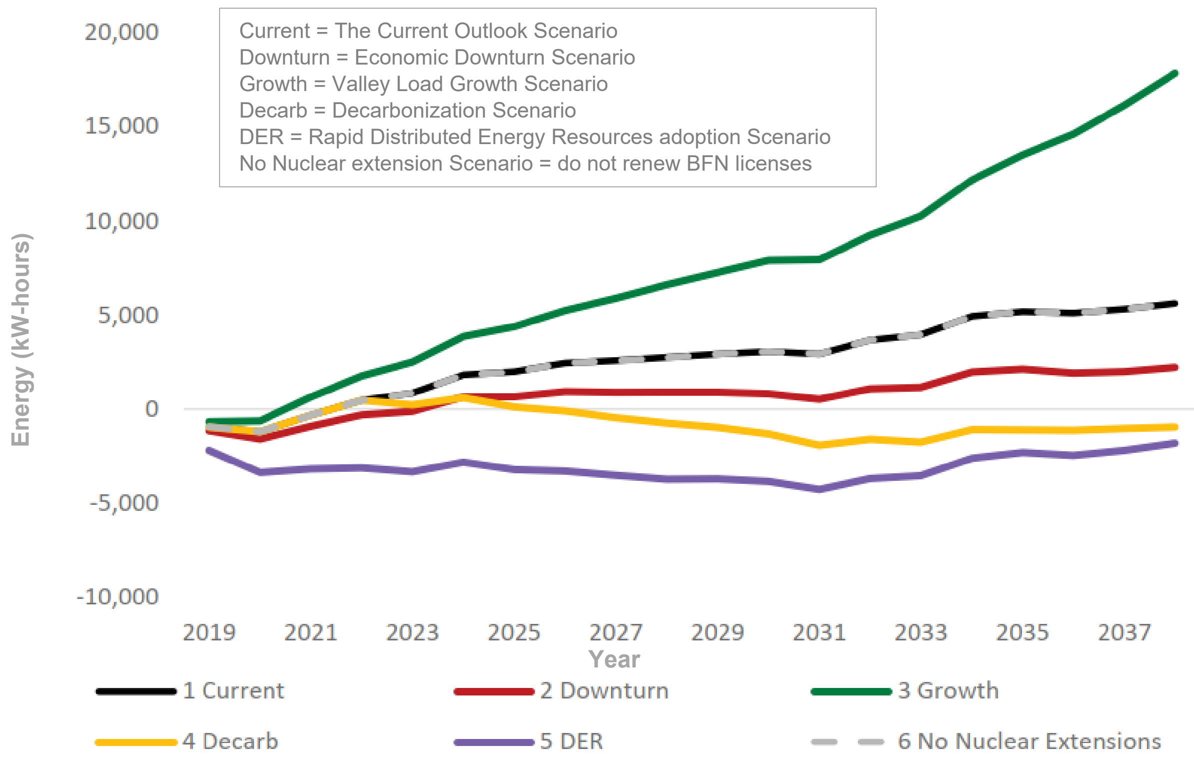
Source: (TVA 2019b)

Figure 1.4-3. Baseline Firm Capacity, Summer Net Dependable MW

In FY 2020, 41 percent of TVA's energy was produced from the nuclear fleet. Coal plants produced about 15 percent of the generation, while the gas fleet produced about 21 percent. Hydro plants produced approximately 10 percent, 13 percent was produced from PPAs from renewable and non-renewable resources (TVA 2021g).

A capacity gap is the difference between total supply and total demand. More specifically, it is the difference in megawatts between a power provider's existing firm capacity and the forecast annual peak adjusted for any interruptible customer loads and long-term planning reserve requirements. Figure 1.4-3 shows TVA's estimated capacity gap or shortfall based on the existing firm capacity and annual firm requirement for the Current Outlook scenario. Figure 1.4-4 shows the rage of capacity gaps corresponding to all the scenarios evaluated in the IRP and described in detail in Chapter 6 of the IRP. Firm requirements were greatest in the Valley Load Growth scenario (Scenario 3) and lowest in Rapid Distributed Energy Resources Adoption scenario (Scenario 5). The remaining scenarios fell within this range. The shape of the firm requirement curves influenced the type and timing of resource additions in the strategies. The timing of resource additions was a function of the existing system capacity and the impact of the attributes used to define each strategy. It is important to note that the capacity gap for the Current Outlook scenario (Scenario 1) and No Nuclear Extensions scenario (Scenario 6) are the same.

Chapter 8 of the IRP addresses the alternative strategies by which TVA could acquire additional capacity and generation to meet the need for power shown in Figures 1.4-3 and 1.4-4 (TVA 2019b). TVA anticipates using a mix of resources, including renewable resources (solar, wind, hydro), energy efficient demand response programs, and natural gas-fired generation to provide the additional resources to meet future needs. Given the magnitude of the capacity and energy need, and to avoid the risk of relying on only one fuel or technology, no single resource is used to meet all future energy and capacity requirements.



Source: (TVA 2019b)

Figure 1.4-4. Capacity Gap Range

1.5. The NEPA Process

This SEIS has been prepared consistent with CEQ's 2020 regulations for implementing NEPA at 40 CFR 1500-1508 (85 Federal Register [FR] 43304-43376, July 16, 2020). TVA's 2020 NEPA regulations at 18 CFR 1318 were also applied (85 FR 17434, Mar. 27, 2020). Further, the EA is consistent with CEQ's recently finalized rule (87 FR 23453, April 20, 2022) amending certain provisions of its 2020 regulations.

NEPA requires federal agencies to consider the reasonably foreseeable impacts of their proposed actions on the environment before choosing to take the actions. Actions, in this context, can include new and continuing activities that are conducted, financed, assisted, regulated, or approved by federal agencies, as well as new or revised plans, policies, or procedures. If a major federal action is expected to have a significant environmental impact, t, the agency must prepare an EIS for public and agency review. The SEIS process must include public involvement and analysis of a reasonable range of alternatives. This SEIS is an analysis of the potential impacts to the natural and human environment from the proposed action, as well as identified alternatives. CEQ regulations (40 CFR 1507.3) require federal agencies to make environmental review documents, comments, and responses a part of each agency's administrative record.

This SEIS provides updated information presented in the 2002 SEIS for the license renewal of BFN (TVA 2002). Many of the conditions described in the 2002 SEIS remain consistent such as site history, topography, geology, hydrology, and climate. Additionally, general conditions of BFN operation remain consistent with the 2002 SEIS. Changes that have occurred since 2002 include recovery and operation of Unit 1, expansion of the ISFSI pad, replacement of five of the original six helper cooling towers (Cooling Towers 1 and 3-6), construction and operation of Cooling Tower 7, and scheduled replacement of Cooling Tower 2 by 2027.

In September 2015, TVA requested an amendment to the 2006 Renewed Facility Operating Licenses to allow Units 1, 2, and 3 to operate at up to 120 percent of the operating license thermal power (OLTP; i.e., 120 percent of 3,293, or 3,952 megawatts thermal [MWt] per unit) (TVA 2015). The BFN units had previously been uprated by 5 percent (from 3,293 to 3,458 MWt) in 1998 (Units 2 and 3) and 2007 (Unit 1). Thus, the remaining power increase was approximately 15 percent increase for each BFN unit. In 2017, the NRC issued its Environmental Assessment and Finding of No Significant Impact for Browns Ferry Nuclear Plant Units 1, 2, and 3 (NRC 2017) supporting an increase in the maximum licensed thermal power level for each reactor from 3,458 MWt to 3,952 MWt.

1.5.1. Public Scoping

The NEPA process requires public participation and interagency coordination and review during the preparation of an EIS. This section summarizes TVA's efforts to involve the public, agencies, and tribes to help define the content of the SEIS.

Public scoping was initiated on June 1, 2021, when TVA published a Notice of Intent (NOI) in the Federal Register. The NOI announced TVA's plans to prepare an SEIS to address the potential environmental effects associated with extending the operation of BFN Units 1, 2, and 3 for an additional 20 years (Appendix A). The NOI initiated a 30-day public scoping period, which concluded on July 1, 2021. In addition to publishing the NOI in the Federal Register, TVA published notices regarding this effort in two local newspapers (i.e., The Decatur Daily and The News Courier), issued a news release to media, and posted the news release on the TVA Web site.

TVA also created a virtual meeting room that was available for the duration of the project. The URL link to the virtual meeting room was included in the NOI and can still be accessed through TVA's website (https://www.tva.com/environment/environmental-stewardship/environmental-reviews/nepa-detail/browns-ferry-nuclear-plant-subsequent-license-renewal). The virtual scoping meeting room contains information on the NEPA process and the proposed action, as well as links to TVA and NRC websites related to the project. The virtual scoping meeting room also allows the public to submit a comment or feedback on the project during open comment periods (scoping and draft SEIS review). Posterboards and screenshots from the virtual scoping meeting room are included in the Scoping Report (Appendix A).

As summarized in the Scoping Report, TVA received a total of 23 comments regarding the SLR of BFN Units 1, 2, and 3 from five commenters. Of the five comment submissions, two were from federal entities (U.S. Environmental Protection Agency [USEPA] and U.S. Geological Survey) and three were from members of the public. Nine of the 23 comments received were in regard to safety and aging infrastructure. The remaining comments received pertained to alternatives, general environmental concerns, air quality, water quality and stormwater, wetlands and streams, waste disposal, climate, and environmental justice. The comments related to TVA's proposed action are included in Appendix D of the Scoping Report (Appendix A of this SEIS).

1.5.2. Issue and Resource Identification

Based on the scoping process, reviews, and assessments of the proposed action, TVA determined that the scope of the SEIS should include the following topics:

- Land Use
- Geology and Soils
- Surface Water Resources, Hydrology, and Water Quality
- Groundwater Resources
- Floodplains and Flood Risk.
- Wetlands
- Aquatic and Terrestrial Ecology
- Endangered and Threatened Species
- Managed and Natural Areas
- Recreation
- Air Quality, including Meteorology
- Global Climate Change and Greenhouse Gases
- Transportation
- Visual Resources
- Noise and Vibration
- Socioeconomics, including Environmental Justice
- Archaeological Resources and Historic Structures
- Hazardous, Solid, and Low-Level Nuclear Waste
- Radiological Effects of Normal Operations
- Uranium Fuel Cycle Effects
- Nuclear Plant Safety and Security
- Decommissioning

Decommissioning and ongoing spent fuel storage would be necessary actions regardless of TVA's decision to pursue SLR. BFN would undergo decommissioning either at the end of the current licenses or at the end of the proposed subsequent period of extended operation if it is approved by the NRC. A brief introduction of the possible methods and conditions of decommissioning and impacts that the eventual decommissioning of BFN will cause are discussed. Spent fuel would continue to be stored and kept safe at BFN as long as necessary until the DOE takes possession of it. Spent fuel would continue to be created by operating BFN until the end of the current or extended operational period of the operating licenses. Potential environmental impacts associated with ongoing spent fuel storage at the existing onsite ISFSI's at BFN are addressed in this SEIS.

Transmission lines connected to the BFN switchyard are an integral part of the TVA electrical system grid and would, therefore, be in use whether BFN is in operation or shut down. Maintenance (e.g., clearing vegetation in the ROW) of those transmission lines would likewise be a requirement while BFN is in operation, and probably beyond the BFN operational period to maintain the vital electrical system grid. Transmission line operation and maintenance does not depend upon the decision to renew BFN operating licenses; proposed maintenance activities and associated environmental effects would be identical regardless of the decision made. Therefore, the operation of transmission lines and maintenance of ROWs are not addressed in this SEIS. Any maintenance activities conducted in the transmission line ROWs would follow TVA's best management practices for construction and maintenance of transmission lines, *A Guide for Environmental Protection and Best Management Practices for TVA Construction and Maintenance Activities* (TVA 2017b) and TVA's programmatic consultation for ROW Vegetation management (TVA 2018a).

1.5.3. Projects Included in the Evaluation of Cumulative Effects

Cumulative effects are those resulting from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions.

This SEIS considers the contribution of continued operation of BFN to potential regional environmental cumulative impacts. It will assess the potential significance of BFNs impacts in relation to other known or reasonably foreseeable projects. Impacts are defined in CEQ regulations (40 CFR 1508.1(g)) as changes to the human environment from the proposed action or alternatives that are reasonably foreseeable and have a reasonably close causal relationship to the proposed action or alternatives, including those effects that occur at the same time and place as the proposed action or alternatives and may include effects that are later in time or farther removed in distance from the proposed action or alternatives."

In this section, reasonably foreseeable actions authorized or funded by an agency (federal or non-federal) and taking place in the vicinity of BFN are identified. Possible cumulative effects associated with these actions are discussed in the relevant resource sections in Chapter 3. For the purposes of this analysis, actions include those that have been publicly announced before submittal to the NRC of the BFN SLRA. Reasonably foreseeable future actions are those that are ongoing (and will continue into the future), are funded for future implementation, or are included in publicly available plans covering the period prior to and during the operating periods of the renewed BFN licenses. The geographic area affected by cumulative impacts depends on the resource being considered (2013 GEIS). Reasonably foreseeable actions may include individually minor, but collectively significant, actions occurring over a period of time (2013 GEIS). Reasonably foreseeable projects which could contribute to cumulative impacts with respect to BFN include transportation projects and plans, additional industrial development, and water resources projects.

- Expansion of the onsite spent fuel storage capacity at BFN may be required in the future if a national storage solution for the permanent storage of spent fuel does not become available during the proposed subsequent period of extended operation. The current ISFSI storage pads are projected to be filled in year 2036 unless DOE takes possession of the spent fuel and removes it from the site for permanent disposal or processing. The addition of a third ISFSI storage pad to further increase storage capacity at BFN if needed is under consideration, but plans are in the conceptual stage and no installation schedule has been established. A 2017 siting study identified potential locations for an additional ISFSI storage pad.
- Limestone County does not have a comprehensive land use plan, but the cities of Athens (2013), Huntsville (2018), and Decatur (2018) have published either a land use plan or comprehensive plan (Huntsville 2018, Martin 2013, Smith 2018) All three cities are looking to increase population density, and although Limestone County is the third fastest growing county in Alabama (Limestone County 2021c), population growth in the area is slow compared to Alabama's average growth rate (Smith 2018). Desktop research did not result in identification of any information regarding major residential or industrial development projects within a 10-mile radius of BFN; however, it can be assumed that local residential, business, and commercial developments would occur during the proposed subsequent period of extended operation.
- The Federal Bureau of Investigation is expanding its current campus at the Redstone Arsenal in Huntsville, Alabama, approximately 30 miles east of BFN. Currently, there are

approximately 860 employees at the campus, but the FBI anticipates having at least 3,400 people working there by 2026 (Ogrysko 2021).

- Cummings Research Park (CRP), which is approximately 24.5 miles east of BFN, is the second largest research park in the country and includes over 300 companies, more than 26,000 employees and 13,500 students (CRP 2021b). CRP published a Master Plan in 2016 (CRP 2016) and, currently, there is approximately 280 acres of land available for development (CRP 2021a).
- The Town of Courtland, Alabama, approximately 11 miles west of BFN on the south side of Wheeler Reservoir, was awarded a Community Development Block Grant by the State of Alabama Department of Economic and Community Affairs and has begun construction of approximately 8,400 linear feet of new water mains and new customer service lines to replace the aging water system. The Town of Courtland will be working with the West Morgan-East Lawrence Water and Sewer Authority (WMEL 2021).
- As of August 31, 2021, there was one transportation project under construction in Limestone County and eight additional projects were anticipated (ALDOT 2021b). All of these projects are more than 10 miles from BFN. The other counties adjacent to the BFN site, Morgan and Lawrence Counties, are on the south side of Wheeler Reservoir. There are two projects under construction in Morgan County and one planned project in Lawrence County (ALDOT 2021a, ALDOT 2021c), with the closest project being about.16.5 miles away in Lawrence County.

Cumulative impacts associated with these reasonably foreseeable future actions are addressed in the respective resource evaluations in Chapter 3. Cumulative effects are also summarized along with other impacts in Section 2.2 of this SEIS. Radiological effluent releases in water and air do not normally cause cumulative impacts because the limits for release are so restrictive and based on the principle that once released, below the specified limits, there is no cumulative impact. Appropriate environmental monitoring programs are in place to ensure there are no detectable cumulative effects in the local environment. See Section 3.20 for a description of the radiological environmental monitoring program.

1.6. Other Pertinent Environmental Reviews and Documents

BFN site-specific, TVA, and generic information in the following documents were evaluated and used where appropriate during the development of this SEIS. These related documents and their contents are presented in Table 1.6-1.

Table 1.6-1. Environmental Reviews and Documents Pertinent to the BFN SLR SEIS

Type of Review/Agency	Title	Decision of Finding	Summary / Relevance
Environmental Assessment (EA) / TVA	Browns Ferry Nuclear Plant Thermal Performance Program Cooling Tower Capacity Improvements	Finding of No Significant Impact (FONSI) issued June 2020	Action was to replace and upgrade cooling towers 1 and 2 (including the associated cooling tower lift pumps) and upgrade cooling tower 7.

Type of Review/Agency	Title	Decision of Finding	Summary / Relevance
EIS / TVA	2019 Integrated Resource Plan. Volume II. Final Environmental Impact Statement	Record of Decision (ROD) issued September 2019	Action was to assesses the natural, cultural, and socioeconomic impacts associated with the implementation of the 2019 IRP and analyze and identify the relationship of the natural and human environment to each of the five strategies considered in the IRP.
EA / NRC	Proposed Extended Power Uprate (EPU)	FONSI issued June 2017	BFN Operating License Amendment, referred to as an EPU, to authorize an increase in the maximum power level from 3,458 MWt to 3,952 MWt for each unit. The EPU represented an increase of approximately 14.3 percent above the licensed thermal power level of 3,458 MWt per unit.
Environmental Report / TVA	Attachment 42 – Supplemental Environmental Report	Not Applicable	Attachment to the EPU License Amendment Request. The TVA supplemental Environmental Report contained an assessment of the hydrothermal impacts of a proposed output power increase for BFN Units 1, 2, and 3.
GEIS / NRC	Generic EIS for License Renewal of Nuclear Plants (NUREG-1437), Revision 1	ROD issued May 2013	Action was to consider the environmental effects of renewing operating licenses of individual commercial nuclear power plants for an additional 20 years. (results codified in 10 CFR Part 51)
Supplemental EA / TVA	Browns Ferry Nuclear Plant Cooling Tower 3 Replacement	FONSI issued December 2012	Action was to replace cooling tower 3 with a more modern tower that included larger fan motors and a larger cold-water basin due to the partial collapse of the existing cooling tower 3 in July 2012 and the resulting unsafe condition.
EA / TVA	Browns Ferry Cooling Towers – Additions and Replacements	FONSI issued October 2010	Action was to replace four original cooling towers at BFN with larger units and construct Cooling Tower 7.
GEIS, Supplement 21/ NRC	Generic EIS for License Renewal of Nuclear Plants, Supplement 21 Regarding Browns Ferry Nuclear Plant, Units 1, 2, and 3. Final Report. NUREG 1437	ROD issued June 2005	Action was to renew the operating licenses for BFN for an additional 20-year period at EPU of 120 percent.

Type of Review/Agency	Title	Decision of Finding	Summary / Relevance
EA / TVA	Browns Ferry Nuclear Plant Extended Power Uprate for Units 2 and 3 EA, August 2003.	FONSI issued August 2003.	Action was to seek a license amendment from NRC for EPU. Based on new technical and economic analyses, the TVA proposed to use existing cooling towers and derate to mitigate potential thermal impacts of EPU instead of building new cooling towers.
SEIS / TVA	Final SEIS for Operating License Renewal of the Browns Ferry Nuclear Plant in Athens, Alabama, March 2002.	ROD issued May 2002	Action was to seek extension of NRC licenses for BFN Units 1, 2, and 3 at 120 percent of OLTP for an additional 20 years beyond the original 40-year operating license terms. Mitigation measures for increased thermal loads to surface waters included use of existing cooling towers, construction of a new cooling tower, and derating the plant as necessary.
EA / TVA	Browns Ferry Nuclear Plant Units 2 and 3 Power Uprate Project EA, March 2001.	FONSI issued March 2001	Action was to request a license amendment to increase the output of BFN Units 2 and 3 from 105 percent of OLTP to 120 percent.
EA / TVA	Browns Ferry Nuclear Plant Units 2 and 3 Power Uprate Project EA, August 1997.	FONSI issued August 1997	Action was to request license amendment from NRC to increase BFN Units 2 and 3 maximum power level to 105 percent of OLTP.
ES[1] / AEC[2]	Browns Ferry Nuclear Plant, Units 1, 2, and 3 Final ES, Volumes 1-3, July 1971.	ROD issued August 1972	Action was to construct and operate BFN.

[1] The early TVA EIS documents were titled Environmental Statements (ES)
[2] Atomic Energy Commission (AEC); now the Nuclear Regulatory Commission (NRC)

1.7. Permits, Licenses, and Approvals

TVA maintains applicable permits for operation of BFN and would obtain all necessary permits, licenses, and approvals required for the alternative selected. Table 1.7-1 provides a list of current permits and licenses that would be maintained throughout the proposed subsequent period of extended operation. Table 1.7-2 provides a list of the other federal environmental regulations and guidance that potentially are relevant to plant activities.

Table 1.7-1. Current Contracts and Permits

Contract or Permit Type	Current Authorization	Notes
NRC	DPR-33	Current Unit 1 operating license
NRC	DPR-52	Current Unit 2 operating license
NRC	DPR-68	Current Unit 3 operating license
NPDES	AL0022080	Permit issued June 2018

Contract or Permit Type	Current Authorization	Notes
Regulated Waste Permit (Resource Conservation and Recovery Act [RCRA])	AL8640015410	Regulated waste (Hazardous waste, used oil, universal waste permit)
Air	708-0003-X005	Minor source permit issued June 2017
Air	708-0003-X005	Synthetic minor permit (i.e., emergency generators, diesel FP, auxiliary boilers) issued November 2020
Radioactive material shipment	T-AL002-L22	License to ship radioactive materials, renewed annually
Radioactive material shipment	W0019	Ship radioactive material
Radioactive material shipment	1505009347	Ship radioactive material, renewed annually
Solid waste contract	14867	Republic Services

Table 1.7-2. Relevant Federal Environmental Regulations and Guidance

Statute / Agency / Executive Order	Authority	Activity Covered
NRC	10 CFR Parts 50, 51, and 54	Operation of commercial nuclear plants and license renewal.
Endangered Species Act, USFWS	16 U.S.C. §1531 *et seq.*	Consultation with USFWS in the event that proposed activities at BFN have potential to affect federally listed species.
Bald and Golden Eagle Protection Act	16 U.S.C. 668-668d	Federal statute that protects two species of eagles.
Migratory Bird Treaty Act	16 U.S.C. 703-712	Prohibits the take (killing, capturing, selling, trading, and transport) of protected migratory bird species without prior authorization by USFWS.
National Historic Preservation Act of 1966	16 U.S.C. 470 et seq.	Consultation with state and tribal historical preservation officers in the event that proposed activities at BFN have potential to impact historic properties and cultural traditions, and historical properties listed, or eligible for listing, on the National Registry of Historical Places.
Clean Air Act	42 U.S.C. 7401 *et seq*.	Federal law that regulates air emissions from stationary and mobile sources.
Federal Clean Water Act	33 U.S.C. 1344 (Section 404) 33 U.S.C. 1341 (Section 401)	Actions involving wetlands and/or stream crossings would be subject to federal Clean Water Act Section 404 permit requirements. Section 401 Water Quality Certification. Alabama Department of Economic and Community Aquatic resource alteration permit may be required for any alterations to the streams and wetlands.
Rivers and Harbors Act of 1899	Section 10	Requires authorization from the Secretary of the Army, acting through the Corps of Engineers, for the construction of any structure in or over any navigable water of the United States.

Statute / Agency / Executive Order	Authority	Activity Covered
Executive Order 11514*	40 CFR Parts 1500–1508	Requires federal agencies to protect and enhance the quality of the environment and develop procedures to ensure the fullest practicable provisions of timely public information and understanding of federal plans and programs that may have potential environmental impacts that the views of interested parties can be obtained.
Executive Order 11988*	18 CFR Part 1318 44 CFR Part 60	Requires federal agencies to avoid floodplain impacts to the extent practicable.
Executive Order 11990*	42 U.S.C. 4321 et seq.; 42 U.S.C. 4331(b)(3)	Requires federal agencies to avoid direct or indirect support of new construction in wetlands whenever there is a practicable alternative.
Executive Order 13423*	42 U.S.C. 4321	Subject to the availability of appropriations, requires agencies to implement sustainable practices including energy efficiency, greenhouse gas emissions avoidance or reduction, and petroleum products use reduction.
Executive Order 12898*	32 CFR 651.17	Directs Federal agencies to identify and address disproportionately high and adverse health or environmental effects of Federal actions on minority and low-income populations
Executive Order 13985*	86 FR 7009	Requires federal agencies to advance racial equity, civil rights, racial justice, equal opportunity, and support for underserved communities.
Executive Order 13990*	86 FR 7037	Addresses protecting public health and the environment and restoring science to tackle the climate crisis. TVA considers Executive Order 13990 in the context of specific statutory requirements as directed by Congress in carrying out its mission.
Executive Order 14008*	86 FR 7619	Directs Federal agencies to tackle the climate crisis at home and abroad by wiring with other countries and partners. TVA considers Executive Order 14008 in the context of specific statutory requirements as directed by Congress in carrying out its mission.

* TVA is a wholly-owned corporate agency and instrumentality of the United States. Federal executive orders may create binding legal obligations for TVA only to the extent that Congress or the Constitution give the President the authority to bind TVA in the relevant area of law or guidance. Many Executive Orders expressly recognize that they do not “impair or otherwise affect . . . the authority granted by law to an executive agency or the head thereof” and that they “shall be implemented consistent with applicable law and subject to the availability of appropriations.” TVA considers relevant Executive Orders in applicable NEPA documents, consistent with applicable court opinion and relevant CEQ guidance, but is not required to comply with or adhere to Executive Orders that otherwise are inconsistent with the authorities granted to TVA through the TVA Act.

TVA anticipates seeking required permits or authorizations as appropriate, from the following governmental entities: NRC; U.S. Army Corps of Engineers; U.S. Coast Guard; USEPA; Alabama Department of Environmental Management; U.S. Fish and Wildlife Service (USFWS); Alabama State Historic Preservation Officer; and Tribal Historic Preservation Officers. TVA anticipates consulting with the required authorities including, but not limited to: The Endangered Species Act; Bald and Golden Eagle Protection Act; Migratory Bird Treaty Act; National Historic Preservation Act; Clean Air Act; and Federal Clean Water Act.

CHAPTER 2 – ALTERNATIVES

The purpose of the proposed action is to help provide continued generation of baseload power from the Browns Ferry Nuclear (BFN) site between 2033 and 2056 by obtaining the Nuclear Regulatory Commission (NRC) subsequent license renewals (SLRs). In addition to evaluating the continued operation of BFN, the Tennessee Valley Authority (TVA) has considered a wide range of options to identify feasible alternatives available to supply approximately 3,900 megawatts electric (MWe) of base load power generation to the Tennessee Valley if TVA does not submit a subsequent license renewal application (SLRA).

Relative to BFN, taking action to continue operation would result in pursuing SLRs. Taking no action to renew the BFN operating licenses would result in ceasing operation of each unit on or before 2033 for BFN Unit 1, 2034 for Unit 2, and 2036 for Unit 3. Alternatives to the proposed action would be the utilization of alternate means to provide adequate capacity and energy in the absence of BFN.

The purpose of this section is to describe the alternatives that were reviewed and discuss why the alternatives evaluated were chosen. A description of the alternatives considered in this Supplemental Environmental Impact Statement (SEIS) are described in Section 2.1. A description of alternatives considered but dismissed from further evaluation are described in Section 2.1.2. Section 2.2 provides a comparison of the alternatives, Section 2.3 provides a summary of impacts, Section 2.4 provides a brief discussion of the preferred alternative, and Section 2.5 provides a summary of mitigation measures and best management practices (BMPs).

2.1. Development of Alternatives

To begin the process of identifying, considering, and narrowing down the alternatives to those reasonably addressing the purpose and need of this proposed action, TVA began with the broad range of supply-side and demand-side actions identified in TVA's 2019 Integrated Resource Plan (IRP). TVA reviewed energy alternatives that meet system generating needs including construction of new generating assets (Section 2.1.2.2), energy alternatives not considered reasonable (Section 2.1.2) including purchased power (Section 2.1.3) and demand-side management (Section 2.1.2.2), and alternatives carried forward for evaluation (Section 2.1.4).

The following criteria were applied to select feasible alternatives to evaluate in detail in this SEIS:

- The option must substantially meet the stated purpose and need.
- Supply-side resource options must be capable of delivering capacity and energy comparable to that provided by BFN (either individually or in combination) without substantially greater environmental impacts.
- Resource options must utilize a developed and proven technology, or one that has reasonable prospects of becoming developed and proven in time to deliver sufficient power by the time BFN's current operating licenses would expire in 2033, 2034, and 2036.

TVA considered each of the replacement alternatives identified in TVA's 2019 IRP in addition to other alternatives (e.g., geothermal and ocean wave energy). These alternatives were evaluated based on their ability to provide reliable baseload power and their ability to be operational prior to the expiration of the current BFN renewed operating licenses.

TVA's 2019 IRP provides a system-wide review on meeting projected future energy demands and the direction on potential replacement power sources that TVA is considering over the planning period from 2019-2038 (TVA 2019b). Specifically, the 2019 IRP forecasted generating assets that would be added to, or removed from, TVA's fleet by 2028 and by 2038. The 2019 IRP and associated Final Environmental Impact Statement (FEIS) (TVA 2019a) evaluated six scenarios or plausible futures, including No Nuclear Extension of BFN, with five strategies per scenario (potential TVA responses to those futures). Using these scenarios, TVA identified a range of potential resource additions and retirements throughout the TVA power service area based upon TVA's system-wide generation planning models.

In this SEIS, TVA elected to present the assessment of a reasonable alternatives as a sliding scale of a combination of individual alternative replacement options, rather than individual alternatives or a single combination of alternatives. This allowed TVA to evaluate an alternative that aligns with TVA's evaluation in the 2019 IRP if there were no nuclear extension of BFN.

The analysis below favors the generation sources that TVA selected in the 2019 IRP for current and future power sources in the TVA service area. The power sources considered as reasonable replacements for the approximately 3,900 MWe of BFN generation include a combination of natural gas-fired combined cycle (CC) generation, natural gas combustion turbine (CT) generation, solar photovoltaic (PV) facilities, storage, and small modular reactors (SMRs). The following sections identify the replacement power sources considered as reasonable (Section 2.1.1) and power sources considered as unreasonable (Section 2.1.2).

2.1.1. Energy Alternatives Considered as Reasonable - Construction of New Generating Assets

Alternative generating technologies were evaluated to identify a combination of candidate technologies that would be capable of replacing the BFN total net baseload capacity of approximately 3,900 MWe at the time the BFN Unit 1, Unit 2, and Unit 3 licenses expire in 2033, 2034, and 2036, respectively. For purposes of this alternatives analysis, TVA assumed that the region of interest (ROI) within which facilities would be sited includes the entire TVA power service area because it is too early to know where exactly the replacement generating assets would be constructed. It is also assumed that each new generating asset would have its own separate environmental review under the National Environmental Policy Act (NEPA) since TVA, as a federal corporate instrumentality, performs NEPA assessments. Further, TVA has limited the analysis of impacts from new generating plant technology alternatives in this SEIS to the technologies it deems as reasonably likely to be commercially viable on a utility scale and operational by 2033. TVA also incorporated capacity factors of generating assets in their assumptions in the 2019 IRP. Capacity factor is a measure of a power plant's actual energy generation compared to the maximum amount it could generate in a given period without any interruption. Thus, capacity factor is the annual generation of a power plant divided by the product of the capacity and the number of hours of a given period. As power plants sometimes operate at less than full output, the annual capacity factor is a measure of both how many hours in the year the power plant operated and at what percentage of its entire production. Assets that run constantly, such as nuclear plants, provide a significant amount of energy with capacity factors greater than 90 percent.

As previously mentioned, the 2019 IRP forecasted TVA generating assets for 2028 and 2038. IRP Scenario 6 specifically evaluated strategies in which there would be no nuclear extension of

BFN. Because the existing BFN renewed operating licenses expire between 2033 and 2036, the 2028 forecasted generating capacity does not consider power replacement needs for the retirement of BFN. However, the 2038 forecasted generating capacity does account for replacement generating assets that would need to be commercially viable on a utility scale and operational before the expiration of BFN's renewed operating licenses in 2033, 2034, and 2036. The difference in the maximum forecasted generating capacity between 2028 and 2038 was calculated and is assumed to be the maximum incremental capacity that could be added for each generating asset to replace BFN power generation before the renewed operating licenses expire. Therefore, the alternative analysis was identified using a combination of the following power sources to meet the NRC criteria for reasonableness for replacement of the BFN generation during the proposed subsequent period of extended operation:

- Natural gas-fired CC generation
- Natural gas-fired CT generation
- Solar generation
- Energy storage
- Nuclear-powered generation in the form of SMRs

Even without consideration for the need of replacement generation at BFN, TVA already expects to add about 10,000 megawatts (MW) of solar generation by 2035 and an additional 4,000 MW of solar by 2038 to meet customer demands and system needs. Additions may be a combination of utility and distributed scale solar facilities. Integrating this significant number and quantity of intermittent resources requires a generation fleet that is highly flexible and capable of ramping up and down quickly to cover gaps in renewable generation which is why gas CTs and energy storage are also included in this alterative. A combination of gas CC, gas CT, solar, storage, and SMR power producing units would provide the equivalent generation to replace the current MWe of generation produced from BFN.

2.1.1.1. Natural Gas-Fired Combined Cycle Generation
Natural gas-fired CC plants are efficient intermediate power generation units with large energy potential as well as the ability to provide grid support and load follow. CCs are composed of multiple natural gas-fired CT generating units which are paired with heat recovery steam generators and one or more steam turbines for increased efficiency and power output. CCs are fully dispatchable year-round with the ability to ramp generation output up and down throughout the day. This ability to ramp up and down throughout the day is increasingly important as TVA begins integrating up to 10,000 MW of solar by 2035 and an additional 4,000 MW of solar by 2038. The high fuel efficiency, relatively low construction cost, and flexibility of CCs lend them to be good candidates for intermediate and baseload operations.

In the 2019 IRP, TVA evaluated the addition of up to 9,800 MW of incremental gas CC capacity by 2038 if a high level of load growth materializes. But for the IRP scenario that anticipated No Nuclear Extension of BFN (Scenario 6), up to 3,900 MWe of incremental gas CC capacity was added (TVA 2019b), of which 1,800 MWe was forecast to be added between 2028 and 2038 during the time when the existing BFN renewed operating licenses would expire. The IRP evaluation included four natural gas CC fueled options:

- One turbine and one steam generator (CC 1 x 1)
- Two turbines and one steam generator (CC 2 x 1)
- Three turbines and one steam generator (CC 3 x 1)
- Three by one integrated gasification combined cycle (IGCC) with carbon capture and storage

For purposes of this analysis, TVA assumed development of a modern natural gas-fired CC plant with design characteristics similar to those being developed elsewhere in the TVA region. TVA has chosen to evaluate a CC plant using a closed-cycle cooling system with cooling towers at an alternate site, due to the lack of available land within the site boundaries of BFN. The CC plant would have an operating life of 40 years. It is assumed that the plant would be designed to minimize air emissions (i.e., heat recovery steam generators equipped with a selective catalytic reduction system and ammonia vaporizers). Table 2.1-1 presents the basic characteristics for the CC gas-fired alternative, and impacts are described in Section 2.1.1.1.

Table 2.1-1. 500-MWe Gas-fired Turbine Annual Emissions (tons per year)

Natural Gas-Fired Stationary Gas Turbines		**Simple Cycle**		**Combined Cycle**	
Pollutant NOx and CO Controlled, Others Uncontrolled	**AP-42 Emission Factor (lb/MMBtu)**	**lb/hr**	**TPY**	**lb/hr**	**TPY**
Criteria Pollutants[1]:					
NO_x (Lean Pre-mix Control)	9.90E-02	440	1,925	302	1,324
CO (Lean Pre-mix Control)	1.50E-02	67	292	46	201
VOC	2.10E-03	9	41	6	28
SO_2	3.4E-03	15	66	10	45
PM/PM10/PM2.5 $_{\text{filterable}}$	1.90E-03	8	37	6	25
HAPs[1]:					
Total HAP			**20**		**14**
1,3-Butadiene	4.3E-07	0	0	0	0
Acetaldehyde	4.0E-05	0	1	0	1
Acrolein	6.4E-06	0	0	0	0
Benzene	1.2E-05	0	0	0	0
Ethylbenzene	3.2E-05	0	1	0	0
Formaldehyde	7.1E-04	3	14	2	9
Naphthalene	1.3E-06	0	0	0	0
PAH	2.2E-06	0	0	0	0
Propylene Oxide	2.9E-05	0	1	0	0
Toluene	1.3E-04	1	3	0	2
Xylenes	6.4E-05	0	1	0	1
	40 CFR 98 Emission Factor (kg/MMBtu)	**lb/hr**	**TPY**	**lb/hr**	**TPY**
GHGs[2]:					
CO_2	53.06	519,378	2,274,878	357,073	1,563,978
CH_4	0.001	10	43	7	29
N_2O	0.0001	1	4	1	3
CO_2e			2,277,227	357,441	1,565,594

[1] Emission factors from EPA's AP42, Chapter 3.1, Tables 3.1-1, 3.1-2a, 3.1-3
[2] Emission factors from 40 CFR 98, Subpart C, Tables C-1 & C-2 for Natural gas (Tables updated in Federal Register Nov. 2013)

2.1.1.2. Natural Gas-Fired Combustion Turbine Generation

Natural gas-fired simple cycle frame CT plants are peaking units with the ability to start and ramp up quickly on short notice as well as the ability to provide grid support and load following. Simple cycle frame CT plants are composed of multiple natural gas-fired CT generating units. CTs draw in air at the front of the unit, compress it, mix it with fuel, and ignite it. The combustion occurs immediately, allowing gases to then expand through turbine blades connected to a generator to produce electricity. CT power plants normally run on natural gas as a fuel; however, they may also be run on low-sulfur fuel oil if needed (TVA 2022e). CTs are fully dispatchable year-round with the ability to meet capacity needs during short periods, typically have the lowest installed capital cost per MW, and offer flexibility to assist in the integration of renewable resources. Aeroderivative (Aero) CT units are highly efficient peaking units similar to TVA's existing natural gas simple cycle frame CTs, but they offer higher cycling capability and no start-up costs. They can achieve full generating capacity from a cold start very quickly and allow for multiple daily starts to more closely follow load. Simple cycle frame CTs have a capacity factor of 1-10 percent while Aero CTs have a capacity factor of 10 to 45 percent.

In the 2019 IRP, for the IRP scenario that anticipated no license extension of BFN (Scenario 6), up to 6,500 MWe of gas CT capacity was forecast in 2038, of which 5,900 MWe was forecast to be added between 2028 and 2038 during the time when the existing BFN renewed operating licenses would expire (TVA 2019b). The IRP evaluated five different natural gas CT options: two simple cycle frame combustion turbines with either three or four turbines, and three Aero CT configurations with two, four, or six turbines. However, CT units generally have a capacity factor less than 5 percent. A 250-MW natural gas-fired CT unit could theoretically produce 2,190 GWh of energy if it ran every hour of the year, but the CT unit would likely only operate about 440 hours of the year and produce only about 110 GWh, resulting in a low capacity factor (TVA 2019b).

Investments in adding CTs to the peaking fleet aligns with the models in the IRP, which recommended substantial solar additions over the next two decades, by enhancing system flexibility to integrate renewables and distributed resources. As the amount of solar generation on the TVA generation portfolio continues to increase, flexibility of the remainder of the fleet becomes even more important. Therefore, TVA assumed development of single-cycle frame CTs or Aero CTs to ensure TVA maintains a reliable peaking fleet and to enhance system flexibility by facilitating the integration of intermittent renewable resources such as solar. As an example, TVA is proposing the addition of 10 natural gas-fired Aero CTs at the existing Johnsonville CT Reservation which would be operational no later than December 31, 2024 (TVA 2022f) and aid, in some combination with the other energy alternatives, in replacement of BFN generation.

2.1.1.3. Solar (with and without storage)

Solar PV systems consist of interconnected PV cells that convert sunlight into electricity. Utility-scale solar costs have fallen substantially over the past 10 years, with forecasts indicating continued declines in real dollars throughout the balance of the decade. Depending on the configuration, technology employed, and other factors, in-Valley utility-scale solar farms can expect a 20 to 27 percent capacity factor. While relatively inexpensive on a cost per megawatt-hour (MWh) basis, solar farms are not dispatchable and generation is intermittent in nature, varying by time of day, weather, and season.

At present, approximately 250 MWe of utility generating capacity in the TVA region is purchased solar power through several programs and long-term power purchase agreements (PPAs). TVA obtains the renewable energy credits from these sites, and the existing PPAs extend through the late 2030s. The 2019 IRP estimated the addition of up to 14,000 MW solar by 2038. For the no nuclear extension scenario in the IRP, up to 5,900 MW solar generation was forecast by 2038, of which 3,800 MWe was forecast between 2028 and 2038 during the time when the existing BFN renewed operating licenses would expire. It is unknown at this time, but it is possible that some of these new solar facilities would be located on TVA-owned lands in the BFN vicinity. Each facility would require varying amounts of land based on its generation capacity.

To provide dependable peak capacity needs for the TVA system, solar generation must be paired with dispatchable resources, such as storage or gas. Battery energy storage systems (BESS) typically represent one of the lowest cost storage options today and setups include a capacity output rating in MW along with an energy rating in MWh, which are customizable at each facility. Dividing the energy rating by the capacity rating provides the number of hours of duration that can be expected from the system at full output. Many utilities have found that four-hour BESS systems provide a good balance of price, output, and duration. The combination of utility-scale solar and battery storage would provide a carbon-free alternative to replace a portion of the BFN generation.

2.1.1.4. Storage (Battery Energy)

Storage units usually serve the same power supply function as peaking units but use low-cost, off-peak electricity to store energy for generation at peak times. As solar penetration on the system continues to increase, long-duration storage facilities will become increasingly more important to balance system demand. The 2019 IRP factored in the addition of up to 5,300 MW by 2038. For the No Nuclear Extension scenario in the IRP, up to 3,000 MW storage was added by 2038 to remain consistent with TVA’s strategy of having a diverse mix of power-generation, of which 1,600 MWe was forecast between 2028 and 2038 during the time when the existing BFN renewed operating licenses would expire. For example, for every 100 MW of distributed solar, TVA included an additional 10 MW of battery storage in their projection modeling (TVA 2019b). The IRP evaluated several types of storage: utility-scale battery storage, pumped storage, compressed air energy storage (CAES), and fuel cells. However, only a few are considered as possible options for supplementing the generating capacity of BFN if the renewed licenses are not subsequently renewed. Storage options considered not reasonable are described below in Section 2.1.2.1.

Most storage additions evaluated in the IRP were anticipated to be utility-scale batteries (TVA 2019b). It was estimated that these batteries would have a maximum capacity of 100 MW summer net dependable capacity (SND) capacity at an efficiency of 88 percent and storage capacity of approximately 4 hours (TVA 2019b). Lithium-ion batteries are another example of a storage resource (TVA 2019b). At the end of 2019, lithium-ion batteries represented more than 90 percent of the installed power and energy capacity of large-scale battery storage in operation in the United States primarily because they have a high energy density, high-cycle efficiency, and fast response times (EIA 2021). A BESS, as discussed in Section 2.1.1.3, typically represents one of the lowest cost storage options today. TVA is installing its first grid-scale BESS near an industrial complex in Vonore, Tennessee. The Vonore BESS will use lithium-ion batteries capable of generating up to 20 MW and storing 40 MWh of energy, which is enough electricity to power over 10,600 homes for three hours. The Vonore BESS will require approximately 10-15 acres of land (TVA 2020d, TVA 2022j).

A new hydro pumped storage unit was also evaluated in the IRP as a resource option. The pumped-storage option would use three reversible turbine generators to either take electricity from the grid by pumping water into a higher altitude reservoir during periods of excess power or add electricity to the grid by using the pumped water to power a turbine as it falls from the upper to the lower reservoir. While TVA currently operates one large hydro energy storage facility in the southeast (i.e., Raccoon Mountain Pumped-Storage Plant which has a SND capacity of about 1,600 MW), TVA is also in the process of initiating a pumped storage study to explore potential sites and develop cost estimates for additional pumped storage on the TVA system. TVA modeled the addition of a pumped storage unit providing 850 MW SND capacity. Although long timelines are required to meet environmental requirements and for construction of pumped storage, this type of storage may be a potentially viable option (in combination with other generation alternatives) by the time the last existing BFN renewed license would expire in 2036 (Unit 3).

2.1.1.5. New Nuclear - SMR

TVA has extensive nuclear operating experience with seven operating nuclear units at three sites, including BFN. The 2019 IRP included the addition of SMRs totaling 1,200 MW to replace one of the three BFN Units in the No Nuclear Extension scenario (TVA 2019b). SMRs require less space and are more flexible to operate than a traditional nuclear plant. Their smaller footprint and standardized manufactured components mean they can be built more quickly, are easier to operate and better fit into the landscape due to their compact size (TVA 2022a). TVA currently holds the only early site permit from the NRC for SMRs at its Clinch River site in Oak Ridge, TN. SMRs have the potential to serve cost-effective baseload or load following needs in the future with low fuel costs, carbon-free generation, advanced passive safety systems, and anticipated cost reductions achieved by assembling components in a factory setting. As yet, no SMRs have been built in the United States, and only NuScale holds an early NRC license authorization for an SMR design. There are substantial cost and timeline risks associated with first-of-a-kind deployment of new technology. Successful partnerships with the U.S. Department of Energy (DOE) and other utility stakeholders are critical to the deployment of this new technology. TVA believes that SMRs could play a role in meeting capacity needs in the early 2030s as additional capacity is retired or expires. TVA has published the Final Programmatic Environmental Impact Statement and Record of Decision (ROD) for the Clinch River Nuclear Site Advanced Nuclear Reactor Technology Park in Oak Ridge, Tennessee (TVA 2022c) and has announced the New Nuclear Program to explore innovative technology and potential locations beyond the Clinch River site for advanced nuclear reactors to support TVA’s decarbonization goal (TVA 2022h). Therefore, construction of SMRs may be a potential base-load generation alternative to SLR for BFN Unit 1, in some combination with the other energy alternatives analyzed here.

2.1.2. Energy Alternatives Not Considered Reasonable

The full range of energy alternatives to replace BFN include power sources that will require development of new generation and power alternatives that will not require new generation, such as purchased power and demand side management. This section addresses the energy alternatives that were not considered reasonable for additional evaluation with regard to replacement of the BFN generation.

2.1.2.1. Alternatives Requiring New Generating Capacity

Wind

Wind is intermittent and, therefore, by itself is not capable of providing firm, fixed, dispatchable baseload power. The capacity factor of a wind turbine normally ranges from 25 percent to 50 percent, although higher capacity factors can be achieved during windy periods (TVA 2021n). For wind power to be viable as a discrete source of power generation that is available during peak hours, energy storage would need to be considered in the planning process, similar to solar. As outlined in the 2019 IRP, wind from both outside and inside the Valley has challenging economics. Out-of-Valley wind must be imported to TVA across interconnected systems, driving significant transmission expense. In-Valley wind would have lower intensity and efficiency and would result in lower capacity factors and higher effective costs (TVA 2019b). Furthermore, there are limited wind resources in the eastern United States and potentially large environmental impacts associated with development of a wind facility. Because wind resources are energy- and capacity-limited resources (TVA 2019b), construction of new wind farms in the TVA service area was not factored into any of the IRP portfolios.

Historically, it has been more financially advantageous to acquire wind power resources through PPAs (TVA 2019b). But TVA does not consider purchasing power to make up for a large portion of generation capacity of BFN as a reasonable alternative to the BFN SLR. There is risk that purchased power could not be delivered and TVA would need to plan total generating reserves to accommodate the potential for undelivered purchased capacity. Therefore, wind power (with or without energy storage) is not considered a reasonable alternative for the replacement of BFN generating capacity.

<u>Hydropower</u>

Construction of a new large-scale hydropower facility capable of generating utility-scale power would require considerable siting considerations due to the area that would be inundated to provide water storage for generation, and the overall environmental impacts associated with the development of the facility would be LARGE. If a new run-of-the-river hydroelectric generating facility was developed in the TVA region (i.e., a facility that redirects the natural flow of a river through a hydroelectric facility with little to no storage), land requirements would be approximately 0.5 acres/MW (TVA 2019a). Based on this estimate, replacement of the generating capacity of only one BFN unit would require approximately 600 acres.

TVA has a Hydro Modernization Program through which outdated turbines and other equipment in the existing hydroelectric plants are replaced and modernized. This has resulted in increases in generating capacity and average efficiency of the hydroelectric plants (TVA 2019a). In the 2019 IRP, all portfolios reflect continued investment in the hydroelectric fleet to maintain capacity and consideration of additional hydro capacity where feasible; however, no new hydropower projects were considered (TVA 2019b). TVA has concluded that construction of a new hydropower facility would have severe environmental impacts and the improvements to existing hydroelectric generating facilities would not be enough to replace BFN generation. Therefore, hydropower is not considered a reasonable alternative to the BFN SLR.

<u>Geothermal</u>

To produce electric power with geothermal energy, underground high-temperature reservoirs of steam or hot water are tapped by wells and the escaping steam rotates turbines to generate electricity (Unwin 2019). Geothermal energy can achieve average capacity factors of 92 percent and can be used for baseload power where this type of energy source is available (Geothermal Energy Association 2013). The major challenge for geothermal development lies in geothermal resource mapping. The National Renewable Energy Laboratory (NREL) has not identified any viable sites for geothermal energy in the eastern United States (NREL 2021). Geothermal energy resources that can be developed for power generation are primarily located in the western United States. Geothermal power plants are currently generating power in Alaska, California, Hawaii, Idaho, Nevada, New Mexico, Oregon, and Utah (NREL 2021). Therefore, TVA has concluded that geothermal energy is not a reasonable alternative to the BFN SLR in the TVA service area.

Biomass

Biomass includes wood waste, animal and other organic waste, certain agricultural crops or waste, energy crops (crops grown specifically to produce biomass for use as fuels), landfill gas, wastewater methane, and other types of waste residues used to create electricity. The generating facilities have typically been built on heavily disturbed landfills or other industrial sites and occupy small land areas. TVA currently purchases electricity generated from landfill gas and wood wastes and generates biomass electricity from Chestnut Ridge Landfill gas (TVA 2019b). The environmental impacts of this generation are, overall, beneficial due to the avoidance of methane emissions and utilization of residues at wood and grain processing plants.

Currently, the largest municipal waste plant in the United States produces 96 MWe of baseload generation (ERC 2018). The land requirements for these vary and are plant specific. In the 2019 IRP, TVA evaluated two options for new biomass generation, including a dedicated biomass facility and a repowered coal unit in which TVA would convert one or more of its existing smaller coal-fired units to exclusively burn biomass. Most of the components of a biomass plant could likely be sited on an existing TVA plant reservation, on areas that have been previously disturbed, but the generating capacity of a biomass facility would be limited due to fuel delivery constraints (TVA 2019b). Fuels for a biomass-fueled generating facility are available in various areas of the TVA region but utilizing municipal solid waste for electricity would be dependent on being close to large population centers that generate large amounts of waste. Otherwise, the harvesting and transportation of trees for use as fuel can result in adverse environmental impacts including the modification or loss of wildlife habitat, sedimentation, reduction in soil fertility, loss of old growth forest, change in forest type and understory vegetation, altered scenery, and competition with other wood-using industries (TVA 2019b).

Overall, biomass plants are unable to produce the large baseloads of electricity that nuclear plants generate without the construction of multiple smaller facilities. The construction and operation of a biomass plant of the size necessary to act as an alternative to BFN would result in MODERATE to LARGE environmental impacts to land use, water quality, ecological resources, and air quality. Therefore, biomass is not considered a reasonable alternative for replacement of the BFN SLR.

Ocean Wave and Current Energy

Although TVA's 2019 IRP did not include tidal, ocean wave or current energy in its energy planning scenarios, these technologies are being included for consistency with licensing applications for other nuclear facilities.

The potential for ocean energy in Alabama has been estimated at 3 terawatt hours (TWH) along the outer shelf and 2 TWH along the inner shelf (EPRI 2011). This potential for ocean energy is low in Alabama and the technology is in its early stages of commercial development. Only one wave energy test site project is currently operating in the Unites States off the coast of Hawaii (DOE 2019) and there are two potential tests sites off the coast of Oregon (PacWave 2021). There is very minimal information available regarding the implementation of this technology in the United States. Additionally, the environmental impacts associated with these facilities have not yet been studied in any detail in the United States. At most, ocean energy would be available only through PPAs, and TVA does not consider purchasing power to make up for a large portion of generation capacity of BFN a reasonable alternative to the BFN SLR. Therefore, ocean energy is not considered a reasonable alternative for replacement of BFN generating capacity.

Combination of Only Renewable Resources (including Solar)

A combination of only renewable resources as generating assets was also considered. This could include any combination of solar, wind, hydropower, biomass, and ocean wave and current energy. Each of these resources was discussed in the sections above. As previously discussed, wind and solar are intermittent and wind is not a viable generation source within the Valley. TVA has not considered new hydropower as a future generating asset in the IRP and upgrades to existing hydropower facilities would be insufficient to replace more than a fraction of the BFN generation. Biomass plants would not be able to produce large amounts of electricity to make a significant contribution to making up the baseload generation of BFN without MODERATE to LARGE environmental impacts. Finally, ocean wave and current energy is not a realistic option because it is in the very early stages of development and because PPAs would be required if available.

The most viable renewable resource is solar which, because of the intermittent nature of the resource cannot be the sole replacement BFN generation. Therefore, using a combination of only renewable resources as an alternative to the BFN SLR was considered but dismissed.

Storage

As discussed in Section 2.1.1.4, TVA has evaluated several types of storage options in the 2019 IRP. Utility-scale battery storage and pumped storage were evaluated as potentially reasonable energy alternatives considered. However, CAES and fuel cells were not considered reasonable alternatives for the replacement of BFN generating capacity.

CAES plants are similar to a pumped-storage plant (Section 2.1.1.4) with the major difference being that instead of pumping water from a lower to an upper reservoir, a CAES plant uses a gas turbine to compress air into an underground cavern where it can be stored under pressure until electricity is required. The pressurized air is then heated and directed through a conventional generator to produce electricity. It is estimated that the SND capacity is approximately 330 MW with 70 percent efficiency; however, there are very few operating CAES plants and information on these systems and their environmental impacts is limited. In addition, they likely would not be commercially available before the existing BFN renewed operating licenses expire, and their environmental impacts is limited. Therefore, a CAES plant is not considered a reliable alternative to the BFN SLR.

Fuel cells as a reliable generation alternative are not presently economically or technologically competitive with other alternatives. The Energy Information Administration (EIA) projects that fuel cells may cost $6,866 per installed kilowatt (total overnight capital costs) (EIA 2022), which is higher than most generation technologies analyzed in the 2019 IRP and this SEIS. This high cost is associated with the durability of fuel cells and the technology to convert natural gas to hydrogen. Therefore, fuel cells are not considered a reliable alternative to the BFN SLR.

Oil

Petroleum (Oil)-fired power plants are generally used for short periods during times of peak electricity demand and otherwise operate mostly at low capacity factors because of the high price, air pollution restrictions, and lower efficiencies of their aging generating technology (EIA 2017). TVA currently owns five diesel generators, but construction of new oil-fired generation does not fit into TVA’s policy to replace high carbon emission fuel sources with generation that has a lower carbon footprint (TVA 2019b). TVA expects to phase out petroleum power purchases by 2028 and has committed to developing cleaner energy and continue to reduce environmental impacts. There are no diesel fuels or other petroleum-based resource options as a primary fuel source under consideration in the 2019 IRP because of the large amounts of carbon dioxide and hazardous air pollutants from these facilities. Thus, TVA has concluded that, due to the high costs and lack of obvious environmental advantage, burning oil to generate electricity is not a reasonable alternative to the BFN SLR.

Coal

TVA currently operates five coal-fired power plants consisting of 25 active generating units with a total capability of approximately 6,900 MW. For the past few years, TVA has implemented a program to reduce coal-fired baseload generation in its service area, retiring and proposing to retire existing coal-fired generation. TVA's program to reduce coal-fired baseload generation in its service area is fundamental to Agency efforts to reduce carbon emissions and comply with anticipated carbon regulation that will become successively more difficult to meet with existing coal fired facilities. Coal mining results in significant environmental impacts on numerous resources including air quality, water quality, and biological resources. The mining and combustion (burning) of coal also release high levels of greenhouse gases, including methane and carbon dioxide, contributing to climate change impacts. Due to higher relative capital costs, none of the 2019 IRP scenarios included additional coal in the capacity expansion, but it did include six coal expansion options, including two coal-fired IGCC options and four supercritical pulverized coal (SCPC) facilities (TVA 2019b). Coal-fired IGCC is a gasification process that produces synthetic natural gas from coal to use as fuel in the combined cycle process. SCPC are similar to conventional pulverized coal plants, but they can operate at much higher temperatures and pressures to increase efficiency. This results in the use of less coal and lower emissions. However, implementation of IGCC and SCPC options are very cost prohibitive compared to natural gas and IGCC technologies have been installed on a very limited scale (TVA 2019b).

TVA has identified the retirement of several of their coal-fired power plants and no new coal-fired generation is proposed in the IRP; therefore, this source of generation is not considered a reasonable alternative to the BFN SLR.

2.1.2.2. Alternatives Not Requiring New Generating Capacity

Purchased Power

TVA has evaluated conventional and prospective power supply options that could be reasonably implemented before the existing BFN renewed operating licenses expire. The TVA Act authorizes TVA to exchange, buy or sell power with 13 neighboring electric utilities at interconnection voltages ranging from 69-kV to 500-kV. This arrangement gives TVA the ability to purchase power when its generating capacity cannot meet demand or when purchasing power from a neighboring utility is more economical for TVA than generating it. The arrangement also allows TVA to sell power to neighboring utilities when its generation exceeds demand (TVA 2019b). Purchased power does not include solar PPAs which are electrical power agreements in which TVA purchase solar electricity from specific companies that intend to own and operate solar facilities specifically to sell the power to an electric power company. Although purchased power can be a component of a reasonable alternative, there is risk that purchased power will not be delivered and TVA must plan total generating reserves to accommodate the potential for undelivered purchased capacity (TVA 2019b). Therefore, TVA does not consider purchasing power to make up for the total generation capacity of BFN as a reasonable alternative to the BFN SLR.

Demand-Side Management

Demand side resources, such as Energy Efficiency (EE) and Demand Response (DR), reduce demand by either installing efficiency measures to reduce energy use across all hours or provide on-demand load reduction during times of heavy demand by issuing a “call” to contractually non-firm load. TVA currently offers EE programs under its EnergyRight® brand, in partnership with Local Power Companies, and will continue to offer programs for the foreseeable future. In recent years, TVA has placed increased emphasis on its missional offerings, including low-income assistance through its Home Uplift program and community redevelopment through its Community Centered Growth program. TVA also has extensive experience with DR, with over 1,500 MW of DR capacity today. A large percentage of this capacity is currently contracted with industrial customers, although TVA has DR contracts for aggregated commercial customers as well. Additionally, TVA has been piloting a program in the residential DR space, which has the potential to offer additional diversification in its DR portfolio. TVA anticipates initiating an updated Energy Programs Potential Study in 2021 and completing it in 2022, which will further inform costs and depth of EE and DR potential in the Tennessee Valley. Demand side EE and DR resources are well positioned to help TVA absorb load growth resulting from increased electrification of the economy, from sources such as electric vehicles or appliance fuel switching (gas to electric). However, demand side resources do face challenges around timing and limits on dispatchability. EE programs take time to scale and market, while also facing increasing costs for higher depth and penetration levels. DR programs allow TVA to offset physical capacity needs; however, they are limited in the number of calls available. While demand side options have the potential to contribute to the overall system solution, the capacity and energy needs required to replace the generating power of BFN make these options not viable replacement options.

Uprating and Delayed Retirement of Existing Generating Capacity

Extending the lives of existing non-nuclear generating plants beyond the time they were originally scheduled to be retired represents another potential alternative to SLR. Since 2010, TVA has retired six coal-fired power plants (33 generating units) and currently has five coal-fired power plants consisting of 25 active generating units. However, several of these units will be retired before or near the expiration date of the existing BFN renewed operating licenses. TVA does not consider the delayed retirement of coal-power generating assets to be a reasonable alternative to the BFN SLR because it is not in line with TVA's commitment to reduce carbon emissions and goal of moving toward net-zero carbon emissions by 2050 (TVA 2021i). . For these reasons, TVA does not consider the delayed retirement of non-nuclear generating units to be a reasonable alternative to the BFN SLR.

2.1.3. Conclusion

TVA operates the nation's largest public power system. It provides power to more than 10 million people, through 153 local power companies and 58 directly served customers, in an area encompassing 80,000 square miles, including most of Tennessee and parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia (TVA 2019b). TVA's portfolio has evolved over the past decade to a more diverse, reliable, and cleaner mix of generation resources. Currently, more than half of TVA's generation is carbon-free. TVA's current generating assets include 3 nuclear sites, 5 coal-fired sites, 29 hydroelectric sites, 1 pumped-storage site, 9 combustion turbine gas sites, 8 combined cycle gas sites, 1 co-generation unit, and 13 solar energy sites. These assets provided 37,896 MW (megawatt) summer net capability at the end of FY 2021 (TVA 2021g). This capacity included units fueled by nuclear (41 percent), natural gas (21 percent), coal (15 percent), hydroelectric (10 percent), and 13 percent from renewable and non-renewable purchased power (TVA 2021i). The diversity of generation sources is designed to provide reliable, low-cost power while reducing the risk of disproportionate reliance on any single resource.

TVA has considered alternatives to providing capacity and energy from 2033-2056, including renewing BFN operating licenses and other alternatives requiring or not requiring new generating capacity. Power uprates of existing generation assets are not sufficient by themselves to meet forecasted capacity needs. Even with substantial energy demand reduction through conservation measures, TVA would still have to add new generation to balance resources with the projected load requirements through 2056.

Construction of other types of generating capacity as an alternative to the BFN SLR was evaluated and included fossil fuel energy sources as well as renewable and nuclear energy sources. As described in Section 2.1.2, alternatives such as wind, hydropower, geothermal, biomass, ocean wave and current energy, combinations of only renewable energy, storage, oil, and coal, are not reasonable alternatives to the BFN SLR for various reasons. Wind resources are energy- and capacity-limited and not a viable generation source in the Tennessee Valley region. Environmental impacts associated with the development of new hydropower resources would be LARGE as compared to the BFN SLR and improvements to existing hydropower generating facilities would not be sufficient to replace BFN generation. Viable sources of geothermal energy have not been identified in the Tennessee Valley region. Construction of a biomass plant sufficient to replace BFN generation would result in MODERATE to LARGE environmental impacts. Minimal information is available regarding ocean wave and current energy generation and at best this power would only be available through PPAs and would be insufficient to make up for a large portion of BFN generation capacity. A combination of only renewable resources (including solar) was considered. For the reasons described above, most renewable generation options would not produce significant generation. Solar is intermittent and therefore is insufficient to be the sole, or even the major component of replacement generation for BFN. Therefore, using a combination of only renewable resources as an alternative to the BFN SLR was considered but dismissed. CAES and fuel cell storage options are not viable alternatives due to limited information about the technology (CAES) and cost (fuel cells). TVA expects to phase out petroleum power purchases by 2028, implementation of IGCC and SCPC options are cost prohibitive and IGCC technologies have limited implementation, further, TVA has committed to developing cleaner energy and continue to reduce environmental impacts and no new coal-fired generation is proposed in the IRP, therefore, both oil and coal are not viable alternatives to BFN generation.

Construction of new generating assets sufficient to replace BFN generation would have to include a combination of sources including a mix of natural gas-fired CC generation, natural gas-fired CT generation, solar generation, energy storage, and nuclear-powered generation in the form of SMRs. No single generation option would be sufficient to replace BFN generation.

Additionally, TVA considered alternatives not requiring new generating capacity including purchased power, demand-side management, and uprating and delayed retirement of existing generating capacity. Although purchased power can be a component of a reasonable alternative, there is risk that purchased power will not be delivered and TVA must plan total generating reserves to accommodate the potential for undelivered purchased capacity. Therefore, TVA does not consider purchasing power to make up for the total generation capacity of BFN as a reasonable alternative to the BFN SLR. Demand side resources such as EE and DR face challenges around timing and limits on dispatchability. The capacity and energy needs required to replace the generating power of BFN make these options not viable replacement options. Delayed retirement of coal-power generating assets is not in line with TVA’s commitment to reduce carbon emissions and goal of moving toward net-zero carbon emissions by 2050 (TVA 2021i). This would also result in higher environmental issues, does not meet the goals identified in the 2019 IRP to lower air emissions. Therefore, delayed retirement of non-nuclear generating units is not a viable alternative to the BFN SLR.

2.1.4. Alternatives Carried Forward for Evaluation

As described in Section 2.1, TVA has considered a wide range of actions to supply 3,900 MWe of baseload power generation between the years 2033-2056 and to meet the other identified purposes of this proposed action. Relative to BFN, taking action to continue operation would result in pursuing renewal of the operating licenses for Units 1-3. Taking no action to renew the BFN operating licenses would result in ceasing operation of BFN Unit 1 in 2033, Unit 2 in 2034, and Unit 3 in 2036. Subsequently, TVA would need to rely on alternate means to provide adequate capacity and energy in the absence of BFN. As described above, alternatives sufficient to meet the project purpose and need include construction of new generating capacity. Therefore, in this SEIS, changes in the construction of new generating capacity to compensate for the loss of BFN are key components of implementing a No Action Alternative.

2.1.4.1. Alternative A – No Action Alternative

The No Action Alternative (Alternative A) would be the decision not to submit a SLRA to the NRC and renew the BFN operating licenses in accordance with NRC regulations. If Alternative A were to be selected, TVA would allow the current BFN operating licenses to expire at the end of their terms, shutting down each unit no later than the current license expiration dates: December 20, 2033 for Unit 1, June 28, 2034 for Unit 2, and July 2, 2036 for Unit 3.

Unlike the Proposed Action, the No Action Alternative does not provide a means of meeting future electric system needs. Therefore, unless replacement generating capacity is provided as part of the No-Action Alternative, approximately 3,900 MWe of baseload generation would no longer be available to meet TVA's electricity customers' needs, and the alternative would not satisfy the Purpose and Need for the Proposed Action. For this reason, the No-Action Alternative is defined as having two components: (1) replacing the generating capacity of BFN with alternative generating supply available during or by the end of the term of the existing BFN renewed operating licenses license renewal term and (2) decommissioning the BFN facility, as described below.

BFN's 3,900 MWe of electric generating capability provides power to the Tennessee Valley Power Service Area. The Tennessee Valley obtains approximately 40 percent of its power from nuclear generation and BFN provides approximately half of that total. This power would be unavailable to customers in the event the existing BFN renewed operating licenses are not subsequently renewed. Replacement options to consider include construction of a combination of new generating capacity using energy from natural gas, solar, storage, and nuclear SMRs. Section 2.1.1 describes each of these feasible alternatives in detail. The alternative energy options described in Section 2.1.1 are considered part of the No Action Alternative.

Decommissioning

If BFN is shut down as required by the current licenses, each unit would then be required to enter the long-term process of decommissioning. TVA notes that decommissioning activities and their impacts are not discriminators between the Proposed Action and the No Action Alternative as BFN will have to be decommissioned regardless of the NRC decision on SLR, which would only postpone decommissioning for another 20 years. TVA evaluated the impacts from decommissioning in the supplemental EIS for the license renewal of BFN, which concluded that the timing of decommissioning would not influence the environmental impacts of decommissioning (TVA 2002). The NRC had also established in the 2013 GEIS that the timing of decommissioning operations does not substantially influence the environmental impacts of decommissioning (NRC 2013b). During decommissioning, BFN would be placed in a safe condition and all fuel would be removed from the reactors. Once BFN achieves safe shutdown conditions, the current BFN work force (2,147 permanent and contract workers) would decline over a period of a few years to a minimal maintenance size.

Decommissioning activities would begin after the permanent and safe shutdown of the units is achieved and after the formal decommissioning plans are approved by the NRC. TVA typically begins making future land-use decisions after NRC decommissioning plans are approved. During decommissioning, a new but smaller temporary work force would be employed to deconstruct the radioactive components and structures, while stored radioactive waste would be shipped offsite for permanent disposal. Based on potential new land-use changes, the work force would remove and clear any buildings, structures, facilities, impoundments, etc. that would not be part of the new land-use plans for the site property. The goal of decommissioning would be to remove and appropriate dispose of all radioactive materials throughout the BFN facility and return the site to a condition that no longer requires any control or oversight by the NRC.

The ISFSI would continue to be regulated by the NRC under its separate general license. The ISFSI would be operated as a separate facility until the DOE takes responsibility for the spent fuel and removes it from the site. Eventual decommissioning of the ISFSI would be conducted according to NRC and other applicable requirements.

Upon achieving shutdown conditions, the base load electrical power generation capacity would be lost, and TVA's ability to provide adequate power could be affected. TVA has the responsibility to ensure that the loss of BFN electrical base load generation does not adversely impact the TVA transmission system and its customers. Taking no action to renew the BFN operating licenses would result in ceasing operation of BFN Unit 1 in 2033, Unit 2 in 2034, and Unit 3 in 2036. Subsequently, TVA would need to rely on alternate means to provide adequate capacity and energy in the absence of BFN. Alternatives sufficient to meet the project purpose and need include the construction of new generating capacity. Therefore, in this SEIS, changes in the construction of new generating capacity to compensate for the loss of BFN as described in Section 2.1.1 are key components of implementing a No Action Alternative.

2.1.4.2. Alternative B – BFN Subsequent License Renewal

Under Alternative B TVA would seek renewal of operating licenses to allow for the continued operation of Units 1, 2, and 3 for an additional 20 years. Under Alternative B, TVA would submit the SLRA to the NRC. Assuming the NRC approves the SLRA, BFN would be available as a reliable base load generation plant until midnight on December 20, 2053 for Unit 1, until midnight on June 28, 2054 for Unit 2, and until midnight of July 2, 2056 for Unit 3.

<u>Continued Operation During the Proposed Subsequent Period of Extended Operation</u>

Under Alternative B, the three General Electric Boiling Water Reactors (BWRs) would continue to operate within the approved design basis and operational limits as allowed by the NRC licenses. Routine operations would include operation at extended power uprate. Chapter 1 provides a detailed description of BFN.

Under Alternative B, the BFN BWRs would continue to produce steam and electrical power by steam-driven turbine generators. The cooling water needed to support BFN power generation would be drawn from Wheeler Reservoir. Once-through cooling would continue to be used, with helper cooling towers operating when river temperatures near one or more of the NPDES limits to ensure BFN complies with regulatory thermal limits. Water from the circulating water system would continue to be discharged into Wheeler Reservoir in accordance with BFN's NPDES permit. As discussed in Section 3.1, water withdrawal and discharge would continue to be approximately 3,124 million gallons per day (MGD) and 3,107 MGD, respectively for all three units (as estimated from water use between 2016 and 2021); there is little consumptive water loss (approximately 16.6 MGD) with this method of operation.

Solid Low Level Radioactive Waste (LLRW) would continue to be generated during the proposed subsequent period of extended operation. During the proposed subsequent period of extended operation, the quantity of dry active waste (DAW) processed and shipped offsite annually would be expected to be consistent with current annual generation volumes; for example, approximately 34,600 cubic feet of LLRW was generated at BFN in 2020. Routine releases of small amounts of radioactive liquids and gases would also continue during the proposed subsequent period of extended operation and would continue to be controlled in accordance with federal regulations to ensure protection of human health and the environment. Section 3.21 provides a detailed discussion of radioactive wastes.

Operation of BFN during the proposed subsequent period of extended operation would continue to support TVA's goal of reducing carbon emissions from electrical power generation. Air emissions from nuclear generation are extremely low, with emissions related mostly to the offsite uranium fuel production, transportation, vehicle use, and occasional use of onsite support equipment such as emergency diesel generators and heavy equipment. BFN's greenhouse gas emissions are incredibly low in comparison with fossil-fueled electrical power generation. In 2019, coal-fired electricity generation made up 23 percent of United States electricity generation and produced 2,257 pounds of carbon dioxide (CO_2)/MWh of electricity, while natural gas-fired electricity generation made up 38 percent of United States electricity and produced 976 pounds of CO_2/MWh (EIA 2021). Nuclear power made up about 20 percent of United States electricity generation in 2019 and is considered a zero-emission energy source (EIA 2021), so the continued operation of BFN supports TVA's carbon free generation portfolio goals. For further discussion of air quality and greenhouse gases, see Section 3.12.

Routine maintenance and upkeep of BFN would continue through the proposed subsequent period of extended operation to ensure the safe and reliable operation of the three units. All programs, procedures, and training of personnel would ensure the units could continue to operate at a high capacity factor (>90 percent) and produce reliable base load generation.

Current work force requirements, approximately 2,147 personnel, would continue during the additional years of operation. No changes in manpower for normal operations or refueling outage support are anticipated. Very little change to current operational needs would be expected.

Refueling of one third of the fuel in each unit is performed approximately every 24 months. Refueling outages occur for approximately 28 to 35 days. During each refueling outage, spent fuel would be removed from the reactor core and new fuel bundles would replace the old. The unusable spent fuel would be stored in the spent fuel storage pools until they could be moved to dry cask storage on the onsite ISFSI.

The renewal of the BFN licenses would allow for the proposed subsequent period of extended operation of the units under the same requirements, technical specifications, and limits currently in place. Any changes to the provisions of the operating licenses (i.e., license amendments) would require NRC approval in accordance with applicable regulations. No changes would be expected for the permits currently in place. The current programs, procedures, and permits would be followed; no major changes would be needed to implement this alternative.

The routine plant operation and maintenance activities that would be performed during the proposed subsequent period of extended operation are not refurbishments as described in Sections 2.1.2 of the GEIS (NRC 2013) and would be managed in accordance with appropriate TVA programs and procedures.

Base Load Generation, Reliability, and Grid Stability

During the proposed subsequent period of extended operation, BFN would continue to supply approximately 3,900 MWe of base load power for a period of 20 additional years. BFN would be expected to continue to supply reliable power by maintaining an average capacity factor of greater than 90 percent. Due to its large and stable generation capacity, BFN would be able to support transmission grid stability, ensuring consistent electrical frequency and voltage.

Uranium Usage and Spent Fuel

Extended operation during the proposed subsequent period of extended operation would require approximately 10 additional fuel cycles per unit, resulting in approximately 3,900 acres of additional land being affected by the uranium mining necessary to fuel BFN. This acreage was calculated by using the NRC estimation of approximately 1 acre per MW would be affected for mining and processing the uranium during the operating life of a nuclear power plant (NRC 1996). The uranium would likely be sourced from Canada, Australia, or the United States. The generic calculation of land use is for the lifetime of a nuclear unit, and is conservative for this analysis of only 20 years.

BFN has two onsite ISFSI storage pads used to safely store spent fuel in licensed and approved dry cask storage containers. The ISFSI pads are licensed separately from BFN Units 1, 2, and 3 Renewed Facility Operating Licenses and would remain in place until the DOE takes possession of the spent fuel and removes it from the site for permanent disposal or processing. Expansion of the ISFSI would be required in the future if a national storage solution for the storage of spent fuel does not become available during the proposed subsequent period of extended operation. The current ISFSI storage pads are projected to be filled on or before year 2036. The addition of a third ISFSI storage pad to further increase storage capacity is under consideration, but plans are in the conceptual stage and no installation schedule has been established. A siting study conducted in 2017 showed that the BFN site has adequate space onsite to accommodate the construction of an additional ISFSI pad if necessary. The environmental impacts associated with this potential expansion would be assessed as needed under a future licensing and NEPA process.

Waste

On September 19, 2014, the NRC approved the final rule on “Continued Storage of Spent Nuclear Fuel” (10 Code of Federal Regulations 51.23) and associated Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel (NUREG-2157), expressing the NRC’s confidence that it is technically feasible to safely store spent nuclear fuel without significant environmental impacts. The evaluation of environmental impacts of continued storage were site-specific reviews, but NRC concluded that impacts would not vary significantly across sites, and could be analyzed generically (NUREG-2157).

Non-radioactive waste (general trash, hazardous waste, and special waste) would be generated at the same annual rates as they are currently generated at BFN. From January to June 2021, BFN generated 2.05 tons. BFN also has an active recycling program that segregates and recycles scrap metal, cardboard, office paper, wood pallets, aluminum cans, plastic bottles and batteries. The segregated materials are accepted for recycling by TVA-approved waste vendors.

The average monthly hazardous waste generated between 2016 and 2021 was approximately 5,879 lbs. Detailed discussion of non-radioactive waste is provided in Section 3.19.

Decommissioning

As described in Section 2.1.4.1, decommissioning activities and their impacts are not discriminators between the Proposed Action and the No Action Alternative as BFN will have to be decommissioned regardless of the NRC decision on SLR, which would only postpone decommissioning for another 20 years. The characteristics of decommissioning as described in Section 2.1.4.1 apply to the Proposed Action Alternative.

2.2. Summary of Impacts

Table 2-2 below provides a summary of the potential environmental impacts of the Action and No Action Alternatives. As a general guide to the evaluation of impacts for this SEIS, significance is used as a subjective interpretation of the intensity of the impact. As used here, the term small means that there will be no quantifiable alteration of the resource. Moderate refers to impacts that can be observed and must be considered as causing some change to the resource. A large impact clearly produces an observable impact, and the impact would clearly need to be evaluated for mitigation or producing an impact that may eliminate it from consideration due to a definite negative impact. The terms small, moderate, and large are used to evaluate impacts throughout this SEIS.

There are substantial differences between the alternatives concerning air emissions. Should TVA decide to take no action to renew BFN operating licenses, the likely increased use of existing gas units, as well as the potential construction of additional gas units, would increase emissions from those sources. Under Alternative B, continued operation of BFN helps reduce emissions of carbon and air pollutants, consistent with TVA’s environmental policy.

Table 2.2-1. Summary of the Environmental Impacts of the No Action and Action Alternatives

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Land Use	Changes in land use, land acquisition, or land conversion.	*Impacts of BFN shutdown:* No changes in onsite land use patterns. Potential decrease in offsite land-use impacts from decreased uranium mining demand. *Impacts due to new generation assets:* Alternative sources for energy include a combination of natural gas-fired combined cycle (CC) generation, natural gas combustion turbine (CT) generation, solar photovoltaic (PV) facilities, energy storage facilities, and small modular reactors (SMRs). Some of these alternative sources could be sited on the nearly 880-acre BFN site and some would be sited offsite. Impacts to land use associated with construction of these new sources for energy would be small to moderate.	No changes to offsite or onsite land use Impacts associated with expansion of ISFSI would be assessed under a licensing process separate from that of the BFN SLR. Incremental contribution to cumulative impacts to land uses would be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Geology and Soils	Seismic adequacy	*Impacts of BFN shutdown:* No impacts from potential minor seismic event(s) would be expected during shutdown activities. *Impacts due new generation assets:* The site chosen for any replacement generation facility would be evaluated for geologic conditions and potential seismic impacts during the site-selection process Impacts would largely be associated with ground-disturbing activities associated with the new construction and would be expected to be small.	No changes or new impacts.
	Changes or use of geological resources	*Impacts of BFN shutdown:* Anticipated impacts to soils from decommissioning would be small. *Impacts due new generation assets:* Potential effects from construction could include excavation, grading, and blasting. Impacts could range from small to moderate and would depend on the type and extent of soil disturbance activities.	No changes or new impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Surface Water	Surface water hydrology and water quality.	*Impacts of BFN shutdown:* Impacts to surface water quality would be small, and potentially beneficial. *Impacts due to new generation assets:* The characteristics of the surface water impacts would be expected to be small because they would be controlled under an NPDES permit that would be regulated by the state in which the plant(s) is located. There is a potential that some erosion and sedimentation may occur during construction; however, construction would be temporary, and the implementation of best management practices (BMP) should limit any potential impacts to surface water quality. Depending on the water source, the impacts on water quality caused by plant discharge could have noticeable impacts. The plant would have to maintain compliance with the plant's NPDES permit. Impacts would be expected to be small.	All releases to surface water would be controlled as per NPDES permits and impacts would remain small. BFN complies with current NRC regulations. No change is anticipated regarding potential impacts from the current level of small impacts anticipated.
	Surface water use and trends.	*Impacts of BFN shutdown:* Impacts to surface water use would be small, and potentially beneficial. *Impacts due new generation assets:* Surface water use impacts would depend on the volume of water withdrawn for makeup water for each new generation source relative to the amount available from the intake source and the characteristics of the surface water. The overall impacts could be small for water use impacts during normal flows and possibly large impacts during extreme low-flow conditions. Potential impacts can be mitigated by derating (reducing the thermal output of the plant by reducing its electrical power rating) during periods of thermal sensitivity.	Direct, indirect, and cumulative effects of chemical and thermal discharges would be small. No changes in current level of small impacts to water supply. No cumulative effects to water supply are expected.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Surface Water (continued)	Hydrothermal effects of plant operation.	*Impacts of BFN shutdown:* Impacts would be small, and potentially beneficial. *Impacts due new generation assets:* Hydrothermal impacts on surface water from an SMR or gas-fired plant would be site specific, and dependent on the volume and temperature of water discharged. The use of cooling towers and compliance with the NPDES permit should minimize impacts which could range from small to large.	BFN would continue to operate within the thermal limits set by BFN's NPDES permit and without measurable adverse impact. BFN is in compliance with current NRC and ADEM regulations related to thermal discharge evaluation requirements; therefore, no change regarding any potential impact from the current level of small impact would be anticipated, including to cumulative impacts.
	Chemical additives for plant operation.	*Impacts from BFN shutdown:* The use of chemical additives would decrease and eventually end resulting in small and potentially beneficial impacts. *Impacts due new generation assets:* Plant discharges would be regulated by the state in which the plant is located. An NPDES permit would be required, and the plant would comply with applicable water quality standards and criteria. Therefore, when the new generation source commences operation, the direct, indirect, and cumulative effects of chemical discharges would be expected to be small.	Current use and discharge of chemical additives is expected to remain the same during the proposed subsequent period of extended operation. There would be no change in impact from the current level of small impact.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Groundwater	Chemical and radiological impacts to groundwater.	*Impacts from BFN shutdown:* No effects to the groundwater hydrology, groundwater use, or groundwater quality.	No change from current level of small impact.
	Groundwater use.	*Impacts due new generation assets:* Groundwater impacts for new generation resources would depend on the use of groundwater and construction activities required to build the plant, aquifer conditions, and other withdrawals and on the type of plant constructed. With compliance with all permits and regulations and use of BMPs, chemical and radiological impacts to groundwater would be anticipated to be small. Although it is unlikely that groundwater would be used for makeup and/or cooling water, it would depend on site-specific conditions and therefore the impacts could be moderate to large.	No groundwater use at BFN. No impact anticipated.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Floodplains and Flood Risk	Construction or modification of the floodplain.	*Impacts from BFN shutdown:* No impact is anticipated on any floodplain or flood risk since a majority of the site is located outside of the floodplain. Negligible beneficial impacts would occur if facilities within the 100-year floodplain were removed upon shutdown. *Impacts due to new generation assets:* Construction and operation of a new plant(s) would introduce construction impacts and new incremental operational impacts. All proposed construction would be evaluated to ensure consistency with EO 11988. Proper standard erosion-control measures would be followed to minimize the potential for adverse impacts on floodplains. Therefore, impacts would be anticipated to be small.	No increase in flood risk and no new impacts to floodplains in the Wheeler Reservoir watershed.
Wetlands	Destruction of wetlands or degradation of wetland functions.	*Impacts from BFN shutdown:* No impacts to wetland resources on or in the vicinity of BFN would be anticipated. *Impacts due to new generation assets:* Construction of new generating sources for energy would result in small to large impacts depending on the physical location of the plant structures and footprint.	Impacts would be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Aquatic Ecology	Destruction of aquatic organisms; degradation or destruction of aquatic habitat.	*Impacts due to BFN shutdown:* Elimination of impingement and entrainment, thermal effects, non-cooling water discharge, maintenance dredging, and other operational effects generally would be expected to be small and beneficial for aquatic resources. *Impacts due to new generation assets:* Construction and operation of new SMR plant(s) could range from small to large depending on plant design, organisms present, source water, and receiving water. Construction and operation of other generating sources would range from small to large depending on location of the plant and supporting structures. Impacts would be mitigated through use of BMPs and adherence to permit and regulatory requirements.	Impacts from impingement and entrainment, thermal effects, non-cooling water discharge, maintenance dredging, and other operational effects would be small.
Terrestrial Ecology	Removal or degradation of terrestrial vegetation, wildlife habitat, and/or wildlife.	*Impacts due to BFN shutdown:* The elimination of operational effects would be expected to be small and beneficial for terrestrial resources. *Impacts due to new generation assets:* In association with construction of a new generation facility, impacts would occur to terrestrial plants cleared to accommodate the new plant site. Wildlife in the vicinity may be able to relocate and would have lesser impacts due to displacement, habitat loss, and fragmentation. Direct and indirect impacts from construction of these new sources for energy would range from small to moderate. Small cumulative impacts to terrestrial vegetation and wildlife.	No change from current BFN operations and impacts would be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Endangered and Threatened Species	Mortality, harm, or harassment of federally listed or state-listed species including impacts to their critical habitat.	*Impacts due to BFN shutdown:* The elimination of operational effects would be expected to be small and beneficial for threatened and endangered species. *Impacts due to new generation assets:* Possible alternative sources could be sited onsite or offsite. Small to large indirect and direct impacts from alterations in land use patterns and human population density and growth rates that could alter habitats. Construction of generating sources could have small to large cumulative impacts from potential habitat loss, habitat fragmentation, and loss of biodiversity.	No effect on the gray bat, Indiana bat, northern long-eared bat, and tricolored bat. BFN operations that could result in tree removal would be assessed in separate environmental reviews and Section 7 Consultation would occur as appropriate to address potential impacts. Small impacts on monarch populations, bald eagles, migratory birds, aquatic species.
Managed and Natural Areas	Degradation of the value or quality of natural areas.	*Impacts due to BFN shutdown:* No impacts to managed and natural areas in the vicinity would be expected. *Impacts due to new generation assets:* Avoidance planning would likely place any potential new generation plants at a safe distance from most natural areas, therefore impacts would be small. However, over time there could be small to large cumulative impacts resulting from additional development.	Impacts would remain small. Cumulative impacts would be small.
Recreation	Degradation or elimination of recreational facilities or opportunities.	*Impacts due to BFN shutdown:* No impacts are anticipated. *Impacts due to new generation assets:* Alternative generation facility locations would be assessed for potential adverse impacts. If a potential facility were sited near a recreational, scenic, or culturally significant area, then noise, dust, viewshed, and watershed impacts could range from small to moderate.	No impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Meteorology, Air Quality, Climate Change and Greenhouse Gasses	Local meteorology and meteorological conditions.	*Impacts due to BFN shutdown:* No impact to meteorology and impact to air quality would be slightly beneficial. *Impacts due to new generation assets:* Prior to construction of a new generating plant, local meteorological conditions would be evaluated to model dispersion characteristics as well as the potential impact on the local air quality from the operation of the new facility.	No impact.
	Emissions resulting in increases of air pollutants.	*Impacts due to BFN shutdown:* Once the destruction and recycling of site structures and facilities began, there would be a brief period of increased pollutant emissions from construction-type activities resulting in temporary adverse air quality impacts. These would be minimized through use of BMPs and adherence to all applicable regulations. *Impacts due to new generation assets:* Construction of alternative generation sources would result in a temporary increase in fugitive dust emissions, vehicular traffic emissions, heavy equipment emissions, and concrete batch plant emissions. BMPs would be used to control the sources of emissions, and the impacts would be small and of short duration. Depending on alternative power generation methods, adverse operational impacts to air quality would be small to moderate.	BFN is not a significant source of air pollutants, and the impact of operation for an additional 20-year period would be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Meteorology, Air Quality, Climate Change and Greenhouse Gasses (continued)	Climatology and effects due to climate change.	*Impacts due to BFN shutdown:* Small impacts on GHGs as a result of emissions during decommissioning. These impacts would be temporary and would not be expected to contribute to climate change. *Impacts due to new generation assets:* Small impacts on GHGs from the construction of alternative generation sources. These impacts would be temporary and would not be expected to contribute to climate change. Operation of a new SMR or solar plant(s) would not create a significant source of pollutants including GHG, because those facilities produce considerably less air pollutants when compared to fossil-fueled generation sources. Therefore, the environmental impact of a new SMR or solar plant(s) would be small. Operation of a new natural gas fired turbine plant would increase some GHGs and impacts would be small to moderate.	The impacts of BFN on global climate change and greenhouse gas emissions would be expected to be small.
	Gasoline and diesel emissions from vehicles and equipment.	*Impacts due to BFN shutdown:* Vehicle and equipment emissions would initially increase during decommissioning of BFN which would result in small temporary impacts on GHG emissions. *Impacts due to new generation assets:* Vehicle and equipment emissions would initially increase during construction of any alternative generation resources which would result in small temporary impacts on GHG emissions.	No changes or new impacts would occur.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Transportation	Elevated levels of traffic from construction work force and deliveries.	*Impacts due to BFN shutdown:* Any decline in traffic due to plant closure would likely be partially offset by future development. *Impacts due to new generation assets:* Construction and operation of a new generation facility would potentially impact the transportation infrastructure and traffic load on the roadways associated with a site. Mitigation of potential transportation impacts due to the location of a facility may be necessary because of expected increases in construction and operation traffic. Therefore, impacts could range from small to moderate.	No changes or new impacts expected.
Visual Resources	Effects on scenic quality, degradation of visual resources.	*Impacts due to BFN shutdown:* No adverse impacts. *Impacts due to new generation assets:* The impact on the visual resources of an area would be dependent upon the physical, biological, and cultural characteristics of the potential new generation site. The level of impact anticipated during construction and operation would range from small to moderate and vary depending upon viewer distance from the site, the abundance of trees, hilly terrain, and mitigation measures used, such as utilizing landscape materials on site, and painting techniques applied to facility structures.	No new impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Noise and Vibration	Generation of noise at levels causing a nuisance to the community.	*Impacts due to BFN shutdown:* A drop in industrial noise would result in a small beneficial impact long-term. *Impacts due to new generation assets:* Noise impacts for a new generation facility and transmission systems are dependent on the distance to the nearest critical receptor. Noise for the construction of a new generation plant is expected to be small to moderate (depending on location and type of sensitive receptor) because most noise-producing construction activities are of short duration and the construction is temporary, and there are numerous mitigation methods that can be implemented to limit the impact of noise. Operational noise would also be anticipated to be small.	Impacts would be small. No change from the current condition.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Socioeconomics	Changes in local populations, employment, and incomes.	*Impacts due to BFN shutdown:* Impacts related to loss of jobs and income would be short-term and small. *Impacts due to new generation assets:* Potential effects from construction and operation of new assets could help offset the loss of jobs from BFN shutdown, it could also result in a small shift in population both during construction and operation. Therefore, impacts could range from small to moderate, depending on site specific site conditions.	No changes in operating employment levels. No new impacts to population, local employment, or income.
	Changes in availability of housing.	*Impacts due to BFN shutdown:* May cause housing costs to slightly decrease which would result in short-term and small impacts. *Impacts due to new generation assets:* Population shifts related to construction of new generation sources could place pressures on the housing market during both construction and operations. impacts could range from small to large depending on available housing surrounding the potential site areas.	No changes or new impacts.
	Local government revenues.	*Impacts due to BFN shutdown:* Small impact on local government revenues as a result in potential changes in TVA's payment in lieu of taxes. *Impacts due to new generation assets:* Construction and operation of replacement generation sources would result in a beneficial impact if the total amount of TVA-managed land in any individual county increased. Revenue increases would be proportionally small. Impacts from construction and operation would be beneficial.	No changes or new impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Socioeconomics (continued)	Police, fire, and medical services.	*Impacts due to BFN shutdown:* Phased reduction in the need for public safety services and emergency personnel. These changes would likely be offset by continued growth in the counties in the vicinity of BFN. *Impacts due to new generation assets:* Depending on the proximity to population centers and the availability of emergency services in the vicinity of these generation resources, the influx of construction workers could impact the ability of an area's police, fire, and medical facilities to provide support requiring additional resources. The expansion of public safety services would support incoming operational staff and families expected to permanently move to the area, as well as other further county population growth. Therefore, impacts could range from small to moderate.	No changes or new impacts.
	Schools and education.	*Impacts due to BFN shutdown:* The loss of operational jobs could result in a loss of population and result in reduced school enrollment. Impacts would likely be small. *Impacts due to new generation assets:* The arrival of workers and the facility would bring new monies to a region through direct and indirect spending, and in the long run, the costs of providing education for additional students should be offset by the increase in tax revenues and plant equivalent payments, therefore impacts should be small.	No changes or new impacts.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Environmental Justice	Disproportionate effects on low-income and/or minority populations.	*Impacts due to BFN shutdown:* impact is expected to be short-term and small with no disproportionate impacts to potential environmental justice communities of concern. *Impacts due to new generation assets:* Environmental justice issues would depend on the proposed location of the new generation assets and impacts could range from small to moderate based on pressure on food and housing process, or increases in road congestion or noise near residential communities	No disproportionate effects on low-income or minority populations. No incremental contribution of the continued operation of BFN to the cumulative environmental justice conditions in the region during the proposed subsequent period of extended operation

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Archaeological and Historic Resources	Damage to archaeological sites or historic structures.	*Impacts due to BFN shutdown:* Any decommissioning activities, including but not limited to demolition could result in adverse effects to the National Register of Historic Places-eligible BFN historic district and contributing structures Should any activity related to decommissioning be proposed that would modify BFN or affect any of the potentially-eligible archaeological sites, TVA will follow the steps of §800.5 for assessing adverse effects and, if required, the steps of §800.6 for resolving adverse effects. *Impacts due to new generation assets:* All lands involved in the undertaking would likely need an inventory and evaluation of cultural resources to identify historic properties and may require avoidance plans or other actions to mitigate adverse effects from proposed ground-disturbing actions and/or visual effects related to physical activities at the proposed site. The effects on cultural resources could, depending on the site, range from small to large. The anticipated NHPA Section 106 process would ensure that any historic properties would be properly identified and managed and that potential impacts would be considered and mitigation developed as appropriate.	No effect to archaeological and historic resources within BFN site or vicinity are expected. Should any activity related to SLR be proposed that would modify BFN or affect any of the potentially-eligible archaeological sites, TVA will follow the steps of §800.5 for assessing adverse effects and, if required, the steps of §800.6 for resolving adverse effects.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Hazardous, Solid, and Low-Level Radioactive Wastes	Generation and disposal of hazardous, sold, and low-level radioactive wastes.	*Impacts due to BFN shutdown:* Impact on the environment from waste generated during the period of decommissioning would be small. *Impacts due to new generation assets:* The quantities and types of solid waste generated by the construction and operation of replacement generation resources would be determined primarily by the number of acres, the initial condition of the selected site(s), and the location and type of technology chosen. Any construction and demolition wastes generated during the building and renovation process would be managed through the TVA waste disposal contracts to access the permitted disposal capacity or recycling facilities, as needed. Construction of new transmission lines has a potential to produce large volumes of solid waste. TVA-established management practices would ensure impacts to the public and the environment are small.	Waste would continue to be handled according to TVA approves procedures and federal regulations. Impacts would continue to be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Radiological Effects of Normal Operations	Effects to humans and nonhuman biota from normal radiological releases.	*Impacts due to BFN shutdown:* Decommissioning effluent releases would be small. *Impacts due to new generation assets:* There would be no radioactive effects during the construction of a new SMR plant(s) unless the construction takes place at the location of another operating nuclear plant, or there are multiple units being built and one unit becomes operational before the other(s). The radiological impacts from the construction of a new nuclear plant would be of minor significance to the construction workers. There would be no expected observable impacts from radioactive liquid or gaseous releases from a new SMR plant(s) during normal operations. The REMP would be set up for the new SMR plant(s) to ensure there are no measurable indirect or cumulative effects to the environment offsite of the new location or to the public. There would be no radioactive impacts from the construction and operation of other potential generation resources.	Annual doses to the public are well within regulatory limits; no observable health impacts are expected. No changes or new impacts are expected. Doses to nonhuman biota would be well below regulatory limits; no noticeable effects are expected and impacts are expected to remain small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Uranium Fuel Cycle Effects	Radioactive waste volumes and disposal.	*Impacts due to BFN shutdown:* Impacts associated with radioactive waste handling, storage, and transportation for decommissioning activities would be expected to be small. *Impacts due to new generation assets:* If new SMR generation were selected, the approved design would be subject to the same requirements for handling and processing radioactive waste at BFN. Similar to BFN, the environmental impacts associated with radioactive waste handling, storage, and transportation would be expected to be small and potentially less than BFN. There would be no environmental impact related to radioactive waste during the construction or operation of any non-nuclear power generation facility.	Impacts to the public and the environment resulting from processing, storage, and transportation of solid radwaste, including cumulative effects of waste storage from BFN would remain small. During decommissioning, the plant would ship all stored radioactive material to be processed or to its final disposal. Transportation impacts of all types of radioactive waste would be expected to be small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Uranium Fuel Cycle Effect (continued)	Radioactive waste transportation.	*Impacts due to BFN shutdown:* Generation of routine operational radioactive waste would cease. However, decommissioning of active components would generate waste and result in in small impacts. *Impacts due to new generation assets:* Impacts associated with radioactive material transportation at any new SMR facility would be small.	The impact to members of the public resulting from processing, storage, and transportation of solid low-level radioactive waste would be small.
	Spent fuel.	*Impacts due to BFN shutdown:* No additional spend fuel would be generated after BFN is shutdown. Small impacts as it is operated under a separate license. *Impacts due to new generation assets:* Impacts associated with spent fuel storage at any new SMR generation facility would be expected to be small. There would be no environmental impact related to spent nuclear fuel during construction or operation of any non-nuclear power generation facility. Potential effects from construction and operation of any replacement generation resource would be evaluated in separate analyses	Small impacts from the operation of the ISFSI, as it is operated in accordance with all applicable regulations. Additional ISFSI storage capacity would be required before 2036 if DOE does not take possession of spent fuel. Impacts from the construction and operation of an additional storage pad would be assessed in a separate evaluation and would be expected to have small cumulative impacts including small direct impacts from radiation doses from the ISFSI for onsite workers and people in the surrounding area.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Nuclear Plant Safety and Security	Postulated design-basis accidents.	*Impacts due to BFN shutdown:* All equipment and facilities would be properly maintained to ensure high integrity and safety of all systems through the end of operation and decommissioning. *Impacts due to new generation assets:* Impacts at any new SMR facility would be expected to be small. For any non-nuclear electrical power generation facility, there would be no applicable environmental impact related to DBAs.	In all cases, the doses to an assumed individual at the exclusion area boundary and low population zone are a fraction of the regulatory dose limits. Environmental risks due to postulated radiological accidents are small.
	Severe accidents.	*Impacts due to BFN shutdown:* Impacts would no longer be applicable. *Impacts due to new generation assets:* Impacts at any new SMR facility would be expected to be small and of no significance. For any non-nuclear electrical power generation facility, there would be no applicable environmental impact related to severe radiological accidents.	Severe accident analysis indicates that the risk is small and meets all safety goals.
	Plant security.	*Impacts due to BFN shutdown:* Small impacts and bound by the server accident scenarios. *Impacts due to new generation assets:* Impacts for an SMR facility would be bound by the severe accident scenarios and would be expected to remain small. For any non-nuclear electrical power generation facility, nuclear plant security regulations are not applicable.	TVA is in compliance with all regulations on plant security and plant security related impacts would remain small.

Resource	Attribute/Potential Effects	Alternative A – BFN Shutdown	Alternative B – BFN Subsequent License Renewal
Nonradiological Public Health and Safety	Electric shock and microbiological hazards.	*Impacts from BFN shutdown:* Electric shock hazards from in-scope transmission lines would be nullified. Impacts to public health would be small and beneficial from the reduced heating of waters for thermophilic organisms. *Impacts due to new generation assets:* Potential effects from construction and operation of new generation assets would be evaluated in separate analyses and impacts could range from small to moderate.	The public is precluded from accessing the site and from direct contact with transmission lines, therefore, possible shock hazard is small. No new impacts to public health from thermophilic organisms are anticipated.
Decommissioning	Environmental, cultural, and socioeconomic impacts.	Impacts would be similar to Alternative B and small.	Delaying decommissioning of the BFN reactors as a result of SLR would have small beneficial and negative impacts.

2.3. The Preferred Alternative

TVA has identified Alternative B – BFN Units 1, 2, and 3 SLR as the preferred alternative. Implementing the preferred alternative would provide the Tennessee Valley with an additional 20 years of reliable base load power while promoting TVA's goals to eventually eliminate carbon emissions, make beneficial use of existing assets, and deliver power to TVA's service area at the lowest feasible cost. As an existing plant, continued operation of BFN would not result in additional environmental impacts to new resources, while contributing to meeting the demand for base load energy sources on the TVA system in the future.

2.4. Summary of Mitigation Measures and Best Management Practices

Best Management Practices (BMPs) identified in Chapter 3 to avoid, minimize, or reduce adverse impacts to the environment in association with the preferred alternative are summarized below. Because BFN would continue operating within all applicable federal, state, and local regulations and because no new construction or modifications to the facility would occur during the proposed subsequent period of extended operations, no new mitigation measures would be required beyond those already implemented as a result of initial construction and operations.

- BMPs would be implemented including those described in A Guide for Environmental Protection and Best Management Practices for Tennessee Valley Authority (TVA 2017), stormwater pollution and Spill Prevention, Control, and Countermeasure (SPCC) plan, and other permit conditions
- BFN also has an Integrated Pollution Prevention Plan that addresses storage, secondary containment, and inspections of fuel, hazardous materials, and chemicals like biocides. Attachment 5 of the plan provides an inventory of all of the tanks, pumps, transformers, and other containers where these materials are used or stored, including the type of secondary containment for each. The secondary containment limits the potential for minor chemical spills to occur outside of containment areas.
- The discharge of chemicals to surface water would be regulated by the conditions set forth in the NPDES permit.
- Dredged material would be disposed of on land lying and being outside the 500-year floodplain in an onsite spoils area and above the 500-year flood elevation.
- Water-use and water-dependent structures and facilities would be located within 100-year floodplains, and flood-damageable equipment and facilities would be located at a minimum outside 100-year floodplains, and Critical Actions would be located at a minimum outside 500-year floodplains
- All handling and disposal of non-radioactive and radioactive wastes would be in accordance with applicable rules, regulations, and requirements of local, state, and federal laws.

CHAPTER 3 – AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

The Browns Ferry Nuclear Plant (BFN) has been the subject of many environmental reviews. The environmental consequences of constructing and operating BFN were addressed comprehensively in Tennessee Valley Authority's (TVA's) 1972 Final Environmental Statement (TVA 1972). Subsequent environmental reviews have updated that original analysis (Section 1.6). This chapter updates the information contained in those earlier reviews and identifies any new or additional effects that could result from the proposed subsequent period of extended operation of BFN.

TVA has identified the significance of the impacts associated with each issue as small, moderate, or large, to be consistent with the NRC criteria found in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, footnote 3:

> SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.
>
> MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
>
> LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The following sections evaluate the potential environmental impacts of the BFN subsequent license renewal (SLR) and of the no action alternative for all the potentially affected environmental and human health resources.

3.1. Land Use

Located in Limestone County, Alabama on the north shore of Wheeler reservoir at Tennessee River Mile (TRM) 294, BFN is across the reservoir from Lawrence and Morgan Counties. This section addresses land use in the three counties within six miles of BFN, as shown in Figure 1.2-2.

3.1.1. Affected Environment – Land Use

3.1.1.1. Offsite Land Use

<u>Limestone County</u>

As shown in Figure 1.2-1, BFN is located in Limestone County in northwest Alabama. The County is bordered by Lauderdale County to the west, Madison County to the east, and Lawrence and Morgan Counties to the south on the southern shore of the Tennessee River. Northern Limestone County is bordered by Giles and Lincoln Counties in Tennessee. Limestone County is approximately 559 square miles or 357,760 acres of land (Siebenthaler 2020). Limestone County has several types of natural features due to its location at the foothills of the Appalachian Mountains. The section of the Tennessee River that flows along Limestone County's southern borders extends 77 miles and includes Wheeler Reservoir formed from impounding dams, Guntersville Dam and Wheeler Dam (TVA 2021m). The county has various types of trails including eight public birding trails along Wheeler Reservoir and throughout the Wheeler National Wildlife Refuge (Alabama Birding Trails 2021). Other trails and outdoor recreation areas sit along the Elk River, which flows for 15 miles from Veto, Alabama south to the Tennessee River (Limestone County 2021a). The Swan Creek Wildlife Management Area is also located within Limestone County, approximately 5 miles southeast of BFN.,

Located in Decatur, Alabama about 15 miles to the southeast of BFN, Wheeler National Wildlife Refuge is a unit of the National Wildlife Refuge System consisting of 35,000 acres of Limestone and Morgan County. The land is used to manage and protect a diverse range of habitats including federally listed, threatened, or endangered species. Recreational activities at the Wheeler National Wildlife Refuge include wildlife education and observation, hiking, boating, fishing, and seasonal day camps (USFWS 2017, USFWS 2020b).

BFN is located on Wheeler Reservoir at TRM 294 in Limestone County. The Reservoir extends from Guntersville Dam at TRM 349 to Wheeler Dam at TRM 274.9. Table 3.1-1 describes land cover in the 6-mile (10-kilometer) region based on data downloaded from the National Land Cover Database (NLCD) 2019 (NLCD 2019). Figure 3.1-1 shows the land cover within a 6-mile radius of BFN.

Table 3.1-1. Land Cover Within a 6-Mile Radius of BFN Property Boundary

Land Use/Land Cover Type	6-Mile Radius Acreage	Percent of Total (%)
Cultivated Crops	23,499.40	32.45
Open Water	15,999.16	22.1
Hay / Pasture	10,985.12	15.17
Woody Wetlands	8,894.84	12.28
Deciduous Forest	3,070.03	4.24
Developed, Open Space	2,334.35	3.22
Emergent Herbaceous Wetlands	1,550.93	2.14
Developed, Low Intensity	1,208.94	1.67
Evergreen Forest	1,128.78	1.56
Developed, Medium Intensity	1,016.20	1.4
Developed, High Intensity	796.43	1.1
Mixed Forest	705.49	0.97
Shrub/Scrub	561.86	0.78
Herbaceous	454.66	0.63
Barren Land (Rock/Sand/Clay)	201.62	0.28
Total	72,407.82	100

Source: Land cover data from NLCD 2019 (as shown in Figure 3.1-1).

Limestone County contains six incorporated cities and towns (Ardmore, Athens, a small portion of Decatur [which is primarily located in Morgan County], Elkmont, Lester, and Mooresville), of which only Athens and Decatur are within the 6-mile radius of BFN. The City of Athens which is the seat of Limestone County, published a future land use and development plan in 2013 that discusses further urban development and expansion plans to meet the needs of their growing population (Limestone County 2021d, Martin 2013). Similar to the overall population of the state, Limestone County is experiencing population growth.

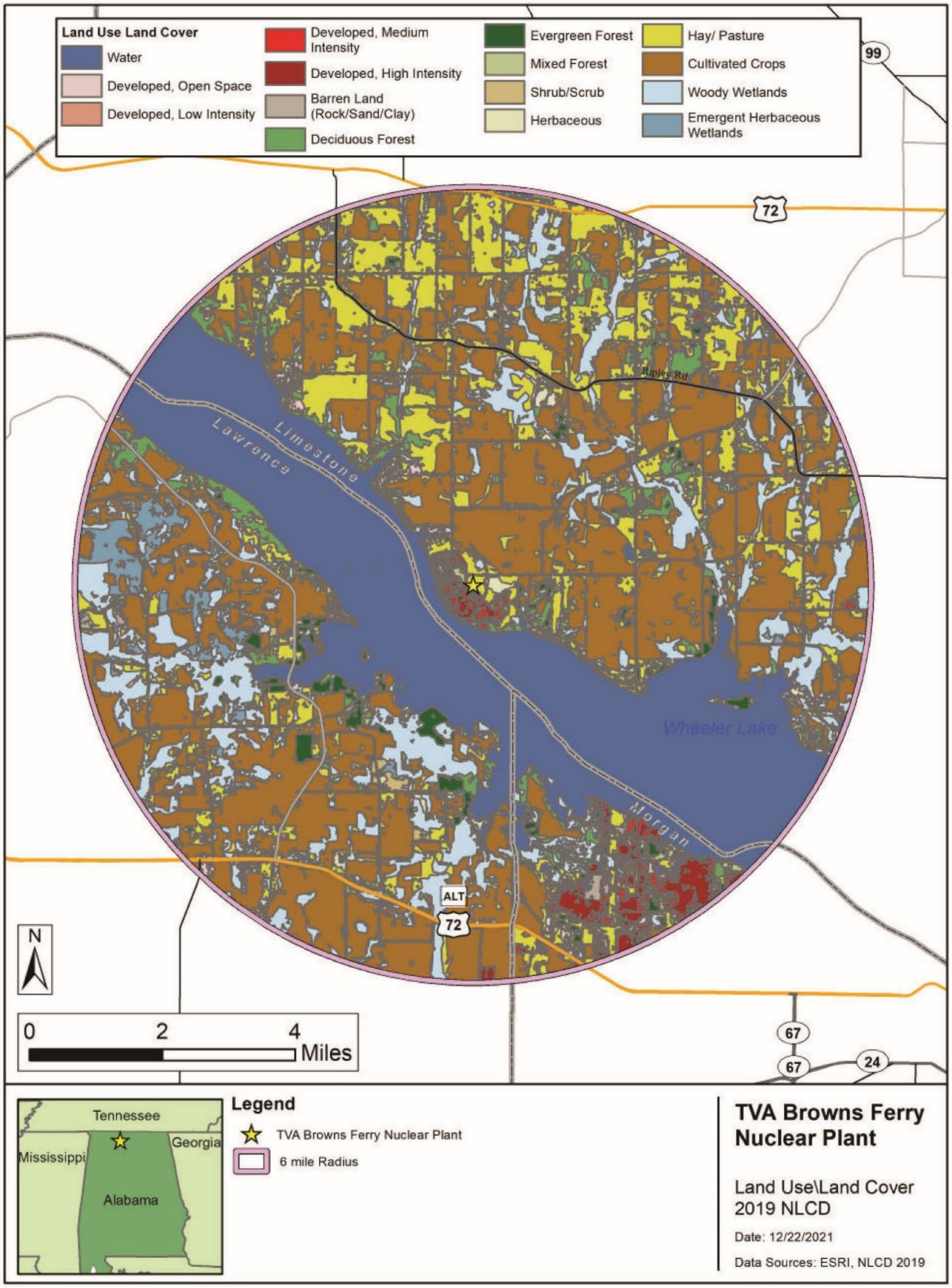


Figure 3.1-1. 6-Mile Radius BFN Land Use/Land Cover Map

Over 48 years, from 1969 to 2017, the amount of land used as farmland reduced by a total of 76,473 acres of farmland, representing a 25.4 percent loss of farmland in Limestone County. In 1969, the county used 301,295 acres for agriculture. By 2017, only 224,822 acres of the county was used for agriculture (USDA 2017b, USDA 1969).

Lawrence County

Lawrence County is situated in northwest Alabama. The County is bordered by Morgan County to the east, Cullman County to the southeast, Winston County to the south, Colbert and Franklin Counties to the west, and Lauderdale and Limestone Counties across the Tennessee River to the north. Lawrence County is approximately 693 square miles or 443,520 acres. The section of the Wheeler Reservoir that borders Lawrence County extends 64 miles (Lawrence County Chamber of Commerce 2021a). About 22.5 miles south of BFN, Bankhead National Forest takes up a quarter of the county's southern portion. Lawrence County is also home to many other natural areas, including Mallard-Fox Creek State Wildlife Management Area (about 2.5 miles south of BFN), Joe Wheeler State Park (about 13 miles southeast of BFN) and other wilderness areas and recreation parks (Lawrence County Chamber of Commerce 2021a, Lawrence County Chamber of Commerce 2021b).

Lawrence County contains six incorporated cities and towns (Courtland, Hatton, Hillsboro, Moulton, North Courtland, and Town Creek), of which only a small portion of Hillsboro is within the 6-mile radius of BFN. Although there are no zoning, building, or occupancy permits required in unincorporated areas of Lawrence County, local municipalities have primary authority and responsibility for land development and zoning within their respective limits. As a result, zoning regulations vary from municipality to municipality, with some being much more restrictive than others. However, Lawrence County does have subdivision regulations, a floodplain ordinance, and a pipe/access permit (Lawrence County Road Department 2020).

The population of Lawrence County is experiencing an overall increase in population (USCB 2022a). The amount of farmland has decreased since 1969. In 1969, there were 260,081 acres of farmland in Lawrence County. By 2017, farmland totaled only 213,747 acres, or a loss of 46,334 acres (17.8 percent) between 1969 and 2017 (USDA 2017a, USDA 1974).

Morgan County

Morgan County is situated in northwest Alabama. The County is bordered by Limestone and Madison Counties to the north, Marshall County to the east, Winston and Cullman to the south, and Lawrence County to the west. It is approximately 579 square miles of land or 370,560 acres (USCB 2021a). With 40 miles along Wheeler Reservoir, Morgan County is abundant with trails, parks, marinas, and ports. The County seat, the City of Decatur, has many parks and recreational areas including parts of the Wheeler National Wildlife Refuge and throughout the built-up urban areas along the Wheeler Reservoir (Morgan County Alabama 2021a). There are seven cities/towns in Morgan County (Decatur, Eva, Falkville, Hartselle, Priceville, Somerville, and Trinity), and the rest of the land is unincorporated (Morgan County Alabama 2021b). As shown in Figure 1.2-2, only the extreme northwestern tip of Morgan County is within the 6-mile radius of BFN along with parts of Decatur and Trinity, with an arm of Decatur hugging the shoreline of Wheeler Reservoir to the north and east of Trinity. As shown in Figure 3.1-1, most of Decatur's land use is high and medium intensity developed land along Wheeler Reservoir (NLCD 2019). In the past, Decatur has been a focal point of development within Morgan County and future growth is anticipated (City of Decatur Alabama 2020). Morgan County and the City of Decatur have coordinated an approach to growth and land development, zoning and ordinances, and other land use actions in the City of Decatur's 2018 Comprehensive Plan as well as their 2020-2024 Consolidated Plan and 2020 Action Plan (City of Decatur Alabama 2020, Smith 2018).

Similar to the overall population of the state, Morgan County is experiencing population growth (USCB 2021a, USCB 2022a). Over 48 years, from 1969 to 2017, the amount of land used as farmland reduced by a total of 96,636 acres of farmland, representing a 41.7 percent loss of farmland in Morgan County. In 1969, the county used 231,500 acres for agriculture. By 2017, only 134,864 acres of the county was used for agriculture (USDA 2017c, USDA 1969).

3.1.1.2. Onsite Land Use

BFN consists of approximately 880 acres. The BFN generation facility includes buildings and facilities as described in Section 1.2 (also see Figure 1.2-3).

Table 3.1-2 and Figure 3.1-2 show the amount of onsite acreage in various land cover categories based on data downloaded from the NLCD 2019 (NLCD 2019). It should be noted that the land cover classifications in the NLCD are based on satellite data and may not represent actual ground conditions. For example, no hay/pasture or cultivated crops are actually grown within the BFN property.

Table 3.1-2. Land Cover Within the BFN Property Boundary [1]

Land Use/land Cover Type	Onsite Acreage	Percent of Total (%)
Hay / Pasture	233.16	26.7
Developed, Medium Intensity	174.87	20.02
Developed, High Intensity	92.85	10.63
Developed, Low Intensity	87.05	9.97
Herbaceous	52.34	5.99
Deciduous Forest	43.89	5.02
Open Water	41.91	4.8
Developed, Open Space	33.69	3.86
Cultivated Crops	30.1	3.45
Mixed Forest	29.5	3.38
Woody Wetlands	26.71	3.06
Barren Land (Rock/Sand/Clay)	16.81	1.92
Shrub/Scrub	5.83	0.67
Evergreen Forest	4.79	0.55
Emergent Herbaceous Wetlands	0.22	0.03
Total	873.72	100

Note: Fee acreage for the BFN Reservation is approximately 880 acres. A land survey has not been conducted to create a Geographic Information System (GIS) shapefile of the property. The GIS shapefiles of the BFN Reservation used for this analysis includes 873.72 acres of the property.
Source: Land cover data from NLCD 2019 (as shown in Figure 3.1-2).

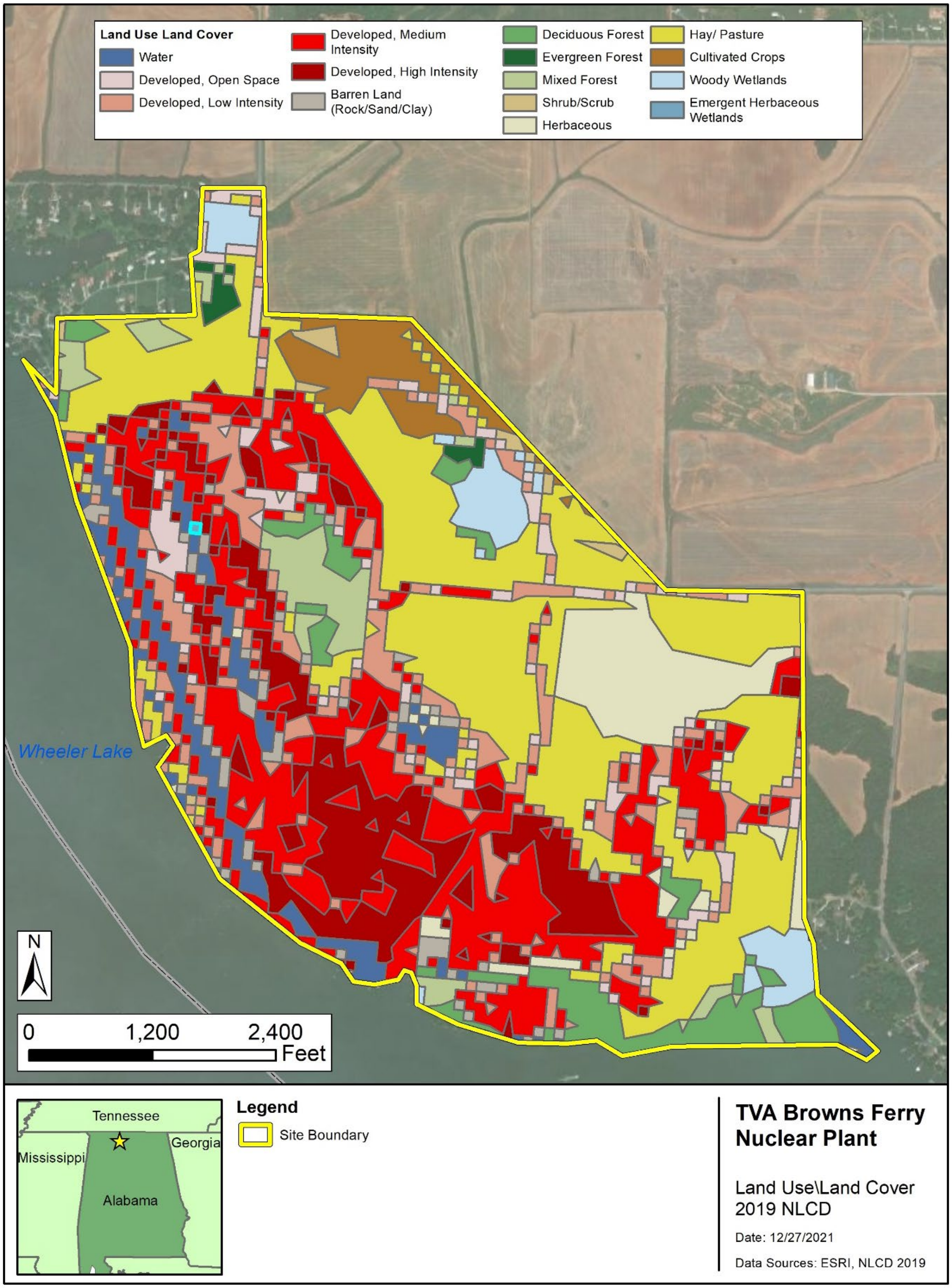


Figure 3.1-2. Onsite BFN NLCD Land Use/Land Cover Map

3.1.2. Environmental Consequences – Land Use

This section addresses impacts to land use from the No Action Alternative (Alternative A) and from the proposed subsequent period of extended operation of the BFN SLR (Alternative B). Regardless of the option chosen, decommissioning must be completed within the 60-year period following permanent cessation of operations and permanent removal of fuel.

Alternative A – No Action Alternative

Under the No Action Alternative, no changes in onsite land-use patterns would be anticipated. While the plant would undergo decommissioning, the site would probably remain developed, possibly with the establishment of an alternative generation resource. If uranium fuel is no longer required at BFN, there could be a resulting decrease in land-use impacts at source uranium mining operations due to reduced demand.

TVA would need to replace the 3,900 megawatts electric (MWe) of BFN generation under the No Action Alternative. Some of these alternative sources could be sited on the nearly 880-acre BFN site and some would be sited offsite. Should a new facility be constructed on a greenfield site, changes to offsite land use would be anticipated with the potential for loss of natural habitat and agricultural land. Should the site be a brownfield or developed site, impacts to land use would vary. If the replacement generation resource included an SMR plant(s) there may be no net change in offsite land-use impacts from the mining of uranium fuel, if supplies destined to be used during the proposed BFN subsequent period of extended operation were redirected for use at the SMR facility. It is also possible construction of the new generation facilities would result in additional land-use impacts for transmission, railroad, and/or pipeline ROWs. Potential effects would be evaluated in separate analyses once new generation construction project locations and technologies are specifically identified. Impacts to land use associated with construction of these new sources for energy would be small to moderate.

Alternative B – Proposed Action

Under the BFN SLR Alternative, the Preferred Alternative, TVA would have the option to continue operating BFN Units 1, 2, and 3 during the proposed subsequent period of extended operation until the renewed operating licenses expire in 2053, 2054, and 2056, respectively, before terminating operations and initiating decommissioning for the units in accordance with the Nuclear Regulatory Commission (NRC) requirements. Under this Alternative, ongoing operations at BFN during the proposed subsequent period of extended operation would not be expected to result in changes to onsite land use. No refurbishment or other changes to plant structures or activities would be associated with the SLR for BFN.

The current independent spent fuel storage installation (ISFSI) storage pads are projected to be filled on or before year 2036, if the U.S. Department of Energy (DOE) does not develop a permanent offsite storage in the foreseeable future. In that case, an additional ISFSI storage pad would be required to further increase storage capacity during the proposed subsequent period of extended operation. If necessary, the BFN site has adequate space onsite to accommodate the construction of a third ISFSI pad. Impacts associated with this expansion would be assessed under a licensing process separate from that of BFN Units 1, 2, and 3 Subsequent Renewed Facility Operating Licenses.

Continued operation of BFN during the proposed subsequent period of extended operation would not be anticipated to impact to offsite land use. No major refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would affect offsite land use. Continued maintenance and outages would not result in new impacts to offsite land use beyond those previously considered.

Therefore, because changes anticipated for onsite land use during the proposed subsequent period of extended operation would be small and because no changes are anticipated to change current impacts to offsite land use, the overall impact to land use associated with the BFN SLR would be small and the incremental contribution to cumulative impacts to land use would also be small.

3.2. Geology and Soils

3.2.1. Geology

3.2.1.1. Affected Environment – Geology

BFN is located on the southern margin of the Highland Rim section of the Interior Low Plateaus physiographic province (USGS 2003). This is characterized by a young-to-mature plateau exhibiting moderate relief. Elevations vary from 600 feet above mean sea level (msl) on the north shore of Wheeler Reservoir to approximately 800 feet above msl 10 miles north at Athens, Alabama. Surface water generally flows from the northeast to the southwest through Poplar, Round Island, and Mud Creeks.

BFN is located on a river terrace surface with an average elevation of 575 feet above msl. This surface represents a historic floodplain of the Tennessee River developed when the river was flowing at a higher level. The most recent floodplain is now inundated by the waters of Wheeler Reservoir. Plant grade is at 565 feet above msl. Throughout most of the Paleozoic Era the region was at or slightly below sea level, and more than 5,000 feet of limestone, dolomite, and shale were deposited.

The plateau on which the BFN site lies is underlain by near-horizontal limestone strata of Mississippian age having an aggregate thickness of slightly over 1,000 feet. According to the Alabama Geological Survey, the formations and their maximum thicknesses, in ascending order are: Fort Payne (207 feet); Tuscumbia (200 feet); Ste. Genevieve (43 feet); Bethel (40 feet); Gasper (160 feet); Cypress (7 feet); Golconda (70 feet); Hartselle (200 feet); and Bangor (90 feet). The bedrock is mantled by varying thicknesses of cherty clay, silt, sand, and gravel of residual and alluvial origin. The only formations within the BFN Reservation are the unconsolidated materials overlying bedrock and the Tuscumbia limestone and the Fort Payne Formation (USDA 2021).

Within the BFN property boundary, the beds of the Tuscumbia and Fort Payne formations are essentially horizontal in orientation. The direction of dip varies considerably but has an overall westward major component. Bedrock is cut by a pattern of near-vertical joints, and close to the surface of bedrock solution channels have developed along these joints, especially in the Tuscumbia Limestone. At depth in the less soluble Fort Payne, the joints are tight and most are cemented with calcite.

Faulting is not a significant factor in considering the geologic structure in the BFN area. No active faults showing recent surface displacement are known within a 200-mile radius of the site. The nearest known ancient fault is in Lawrence County, Alabama, 16.5 miles to the west-southwest from the BFN site, and is one of three apparently related near-vertical faults. The vertical displacement varies from 0 to 60 feet and cuts Mississippian bedrock. At the BFN site, the only indications of any rock movement are small shears along bedding planes which represent minor readjustments between beds when the area was uplifted at the end of the Paleozoic Era.

Seismicity

BFN is located in an area remote from any known centers of significant seismic activity. The site is 16.5 miles from the nearest known inactive fault and approximately 200 miles from the closest known major active fault, the New Madrid region of the Mississippi Valley. The New Madrid region was the center of a few great earthquakes more than 200 years ago and is currently home to very numerous lighter shocks. Over the past half-century, a few major earthquakes centered at distant points, several light-to-moderate shocks at distant points, and several light-to-moderate shocks with nearer centers have affected the Decatur area at low-to-moderate intensity (TVA 2014). There is continuing seismic activity in the Mississippi Valley, and there is the possibility of another large earthquake in the New Madrid region of Missouri, Arkansas, Tennessee, and Kentucky. An earthquake of intensity XI or XII on the Modified Mercalli Intensity (MMI) Scale at New Madrid might be felt in the Decatur area with an intensity of VII (TVA 2014). An MMI of XI or XII results in total destruction with few to any structures standing. And the corresponding MMI of VII in the Decatur area would result in slight to moderate damage to ordinary structures. Figure 3.2-1 provides a map of earthquake epicenters within 50 miles of BFN. As shown in Figure 3.2-1, most earthquakes in the vicinity of BFN are low energy magnitude 2 and 3 earthquakes. Figure 3.2-2 presents a seismic hazard map within 50 miles of BFN.

Overall, the BFN site is underlain by massive formations of bedrock, thus, providing adequate foundations for all plant structures. The major seismic activity experienced at the site has been caused by distant major earthquakes (TVA 2014).

In response to the recommendations of the NRC's Fukushima Task Force, TVA developed a strategy to improve the ability of each TVA operating nuclear plant, including BFN, to cope with a severe accident using lessons learned from the Fukushima accident. In 2014, TVA completed a re-evaluation of seismic and flood hazards. The existing facilities were constructed to withstand seismic events, but proposed measures would improve TVA's ability to cope with seismic events. TVA has implemented a seismic walk down methodology that meets NRC guidance. During the seismic walk-down, it was determined that Unit 1 and 2 Common Diesel Auxiliary Board Transformers had vulnerabilities and, consequently, TVA replaced both transformers(TVA 2014).

BFN is not located within the 100-year floodplain or below the TVA Flood Risk Profile elevation, thus the BFN site provides a reasonable level of protection from flooding, including flooding associated with seismic events (TVA 2013).

3.2.1.2. Environmental Consequences – Geology

This section addresses impacts to the geologic environment the associated with the No Action and Action Alternatives.

Alternative A – No Action Alternative

Under the No Action Alternative, BFN would undergo shutdown and decommissioning which would have negligible impacts on local onsite geology. There would be no major construction activity onsite. BFN is in compliance with current NRC regulations related to seismic evaluation requirements; therefore, no change regarding any potential impact from the current level of small impact would be anticipated. The future expansion of the spent fuel storage capacity may result in additional seismic evaluation if required by the NRC, however, that would be addressed in a separate licensing and environmental review. Therefore, cumulative impacts to geology would also be expected to be small.

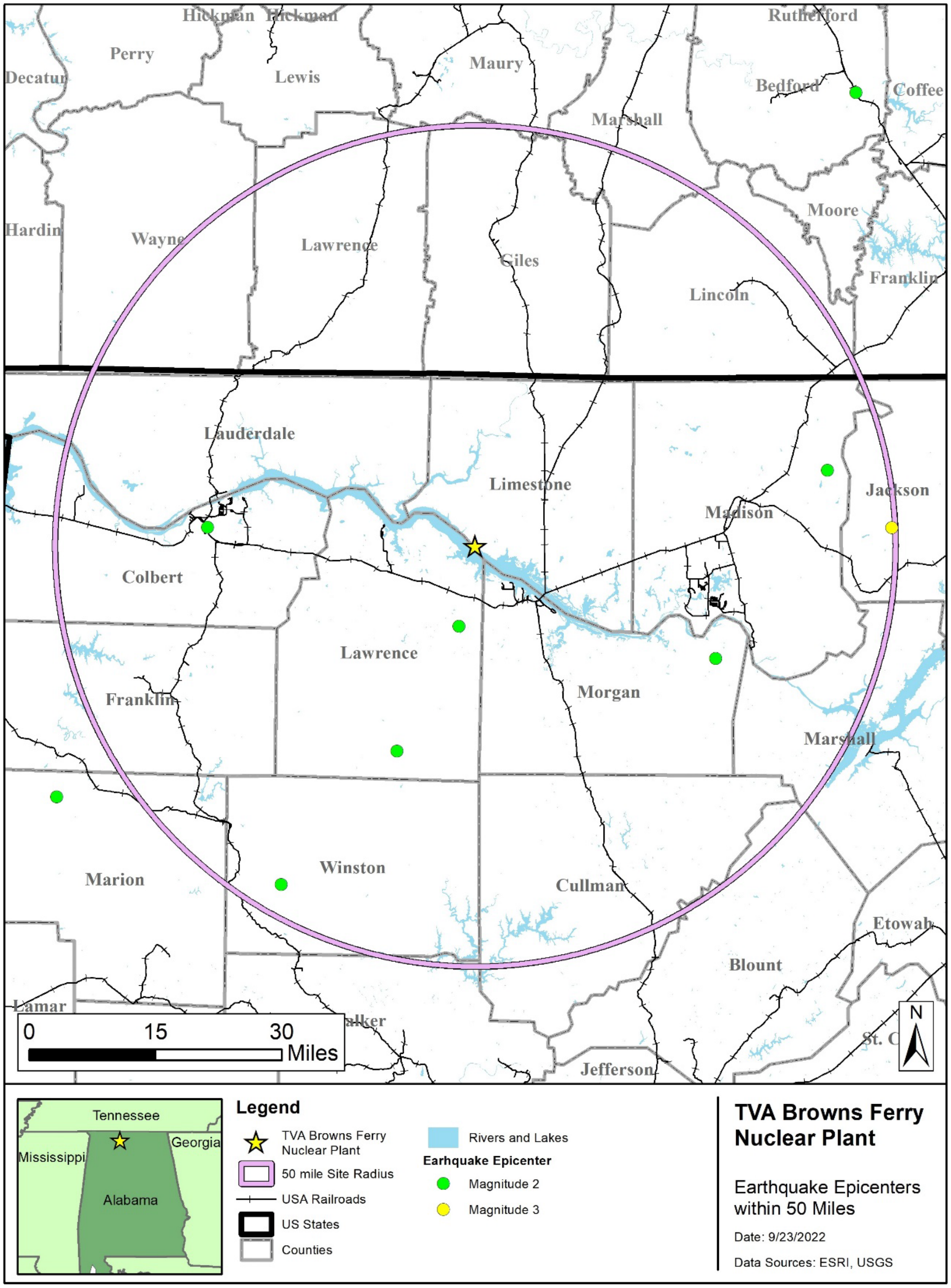


Figure 3.2-1. Earthquake Epicenters within 50 Miles of BFN

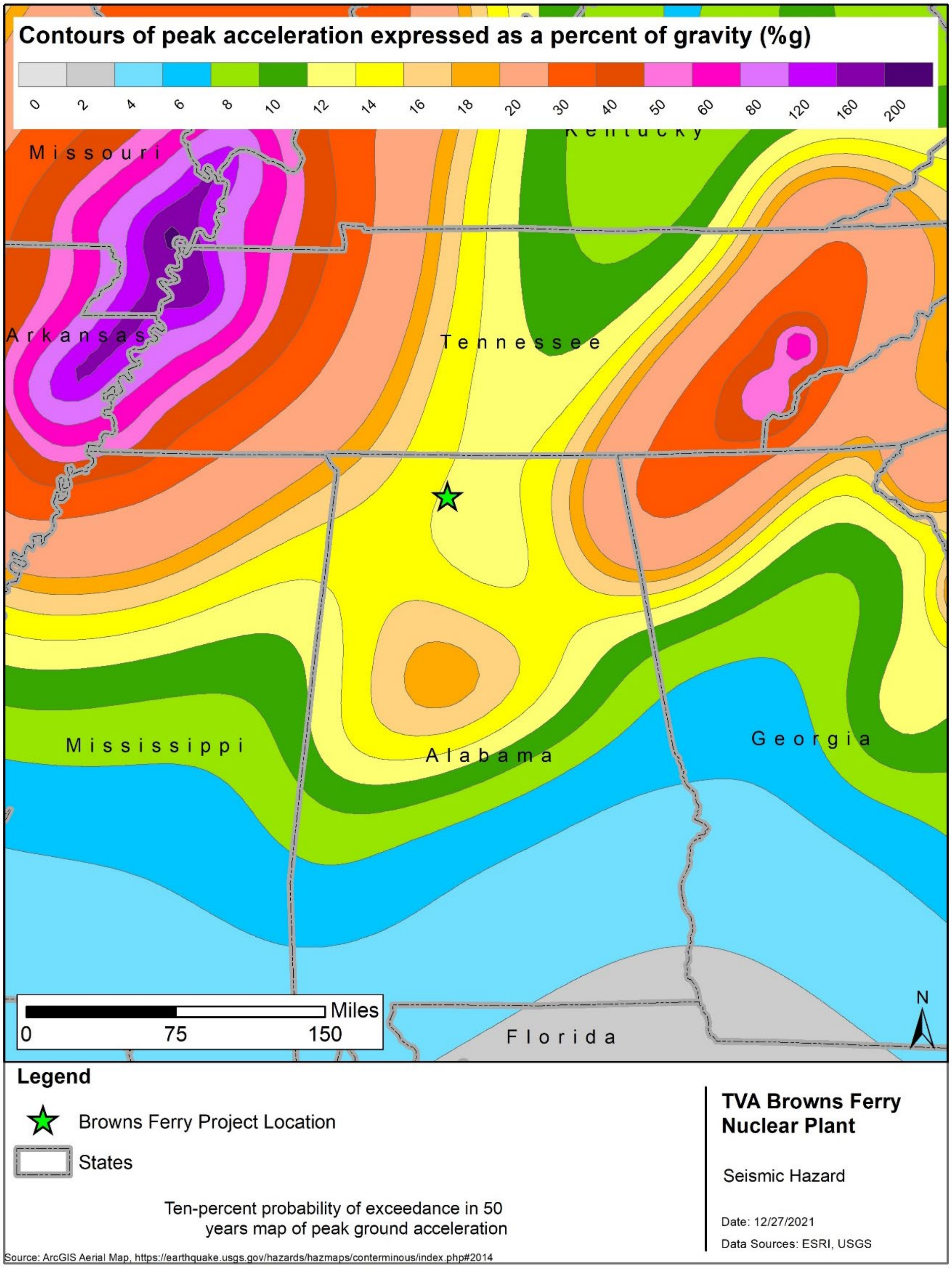


Figure 3.2-2. Seismic Hazard Map within 50 Miles of BFN

The shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. The site chosen for any replacement generation facility would be evaluated for geologic conditions and potential seismic impacts during the site-selection process. Impacts to geology would be associated with the ground-disturbance activity and could include excavation and blasting. Should the replacement generation be an SMR plant(s), that facility would be required to meet or exceed the current federal regulations for seismic performance (10 CFR Part 50, Appendix S). It is assumed the impacts related to seismic activity for any other generation resource would be less than those for an SMR plant(s). Therefore, the impacts related to geology, including seismic activity would be expected to be small for the replacement generation resource. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

<u>Alternative B – Proposed Action</u>

Under Alternative B, continued operation of BFN units should have no impact on geological resources or the natural level of seismic activity in the area. Because no changes are anticipated to existing conditions with respect to geological resources during the proposed subsequent period of extended operation, the impact to the region's geology from the continued operation of BFN would be small. BFN is in compliance with current NRC regulations related to seismic evaluation requirements. No change regarding any potential impact from the current level of small impacts would be anticipated during the proposed subsequent period of extended operation.

3.2.2. Soils

3.2.2.1. Affected Environment – Soils

Soils at the site have been extensively excavated and reworked as a result of BFN construction. Figure 3.2-3 provides the soil map for the BFN property based on the initial 1966 soil survey. Some of these soils are likely no longer present within the central areas of BFN. Table 3.2-1 shows the characteristics of the mapped soils. The initial soils investigation program in 1966 was performed to establish the allowable bearing value for soil-supported structures. It was determined that the original ground surface was at approximately 15 feet above the planned final plant grade. The top 15 to 20 feet was classified as alluvial terrace deposits consisting of a red to reddish brown sandy clay with a lean to medium lean silty clay with a maximum thickness of 30 feet. Below the alluvial terrace deposits was approximately 40 feet of medium to fat clays and plastic silts interbedded with beds of gravelly chert (TVA 2006). The groundwater table was detected at an elevation of 555.1 feet above msl, corresponding with the current level of Wheeler Reservoir.

A soil investigation was also performed in 1980 to support the low-level radioactive waste (LLRW) storage facility. As referenced in the Browns Ferry Nuclear Plant Low-Level Radwaste Storage Facility Pathway Analysis, measured soil thickness varied from 37 to 50 feet (TVA 2006). The uppermost layer consisted of red lean clays to depths ranging from 2 to 18 feet and averaging 16 feet. Below this layer was an intermediate layer of discontinuous tan to red medium to high plasticity clays. These clays were up to 26 feet thick and averaged 16 feet in thickness. Immediately above bedrock, a continuous layer of basal cherty clay (clayey chert) averaging 18 feet thick was encountered.

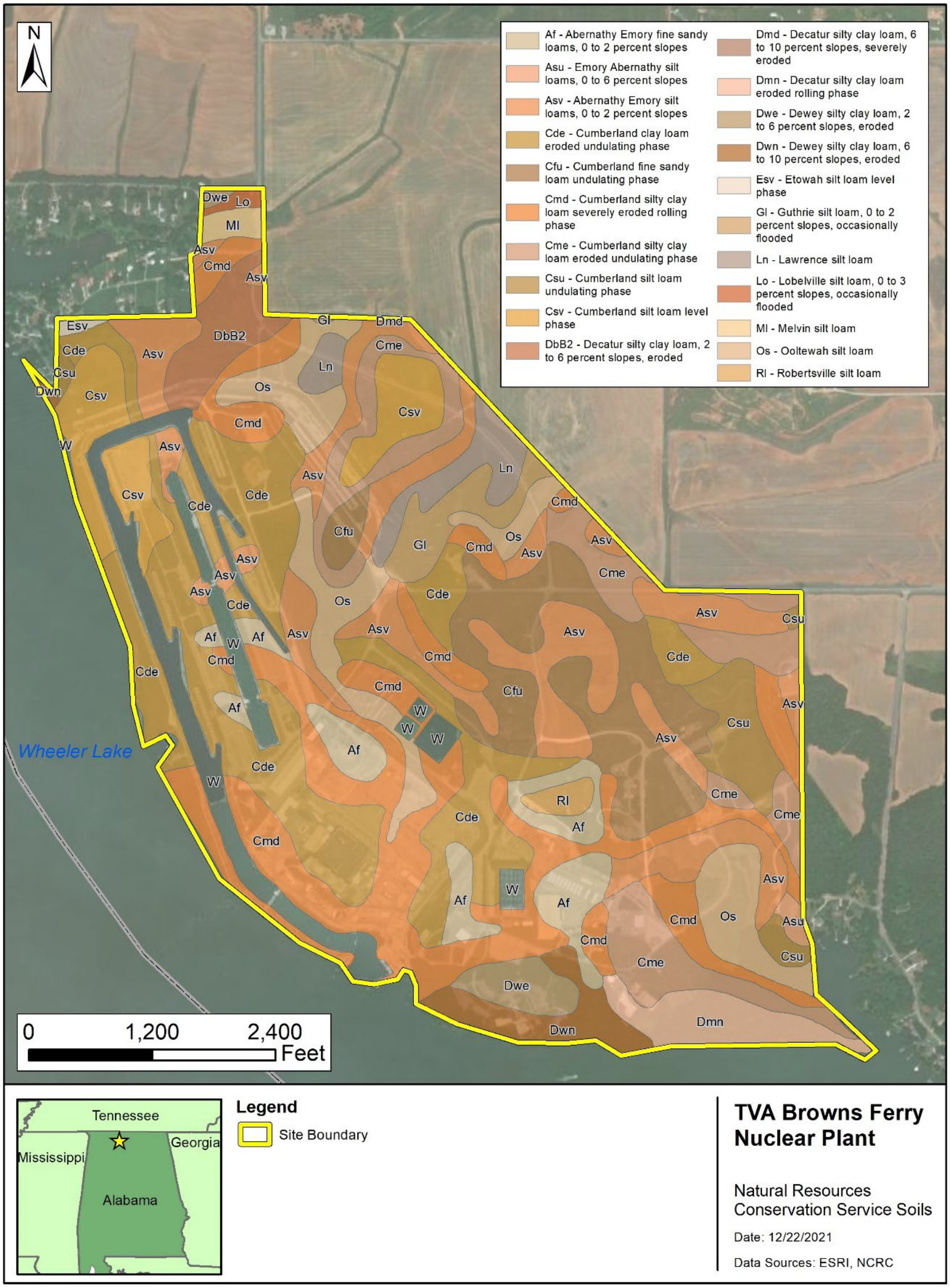


Figure 3.2-3. BFN Soil Map

Table 3.2-1. Agricultural Soil Characterization Details

Map Designation	Soil Series (a)	USDA Soil Texture Classification	Prime Farmland	Farmland of Statewide Importance	Erosion Potential (a)
Af	Abernathy Emory, 0 to 2 percent slopes	fine sandy loams	Yes	No	0.32
Asu	Emory Abernathy, 0 to 6 percent slopes	silt loams	Yes	No	0.43
Asv	Abernathy Emory, 0 to 2 percent slopes	silt loams	Yes	No	0.43
Cde	Cumberland eroded undulating phase	clay loam	Yes	No	0.28
Cfu	Cumberland undulating phase	fine sandy loam	Yes	No	0.28
Cmd	Cumberland severely eroded rolling phase	silty clay loam	No	No	0.28
Cme	Cumberland eroded undulating phase	silty clay loam	Yes	No	0.28
Csu	Cumberland undulating phase	silt loams	Yes	No	0.32
Csv	Cumberland level phase	silt loams	Yes	No	0.32
DbB2	Decatur, 2 to 6 percent slopes, eroded	silty clay loam	Yes	No	0.32
Dmd	Decatur, 6 to 10 percent slopes, severely eroded	silty clay loam	No	Yes	0.28
Dmn	Decatur eroded rolling phase	silty clay loam	No	Yes	0.28
Dwe	Dewey, 2 to 6 percent slopes, eroded	silty clay loam	Yes	No	0.24
Dwn	Dewey, 6 to 10 percent slopes, eroded	silty clay loam	No	Yes	0.28
Esv	Etowah level phase	silt loam	Yes	No	0.32
Gl	Guthrie , 0 to 2 percent slopes, occasionally flooded	silt loam	No	No	0.43
Ln	Lawrence	silt loam	Yes	No	0.32
Lo	Lobelville , 0 to 3 percent slopes, occasionally flooded	silt loam	Yes	No	0.32
Ml	Melvin	silt loam	No	Yes	0.37
Os	Ooltewah	silt loam	No	No	0.43
Rl	Robertsville	silt loam	No	No	0.43

Source: (NRCS 2020)

3.2.2.2. Environmental Consequences – Soils

This section addresses impacts to soils from the No Action and Action Alternatives.

Alternative A – No Action Alternative

Shutdown and decommissioning of BFN could result in ground-disturbing activities including site grading during site restoration activities. Anticipated impacts to soils from decommissioning would be small.

Under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. If the new generation resources were constructed on a greenfield site, impacts to soils from ground disturbing activities could range from small to moderate depending on the presence of prime farmland soils or farmland of statewide importance and the level of impact to those farmland soils as compared to regional trends. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

Under Alternative B, impacts to soils on the site as a result of activities associated with the SLR term would be insignificant. No refurbishment or plant modifications are currently scheduled that would result in soil impacts during the proposed subsequent period of extended operation. Minor ground disturbing activities associated with onsite maintenance activities could impact soils. With no changes to existing conditions with respect to soils anticipated during the proposed subsequent period of extended operation, there would be no anticipated incremental contribution to cumulative impacts to the region’s soils associated with the continued operation of BFN.

3.3. Surface Water Resources

The dominant water requirement at most nuclear power plants is cooling water, which in most cases is obtained from surface water bodies. For this reason, most power plants are located near suitable supplies of surface water, such as rivers, reservoirs, or lakes. Because of the interaction between power plants and surface water, issues may arise in terms of both quantity and quality. A summary of the surface water hydrology and water quality for BFN, including a discussion about alternatives and their impacts, is presented in this section.

3.3.1. Surface Water Hydrology and Water Quality

3.3.1.1. Affected Environment – Surface Water Hydrology and Water Quality

Surface Water Hydrology

BFN is located on the north shore of Wheeler Reservoir at TRM 294 in Limestone County, Alabama. For orientation, TRM 0.0 is downstream where the Tennessee River joins the Ohio River in Paducah, Kentucky (TVA 2021h). Wheeler Dam is downstream of BFN at TRM 274.9 and Guntersville Dam lies upstream at TRM 349.0. The location of BFN is within the TVA reservoir system is shown in Figure 3.3-1.

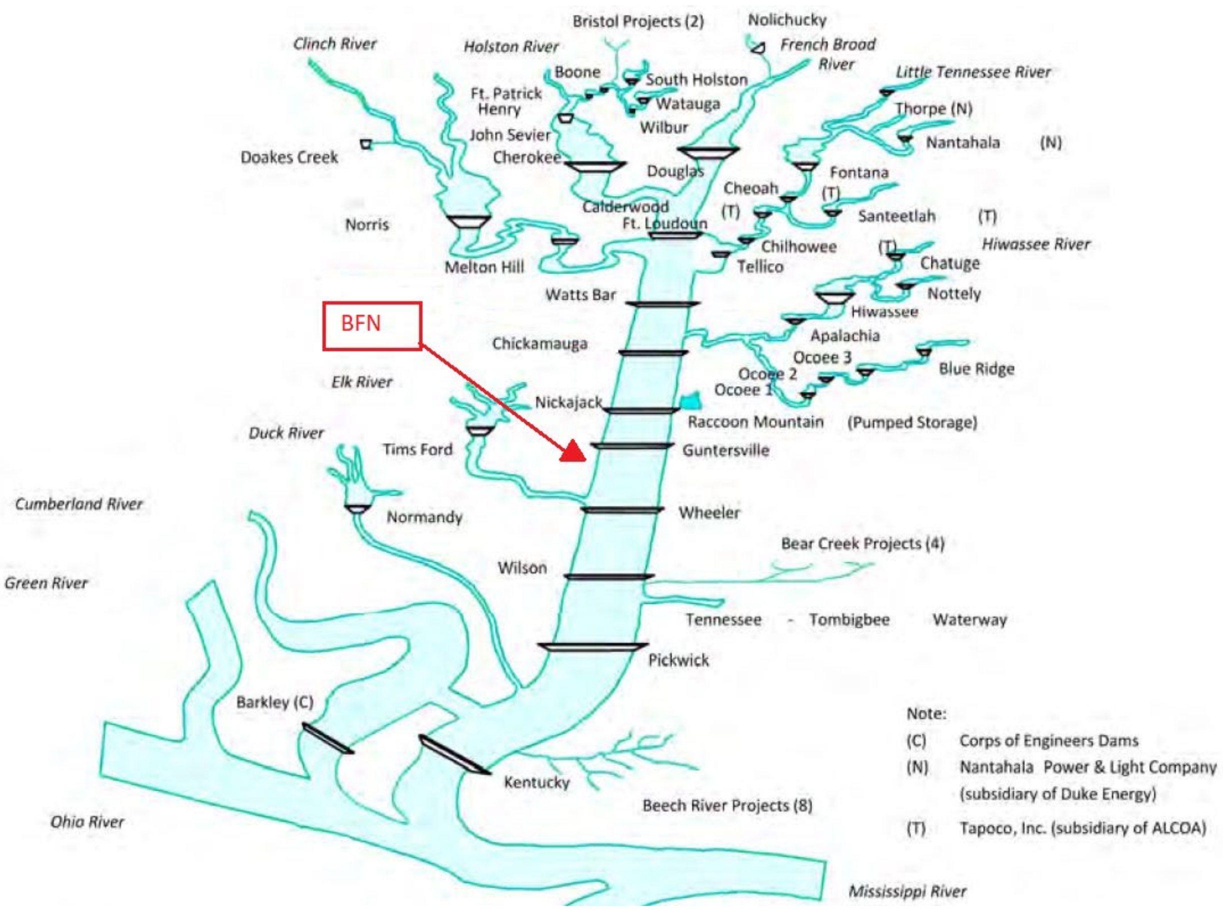


Figure 3.3-1. TVA Reservoir System

Wheeler Reservoir was created in 1936 as one of the first major dam projects on the Tennessee River for flood control, power generation, and navigation as well as for aquatic resources, water supply, and recreation (TVA 2021k). It is one of nine reservoirs that create a stairway of navigable water on the Tennessee River from Knoxville, Tennessee, to Paducah, Kentucky and is the second largest reservoir in the 652-mile Tennessee River System (TVA 2021k). Wheeler Reservoir covers a surface area of 67,070 acres, has 1,027 miles of shoreline, has a volume of 1.05 million acre-feet, and has a hydraulic retention time of 10.7 days. The width of Wheeler Reservoir in the vicinity of BFN ranges from 1 to 1.5 miles and is relatively shallow, with an average depth of 15 feet and a maximum depth of 60 feet. Normal summer pool elevation is 556 feet above msl, with a minimum level of 550 feet above msl. Wheeler Reservoir usually reaches summer elevation annually by April 15. Fall drawdown, in anticipation of winter rains, usually begins after Labor Day (TVA 2021j). The 7Q10 flow rate for the Tennessee River ranged from 4,880 cubic feet per second (cfs) at TRM 333.9 to 8,650 cfs at TRM 256.7 (USGS 2017). The 7Q10 flow rate is the lowest 7-day average streamflow occurring on average once every 10 years. TRM 256.7 is located 2.7 miles downstream of Wilson Dam, and TRM 333.9 is located 39 river miles above BFN. Average daily flow of the Tennessee River at the Guntersville Dam from 1939 to 2015 was 33,500 cfs. The average annual daily minimum flow of the Tennessee River from 2017 to 2021 was 13,231 cfs.

There are also several artificial secondary surface water bodies associated with operations on the site, including the hot water channel, cold water channel, intake channel, wastewater lagoons, and sediment ponds. Water level elevations in these secondary surface water features, particularly the hot water channel and cold water channel, are dependent on various plant operations and the water level in Wheeler Reservoir. The intake channel is generally maintained at an elevation equivalent to that in Wheeler Reservoir (Arcadis 2021).

Onsite Surface Water Features

Field assessments of onsite surface water features were conducted in September 2021 to determine stream, drainage, pond, and wetland presence, extent, and condition within the BFN site (TVA 2021d). Wetland features are discussed in Section 3.6.1.

Stream and drainage features present on the BFN site are summarized in Table 3.3-1. Streams were delineated in the field using the methods contained within the U.S. Army Corps of Engineers (USACE) *Jurisdictional Determination Form Instructional Guidebook*. Streams were assessed and classified as perennial, intermittent, or ephemeral in the field using the Tennessee Division of Water Pollution Control's *Hydrologic Determination Field Data Sheet* (Version 1.5). The entire length of each stream was walked to assess the various geomorphic, hydraulic, and biological parameters associated with determining stream classification.

Table 3.3-1. Summary of Streams and Drainage Features

Stream ID	Width (ft) at Top of Bank	Depth (ft) at Top of Bank	TDEC Score
Ditch 1	NA	NA	NA
Ditch 2	NA	NA	NA
Stream 1	10.5	5.0	40.0
Stream 2	6.0	2.0	19.0
Stream 3	3.0	2.5	19.0
Stream 4	4.0	0.5	10.5
Stream 5	12.0	9.0	32.5
Stream 6	6.0	2.0	15.0
Stream 7	17.5	8.0	40.5
Stream 8	18.0	6.0	27.5

Source: (TVA 2021d)
NA = not applicable

Delineated stream/drainage features included two constructed ditches, two ephemeral streams, three intermittent streams, and three perennial streams. General descriptions of each feature identified within the BFN site are provided below. See Figure 3.3-2 for feature locations.

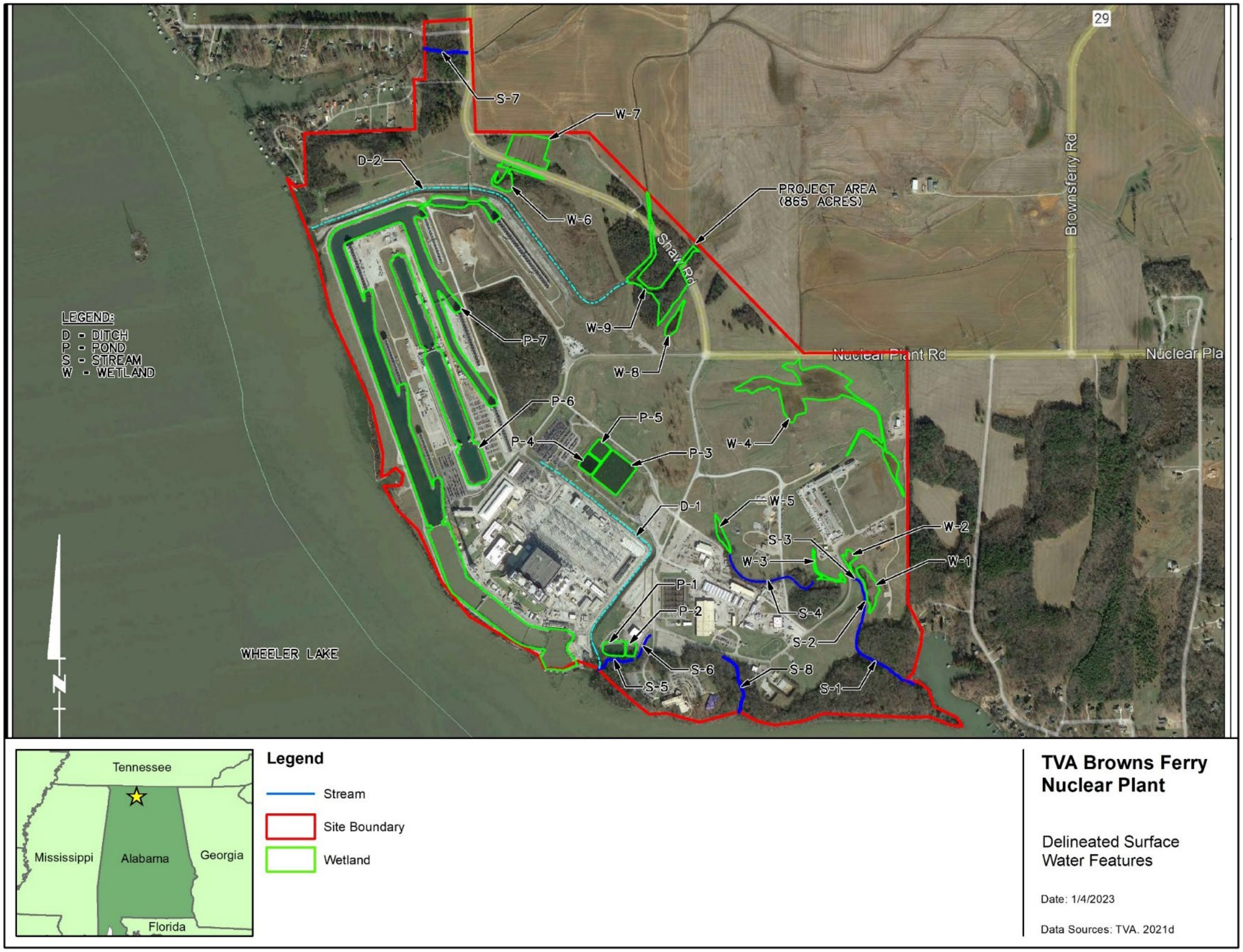


Figure 3.3-2. Delineated Surface Water Features

Stream 1 was identified in the southeastern portion of the site, downstream of Stream 2. Hydrology within the drainage basin has been significantly altered by development. The channel alignment also appears to have been straightened during past activities on the property. Much of the water observed within the channel appears to be backwater from Wheeler Reservoir and not contribution from upstream sources. Fish and amphibians were readily observed along the reach. Hydric soils were also observed within the channel. Stream 1 has an average width of 10.5 feet and average depth of 5 feet.

Stream 2 was identified in the southeastern portion of the site. Hydrology within the drainage basin has been significantly altered by development. Much of the channel bottom is covered by wetland plants. Flowing water was observed, though the stream is dominated primarily by pools and appears to lack the energy required to erode a significant channel through the soil profile. Hydric soils were observed within the channel. Stream 2 has an average width of 6 feet and an average depth of 2 feet.

Stream 3 is located downstream of Wetland 2 and flows south into Stream 2. The stream is hydrologically supplied by stormwater runoff that is stored in Wetland 2 and slowly released downstream. Hydrology within the drainage basin has been significantly altered by development. Considering the length of this stream is less than 25 feet, its depth (2.5 feet) suggests that high flows are common following large rain events. Stream 3 lacks much structure in terms of geomorphology and more closely resembles a roadside ditch than a stream. Hydric soils were observed within the channel. Stream 3 has an average width of 3 feet and an average depth of 2.5 feet.

Stream 4 flows east through the site where the channel dissipates upstream of Wetland 3. Hydrology for this stream has been significantly altered by development. This wet weather conveyance reach lacks the frequent flows and erosive energy necessary to scour out a true channel. Field observations indicate that the stream exhibits flow only immediately following large rain events. The sinuosity of the reach is due to modification of the channel from development of the property. Hydric soils were not observed within the channel. Stream 4 has an average width of 4 feet and an average depth of 0.5 feet.

Stream 5 was identified northwest of the Training Center downstream of Stream 6. The stream flows southwest through the property and into Wheeler Reservoir. The channel is severely incised with channel depths exceeding 10 feet. Hydrology within the drainage basin has been significantly altered by development. Aquatic life was observed in the downstream end of the reach where backwater from Wheeler Reservoir extends upstream. Hydric soils were observed within the channel. Stream 5 has an average width of 4 feet and average depth of 2 feet.

Stream 6 was identified northwest of the Training Center upstream of Stream 5. The upstream end of Stream 6 is a headwall where stormwater captured by storm infrastructure discharges. The channel bottom and side slopes are lined with rip rap to prevent erosion and scour following rain events. Hydrology within the drainage basin has been significantly altered by development. Water was not observed within the channel of this wet weather conveyance during field investigation. Hydric soils were not observed within the channel. Stream 6 has an average width of 6 feet and an average depth of 2 feet.

Stream 7 was identified in the northern portion of the property near the intersection of Paradise Shores and Shaw Road. The stream flows east to west through a narrow portion of the property. Continuous bed and bank, grade control, and in-channel structure were readily observed in the field. The channel is well developed through the soil profile. Aquatic life was observed throughout the reach. Hydric soils were observed within the channel. Stream 7 has an average width of 17.5 feet and an average depth of 8 feet.

Stream 8 was identified northeast of the Training Center and flows south through the property to flow into Wheeler Reservoir. The upstream end of Stream 8 is a headwall where stormwater captured by storm infrastructure discharges. The channel bottom and side slopes are lined with rip rap in the upstream portion of the reach to prevent erosion and scour during rain events. Continuous bed and bank, grade control, and lack of vegetation within the channel were readily observed in the field. The reach is well developed through the soil profile. Hydric soils were observed within the channel. Stream 8 has an average width of 18 feet and an average depth of 6 feet.

Ditch 1 was identified southeast of the Turbine Building and converges with Stream 5 near the property boundary. Backwater from Wheeler Reservoir was observed in the downstream end of the feature. No ordinary high-water mark was observed during field investigation. The channel bottom and side slopes are lined with rip rap to prevent erosion and scour following construction of the channel.

Ditch 2 was identified northwest of the cooling towers and extends to the downstream end of Wetland 9. No ordinary high-water mark was observed during field investigation. The channel bottom and side slopes are lined with rip rap to prevent erosion and scour following construction of the channel.

Seven ponds totaling approximately 69 acres are present on the BFN site (See Figure 3.3-2 for locations). General descriptions of each feature are provided below.

Pond 1 and Pond 2 are adjacent to each other between the Intake Forebay and Training Center. The ponds are lined with an impermeable membrane and likely function to provide water for facility operations. Ponds 1 and 2 appear to be isolated with no outlet structures observed. No vegetation was observed within the ponded areas.

Ponds 3, 4, and 5 are adjacent and located north of the 500 kilovolt (kV) Switchyard. The ponds are part of a three-pond system designed to manage wastewater from facility operations. The ponds appear to be isolated with no outlet structures observed.

Pond 6 is located northwest of the Administration Building between two rows of cooling towers. The pond is divided into three chambers and appears to be used for facility operations. Pond 6 appears to be isolated from adjacent waters with no inlet or outlet structure observed. Pond slopes are lined with rip rap and no vegetation was observed.

Pond 7 was identified along the western property boundary adjacent to Wheeler Reservoir. The pond is divided into chambers that provide cold water to facility operations. Water is supplied to Pond 7 via the Intake Forebay located on Wheeler Reservoir. Slopes of the pond are lined with rip rap and no vegetation was observed.

<u>Water Quality</u>

Stormwater and Other Discharges

ADEM has USEPA authorization to implement the National Pollutant Discharge Elimination System (NPDES) in Alabama for facilities such as BFN. ADEM (1) regulates thermal discharges in accordance with CWA Section 316(a) to control thermal impacts on the aquatic environment in the receiving water, and (2) implements CWA Section 316(b) requirements to ensure that the location, design, construction, and capacity of industrial cooling water intake structures reflect the best technology available for reducing adverse environmental impacts. The BFN NPDES permit (No. AL0022080) also regulates discharges of pollutants to Wheeler Reservoir in outflows including once-through cooling water from the condenser circulating water, raw cooling water, turbine building station sump effluent, intake building sump effluent, and liquid radwaste system (ADEM 2018). The NPDES permit was renewed by TVA with an effective date of July 1, 2018, and expiration date of August 31, 2023. TVA will continue to renew and comply with the permit as long as the outfalls remain operational. The permit establishes discharge limitations and monitoring requirements for specific constituents by outfall, based on the type of wastewater discharged through the respective outfall.

Section 303(d) of the Clean Water Act

Alabama assesses the water quality of streams every other year and develops a draft 303(d) list for impaired waterbodies. Under Section 303(d) of the 1972 Clean Water Act (CWA), States, territories, and authorized tribes are required to develop lists of impaired waters. These are waters that do not meet water quality standards. The law also requires that these jurisdictions establish priority rankings for waters on the lists and develop total maximum daily loads (TMDLs) for these waters with the goal of removing them from the 303(d) list over time (USEPA 2021b). Table 3.3-2 presents the impairment information for Wheeler Reservoir from the Alabama 2020 303(d) list (ADEM 2020). The only impaired waterbody in Wheeler Reservoir listed in the table below that is not of low TMDL priority is Elk River (AL06030004-0405-101), which is listed as high priority.

TVA Reservoir Monitoring Program

Wheeler Reservoir has been monitored for ecological health every two years since 1994, and more recently every three years, with the most recent report released for 2017. There are five health indicators that have been used to assess aquatic health: dissolved oxygen, chlorophyll, benthic macroinvertebrate community, fish assemblages, and sediment quality. Values of good, fair, or poor are assigned to each metric.

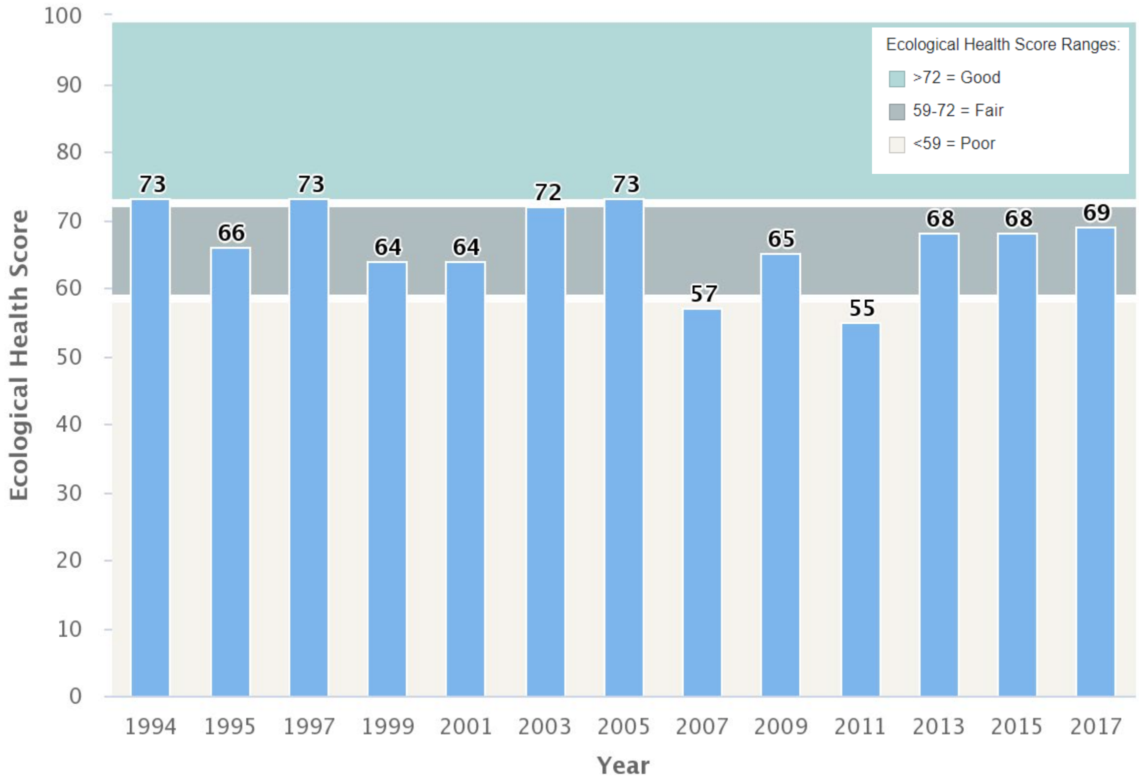
Four locations are monitored: forebay (deep, still water near the dam) at TRM 277.0, middle reservoir at TRM 295.9, Elk River embayment (Elk River Mile 6.0), and the inflow (river-like area at the extreme upper end of reservoir) at TRM 348.0 (TVA 2018c). The data from these sites characterize the Wheeler Reservoir's biological conditions and water quality near the BFN site. General ecological health has been rated as "good" or "fair" for all monitoring years except for 2007 and 2011 when it was rated "poor" due in large part to the low flow (drought) conditions (Figure 3.3-3). Table 3.3-3 presents the 2017 ecological health ratings for Wheeler Reservoir at the four monitoring sites. These metrics are briefly explained in the following paragraphs (TVA 2018c).

Table 3.3-2. 303(d) List of Impaired Waters and Tributaries to Wheeler Reservoir

Waterbody ID	Impaired Waterbody	County	Cause	Pollution Source
AL06030002-1205-100	Tennessee River (Wheeler Lake) from Wheeler Dam to five miles upstream of Elk River	Lawrence, Lauderdale	Nutrients	Agricultural
AL06030002-1101-101	Swan Creek from Wheeler Lake to Huntsville Browns Ferry Road	Limestone	Nutrients	Agriculture Municipal Urban runoff/storm sewers
AL06030002-1101-111	Swan Creek (Wheeler Lake)	Limestone	Nutrients	Agriculture
AL06030002-0906-600	Limestone Creek (Wheeler Lake) from Tennessee River to end of embayment	Limestone	Mercury	Atmospheric deposition
AL06030002-1014-101	Flint Creek (Wheeler Lake)	Morgan	Nutrients	Agriculture
AL06030002-1014-103	Flint Creek from L&N Railroad to Alabama Highway 36	Morgan	Mercury	Atmospheric deposition
AL06030002-1103-111	Round Island Creek (Wheeler Lake) from Tennessee River to end of embayment	Limestone	Mercury Nutrients	Atmospheric deposition Agriculture
AL06030002-0505-111	Indian Creek (Wheeler Lake) from Tennessee River to end of embayment	Madison	Nutrients	Agriculture
AL06030002-0606-111	Cotaco Creek (Wheeler Lake) from Tennessee River to end of embayment	Morgan	Nutrients	Agriculture
AL06030002-0902-100	Tennessee River (Wheeler Lake) from Flint River to Guntersville Dam	Madison, Marshal	Nutrients	Agriculture
AL06030002-0904-100	Tennessee River (Wheeler Lake) from Indian Creek to Flint River	Madison, Marshal	Nutrients	Agriculture
AL06030002-0906-102	Tennessee River (Wheeler Lake) from Cotaco Creek to Indian Creek	Madison, Marshal	Nutrients	Agriculture
AL06030002-1102-102	Tennessee River (Wheeler Lake) from US Highway 31 to Flint Creek	Limestone, Morgan	Nutrients	Agriculture
AL06030002-1102-103	Tennessee River (Wheeler Lake) Flint Creek to Cotaco Creek	Limestone, Madison, Morgan	Nutrients	Agriculture
AL06030002-1102-211	Bakers Creek (Wheeler Lake) from Tennessee River to end of embayment	Limestone	Nutrients perfluorooctane sulfonate (PFOS)	Agriculture Industrial
AL06030002-1102-311	Dry Branch (Wheeler Lake) from Tennessee River to end of embayment	Limestone	Nutrients	Agriculture
AL06030002-1107-102	Tennessee River (Wheeler Lake) from five miles upstream of Elk River to US Highway 31	Limestone, Lawrence	Nutrients PFOS	Agriculture Industrial

Waterbody ID	Impaired Waterbody	County	Cause	Pollution Source
AL06030002-1201-111	Spring Creek (Wheeler Lake) from Tennessee River to end of embayment	Lawrence	Nutrients	Agriculture
AL06030002-1202-200	Neeley Branch from Snake Road bridge to its source	Lauderdale	Pathogens (*E.coli*)	Pasture grazing
AL06030004-0405-101	Elk River (Wheeler Lake) from Tennessee River to Anderson Creek	Lauderdale and Limestone	pH and nutrients	Crop production (non-irrigated) and pasture grazing
AL06030002-1204-101	Second Creek (Wheeler Lake) from Tennessee River to first bridge upstream from US 72	Lauderdale	Nutrients	Agriculture

Source: (ADEM 2020)



Source: (TVA 2018c)

Figure 3.3-3. Wheeler Reservoir Ecological Health Ratings, 1994-2017

Table 3.3-3. Reservoir Ecological Health Indicators for Wheeler Reservoir, 2017

Monitor Location	Dissolved Oxygen	Chlorophyll	Bottom Life	Fish	Sediment
Forebay	Poor	Poor	Poor	Good	Good
Mid-reservoir	Good	Good	Good	Good	Fair
Elk River embayment	Poor	Poor	Poor	Good	Good
Inflow	-	-	Good	Good	-

Source: (TVA 2018c)
"-" indicates no data was available at this location for the health indicators tested.

Reservoir Ecological Health Indicators

Dissolved Oxygen

The reservoir has a notable gradient in dissolved oxygen concentrations, decreasing from the surface to the bottom. Low dissolved oxygen concentrations are particularly evident during summer and fall seasons. Dissolved oxygen data were not collected for the inflow location. Dissolved oxygen in 2017 was rated "good" at the mid-reservoir location and "poor" at the forebay and the Elk River embayment. The lower ratings were due to low dissolved oxygen concentrations (<2 milligram per liter) in the lower water column during the summer. Dissolved oxygen has rated "good" at the mid-reservoir location in all previous years, but ratings have varied between “good”, “fair”, and “poor” at the forebay and embayment locations, primarily in response to reservoir flows (TVA 2018c).

Chlorophyll

High chlorophyll levels in surface waters indicate the presence of algae in surface waters. Algae are typically an indicator of increased nutrient concentrations usually due to fertilizer runoff into surface waters. Chlorophyll concentrations can increase and decrease rapidly due to changing conditions which can affect other health indicators such as dissolved oxygen and fish life. In 2017, chlorophyll levels were rated as “good” in the mid-reservoir and “poor” in the forebay and Elk River Embayment. Chlorophyll data were not collected for the inflow location. Chlorophyll levels are typically highest in the summer when water temperatures are higher and there are increased concentrations of nutrients, particularly nitrogen and phosphorus.

Bottom Life

Bottom life, or benthic communities, are a measure of the water quality of incoming water and sediment. Decreased water quality and increased rates of sedimentation or sediment contamination can negatively impact bottom life. In 2017, the mid-reservoir and inflow were both considered “good”, while the forebay and Elk River Embayment were both considered “poor”. The “poor” ratings at the Elk River Embayment and forebay were due to low dissolved oxygen concentrations in the summer, which leads to low populations of benthic communities with only some tolerant benthic invertebrates surviving (TVA 2018c).

Fish Health

Fish health is a measure of the type and abundance of fish located in the reservoir as well as their overall health. Fish health is an important measure of water quality. For all four locations that were measured, fish health was rated as “good”, indicating that water quality was good for fish communities. A total of 51 species of fish were observed throughout the reservoir including largemouth bass, benthic invertivores and intolerant species (species that require good water quality conditions) were well represented at each location (TVA 2018c).

Sediment

Sediment quality is based on the detection and concentration of chemicals in the sediment including pesticides, polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), chlordane, and heavy metals. Sediment was rated “good” at the forebay and Elk River embayment because low levels of PCBs were detected, and metals concentrations were within background limits. Low levels of PCB were detected in the mid-reservoir, so it was rated “fair”. Sediment quality is typically rated “good” at all three locations, excluding the inflow location. In previous years, PCBs have been detected at various locations throughout the reservoir. DDT and chlordane were detected at the mid-reservoir in 1994 and 2003 respectively (TVA 2018c).

Fish Consumption Advisories

Wheeler Reservoir is classified by the Alabama Department of Environmental Management (ADEM) for use as public water supply, swimming and other whole-body water-contact sports, and fish and wildlife. Water quality is generally good in Wheeler Reservoir, but nutrient loads are a concern. The reservoir is on the 2020 Alabama 303(d) list as partially supporting its designated uses due to excess nutrients attributed to agricultural sources (ADEM 2020). In addition, the Alabama Department of Public Health (ADPH) issued fish consumption advisories for certain areas of the reservoir due to mercury and perfluorooctane sulfonate (PFOS) contamination (ADPH 2020). Mercury occurs naturally in rock and soils but can also originate from other sources, including atmospheric emissions from human activities (fossil fuel combustion, waste incinerations, steel mills) or from natural processes (forest fires, volcanoes).

PFOS is a man-made compound used in a variety of industrial and commercial products. PFOS is no longer manufactured in the United States and its use is being phased out (USEPA 2021a).

Thermophilic Microorganisms
Some thermophilic (heat adapted) microorganisms are pathogens and have the potential to affect public health. Nuclear power plants typically discharge cooling water into a reservoir system, which heats water downstream of the plant. It is necessary to determine whether discharge characteristics promote survival and reproduction of pathogenic thermophilic microorganisms. Organisms of concern include enteric pathogens *Salmonella* and *Shigella*, *Pseudomonas aeruginosa* bacterium, *Actinomycetes* (thermophilic fungi), *Legionella* bacteria, and pathogenic strains of the free-living *Naegleria* and *Acanthamoeba* amoeba (NRC 2013).

Bacteria pathogenic to humans usually thrive at temperatures above 30 degrees Celsius (ºC; 86 degrees Fahrenheit [ºF]) and are ubiquitous in the environment. During the summer months temperatures in Wheeler Reservoir are at their highest, which is when there is the most concern for human pathogens. In terms of hydrothermal impacts on Wheeler Reservoir, operation of the circulating water system is regulated by the State of Alabama under the NPDES permit number AL0022080 (ADEM 2018). The permit specifies that the river ambient temperature is measured by an upstream monitor located at about TRM 297.8, and that impacts relative to the ambient are measured by three downstream monitors located at about TRM 293.5. The upstream monitor is about 3.8 miles upstream of the diffusers, whereas the downstream monitors are located near the end of a mixing zone, which extends 2,400 feet (0.45 miles) below the diffusers (ADEM 2018). The current NPDES permit specifies that at the downstream end of the mixing zone, the operation of the plant may not cause:

- The measured 1-hour average temperature to exceed 93 °F,
- The measured daily average temperature to exceed 90°F, and
- The measured daily average temperature rise (relative to ambient) to exceed 10°F.

3.3.1.2. Environmental Consequences – Surface Water Hydrology and Water Quality

Alternative A – No Action Alternative
Under the No Action Alternative, BFN would continue to operate until all three current plant operating licenses expire by 2036. Following plant shutdown, heated water from the condenser circulating water (CCW) system would cease to be discharged to Wheeler Reservoir and water quality impacts would be limited to those associated with plant closure and decommissioning. The rate of consumptive water use would decrease by 4 million gallons per day (MGD). Stormwater discharges would continue to be controlled under an NPDES permit associated with discharges for these activities. The method of decommissioning has not been determined, but may include use of surface water for dust control. If so, the amount of water to be used would likely be minimal, and the duration would be temporary. Overall, impacts to surface water quality in association with the shutdown and decommissioning of BFN under the No Action Alternative would be small, and potentially beneficial.

Additionally, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. For a replacement SMR plant(s) at an alternate site, new intake and discharge structures would need to be constructed to provide water needs for the facility. The impact would depend on the volume of water withdrawn for makeup, relative to the amount available from the intake source. The characteristics of the surface water impacts would be expected to be small because they would be controlled under an NPDES permit that would be regulated by the state in which the plant(s) is located. There is a potential that some erosion and sedimentation may occur during construction; however, construction would be temporary, and the implementation of best management practices (BMP) should limit any potential impacts to surface water quality.

Water quality impacts for a new SMR plant(s), depending on the technology chosen and the location, would be bounded by the current discharge at BFN. If the source of water for the new nuclear power plant were different than the source for BFN, the impact of shutting down BFN might reduce the effects on the Wheeler Reservoir, but would transfer impacts to the other waterbody. In addition, maintaining compliance with the plants NPDES permit would limit potential impacts.

Cooling water at any other alternate generation site would likely be withdrawn from a surface waterbody, if needed, and its discharge would be regulated by permit as appropriate. Depending on the water source, the impacts on water quality caused by plant discharge could have noticeable impacts. The impacts of a new gas-fired plant utilizing a closed-cycle cooling system at an alternate site are considered small, because the plant would have to maintain compliance with the plant’s NPDES permit. Water quality impact from sedimentation during construction is categorized as small. Operation water quality impacts would be similar to, or less than, those from other centralized generating technologies. Surface water impacts would remain small.

Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. The type and level of impact would vary depending upon proximity, mitigation measures, and general construction and operation practices. Impacts, including cumulative impacts, could range from small to moderate.

Alternative B – Proposed Action

Under Alternative B, there would be no major construction activity. Current plant water withdrawal and discharge water quality would remain the same during the proposed subsequent period of extended operation. As presented in Section 3.3.4.2, treatment chemicals are largely consumed or diluted, leaving very small concentrations by the time they are discharged. The BFN NPDES permit would assure continued compliance with applicable water quality standards and criteria. Therefore, there would be no change in impact from the current level of small impact. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation.

Spill prevention, containment, and countermeasure (SPCC) plan, and other permit conditions would avoid or minimize any impact on surface water resources from BFN operational and maintenance activities during the proposed subsequent period of extended operation. For these reasons, TVA concludes that impact on surface water, including cumulative impacts, would be small and no mitigation measures are required other than those already in place.

3.3.2. Surface Water Use and Trends

3.3.2.1. Affected Environment – Surface Water Use and Trends

There are twelve potable water intakes on Wheeler Reservoir withdrawing a total of approximately 169 MGD for municipal and industrial use. Wastewater discharges include 13 municipal locations discharging approximately 73 MGD. Six (non-TVA) industrial entities discharge approximately 100 MGD (Sharkey and Springston 2022).

The major public uses of the reservoir are for water supply, recreation, and waste disposal. The nearest upstream community surface water supply intake is at Decatur, Alabama, on Wheeler

Reservoir 12 miles upstream from BFN which withdraws an average of 26.02 MGD. The first downstream water intake is the West Morgan-East Lawrence Water Authority 7.5 miles downstream from BFN which withdraws an average of 6.89 MGD.

There are also major industrial water users located both upstream and downstream within 15 miles of BFN. Upstream from BFN, Indorama Ventures Xylenes & PTA (5.5 miles upstream) withdraws an average of 9.76 MGD, 3M Company Decatur Facility (5.7 miles upstream) withdraws an average of 11.77 MGD, and Ascend Performance Materials (8 miles upstream) withdraws an average of 72.50 MGD. Downstream from BFN, International Paper Company (11.4 miles downstream) withdraws 0.01 MGD. These users withdraw water from Wheeler Reservoir each day for process and cooling needs. The majority of this water is subsequently returned to the reservoir.

In 2020, an average of 8,368 MGD (surface water and groundwater) were used for public supply, industrial water supply, irrigation, and thermoelectric power generation in the Tennessee River watershed. Only 4.8 percent of the total water withdrawn, or about 403 MGD, was used consumptively. By the year 2045, even though water demands from public water supply and irrigation are expected to increase, water withdrawals are projected to decline by 11 percent from 2020 levels, primarily due to the retirement of old power plants (Sharkey and Springston 2022).

3.3.2.2. Environmental Consequences – Surface Water Use and Trends

<u>Alternative A – No Action Alternative</u>

Under the No Action Alternative, the decision not to extend operation of the BFN units past the current expiration dates of the operating licenses would result in shutdown of the reactors and decommissioning of the BFN site. Once the plant shuts down, BFN would cease to draw cooling water from Wheeler Reservoir. The method of decommissioning has not been determined, but may include use of surface water for dust control. If so, the amount of water to be used would likely be minimal, and the duration would be temporary. Overall, impacts to surface water use in association with the shutdown of BFN under the No Action Alternative would be small, and potentially beneficial as overall consumption rates for Wheeler Reservoir would become a fraction of the rate of withdrawal of the operating plant.

Under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system.

Surface water use impacts would depend on the volume of water withdrawn for makeup water relative to the amount available from the intake source and the characteristics of the surface water. A SMR or natural gas-fired plant(s) would be built with a closed-cycle cooling system which would increase surface water consumption from operation of the cooling towers; however, the beneficial impact would be a reduction in the number of fish and shellfish entrained or impinged. The overall impacts could be small for water use impacts during normal flows and possibly large impacts during extreme low-flow conditions. Potential impacts can be mitigated by derating (reducing the thermal output of the plant by reducing its electrical power rating) during periods of thermal sensitivity. For other generation options, surface water use impacts would be expected to be similar but on a smaller scale than those described for new nuclear generation. The volume of water used would be expected to be smaller for a natural gas-fired plant if the waterbodies were of the same size and quality as for the SMR plant site, and the impact would be expected to be small. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

<u>Alternative B – Proposed Action</u>

The largest withdrawal/discharge from Wheeler Reservoir is cooling water from BFN. Between 2016 and 2021, consumptive and offstream water use in Wheeler Reservoir has not resulted in significant use conflicts due to the large volume of reservoir water available, the high river flow rate, and the return of most of the water withdrawn. BFN withdraws 3,124 MGD on average, while consuming 16.6 MGD, or 0.53 percent of water withdrawn. Almost all of the water withdrawn is used for once-through cooling (open cycle or open mode).

Regulatory control of withdrawal rates and NPDES permit limits for return water quality also mitigate potential conflicts. Potential trade-offs can occur with instream water uses (e.g., instream use conflicts affect aquatic life, waste assimilation, navigation, power generation, flood control, and lake levels). These potential conflicts are addressed by operating procedures, legal requirements, and regulatory procedures. Impacts on the Tennessee River from operation of the circulating water system, are regulated by the State of Alabama under NPDES permit number AL0022080 (ADEM 2018). The permit (Outfalls DSN001, DSN0011 and DSN0012) requires that BFN report discharge water temperature, pH, chlorine, temperature differentials between upstream and downstream monitoring points, and flow (ADEM 2018).

Under Alternative B, BFN's surface water withdrawal and discharge volumes during the proposed subsequent period of extended operation are expected to be consistent with the plant's current water withdrawals and discharge volumes. Therefore, impacts to surface water use, including cumulative impacts, would remain unchanged and small.

3.3.3. Hydrothermal Effects of Plant Operation

A summary of the surface water hydrothermal effects of BFN operation including a discussion of alternatives and their impacts is presented in this subsection.

3.3.3.1. Affected Environment – Hydrothermal Effects of Plant Operation

Surface water runoff at BFN is derived from precipitation remaining after losses due to infiltration and evapotranspiration. It can generally be classified as local surface runoff or streamflow. Surface water runoff from the plant site is to Wheeler Reservoir. The Tennessee River drainage area at Wheeler Dam is approximately 29,590 square miles (TVA 2017).

<u>Plant Surface Water Use</u>

Wheeler Reservoir is the source for cooling water systems for BFN. BFN uses a once-through or open mode condenser circulating water (CCW) system to dissipate waste heat from the plant steam turbines. The water is withdrawn from Wheeler Reservoir by an intake structure located at about TRM 294.3. The CCW system is designed to provide a flow of approximately 675,000 gallons per minute (gpm) to the condensers, with a flow of approximately 25,000 gpm to each unit. When all three units are in operation, this water is pumped through the plant at the rate of about 4,400 cfs. Between 2016 and 2020, BFN withdrew approximately 3,035 million gallons per day (MGD). Most of the water withdrawn at the plant intake is returned to Wheeler Reservoir. Water losses by evaporation and drift occur for the CCW system when the helper cooling towers are in service. Between 2016 and 2020, losses were approximately 4.0 MGD, or 0.13 percent of the total withdrawal.

Wheeler Reservoir water use by BFN is managed per the TVA Reservoir Operations Study published in 2004 (TVA 2004). Eleven major issues were evaluated, including reservoir and downstream water quality, environmental resources, reservoir pool levels, recreation flows, economic development, water supply, navigation, flood risk, power reliability, power costs, and capital costs. Discharges from the BFN are regulated by the ADEM NPDES Permit No.

AL0022080. The permit (Outfalls DSN001, DSN0011 and DSN0012) requires that BFN report discharge water temperature, pH, chlorine, temperature differentials between upstream and downstream monitoring points, and flow (ADEM 2018).

Water withdrawals from the Wheeler Reservoir in 2021 by BFN for cooling water purposes averaged 108,448 million gallons per month with the highest withdrawal rates in August, and lowest in March. Return discharges in 2021 averaged 106,036 million gallons per month with August and March having the highest and lowest volumes respectively. In 2021, 28,940 million gallons of water from Wheeler Reservoir were consumed, with the highest consumption in April (20,471 million gallons), and the lowest consumption occurred in May (43 million gallons). The average monthly consumption for 2021 was 2,411 million gallons per month.

Current NPDES Permit

In terms of hydrothermal impacts on Wheeler Reservoir, operation of the circulating water system is regulated by the State of Alabama under the National Pollutant Discharge Elimination System (NPDES) permit number AL0022080 (ADEM 2018). As described previously, the permit specifies that the river ambient temperature is measured by an upstream monitor located at about TRM 297.8, and that impacts relative to the ambient is measured by three downstream monitors located at about TRM 293.5. The upstream monitor is about 3.8 miles upstream of the diffusers, whereas the downstream monitors are located near the end of a mixing zone, which extends 2,400 feet (0.45 miles) below the diffusers (ADEM 2018). The current NPDES permit specifies that at the downstream end of the mixing zone, the operation of the plant may not cause:

- The measured 1-hour average temperature to exceed 93 °F,
- The measured daily average temperature to exceed 90°F, and
- The measured daily average temperature rise (relative to ambient) to exceed 10°F.

Regulatory control of withdrawal rates and NPDES permit limits for return water quality also mitigate potential conflicts. Potential trade-offs can occur with instream water uses (e.g., instream use conflicts affect aquatic life, waste assimilation, navigation, power generation, flood control, and lake levels). These potential conflicts are addressed by operating procedures, legal requirements, and regulatory procedures. Impacts on the Tennessee River from operation of the circulating water system, are regulated by the State of Alabama under NPDES permit number AL0022080 (ADEM 2018). The permit (Outfalls DSN001, DSN0011 and DSN0012) requires that BFN report discharge water temperature, pH, chlorine, temperature differentials between upstream and downstream monitoring points, and flow (ADEM 2018)

3.3.3.2. Environmental Consequences – Hydrothermal Effects of Plant Operation

Alternative A – No Action Alternative

Under the No Action Alternative, the plant would continue to operate until all three current plant operating licenses expire by 2036. Following plant shutdown, the amount of water used and the release temperature of water returned to the reservoir would be reduced as the reactors shut down and less water is needed for cooling. The rate of consumptive water use would decrease by 7.2 million gallons per day (MGD)[1] which equates to approximately 0.23 percent consumption of the total water withdrawn. Any additional potential water quality impacts would be limited to those associated with plant closure and decommissioning. Overall, impacts to

[1] Consumptive water use average includes data from 2017-2021. One non-routine outlier event was not factored into this average.

surface water temperatures, in association with the shutdown and decommissioning of BFN under the No Action Alternative would be small, and potentially beneficial.

Under the No Action Alternative however, the shutdown of BFN would also require construction of replacement power either at BFN or elsewhere within the TVA system.

Hydrothermal impacts on surface water from an SMR or gas-fired plant would be site specific, and dependent on the volume and temperature of water discharged. Either type of plant would be required to obtain and maintain an NDPES permit. Discharge would contain dissolved solids and be regulated by the state issuing the NDPES permit. There could be large impacts during low river flow conditions; however, the use of cooling towers and plant derate (reduced power) should mitigate this impact. Because the location of the plant has not been determined, any cumulative impacts would have to be evaluated during the plant licensing or permitting process. Overall, potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. Impacts could range from small to large.

Alternative B – Proposed Action

Under Alternative B, no refurbishment or plant modifications that would have effects on water resources are planned during the proposed subsequent period of extended operation. BFN would continue to operate within the thermal limits set by BFN's NPDES permit and without measurable adverse impact to the balanced indigenous population during the proposed subsequent period of extended operation. The effect on currents near the intake and discharge locations for BFN during the proposed subsequent period of extended operation is expected to be localized, as any previous problems would have been mitigated during the early operational period of the plant. The size of Wheeler Reservoir precludes significant current alterations except in a limited area in the vicinity of the intake and discharge structures. BFN is in compliance with current NRC and ADEM regulations related to thermal discharge evaluation requirements; therefore, no change regarding any potential impact from the current level of small impact would be anticipated, including to cumulative impacts.

3.3.4. Chemical Additives for Plant Operation

A summary of the chemical additives during BFN operation, including a discussion about alternatives and their impacts, is presented in this section.

3.3.4.1. Affected Environment – Chemical Additives for Plant Operation

Types of chemicals currently used in operating plant cooling water systems are described as follows:

- Scale Inhibitors. Also called anti-scalants, these chemicals inhibit the formation of lime (calcium oxide) deposits that would otherwise tend to form on the high temperature surfaces of the heat exchanger tubes and limit the deposition of other chemical forms of oxide scale upon the heat exchanger tubes. Anti-scalants are organic (carbon-based) polymers containing phosphate attachments on the molecule.
- Corrosion Inhibitors. Corrosion inhibitors behave as "oxygen scavengers" and tend to draw up and chemically bind available oxygen, which makes less oxygen locally available to form rust compounds, which are metal oxides.
- Molluscicide. Ammonium chloride or a quaternary amine can be used for zebra mussel and Asiatic clam control.

- Dehalogenation Agent. Sodium bisulfite may be utilized to ensure that the oxidizing biocide (total residual oxidant) discharge limit as it pertains to the total residual halogen, usually chloride, is not exceeded.
- Detoxification Agent. Bentonite clay may be required to detoxify the molluscicide chemical from the water through absorption at a ratio of 5:1 to the quaternary amine.
- Biopenetrant. Non-ionic surfactant (a simple soap) may be applied to increase the efficacy of the oxidizing biocide by cleaning off the surfaces of the biota to make the chlorine-based (or other halogen such as bromine-based) biocide or molluscicide chemical penetrate more effectively into the biological material, or biota.

All chemicals are approved prior to use by the appropriate state regulatory agencies, and qualified TVA personnel who determine the best possible chemicals to use based on site-specific needs. TVA's operational philosophy regarding chemical additives for plant operation reflects minimization of chemical use through an optimization program. The optimization program includes (1) monitoring operating plant parameters, (2) continually evaluating water chemistry, and (3) inspecting equipment to minimize the total amount of chemicals added. Prior to use in TVA plants, chemicals undergo an extensive toxicological review and comparison with maximum instream wastewater concentrations to ensure water quality standards are met.

BFN water treatment processes are controlled to comply with state water quality criteria and applicable NPDES permit conditions to ensure protection of the receiving waterbody. The standards and criteria applied by the state in establishing NPDES permit limits and requirements are to protect public health and water resources, as well as to maintain the designated uses for the receiving waterbody. BFN continues to operate in compliance with the NPDES permit requirements.

3.3.4.2. Environmental Consequences – Chemical Additives for Plant Operation

Alternative A – No Action Alternative

As a consequence of shutdown and decommissioning of BFN, impacts to surface water quality from chemical additives would decrease and eventually end. Therefore, under the No Action Alternative impacts would be small, and potentially beneficial.

However, additionally under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system.

The impacts of new SMR or new natural gas-fired generation generally are similar in that they depend largely upon the sites that would be chosen and the measures taken to reduce or avoid potential impacts. For a new SMR plant or gas turbine, the treatment chemicals added would be expected to be largely consumed, leaving very small concentrations by the time they are discharged. The amount of chemicals used for a gas turbine cooling operation would be less than for an SMR plant(s) based on the smaller scale of the individual units and components and less restrictive requirements on plant components. Plant discharges would be regulated by the state in which the plant is located. An NPDES permit would be required, and the plant would comply with applicable water quality standards and criteria. Therefore, when the new generation source commences operation, the direct, indirect, and cumulative effects of chemical discharges would be expected to be small.

Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

These separate analyses would investigate potential impacts to surface water quality. The type and level of impact would vary depending upon proximity, mitigation measures, and general construction and operation practices. Impacts could range from small to moderate.

Alternative B – Proposed Action

Under Alternative B, the volume of the cooling water discharge would continue to be small when compared to flow in Wheeler Reservoir, and the treatment chemicals added are largely consumed, leaving very small or non-detectable concentrations by the time they are discharged. The BFN NPDES permit would assure continued compliance with applicable water quality standards and criteria. Therefore, there would be no change in impact from the current level of small impact during the proposed subsequent period of extended operation.

3.3.5. Surface Water Resources Conclusion

Impacts from plant water discharges would be expected to be small for operating BFN during the proposed subsequent period of extended operation. Because water temperatures in Wheeler Reservoir are critical to both BFN operation and to resources within the reservoir, long-term increases in reservoir temperatures due to global warming may affect the ability to operate the plant in the future in the same way as it is currently operated. For operational purposes, TVA may be required to extend the duration of operation of the helper cooling towers, or modify their flow rates. The increases in ambient water temperature, and its effect on operations, would be considered by ADEM in establishing temperature limits in discharges during periodic renewals of the NPDES permit.

Surface water impacts would be small to moderate during construction of alternative new generation units under the No Action Alternative. Cumulative effects would also be expected to be small and would not warrant mitigation. This determination was arrived at by considering effects from existing water users with intakes on Wheeler Reservoir. The major public uses of the reservoir are for water supplies, recreation, and waste disposal. None of the proposed or in-progress projects in the vicinity discussed in Section 1.5.1.3 would impact water use beyond the TVA's capacity to regulate it.

3.4. Groundwater Resources

A discussion of groundwater hydrology, groundwater use and trends, and groundwater quality for BFN is provided in this section.

3.4.1. Affected Environment – Groundwater

3.4.1.1. Groundwater Hydrology

Regional shallow groundwater flow is generally to the southwest towards the Tennessee River's Wheeler Reservoir (Arcadis 2021). Water level measurements collected at wells installed from 2014 through 2016 suggest that local groundwater flow is also generally to the southwest. However, groundwater flow is complicated due to the presence of building foundations set into bedrock and underground utility corridors located beneath the water table. There are three principal hydrogeologic units onsite: unconsolidated sediments (silty/sandy clays and coarse-grained backfill), the underlying Tuscumbia Limestone, and the Fort Payne Chert. The Tuscumbia Limestone weathers readily and can form solution features along some bedding planes or fractures (Arcadis 2021). Groundwater flow in the Fort Payne Chert is likely inhibited by the formation's resistance to chemical weathering and limited to fractures and partings. It should be noted that limited data exist relative to the Fort Payne Chert, but borings in the vicinity of the site indicate the area is less prone to weathering (Arcadis 2021). It is reasonable to assume that hydraulic connection exists between the bedrock formations and the overlying sediments.

Wheeler Reservoir is the primary discharge location for groundwater at BFN. There are also a number of artificial secondary surface water bodies associated with operations that could potentially influence groundwater flow on the site because they are unlined, including the hot water channel, cold water channel, intake channel, wastewater lagoons, and sediment ponds. However, the degree to which these artificially controlled water bodies affect groundwater flow has not been determined. Water level elevations of these secondary surface water features, particularly the hot water channel and cold water channel, are artificially controlled by site operations, depending on various plant operations and reservoir height. While the elevation of the intake channel is generally maintained at an elevation equivalent to Wheeler Reservoir, the elevations of the hot water and cold water channels are not known. Natural and artificial fluctuations in surface water elevations can vary greatly and impact groundwater flow at the site, although these rates are not well quantified. Seasonal groundwater fluctuation strongly correlates with the Wheeler Reservoir elevation, which suggests a high degree of surface water-groundwater communication in both hydrogeologic units (Arcadis 2021).

Shallow groundwater at BFN occurs within unconsolidated terrace deposits and residual soils, and along the epikarst, a relatively thin weathered horizon at the top of bedrock. Below the epikarst, groundwater occurs exclusively in fractures and solution features of the Tuscumbia limestone and Fort Payne chert. The Tuscumbia limestone and Fort Payne chert are collectively described as the Tuscumbia-Fort Payne aquifer system. This aquifer system is the primary water-bearing unit in the site vicinity from a regional perspective since it is a source of water for both wells and springs in the area (Arcadis 2021).

Recharge to the shallow groundwater system at the plant site is derived primarily from precipitation. As stated in the 2021 Site Conceptual Model, annual precipitation ranged from 39.48 inches in 2016 to 57.32 inches in 2020 (Arcadis 2021). Regional water balance studies show that approximately 10 to 13 inches of precipitation per year enters groundwater storage (USGS 1978).

Groundwater levels at the site are generally highest during the months of January through March. During September and October, water levels are usually at a minimum. Correlation between water levels in site wells and neighboring surface waters indicates that the Wheeler Reservoir and plant water channels exert some control on local groundwater elevations and hydraulic gradients through hydrostatic pressure in the subsurface. The direction of groundwater movement is generally west-southwest toward the Wheeler Reservoir. Exceptions to this directional flux occur at the plant site during dewatering operations (which can reverse gradient conditions), in the vicinity of leaking water lines serving the site, in areas of topographic highs/lows, and in the vicinity of the LLRW storage facility where more complex movement exists.

Within overburden soils at the site, groundwater movement is predominantly downward. Local areas of lateral flow likely occur near some streams, topographic lows, and where extensive root systems exist. The saturated hydraulic conductivity of site soils in the vicinity of the LLRW storage facility averages 3.7E-08 feet per second, which is typical of clay soil (Boggs 1982). Water supply wells developed within such low permeability soils are primarily of limited capacity. Based on aquifer testing in a similar setting, the cherty gravel horizon near bedrock (epikarst) can be significantly transmissive (TVA 1993). Measured transmissivity values suggest horizontal hydraulic conductivity values that are from one to two orders of magnitude greater than those measured in the shallow Tuscumbia limestone (TVA 1993). Observations of groundwater levels during early site borings also suggest that groundwater within the epikarst zone and Tuscumbia-Fort Payne aquifer might be confined (Arcadis 2021).

Groundwater flow in the Tuscumbia limestone occurs solely in fractured and weathered zones. The orientation of fractures and solution features within the Tuscumbia is coincident with a structurally controlled joint system (i.e., along strike and dip). Studies by TVA indicate that the transmissivities of bedrock fractures and solution features in the Tuscumbia may decrease with depth (TVA 1993). However, the interconnectivity of these features is equally important. Although fractured, the silty, siliceous nature of the Fort Payne chert inhibits the development of solution features. Therefore, the average permeability of the Fort Payne chert at the site is expected to be less than that of the Tuscumbia limestone (Arcadis 2021).

3.4.1.2. Groundwater Use and Trends

The Tuscumbia-Fort Payne aquifer system provides volumes of water sufficient for domestic supplies and some limited municipal and industrial supplies in the region. Groundwater in this carbonate aquifer system can generally be used without extensive treatment (DOI 1987). Groundwater supply wells within a 20-mile radius of BFN and privately owned groundwater wells within a 2-mile radius of the BFN site have been identified by TVA. The closest known public groundwater supply well (Limestone County Water System) is located approximately 2 miles north of BFN (Geosyntec 2013).

BFN does not use groundwater for plant operation, and site dewatering wells have been inactive since the 1980s. However, there are 33 existing groundwater monitoring wells and one dewatering well included in the well sampling program established in the 2021 Site Conceptual Model. These wells are used to delineate possible radiological discharges to the groundwater (Arcadis 2021).

A reservoir catchment area is a natural drainage area truncated by a dam. Because recharge to the shallow groundwater system at the plant site is derived primarily from precipitation, knowledge of the Wheeler Reservoir Catchment Area is pertinent. In 2020, groundwater withdrawal from Wheeler Reservoir Catchment Area (Figure 3.4-1) was 41.30 MGD. The majority of groundwater use was from public supply (30.88 MGD), followed by irrigation (10.41 MGD) and industries (0.01 MGD) (Bowen and Springston 2018). For the majority of years from 1995 to 2015, there was an overall decreasing trend in groundwater withdrawal, but groundwater only supplied 1.9 percent of the total water withdrawals. In 2020, groundwater supplied 2.2 percent of the total water withdrawals, and 97.8 percent came from surface water (Sharkey and Springston 2022). Based on current usage, it could be assumed that overall groundwater demand would remain fairly constant in the future.

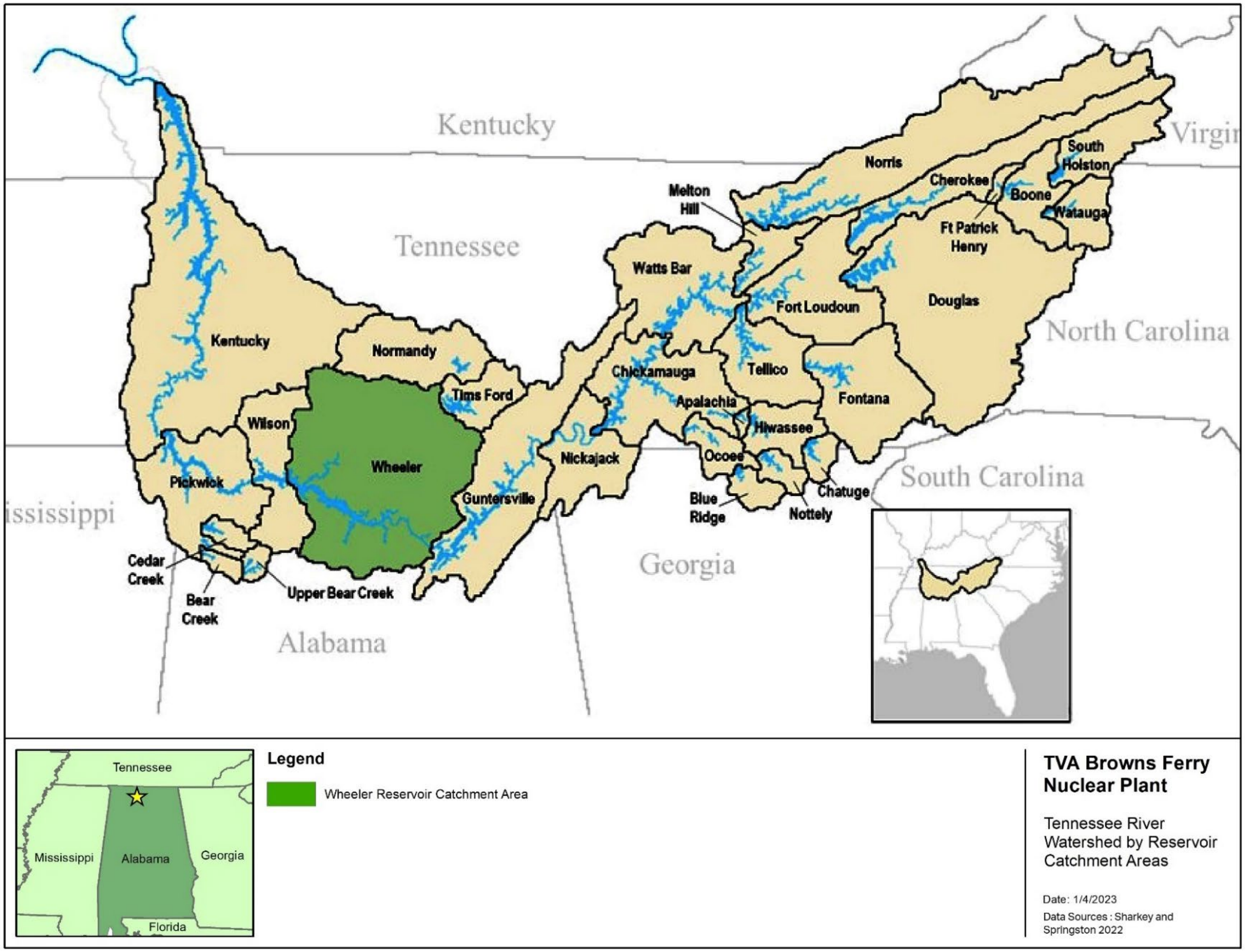


Figure 3.4-1. Wheeler Reserve Catchment Area

3.4.1.3. Groundwater Quality

Tritium

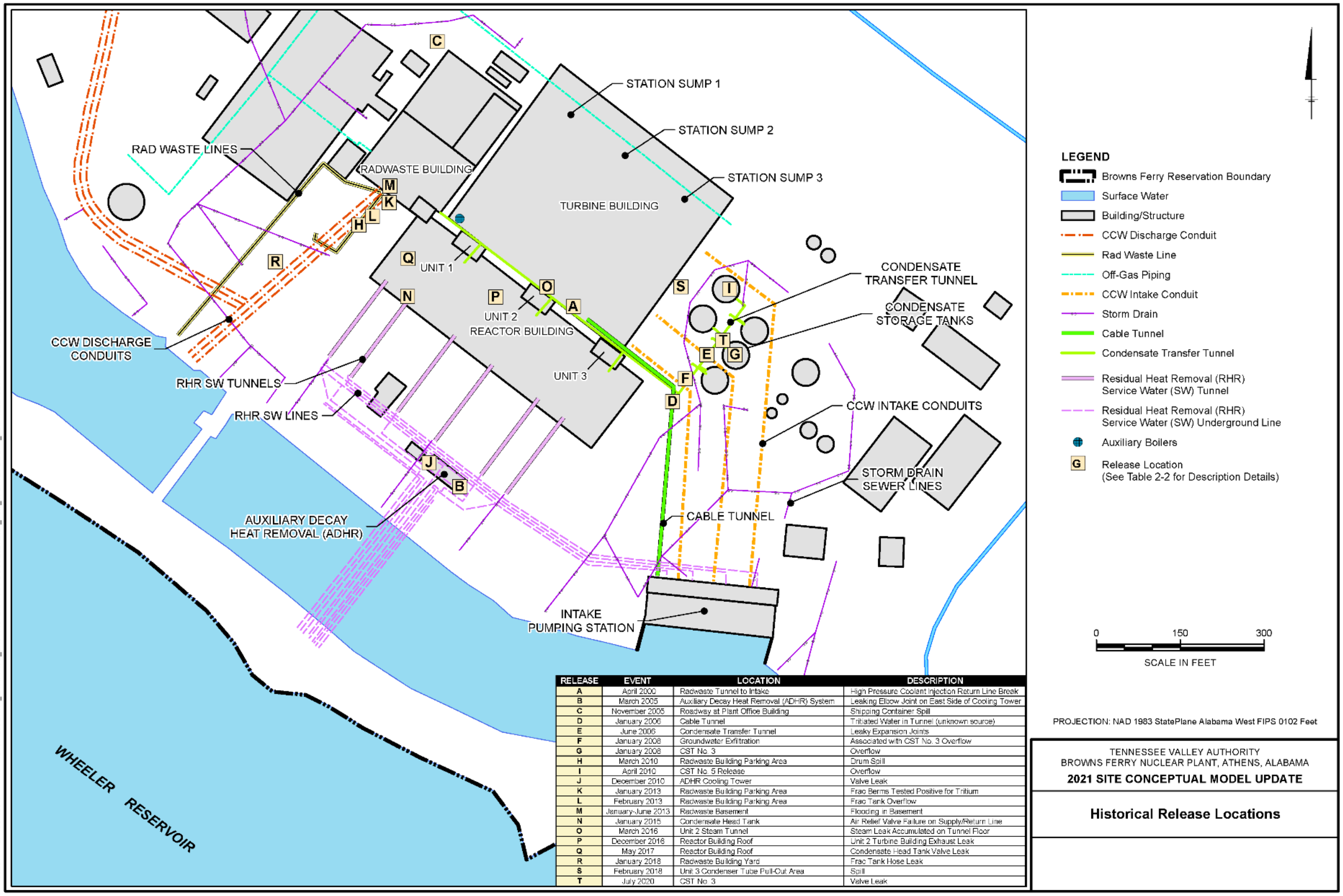
In the early 2000s, BFN initiated the Tritium Releases to Groundwater study to identify the source of low-level tritium detected onsite (TVA 2020c). Results from a groundwater study conducted in 2006 suggested the source of tritiated groundwater was from historical leaks and spills associated with the Radwaste/Condensate Transfer Tunnel. Groundwater and surface water level measurements during that study indicated tritiated groundwater from the site would discharge to the return channel and subsequently Wheeler Reservoir. It was determined at the time that there were no groundwater wells onsite or within 2 miles of the site used as a source of drinking water. Groundwater movement in the area has been determined to be from the plant site toward the Reservoir (TVA 2020c).

As required by 10 Code of Federal Regulations (CFR) 50.75(g), BFN maintains records of spills involving radioactive contamination in and around the facility, equipment, and site. Between April 2000 and April 2016, there were 15 known historical releases of tritiated water. Most of these releases were associated with systems, structures, and components such as the Cable Tunnel, Condensate Transfer Tunnel, Auxiliary Decay Heat Removal System, Condensate Storage Tanks, and Condensate Head Tank. Other tritiated water releases resulted from spills or leaks from temporary storage containers and frac tanks (Arcadis 2016).

From 2016 to 2020, six additional accidental tritiated water releases occurred at BFN. Each of these leaks was estimated to be less than 100 gallons, and therefore were not subject to the voluntary reporting requirements outlined in NEI-07-07. Tritium activity for these spills ranged from trace amounts to 9,230,000 picocurie per liter (pCi/L) (Arcadis 2021). Figure 3.4-2 shows the locations of the historical releases of tritiated water from April 2000 through July 2020, and descriptions of the releases are provided in Table 3.4-1.

Onsite groundwater monitoring was performed as part of the Groundwater Protection Initiative in 2020. BFN monitored a total of 30 groundwater wells located in the protected area and the within TVA controlled areas during 2020. Normal sampling frequencies are quarterly and semiannually, and some wells were sampled monthly if certain criteria are met or for investigation purposes. Samples are routinely analyzed for environmental level tritium and principal gamma emitters with selected wells analyzed for Hard-to-Detect radionuclides (Gross Alpha, Iron-55, Nickel-63, Strontium-89, and Strontium-90). In support of the groundwater program, the site also monitors recapture and onsite storm drains, catch basins and surface water (TVA 2020c).

In 2020, low levels of tritium were detected in 13 onsite groundwater wells; no other plant-related radionuclides were detected in any groundwater well. Tritium concentrations in 2020 groundwater samples ranged from non-detect (less than 163 pCi/L) to 35,400 pCi/L (Dewat-A). BFN has been monitoring a legacy tritium plume in the vicinity of groundwater well Dewat-A located adjacent to the reactor building. This plume is the result of previous leaks in 2015 and 2016 (TVA 2020c).



RELEASE	EVENT	LOCATION	DESCRIPTION
A	April 2000	Radwaste Tunnel to Intake	High Pressure Coolant Injection Return Line Break
B	March 2005	Auxiliary Decay Heat Removal (ADHR) System	Leaking Elbow Joint on East Side of Cooling Tower
C	November 2005	Roadway at Plant Office Building	Shipping Container Spill
D	January 2006	Cable Tunnel	Tritiated Water in Tunnel (unknown source)
E	June 2006	Condensate Transfer Tunnel	Leaky Expansion Joints
F	January 2008	Groundwater Exfiltration	Associated with CST No. 3 Overflow
G	January 2008	CST No. 3	Overflow
H	March 2010	Radwaste Building Parking Area	Drum Spill
I	April 2010	CST No. 5 Release	Overflow
J	December 2010	ADHR Cooling Tower	Valve Leak
K	January 2013	Radwaste Building Parking Area	Frac Berms Tested Positive for Tritium
L	February 2013	Radwaste Building Parking Area	Frac Tank Overflow
M	January-June 2013	Radwaste Basement	Flooding in Basement
N	January 2015	Condensate Head Tank	Air Relief Valve Failure on Supply/Return Line
O	March 2016	Unit 2 Steam Tunnel	Steam Leak Accumulated on Tunnel Floor
P	December 2016	Reactor Building Roof	Unit 2 Turbine Building Exhaust Leak
Q	May 2017	Reactor Building Roof	Condensate Head Tank Valve Leak
R	January 2018	Radwaste Building Yard	Frac Tank Hose Leak
S	February 2018	Unit 3 Condenser Tube Pull-Out Area	Spill
T	July 2020	CST No. 3	Valve Leak

Source: (Arcadis 2021)

Figure 3.4-2. Historical Release Locations at BFN

Table 3.4-1. Summary of Historical Releases at BFN from April 2000 through July 2020

Location	Release Date	Location	Description
A	April 2000 (Discovered October 2000)	Radwaste Tunnel to Intake	A break in the high-pressure core injection return line resulted in impacted water entering the Intake Pumping Station at the entrance to the Cable Tunnel. Radioactive contamination with trace amounts of Mn-54, Co-60, and Cs-137 were found in numerous locations such as the Pumping Station and Cable Tunnel, Waste Sump, CCW. The tunnel was decontaminated.
B	March 2005	Auxiliary Decay Heat Removal System	A leak occurred in an elbow on the east side of the Cooling Tower and at the overflow of the Cooling Tower Basin due to a malfunction of the system level indicators. Low-level radioactive water was released to the concrete pad and ground. Trace amounts of Co-60, Zn-65, Mn-54, Cs-134, Cs-137, Ag-110, and tritium were measured. Soil was excavated.
C	November 2005	Roadway at Plant Office Building	A shipping container carrying used Control Rod Drives leaked contaminated water onto the shipping trailer and the roadway, affecting a small (3-foot square) area. Based on hydrostatic testing of the container, the leak was apparently caused by handling activities.
D	January 2006	Cable Tunnel (between the Turbine Building and the Intake Pumping Station)	Water from an unknown source was discovered (containing tritium, Cs-137, Cs-134, and Co-60).
E	June 2006	Condensate Transfer Tunnel	Degraded expansion joints in the Condensate Transfer Tunnel may have allowed releases to groundwater. An evaluation of the tunnel noted that there was no liner, some joints were in poor shape, several inches of water are often present, and there was a floor drain and sump.
F	January 2008	Water Exfiltration	A leak from an unknown source, along with groundwater, was discovered bubbling out of the ground near the nitrogen tank. Samples were determined to contain low levels of tritium.
G	January 2008	CST No. 3 Overflow	Approximately 11,000 gallons of impacted water overflowed into the Condensate Transfer Tunnel, with the following constituents: tritium, Mn-54, Co-60, I-131, Cs-134, and Cs-137. The majority of the water was collected in sumps.
H	March 2010	Radwaste Building Parking Area	A drum was dropped while in transport via forklift, and the contents (containing tritium, Mn-54, Co-60, Co-58, and Cs-137) were spilled outside of the Radiologically Controlled Area but inside the Protected Area. The water was collected with absorbent media.
I	April 2010	CST No. 5 Release	Water was discovered to be flowing from an open test valve near the top of Condensate Storage Tank No. 3. Approximately 330 gallons were released (containing tritium, Mn-54, Co-60, Co-58, and Cs-137). Soil was excavated.
J	December 2010	Auxiliary Decay Heat Removal System Cooling Tower	A leak from a valve was identified and was believed to be due to system freezing. The leak rate was estimated at 0.5 gpm, with an affected are of approximately 100 square feet. The valve was replaced, and dirt from the area was excavated.
K	January 2013	Radwaste Building Parking Area	Frac berms tested positive for tritium. Water from berms was pumped back to Frac 1 and tested when dry. Smears taken once dry showed no contamination.

Location	Release Date	Location	Description
L	February 2013	Radwaste Building Parking Area	Frac #1 tank overflow due to heavy rain. The puddle outside the berm was pumped back into Frac #1 and ponded water on asphalt was absorbed.
M	January-June 2013	Radwaste Basement	CST-grade, tritiated water flooded the basement floor of Radwaste Building for a 6-month period. It is not known whether tritium was released to the environment during this period.
N	January 2015	Condensate Head Tank	A 0.5-gpm leak from an air release valve was identified, with water (containing tritium) accumulating on the concrete-lined reactor/refuel air zone intake and on the ground.
O	March 2016	Unit 2 Steam Tunnel	A leak within the Unit 2 Turbine Building Steam Tunnel was found, and tritiated water reached groundwater through degraded expansion joints within the tunnel room. A blockage in a floor drain allowed contaminated water to pool on the floor and reach the degraded expansion joints. The expansion joints were repaired via coating application.
P	December 2016	Reactor Building Roof	A leak was observed from the Unit 2 steam exhaust on the Reactor Building Roof, resulting in approximately 80 gallons of tritiated water leaking from the exhaust. It is unclear if tritiated water reached the ground before the leak was repaired.
Q	May 2017	Reactor Building Roof	A leak occurred at the Unit 1 Condensate Head Tank when the vacuum relief valve became stuck open. The leak volume was estimated to be less than 50 gallons before the leak was repaired. The tritiated water overflowed the tank and ran down the side of the Reactor Building onto the ground.
R	January 2018	Radwaste Building Yard	Multiple leaks were observed from hose connections attached to a steel frac tank. A small volume of tritiated water (less than 2 gallons) was released to the ground. The water was frozen when found and the impacted soil was excavated.
S	February 2018	Unit 3 Condenser Tube Pull-Out Area	A leak of less than 100 gallons of tritiated water occurred while rigging the 3A4 Feed Water Heater from the Unit 3 condenser bay to the Unit 3 Condenser Tube Pull-Out Area. Most of the spill was contained within the Pull-Out Area, but some volume may have entered a nearby storm drain or the surrounding ground.
T	July 2020	CST No. 3	A leak was observed at the Unit 3 CST due to severe corrosion to the piping and valve. Approximately 88 gallons of tritiated water was released to the surrounding concrete and soil. Some of the release was routed to the Condensate Transfer Tunnel before the leak was repaired.

Source: (Arcadis 2021)
Element Isotopes Listed: Cesium: Cs-134 and Cs-137; Cobalt: Co-60; Manganese: Mn-54; Silver: Ag-110; Zinc: Zn-65
CST: condensate storage tank

Elevated concentrations of tritium have only been observed at monitoring wells located between the Wheeler Reservoir and the reactor building. Tritium transport in shallow groundwater primarily occurs along two pathways, advective flow through primary porosity and preferential flow along underground utilities, or, essentially, flow through the weaker sections of rock with preferential flow along the pathway created by underground utility structures. Since the Wheeler Reservoir surface elevation is equivalent to the Intake Channel surface elevation, and they are almost always lower than the groundwater elevation, tritium transport via advective groundwater flow ultimately discharges to the Intake Channel. The second flow path for shallow groundwater is along underground utilities. The four utilities most likely to provide preferential transport of tritium are the cable tunnel, the condensate transfer tunnel, the CCW intake conduits, and the CCW discharge conduits. Preferential flow of groundwater through and/or along these utilities likely accounts for the majority of the tritium transport in shallow groundwater at BFN. Ultimately, the most likely tritium fate and transport pathway for tritiated groundwater in the intermediate bedrock is discharge through shallow groundwater into the Intake Channel. However, based on 2020 data, groundwater flow conditions and tritium fate and transport indicate that it is not likely that tritium concentrations exceeding the drinking water standard of 20,000 pCi/L would be measured at the Intake Channel. Furthermore, significant dilution is expected to occur when groundwater discharges to surface water (Arcadis 2021).

3.4.2. Environmental Consequences – Groundwater

This section addresses impacts to groundwater from site construction and operation of the No Action and Action Alternatives.

Alternative A – No Action Alternative

Under the No Action Alternative, the BFN operating licenses would not be extended, resulting in the shutdown of BFN. While there may be a small but temporary impact on groundwater quality during shutdown and decommissioning activities, any residual chemicals from past spills and discontinued industrial practices would degrade over time, leading to improvement in water quality. Overall, there would be no effects to the groundwater hydrology, groundwater use, or groundwater quality from shutdown and decommissioning of BFN.

During shutdown and decommissioning activities, gasoline, diesel fuel, hydraulic lubricants, and other similar products would be used for construction equipment and vehicles. Inadvertent spills of these fluids have the potential to contaminate groundwater. Pursuant to 40 CFR Part 112 and 40 CFR Part 9, TVA would implement a Stormwater Pollution Prevention Plan which would include the use of BMPs to minimize the occurrence of spills and limit their effects. These BMPs include actions such as proper vehicle and equipment maintenance, spill precautions such as use of absorbent pads under equipment, containment for fuel or oil storage tanks, and the maintenance of spill response equipment and materials. Use of these BMPs would minimize the potential for impacts to groundwater quality.

However, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system.

Impacts on groundwater quality from radiological sources such as an SMR facility are expected to be small. TVA would comply with the NEIs groundwater protection initiative, NEI 07- 07 (NEI 2007). This initiative identifies actions to improve utilities management and response to instances where the inadvertent release of radioactive substances may result in low, but detectible, levels of plant-related radioactive materials in subsurface soils and water. Aspects addressed by the initiative include site hydrology and geology, site risk assessment, onsite groundwater monitoring, and remediation. TVA would provide an annual report related to the results of the groundwater monitoring program at the new nuclear plant as directed in NEI 07-07, as well as having the program peer reviewed by industry experts. Actions taken as a result of the groundwater protection initiative would include an increase in monitoring locations, increased number of samples taken, and the review of programs and procedures for best industry practices. The goal of the groundwater protection initiative would be to reduce any impacts on groundwater from the accidental release of radioactive effluents.

Groundwater impacts for new generation resources would depend on the use of groundwater and construction activities required to build the plant. Dewatering activities would likely be needed during foundation construction. If groundwater resources were used for sanitary and potable water use, there would normally be a small impact because the amount of withdrawal would be minimal. Although it is unlikely that groundwater would be used for makeup and/or cooling water, it would depend on site-specific conditions and therefore the impacts could be moderate to large. Overall, groundwater impacts on the aquifer from an alternate generation facility would be site-specific, and dependent on aquifer recharge and other withdrawals. Under both alternatives, chemicals used during construction would be managed using BMPs, thereby limiting the likelihood of chemical contamination of surface water as well as groundwater. With the adoption of either alternative, non-radiological impacts on groundwater quality are expected to be small. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

Under Alternative B, there is no groundwater use onsite, nor is the use of groundwater proposed during the proposed subsequent period of extended operation; therefore, no change in impact is anticipated from the current level of small impact. Gasoline, diesel fuel, hydraulic lubricants, and other similar products would be used for equipment and vehicles during the proposed subsequent period of extended operation. Inadvertent spills of these fluids have the potential to contaminate groundwater. Pursuant to 40 CFR Part 112 and 40 CFR Part 9, TVA would implement a Stormwater Pollution Prevention Plan which would include the use of BMPs to minimize the occurrence of spills and limit their effects. These BMPs include actions such as proper vehicle and equipment maintenance, spill precautions such as use of absorbent pads under equipment, containment for fuel or oil storage tanks, and the maintenance of spill response equipment and materials. Use of these BMPs would minimize the potential for impacts to groundwater quality during the proposed subsequent period of extended operation.

Additionally, all local groundwater near BFN flows directly to Wheeler Reservoir and, therefore, it is improbable that any liquid released from the site would contaminate offsite sources of groundwater supply. Consequently, the potential for contamination of the public and industrial groundwater systems in the BFN area is not anticipated and BFN's incremental contribution to cumulative groundwater use and quality would be small.

3.5. Floodplains and Flood Risk

A floodplain is the relatively level land area along a stream or river that is subject to periodic flooding. The area subject to a one percent chance of flooding in any given year is normally called the 100-year floodplain. The area subject to a 0.2 percent chance of flooding in any given year is normally called the 500-year floodplain.

NRC regulations concerning nuclear plant design with respect to flooding are provided in NRC, 10 CFR Part 50, Appendix A Criterion 2 – *Design Bases for Protection Against Natural Phenomena*. From the standpoint of nuclear plant design and licensing, floodplain and flood risk assessments conducted during the NRC licensing process ensure that nuclear facilities are sited to provide a reasonable level of protection from flooding.

3.5.1. Affected Environment – Floodplains and Flood Risk

BFN is situated on the north bank of Wheeler Reservoir at TRM 294, 55 miles downstream from Guntersville Dam and 19 miles upstream from Wheeler Dam. The 100- and 500-year flood elevations for the Tennessee River near BFN are provided in Table 3.5-1. Less than 15 acres of the BFN site are situated within either the 100- or 500-year floodplain (Figure 3.5-1).

TVA reservoirs have either power storage or flood storage or both. Power Storage is allocated to a range of elevations and water occupying space in that range is used to generate electric power through a dam's hydroturbines. Flood Storage is allocated to another range of elevations and water occupying space within that range is used to store flood water during a flood or high-flow rain event. Some of TVA's dams are able to be surcharged. Surcharge is the ability to raise the water level behind the dam above the top-of-gates elevation. Surcharge can be sustained only for a short period of time during a flood. To control flood-damageable development on TVA lands, TVA uses a concept known as the Flood Risk Profile (FRP) and the TVA Flood Storage Loss Guideline. The FRP is the elevation of the 500-year flood that has been adjusted for surcharge at the dam. The FRP is equal to the 500-year flood elevation at BFN. The Flood Storage Loss Guideline is method used to evaluate the impacts of proposed projects on flood storage.

Table 3.5-1. Tennessee River Flood Elevations

Return Period (years)	Elevation at Tennessee River Mile 292.6 (feet NAVD 88)	Elevation at Tennessee River Mile 295.2 (feet NAVD 88)
100	557.3	557.3
500	557.3	557.3

NAVD 88 – North American Vertical Datum of 1988
Source: (FEMA 2018)

3.5.2. Environmental Consequences – Floodplains and Flood Risk

This section addresses the floodplain and flood risk-related impacts of the Action and No Action Alternatives.

As a federal agency, TVA adheres to the requirements of EO 11988, Floodplain Management. The objective of EO 11988 is "…to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative" (EO 11988, Floodplain Management). The EO is not intended to prohibit floodplain development in all cases, but rather to create a consistent government policy against such development under most circumstances (U.S. Water Resources Council 1978). The EO requires that agencies avoid the 100-year floodplain unless there is no practicable alternative.

Figure 3.5-1. BFN 100-Year and 500-Year Floodplains

EO 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input was reinstated in May 2021. However, implementation of EO 13690 is still in development at the national level. TVA is working with other federal agencies to develop consistent implementing plans for these EO requirements. When those implementing plans are finalized, TVA would incorporate floodplain analysis with respect to EO 13690, in addition to EO 11988. Depending upon the results of these inter-agency efforts, TVA may update the floodplain implementing plan in subsequent NEPA analysis.

Alternative A – No Action Alternative

Under the No Action Alternative, the BFN operating licenses would not be extended, resulting in the shutdown of BFN when the existing licenses expire in 2033, 2034, and 2036. TVA would begin the process of evaluating and planning for the necessary decommissioning of all three BFN units. The shutdown and decommissioning of BFN under the No Action Alternative would have slight beneficial impacts on floodplains if shutdown and decommissioning result in removal of facilities and structures from the floodplain; otherwise, shutdown would have no impact on floodplains or flood risk.

The shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. Plans for replacement power are unknown at this time; however, some associated facilities, structures, and activities could potentially be located within 100-year floodplains.

Construction and operation of a new plant(s) would introduce construction impacts and new incremental operational impacts. New construction could also result in dredging. Consistent with EO 11988, dredging is considered to be a repetitive action in the 100-year floodplain that should result in only small impacts (TVA 1981). To minimize adverse impacts, dredged material would be disposed of on land lying and being outside the 500-year floodplain and above the 500-year flood elevation. By spoiling dredged material outside the 500-year floodplain, dredging in this manner would also comply with the TVA Flood Storage Loss Guideline.

In general, water-use and water-dependent structures and facilities would be located within 100-year floodplains, and flood-damageable equipment and facilities would be located at a minimum outside 100-year floodplains, and Critical Actions would be located at a minimum outside 500-year floodplains, which would be consistent with EO 11988. Should replacement generation be contemplated in the future, a detailed analysis of potential flood impacts would be undertaken at that time.

Alternative B – Proposed Action

Under Alternative B, no refurbishment or plant modifications that would change effects on floodplains in Wheeler Reservoir are planned as a result of SLR.

Because BFN has already been constructed and the major exterior accesses of existing safety-related structures are protected against flooding up to 578 feet, those accesses are above both the 100- and 500-year flood elevations (557.3 feet msl). No major refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would affect offsite land use. Continued maintenance and outages would not result in new impacts to floodplains or increase flood risk in Wheeler Reservoir beyond those previously considered. Therefore, the BFN SLR would be consistent with EO 11988 and the TVA Flood Storage Loss Guideline.

Continued operation of BFN during the proposed subsequent period of extended operation would not be anticipated to impact floodplains and, consequently, the incremental contribution to cumulative impacts to floodplains would also not be anticipated.

The current onsite ISFSI does not have sufficient capacity to support SLR. Spent fuel storage capacity would be expanded, under a separate action, by the addition of a separate additional concrete storage pad prior to exceeding onsite spent fuel storage capacity. The location of the new concrete pad has not been determined, but would be located outside of the 100-year floodplain and above the 500-year flood elevation, which would be consistent with EO 11988 and the TVA Flood Storage Loss Guideline. If SLR is approved, and additional fuel storage capacity is required, the expansion of spent fuel storage capacity would be designed to meet NRC requirements. The development of a new ISFSI would be evaluated in a future NEPA environmental review. Potential cumulative effects to flood risk associated with the implementation of Alternative B would be small.

3.6. Wetlands

3.6.1. Affected Environment – Wetlands

This section describes the onsite wetland resources that may be affected by the operation of BFN during the proposed subsequent period of extended operation. The wetlands that would be affected by the continued operation of BFN are those within the BFN site.

Wetlands are those areas inundated or saturated by surface or groundwater such that vegetation adapted to saturated soil conditions is prevalent (USACE 33 CFR Part 328(b); U.S. Environmental Protection Agency [USEPA] 40 CFR 230.3(t)). Examples include bottomland forests, swamps, wet meadows, isolated depressions, and shoreline fringe along watercourses or impoundments. Due to their landscape position, vegetation structure, and influence on downstream hydrology, wetlands provide a suite of benefits valued by society. These include toxin absorption and sediment retention for improved water quality, storm water impediment and attenuation for flood control, shoreline buffering for erosion protection, and provision of fish and wildlife habitat for commercial, recreational, and conservation purposes. Because of this, wetlands are protected under federal and state laws that mandate wetland avoidance, minimization of impacts, and compensation for loss of wetland function resulting from regulated activities.

The BFN site is located in the Upper Lake Wheeler watershed (HUC10 0603000211). The National Wetland Inventory (NWI) uses coarse aerial imagery to identify potential wetlands at a large scale. Within the Upper Lake Wheeler watershed, the NWI maps approximately 90,000 acres of wetland habitat, covering roughly 42 percent of the watershed's total acreage. The BFN site covers approximately 880 acres on the north side of the Tennessee River/Wheeler Reservoir. Nine wetlands, totaling 24.1 acres, were delineated and assessed across the BFN site during the field reconnaissance for the SLR (Table 3.6-1). Identified wetlands cover less than 3 percent of the BFN study area, which is a smaller percentage than that mapped by the NWI at the watershed scale (Buecker 2021).

Table 3.6-1. Wetlands on the BFN Site

Wetland Identifier	Wetland Type[1]	TVARAM Category[2]	Location on BFN Site	Total Wetland Acreage on BFN Site
Wetland 1	PEM1C	Low (24.5)	Southeast	1.45
Wetland 2	PEM1C	Low (24.5)	Southeast	0.46
Wetland 3	PEM1C	Low (24.5)	Southeast	0.40
Wetland 4	PEM1B	Low (29.5)	Central east	10.61
Wetland 5	PEM1C	Low (26.5)	Central south	0.58
Wetland 6	PSS1C	Moderate (39)	Central	1.33
Wetland 7	PEM1E	Low (28)	North	3.63
Wetland 8	PEM1E	Low (23)	Northeast	0.82
Wetland 9	PFO6E	Moderate (45)	Northeast	4.82
			Total	**24.1**

[1] Classification codes as defined in (Cowardin 1979): P = Palustrine; EM1 = emergent, persistent vegetation; FO6= forested, deciduous vegetation,seasonally flooded/saturated; SS1= scrub-shrub, broad-leaved deciduous vegetation; C = Seasonally flooded; B = Saturated; E = seasonally flooded/saturated
[2] TVARAM category definitions: low = low resource value, moderate = moderate resource value, exceptional = exceptional waters. Category based on wetland score (shown in parentheses).

As discussed in Section 3.3.1.1, field assessments were conducted in September 2021 to determine wetland presence, extent, and condition within the BFN site (TVA 2021d). Wetland determinations were performed according to the USACE standards, which require documentation of hydrophytic vegetation, hydric soil, and wetland hydrology (Environmental Laboratory 1987, USACE 2018, USACE 2012a). Wetland condition was evaluated using a TVA-developed modification of the Ohio Rapid Assessment Method (Mack 2001) specific to the TVA region, referred to as the TVA Rapid Assessment Method (TVARAM). Wetlands were evaluated by their functions and classified into three categories: low quality, moderate quality, and superior quality. Low-quality wetlands are degraded aquatic resources that may exhibit low species diversity, minimal hydrologic input and connectivity, recent or ongoing disturbance regimes, and/or a predominance of non-native species. These wetlands provide low functionality and are considered of low value. Moderate-quality wetlands provide functions at a greater value due to a lesser degree of degradation and/or due to their habitat, landscape position, or hydrologic input. Moderate-quality wetlands are considered healthy water resources of value. Disturbance to hydrology, substrate, and/or vegetation may be present to a degree at which valuable functional capacity is sustained and there is reasonable potential for restoration. High-quality wetlands include those wetlands that offer superior functions and values within a watershed or that are of regional/statewide concern. Characteristics of high-quality wetlands include the following: may exhibit little, if any, recent disturbance; provide essential and/or large scale stormwater storage, sediment retention, and toxin absorption; contain mature vegetation communities; and/or offer habitat to rare species. Conditions found in high-quality wetlands often represent restoration goals for wetlands functioning at a lower capacity.

The nine delineated wetlands on the BFN site cover a total 24.1 acres (Table 3.6-1; see Figure 3.3-2 for locations). These wetlands are primarily located on the eastern portion of the BFN site and include emergent, scrub shrub, and forested wetland communities that exhibit a range of resource values. Each of these wetlands is described below.

Wetland 1 is an emergent wetland located adjacent to a stream in the southeast portion of the BFN site. Surface water, water table, and saturation were observed during field investigation.

Hydrophytic vegetation observed within the wetland included Virginia buttonweed (*Diodia virginiana*), soft rush (*Juncus effusus*), fox sedge (*Carex vulpinoidea*), and swamp smartweed (*Persicaria hydropiperoides*). Soil samples taken within the wetland exhibited hydric indicators, including F7 (depleted dark surface), F8 (redox depressions), and F12 (iron-manganese masses). This wetland scored as low quality using TVARAM, indicating poor provision of wetland functions.

Wetland 2 is an emergent wetland located in the southeast portion of the BFN site. Stormwater runoff from a roadside ditch and adjacent upland areas appears to be the primary water source for this wetland. Surface water, water table, and saturation were observed during field investigation. Hydrophytic vegetation observed within the wetland included Virginia buttonweed, soft rush, fox sedge, and swamp smartweed. Soil samples taken within the wetland area exhibited hydric indicators, including F7, F8, and F12. This wetland scored as low quality using TVARAM, indicating poor provision of wetland functions.

Wetland 3 is an emergent wetland located in the southeast portion of the BFN site. The wetland drains south through a culverted road crossing to a stream. Surface water, water table, and saturation were observed during field investigation. The primary source of hydrology is stormwater runoff from surrounding upland areas. Hydrophytic vegetation observed within the wetland area included smooth false buttonweed (*Spermacoce glabra)* and soft rush. This wetland is located within a drainage ditch lacking an ordinary high-water mark. Soil samples taken within the wetland exhibited hydric indicators including F7, F8, and F12. This wetland scored as low quality using TVARAM, indicating poor provision of wetland functions.

Wetland 4 is an emergent wetland located in the central eastern portion of the BFN site. Portions of the wetland have been channelized during past development of the property. Channelized portions of the wetland did not possess an ordinary high-water mark. The primary source of hydrology for this wetland appears to be concentrated stormwater runoff upstream of the wetland and sheet flow runoff from adjacent uplands. Hydrophytic vegetation observed within the wetland area included false buttonweed, swamp smartweed, soft rush, and southern cattail (*Typha domingensis*). Soil samples taken within the wetland exhibited hydric indicators, including F12. This wetland scored as low quality using TVARAM, indicating poor provision of wetland functions.

Wetland 5 is an emergent wetland located in the central portion of the BFN site. The primary source of hydrology for this wetland appears to be concentrated stormwater runoff upstream of the wetland and sheet flow runoff from adjacent uplands. The wetland is located within a drainage ditch lacking an ordinary high-water mark. Surface water, water table, and saturation were observed during field investigation. Hydrophytic vegetation observed within the wetland included java waterdropwort (*Oenanthe javanica*), fox sedge, and Virginia buttonweed. Soil samples taken within the wetland exhibited hydric indicators, including F7, F8, and F12. This wetland scored as low quality using TVARAM, indicating poor provision of wetland functions.

Wetland 6 is a scrub-shrub wetland located in the central portion of the BFN site. The primary source of hydrology for this wetland appears to be concentrated stormwater runoff upstream of the wetland and sheet flow runoff from adjacent uplands. The wetland is located within a drainage ditch lacking an ordinary high-water mark. Vegetation observed within the wetland included fox sedge, white morning-glory (*Ipomoea lacunose*), tufted lovegrass (*Eragrostis pectinacea*), and woody goldenrod (*Chrysoma pauciflosculosa*). Soil samples taken within the wetland exhibited hydric indicators, including F7 and F8. This wetland scored as moderate quality using TVARAM, indicating a healthy provision of wetland functions.

Wetland 7 is an emergent wetland located in the northern portion of the BFN site. Wetland 7 and Wetland 6 are divided by Shaw Road. Two culverts are installed under the roadway, connecting the two wetlands. The primary source of hydrology for this wetland appears to be concentrated stormwater runoff upstream of the wetland and sheet flow runoff from adjacent uplands. The wetland is located within a drainage ditch lacking an ordinary high-water mark. Vegetation observed within the wetland included fox sedge, white morning-glory, tufted lovegrass, and woody goldenrod. Soil samples taken within the wetland exhibited hydric indicators, including F7, F8, and F12. This wetland scored as low quality using TVARAM, indicating poor provision of wetland functions.

Wetland 8 is an emergent wetland located in the northeastern portion of the BFN site. A man-made berm separates Wetland 8 from Wetland 9. Saturated conditions were observed during field investigation. Hydrophytic vegetation observed within the wetland included marsh bristlegrass (*Setaria parviflora*), Virginia buttonweed, fox sedge, and swamp smartweed. Soil samples taken within the wetland exhibited hydric indicators including F6 (Redox Dark Surface), F8 and F12. This wetland scored as low quality using TVARAM, indicating a poor provision of wetland functions.

Wetland 9 is a forested wetland located in the northeastern portion of the BFN site. Much of the wetland is linear in shape, following excavated channels lacking an ordinary high-water mark. Saturated conditions were observed during field investigation. Vegetation observed within the wetland included swamp smartweed, woody goldenrod, and willow oak (*Quercus phellos*). Soil samples taken within the wetland exhibited hydric indicators, including F6, F8, and F12. This wetland scored as moderate quality using TVARAM, indicating a healthy provision of wetland functions.

The primary effects on wetlands occurred during BFN construction and from right-of-way (ROW) construction and maintenance. EO 11990, Protection of Wetlands, requires federal agencies to minimize impacts on wetlands, and activities in wetlands are regulated under Section 404 of the CWA. Activities that result in the discharge of dredge or fill material in wetlands require a permit from the USACE.

3.6.2. Environmental Consequences – Wetlands

This section addresses impacts to onsite wetlands from the No Action and Action Alternatives.

Alternative A – No Action Alternative

Under the No Action Alternative, the shutdown and decommissioning of BFN are not anticipated to affect wetlands on or in the vicinity of the site. However, TVA would also need to replace the BFN generation.

The impact to wetlands due to building new generation plants and associated transmission lines and pipeline ROWs would range from small to large depending on the physical location of the plant structures and the quantity and quality of wetlands within the potential plant footprint as well as along transmission line and pipeline corridors. A site-specific environmental review would be conducted to identify wetlands and measures to avoid, minimize, and mitigate impacts as appropriate once new generation construction project locations and technologies are specifically identified. TVA actions would comply with the CWA and EO 11990.

Alternative B – Proposed Action

Under the Proposed Action Alternative, no refurbishments or plant modifications that would affect wetlands are planned during the proposed subsequent period of extended operation, and no new and significant information was identified with regard to wetlands. Application of BFN's BMPs and compliance with NPDES regulatory requirements, SPCC plan, and other permit conditions would avoid or minimize any impact on wetland resources from BFN operational and maintenance activities during the proposed subsequent period of extended operation. For these reasons, the impacts on wetlands over the proposed subsequent period of extended operation would be small. No mitigation measures would be required beyond those already in place. The incremental contribution of BFN operations during the proposed subsequent period of extended operation to cumulative impacts on wetlands in the vicinity of BFN also would be small.

3.7. Aquatic Ecology

3.7.1. Affected Environment – Aquatic Ecology

This section describes the ecological resources of the aquatic communities that may be affected by the operation of BFN during the proposed subsequent period of extended operation. The aquatic community that would be affected by water withdrawals and discharges associated with the continued operation of BFN is that of Wheeler Reservoir.

3.7.1.1. *Fish*

TVA monitors the health of the aquatic communities in its reservoirs using a multi-metric Reservoir Fish Assemblage Index (RFAI). Characteristics of a balanced indigenous population are determined holistically by measuring 12 population metrics, scoring the metrics based on expectations of healthy populations in the region, and summing the scores to arrive at an overall RFAI score and health rating (TVA 2021f). Total RFAI scores for Wheeler Reservoir for autumn 2020 were similar between downstream ("46-Good") and upstream ("49-Good") sites, and both were the highest observed at the respective reaches. With the exception of 2005 and 2019, RFAI scores at both reaches have not been statistically different (i.e., were "similar," or differed by six points or less). When compared between reaches, scores since 2000 have not been significantly different (P=0.13) (TVA 2021f).

Table 3.7-1 lists fish species collected by TVA in the vicinity of BFN from autumn 1993-1997, 1999-2011, 2013, 2015, 2017, 2019, and 2020. Sampling sites were nominally located at TRM 292.5 and 295.9. Electrofishing and gill netting locations ranged from 0.5 to 1.0 mile upstream and downstream from these river mile locations (TVA 2021e).

Table 3.7-1. Catch Rates in the Vicinity of Browns Ferry Nuclear Plant (Tennessee River Miles 292.5 and 295.9) from 1993 through 2020

Common Name	Scientific Name	Average CPUE	CPUE Range	Species Occurrence (No. of Samples)[1]
Mississippi silverside	*Menidia audens*	17.2	0.1 - 80.7	40
Gizzard shad	*Dorosoma cepedianum*	15.7	0.3 - 45.7	45
Emerald shiner	*Notropis atherinoides*	11.8	0.1 - 220.3	27
Threadfin shad	*Dorosoma petenense*	9.8	0.1 - 133.3	39
Bluegill	*Lepomis macrochirus*	5.4	0.2 - 19.1	45
Largemouth bass	*Micropterus salmoides*	3.6	0.4 - 13.0	45
Eastern sand darter	*Ammocrypta pellucida*	3.1	3.1 - 3.1	1
Channel catfish	*Ictalurus punctatus*	3.1	0.2 - 7.9	45
Longear sunfish	*Lepomis megalotis*	2.1	0.1 - 5.6	43
Skipjack herring	*Alosa chrysochloris*	2.0	0.1 - 8.0	45
Spotfin shiner	*Cyprinella spiloptera*	1.5	0.1 - 2.7	30
Redear sunfish	*Lepomis microlophus*	1.5	0.1 - 4.6	45

Common Name	Scientific Name	Average CPUE	CPUE Range	Species Occurrence (No. of Samples)[1]
Freshwater drum	*Aplodinotus grunniens*	1.5	0.3 - 3.3	45
Logperch	*Percina caprodes*	1.4	0.1 - 13.7	35
White bass	*Morone chrysops*	1.3	0.1 - 8.6	41
Smallmouth bass	*Micropterus dolomieu*	1.2	0.1 - 5.0	44
Yellow bass	*Morone mississippiensis*	1.1	0.1 - 5.0	44
Spotted sucker	*Minytrema melanops*	1.1	0.1 - 8.9	43
Green sunfish	*Lepomis cyanellus*	1.0	0.1 - 6.6	39
Brook silverside	*Labidesthes sicculus*	0.9	0.1 - 3.8	5
Smallmouth buffalo	*Ictiobus bubalus*	0.9	0.1 - 2.4	42
Blue catfish	*Ictalurus furcatus*	0.8	0.1 - 4.5	44
Sauger	*Sander canadensis*	0.8	0.1 - 4.1	37
Spotted bass	*Micropterus punctulatus*	0.7	0.1 - 2.7	42
Yellow bullhead	*Ameiurus natalis*	0.7	0.7- 0.7	1
Flathead catfish	*Pylodictis olivaris*	0.5	0.1 - 1.6	44
Longnose gar	*Lepisosteus osseus*	0.5	0.1 - 1.8	9
Spotted gar	*Lepisosteus oculatus*	0.5	0.1 - 1.8	33
Golden shiner	*Notemigonus crysoleuca*	0.4	0.1 - 1.8	29
Saddleback darter	*Percina vigil*	0.4	0.4 - 0.4	1
Hybrid striped x white bass	*Morone saxatilis x M. chrysops*	0.4	0.1 - 1.4	11
Striped bass	*Morone saxatilis*	0.3	0.1 - 1.3	21
Black buffalo	*Ictiobus niger*	0.3	0.1 - 1.6	17
Common carp	*Cyprinus carpio*	0.3	0.1 - 1.3	35
Walleye	*Sander vitreus*	0.3	0.1 - 0.5	4
Golden redhorse	*Moxostoma erythrurum*	0.2	0.1 - 1.3	20
Silver redhorse	*Moxostoma anisurum*	0.2	0.1 - 0.9	9
Lake sturgeon	*Acipenser fulvescens*	0.2	0.2 - 0.2	1
Orangespotted sunfish	*Lepomis humilis*	0.2	0.1 - 0.3	4
Striped shiner	*Luxilus chrysocephalus*	0.2	0.1 - 0.3	4
Yellow perch	*Perca flavescens*	0.2	0.1 - 0.7	15
Black redhorse	*Moxostoma duquesnei*	0.2	0.1 - 0.7	26
White crappie	*Pomoxis annularis*	0.2	0.1 - 0.8	24
Quillback	*Carpiodes cyprinus*	0.2	0.1 - 0.3	6
Bullhead minnow	*Pimephales vigilax*	0.1	0.1 - 0.5	20
Bluntnose minnow	*Pimephales notatus*	0.1	0.1 - 0.3	6
Black crappie	*Pomoxis nigromaculatus*	0.1	0.1 - 0.4	24
Warmouth	*Lepomis gulosus*	0.1	0.1 - 0.5	33
Blackside snubnose darter	*Etheostoma duryi*	0.1	0.1 - 0.1	1
Mooneye	*Hiodon tergisus*	0.1	0.1 - 0.2	3
Hybrid sunfish	*Lepomis sp*	0.1	0.1 - 0.2	6
Blackstripe topminnow	*Fundulus notatus*	0.1	0.1 - 0.1	2
River darter	*Percina shumardi*	0.1	0.1 - 0.1	2
River redhorse	*Moxostoma carinatum*	0.1	0.1 - 0.2	4
Shortnose gar	*Lepisosteus platostomus*	0.1	0.1 - 0.1	1
Smallmouth redhorse	*Moxostoma breviceps*	0.1	0.1 - 0.1	1
Stripetail darter	*Etheostoma kennicotti*	0.1	0.1 - 0.1	4
Northern hog sucker	*Hypentelium nigricans*	0.1	0.1 - 0.3	14
Largescale stoneroller	*Campostoma oligolepis*	0.1	0.1 - 0.2	10
Redbreast sunfish	*Lepomis auritus*	0.1	0.1 - 0.3	15
Bowfin	*Amia calva*	0.1	0.1 - 0.1	4
Bigmouth buffalo	*Ictiobus cyprinellus*	0.1	0.1 - 0.1	7

Common Name	Scientific Name	Average CPUE	CPUE Range	Species Occurrence (No. of Samples)[1]
Chestnut lamprey	*Ichthyomyzon castaneus*	0.1	0.1 - 0.1	7
Atlantic needlefish	*Strongylura marina*	0.1	0.1 - 0.1	1
Blackspotted topminnow	*Fundulus olivaceus*	0.1	0.1 - 0.1	1
Central stoneroller	*Campostoma anomalum*	0.1	0.1 - 0.1	1
Grass carp	*Ctenopharyngodon idella*	0.1	0.1 - 0.1	1
Hybrid bass	*Micropterus sp.*	0.1	0.1 - 0.1	2
Hybrid walleye x sauger	*Sander vitreus x S. canadensis*	0.1	0.1 - 0.1	1
Mimic shiner	*Notropis volucellus*	0.1	0.1 - 0.1	1
Rock bass	*Ambloplites rupestris*	0.1	0.1 - 0.1	1
Silver chub	*Macrhybopsis storeriana*	0.1	0.1 - 0.1	4
Snubnose darter	*Etheostoma simoterum*	0.1	0.1 - 0.1	1

Source: (TVA 2021f).
CPUE = catch per unit effort
[1] Number of samples in which species occurred collected by electrofishing and gill netting during 45 sampling events from 1993 through 2020.

Excluding four hybrid fish species, 69 species were collected. Mississippi silverside, gizzard shad, emerald shiner, and threadfin shad were most abundant, exhibiting the highest catch per unit effort (CPUE). Gizzard shad, bluegill, largemouth bass, channel catfish, skipjack herring, redear sunfish, and freshwater drum were the species most widespread in occurrence, having been collected in all samples, while 15 species were collected in only one sample.

3.7.1.2. *Mussels and Other Macroinvertebrates*

TVA conducted a mussel survey at BFN on July 12-13, 2021, to assess the current freshwater mussel assemblage in Wheeler Reservoir immediately adjacent to BFN (Amaker 2021). Mussels were found only in the overbank habitat. The mussel community in this area is characterized by 11 common, widespread, silt-tolerant species. The most numerous species was the washboard (*Megalonaias nervosa*), which was common at most sites sampled and dominated the mussel biomass. All age classes from juveniles to large adults were present. Four snail species also were observed during the survey. All species present during the survey are shown in Table 3.7-2.

Table 3.7-2. Mussel and Snail Species Present During the Survey July 12-13, 2021

Common Name	Scientific Name
Mussels	
Elephant ear	*Elliptio crassidens*
Fawnsfoot	*Truncilla donaciformes*
Fragile papershell	*Potamilis fragilis*
Mapleleaf	*Quadrula quadrula*
Pimpleback	*Cyclonaias pustulosa*
Pink heelsplitter	*Potamilis alatus*
Rock pocketbook	*Arcidens confragosus*
Southern mapleleaf	*Quadrula apiculata*
Threehorn wartyback	*Obliquaria reflexa*
Threeridge	*Amblema plicata*
Washboard	*Megalonaias nervosa*

Common Name	Scientific Name
Snails	
Noble hornsnail	*Pleurocera nobilis*
Olive mysterysnail	*Viviparus subpurpureus*
Pointed campeloma	*Campeloma decisum*
Silty hornsnail	*Pleurocera canaliculata*

Source: (Amaker 2021)

The survey was conducted at six downstream and five upstream stations in the immediate vicinity of BFN. The CPUE ranged from 0.13 to 1.93 mussels per minute at the downstream survey stations and from 0.86 to 3.4 mussels per minute at the upstream stations. Water depths ranged from 8 to 25 feet at downstream stations and from 13 to 18 feet at upstream stations. At various downstream stations, substrate consisted of silt, gravel, and artificial rock piles; Asian clam (*Corbicula fluminea*) and relict shells were present at two stations; and sparse to dense eelgrass (*Vallisneria americana*) was present at two stations. At various upstream stations, substrate consisted of silt, gravel, or rock; and relict *Corbicula* shell was present at two stations.

The results of macroinvertebrate assessments in Wheeler Reservoir have shown that the downstream reaches have scored in the “Excellent” range during eight of ten sample years, including the last four sampling years (TVA 2021f). The macroinvertebrate community structure demonstrates a seasonally abundant and diverse macroinvertebrate community present at both downstream and upstream reaches (Table 3.7-3).

Table 3.7-3. Results of Benthic Macroinvertebrate Functional Feeding Groups Upstream and Downstream of BFN for Sampling Years[1] between 2001 and 2020

Sampling Metric	Downstream Average[3]	Upstream Average[4]
Number of species	24	23
Total mean density (per square meters)	961	703
Percent composition by feeding group[2]		
CF	16	20
CG	43	37
PA	0	0
PR	33	31
SC	7	10
SH	1	2
PI	0	0

[1] Years sampled: 2001-2004, 2006, 2011, 2012, 2013, 2015, 2017, and 2020.
[2] CF = collector/filterer; CG = collector/gatherer; PA = parasitic; PR = predator; SC = scraper; SH = shredder; PI = piercer.
[3] River Miles 291.7, 290.4, 293.2
[4] River Mile 295.9
Source: (TVA 2021f)

In summary, ecological characteristics of benthic macroinvertebrate communities, when compared among the downstream and upstream reaches, have been “similar” since the initiation of sampling.

3.7.1.3. *Aquatic Plants*

TVA collects shoreline and river bottom habitat data upstream and downstream of BFN every 5 years. The data are used to characterize habitats important to fish and find comparable habitats at upstream and downstream sampling sites to minimize habitat differences that might bias interpretation of the results. Aquatic macrophytes are present in low abundance near BFN. Aquatic macrophytes were present in low percentages within both reaches during 2020 habitat surveys conducted by TVA (TVA 2021f). No aquatic macrophytes were observed at either the upstream or downstream reaches.

3.7.1.4. Invasive/Non-Native Aquatic Species

Invasive, non-native, aquatic species observed in the immediate vicinity of BFN are discussed below.

The redbreast sunfish can be found in creeks, rivers and streams with a balanced pH and vegetation (Texas Invasive Species Institute 2014). Adults feed on terrestrial insects, immature and adult aquatic insects, and crayfish. When introduced in non-native habitats, this fish can take over the habitat of native fish species.

The Mississippi silverside has been introduced to reservoirs on the Tennessee and Cumberland Rivers in Alabama, Tennessee, and Kentucky (Smithsonian Environmental Research Center 2022). This species apparently evolved from the estuarine fish, *M. beryllina*, and can tolerate a wide range of temperature and salinity. Mississippi silversides swim in large schools, and feed on zooplankton, insects, small benthic invertebrates, and small fishes.

The common carp is native to eastern Asia, but has been widely introduced, domesticated, and hybridized in the United States and elsewhere (Smithsonian Environmental Research Center 2022). This species feeds on aquatic vegetation and thrives in conditions not suitable for other fish, which made the common carp an attractive import. Common carp can impact native fish species.

Hybrid sunfish are cultured commercially for pond stocking and for fish food, and stocking hybrids is one strategy for controlling sunfish overpopulation (Mischke 2007). Various sunfish species interbreed readily, so hybrid production is relatively simple. Regulations against stocking hybrid sunfish in public waters vary among states.

Branchiura sowerbyi is a tubificid worm established sporadically and widely around the United States (Liebig et al. 2019). It is a benthic deposit bottom feeder that occurs in rivers and warmer waters.

Apocorophium lacustre is an amphipod crustacean that is a recent colonizer of freshwater systems in the United States and Europe (Keller et al. 2017). This species is native primarily in estuarine environments. It is believed to have the potential to alter food webs and may compete with native filter feeders for space and food.

Corbicula fluminea is a filter feeding, non-native, invasive clam species that causes biofouling of power plant and industrial water systems (USGS 2022). This species is consumed by fish and crayfish.

3.7.2. Environmental Consequences – Aquatic Ecology

This section addresses impacts to aquatic ecology from the No Action and Proposed Action Alternatives.

<u>Alternative A – No Action Alternative</u>

Under the No Action Alternative, closure of BFN would eliminate the effects on the aquatic community from current operation. After shutdown, the elimination of impingement and entrainment, thermal effects, non-cooling water discharge, maintenance dredging, and other operational effects generally would be expected to be small and beneficial for aquatic resources at BFN. However, TVA would need to replace the 3,900 MWe of BFN generation.

Effects to aquatic ecosystems associated with building a new SMR plant(s) would vary depending on the physical location of the plant, the location of the intake and discharge structures, and the type of cooling employed by the plant. Construction impacts to aquatic ecology are usually preventable by using industry-approved standards to contain sediment runoff and accidental spills. Construction along the banks or in a body of water can be mitigated by using BMPs. However, temporary and localized effects such as increases in turbidity would be expected. Should dredging be necessary, loss of the local benthic community and temporary increases in turbidity would be expected. Pre-dredge conditions should return as benthic communities re-colonize the area and suspended solids settle out of the water column. Effects from dredging would have only small direct and indirect effects on aquatic communities.

Effects of operation to aquatic habitat would depend on the nature of the source water quality. The source water for cooling in a plant using a closed-cycle cooling system is concentrated up to four times in the cooling tower operations before being discharged as wastewater blowdown, which concentrates the potential impurities already dissolved in the source water. However, the blowdown stream and all wastewater discharges would be regulated by and in compliance with the site-specific NPDES permit.

Impingement and entrainment effects of operation would also be dependent on the quality of the source water and organisms residing within the local habitat. Intake velocities are required to adhere to 316(b) of the CWA (33 USC Section 1326), which minimizes impingement of aquatic organisms. Intake and discharge volumes are lower from plants using a closed-cycle cooling system (as opposed to a once-through system), but the volume of water required increases as the source water quality decreases (as water quality decreases fewer cycles of concentration are possible), which may affect entrainment, impingement, and effects to organisms sensitive to a thermal plume. However, plants that use a closed-cycle cooling system consume more water through evaporation in the cooling towers than plants using a once-through cooling system.

Aquatic organisms susceptible to entrainment are usually planktonic, and thus quite small with limited swimming ability and subject to the motion of the water. The effects of entrainment would depend on local species residing in the source water and the percentage of source water being routed through the plant.

Cooling water discharge is at times warmer than ambient and causes a thermal plume within the receiving waters. Thermal plumes can impede migration of temperature-sensitive aquatic organisms. During winter months, a thermal plume might attract fish, which could increase predation or cause cold shock should the plant cease operation or the fish be chased out of the plume in an attempt to escape predation.

Additionally, discharge can contain contaminants associated with treatment of the intake water or normal plant operation. Depending on the contaminant load within the cooling tower blowdown stream, impacts could range from small to large. However, an NPDES permit would be required prior to discharge and would regulate toxic substances entering receiving waters.

Impacts to aquatic ecology from building a new SMR plant(s) could range from small to large depending on the plant design, organisms present, source water, and receiving water.

Depending on the proximity of other industry affecting area ecology, cumulative effects may also be apparent.

Effects to aquatic ecosystems associated with building a different generation plant would range from small to large depending upon the physical location of the plant, the location of the intake and discharge structures, and the type of cooling employed by the plant. A natural gas-powered generation plant would employ a cooling system similar to that of a SMR generation facility. Although the intake demand associated with natural gas-fired generation is substantially less than that of a nuclear-powered plant, impacts associated with thermal and chemical discharge, and impingement/entrainment of organisms, would be similar.

Potential effects associated with any new generation resource would be evaluated in separate analyses once new generation construction project locations and technologies are specifically identified. Therefore, impacts on aquatic resources from construction and operation of these new sources of energy likely would be small to large.

Alternative B – Proposed Action

Under Alternative B, the Proposed Action, current operational activities at BFN would continue on the existing site, and Wheeler Reservoir would continue to be the source of cooling water and the focus of potential impacts on aquatic resources.

Section 316(b) of the CWA requires that the cooling water intake structure (CWIS) reflect the best technology available (BTA) for minimizing adverse environmental impacts (33 United States Code [U.S.C.] 1326) from entrainment and impingement of aquatic organisms (33 U.S.C. 1326(b). The location, design, construction, and capacity of the CWIS must reflect the BTA for minimizing such impacts. The NRC requires SLR applicants to demonstrate the significance level of impingement and entrainment impacts by providing current CWA Section 316(b) determinations and supporting documentation, or alternatively, by providing site-specific assessments of impingement and entrainment impacts. USEPA issued a final 316(b) rule effective October 2014 for existing power generating and industrial facilities (79 FR 48299; August 15, 2014). Under the rule, the BFN facility, as an existing facility that withdraws more than 125 million gallons of cooling water per day (actual intake flow), is required to provide an Entrainment Characterization Study (§ 122.21(r)(9)) that includes a minimum of 2 years of entrainment data collection. TVA conducted this study to demonstrate compliance with Section 316(b) (TVA 2020c).

The BFN units are cooled by pumping water from Wheeler Reservoir and discharging it back to the reservoir via three large, submerged, diffuser pipes that are perforated to maximize uniform mixing into the flow stream. This straight-through flow path is known as once-through, open cycle, or open mode operation. As originally designed, the maximum thermal discharge from the once-through cooling water system is directed into Wheeler Reservoir, with a temperature increase from the intake to the discharge of 13.9°C (25°F). The flow exits the diffusers and mixes with the reservoir flow. At the edge of the discharge mixing zone, the water temperature is required to be less than 5.6°C (10°F) above ambient water temperature. Some of this cooling water can also be directed through helper cooling towers prior to discharge to reduce its temperature as necessary to comply with environmental regulations. The helper cooling towers are operated only when necessary to meet thermal discharge temperature limits specified in the NPDES permit issued by the ADEM, typically a few months during the hottest part of the summer (usually July and August).

TVA assumes 100 percent mortality of all aquatic organisms that enter the plant. BFN entrains a low percentage of a small portion of the plankton transported past the site. The proportion of cooling water withdrawn from Wheeler Reservoir is small (8.9 percent) compared to the long-term average river flow of 48,300 cfs passing the intake structure (TVA 2020c). ADEM has determined that the cooling water intake structure represents the interim BTA to minimize adverse environmental impacts. BFN is required to operate and maintain the cooling water intake structure in a manner that minimizes entrainment levels.

Entrainment and Impingement Impacts

In accordance with CWA Section 316(b), § 122.21(r)(9), TVA conducted an entrainment characterization study with sampling over 2 years in 2018 and 2019. Ichthyoplankton sampling was conducted during the period from February 20-21, 2018, through December 17-19, 2019. Samples were collected weekly during February through August (expected period of fish spawning) and monthly from September through January. Samples were collected during day and night at all sampling locations. Samples were collected immediately outside the CCW intake channel located at TRM 294.3. To determine the number of fish eggs and larvae available for entrainment, samples were also collected from three equidistant locations along a river transect located at TRM 294.5, immediately upstream from the CCW intake and perpendicular to river flow (TVA 2020c).

During the entrainment characterization study, fish eggs and larvae collected were from 11 families: Clupeidae, Moronidae, Centrarchidae, Atherinopsidae, Sciaenidae, Cyprinidae, Catostomidae, Percidae, Ictaluridae, Fundulidae, and Poeciliidae. The remaining fish eggs and larvae were not identifiable. No species were collected that are currently protected under federal, state, or tribal law. No entrainable shellfish occur in the vicinity of the BFN intake (TVA 2020c).

Clupeids and freshwater drum eggs compose a high percentage of the total ichthyoplankton composition. Fish egg densities (mostly freshwater drum) tended to be lowest along the right descending bank and highest at the mid-channel station during both sampling years. Entrainment data demonstrated annual variations in the relative abundance and spatial-temporal distribution of fish, and fluctuations in river flow are common in the vicinity of BFN. The total annual percentage of all taxa of fish eggs and larvae in the river that were entrained at BFN's cooling water intake was similar between day (fish eggs 1.8 percent; larvae 4.2 percent) and night (fish eggs 4.2 percent; larvae 6.6 percent) during both sampling years combined (TVA 2020c). Fish egg densities in Wheeler Reservoir tended to be lowest along the right descending bank and highest at the mid-channel sampling station.

Based on study findings, BFN entrains a low percentage of a small portion of the ichthyoplankton population transported past the site. TVA assumes 100 percent mortality of all aquatic organisms that enter the plant. This entrainment affects only a small portion of the Tennessee River since fish eggs and larvae spawned below the plant are not subject to entrainment and many of those spawned above the plant become nonplanktonic before reaching the plant intake. Entrainment of fish eggs and larvae by BFN is not considered to be a significant adverse impact on the fisheries resources of Wheeler Reservoir. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would alter the impact from entrainment of ichthyoplankton, and no new and significant information on this issue was identified.

Existing facilities are required to meet BTA for impingement via one of several compliance alternatives. In freshwater, shellfish are limited to crayfish and freshwater mussels. TVA collected data to measure impingement on BFN intake screens during the period from 2007 through 2009. There are no occurrence records of federal listed species near the BFN intake, and only one crayfish has been collected in impingement samples at BFN (TVA 2021e).

Fish taxa collected in impingement samples were designated as forage, commercial, and/or recreational species. Forage fish were defined as those generally regarded as prey for top carnivore fish. Commercially valuable species were defined as those that may be harvested and sold commercially for food or bait in Alabama. Recreationally valuable species were those targeted by anglers or used as bait. During impingement monitoring, a total of 51 fish taxa were collected: 16 taxa were considered forage taxa, 18 commercially valuable, and 28 recreationally valuable, with some taxa included in more than one category (TVA 2021e).

Actual numbers of fish collected in impingement samples during the first year (2,810,778) were more than twice that of the second year (1,172,660), but total taxa were similar between years: 46 and 43 taxa during 2007-2008 and 2008-2009, respectively. The increase in total numbers was due to much higher numbers of threadfin shad. Thirty-eight species were collected during both years, and 13 were collected during only one year. Threadfin shad was the species most susceptible to impingement (TVA 2021e).

The estimated average annual impingement at the CCW intake during the 2007-2009 sampling was 13,942,033 fish; of these, 96 percent were fragile threadfin shad. Over 90 percent of fish impinged on cooling water intake screens at thermal power plants in the southeastern United States typically are threadfin shad and gizzard shad. The preamble to the Section 316(b) existing facilities rule acknowledges the susceptibility and fragility of these species to impingement and focuses impingement mortality requirements on non-fragile species unless additional measures are specified by ADEM. Of the non-clupeid species, yellow bass, bluegill, and freshwater drum were most susceptible to impingement. Peak impingement periods were during the cooler months (November-January), indicating shad impingement may be related to cold shock (TVA 2021e).

TVA conducted a Comprehensive Technical Feasibility and Cost Evaluation Study of the potential implementation of closed-cycle cooling and fine mesh screens at BFN (TVA 2022g). The study concluded that the implementation of a closed-cycle cooling system and fine mesh screens at BFN would not be a prudent or practical measure for entrainment reduction due to the challenges, impacts, costs, schedule, and risks identified. ADEM has determined that the existing CWIS represents the interim BTA (40 CFR 125.98(b)(5)) to minimize adverse environmental impacts in accordance with Section 316(b) of the CWA (33 U.S.C. 1326). BFN is required to operate and maintain the CWIS in a manner that minimizes entrainment and impingement.

The long-term data collected by TVA on the aquatic community of Wheeler Reservoir indicates that the communities downstream and upstream of BFN are similar based on RFAI scores. When compared to the 2000 to 2019 averages, the 2020 RFAI data indicate similarity or improvement in all 12 metrics. The RFAI index incorporates elements used in Section 316 for defining a balanced indigenous community, such as diversity (number of species), trophic levels (categorization by feeding guild), presence of necessary food chain species, non-domination of pollution-tolerant species, and representation of indigenous species. Also, the repetitive sampling and scoring across many years provides a measure of sustainability and trends (TVA 2021f). No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would impact impingement and entrainment of aquatic organisms, and no new and significant information was identified regarding this issue. Based on long-term data from the period of operation of BFN, TVA concludes that the impacts of impingement and entrainment during the proposed subsequent period of extended operation would be small and would require no mitigation measures beyond those already in place.

Thermal Impacts

The BFN cooling water discharge would continue to be operated in compliance with the thermal limitations of the BFN NPDES permit. The discharge is not expected to affect the overall stability of aquatic populations or resources of Wheeler Reservoir. Thermal impacts on aquatic organisms that potentially can result from the operation of nuclear power plant cooling systems include cold shock and thermal barriers to fish migration.

Cold shock can occur when aquatic organisms that have become acclimated to the elevated temperatures of a thermal plume are abruptly exposed to decreased water temperatures when the artificial heat source stops. These effects are most likely to occur in winter. Cold shock events have only rarely occurred at nuclear plants, usually only a few fish were killed, and population-level effects did not result. Gradual shutdown of plant operations generally prevents cold shock events (NRC 2013). In addition, TVA has a protocol in place to decrease the potential for impacts to shad from cold shock that could occur as a result of upstream flow of heated water from the discharge. Shad in the Decatur Flats area immediately upstream of the BFN discharge could experience thermal shock if this occurs. To prevent such events, BFN coordinates with the TVA river forecast center before the first cold front (around December 1). The center notifies BFN of potential issues to minimize impacts and keep the water moving downstream. This procedure and the practice of gradual shutdowns are expected to prevent or minimize occurrences of cold shock events at BFN during the proposed subsequent period of extended operation.

Thermal plumes can create a barrier to fish migration if the mixing zone covers an extensive cross-sectional area of a water body and the plume temperature exceeds levels avoided by fish. However, substantial effects on fish passage from such a scenario have not been reported and would not be expected to occur at BFN given the limited area of the thermal plume compared to the width of Wheeler Reservoir.

No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would impact the thermal discharge, and no new and significant information was identified regarding this issue. Therefore, TVA finds that the thermal impacts of BFN on aquatic resources during the proposed subsequent period of extended operation would be small, and no additional mitigation would be needed.

Radiological Impacts

The 2021 Radiological Environmental Monitoring Program (REMP) compared the radioactive material content in environmental samples to control stations samples (TVA 2021b). There was no identified increase in Cs-137 levels attributed to BFN operation. The concentrations detected were typical of the levels expected to be present in the environment from past nuclear weapons testing and accidents such as fallout from the Chernobyl and Fukushima nuclear plants. Cs-137 was detected in one shoreline sediment sample at a level similar to other low-level detections during previous past monitoring; thus, it is not indicative of a new or ongoing release from BFN. Tritium was not detected in any surface water or sediment samples. No fission or activation products were detected in any of the environmental monitoring samples. No fission or activation products were detected in any of the game fish samples. Only naturally-occurring radioactivity was identified in fish and surface water samples as well as in air particulate samples. The TVA corrective action program database for the period from January 1, 2016, to July 8, 2021, which includes game and commercial fish, showed no condition reports related to exposure to radionuclides.

Measured levels of radioactivity in environmental samples were typical of expected background levels. There was no identified increase in exposure of aquatic organisms to radionuclides attributable to BFN operation from ingestion of fish or exposure to sediment. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would impact the exposure of aquatic organisms to radionuclides and no new and significant information was identified regarding this issue. Therefore, TVA concludes that the impact of radionuclides on aquatic organisms during the proposed subsequent period of extended operation would be small, and further mitigation would not be warranted.

Dredging Impacts

In the 2013 Generic Environmental Impact Statement (GEIS), the NRC expects that dredging at nuclear power plants would be infrequent and of relatively short duration and would affect relatively small areas. Dredging is regulated under permit from the USACE, and the NRC considers compliance with permits to be sufficient to mitigate potential impacts.

The BFN intake channel must occasionally be dredged for maintenance purposes to return the intake channel to design specifications. The intake channel has been dredged only once (in 2018), which was the first time in the 46-year operating history of BFN. TVA evaluates routine maintenance impacts using a National Environmental Policy Act (NEPA) categorical exclusion checklist. Generally, the dredged material would be dewatered using flocculent either in Geo Tubes at a location onsite or in a barge, with filtrate water being returned either to the cold water channel or directly to the river. The dewatered solids would either be deposited at an onsite spoils area or shipped offsite. Maintenance dredging is performed under USACE Mobile District General Permit ALGP-02 (TVA 2018b).

The 2017 and 2018 categorical exclusion checklist for the intake channel dredging did not indicate the need for permitting for aquatic resources or the need for mitigation commitments (TVA 2017a, TVA 2018b). No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would affect aquatic resources with respect to dredging, and no new and significant information was identified regarding this issue. Therefore, TVA concludes that the impact of dredging on aquatic organisms during the proposed subsequent period of extended operation would be small, and further mitigation would not be warranted.

Water Use Impacts

Consumptive water use at BFN includes evaporation through the power generation and cooling systems, including evaporation and drift from the helper cooling towers when the helper cooling towers are in operation, and evaporation of water withdrawn from Wheeler Reservoir due to the thermal loading from water discharged from the facility. This consumptive water use represents a small percentage of the average annual flow in Wheeler Reservoir. During the 6-year period from 2016 through 2021, BFN withdrew cooling water from Wheeler Reservoir at an average annual rate of approximately 3,124 MGD, with average losses due to evaporation and drift of approximately 36 MGD, or 0.53 percent of the total withdrawal. Thus, most of the water withdrawn at the plant intake (almost 99.5 percent) was returned to the reservoir. The water source at BFN for systems other than the cooling water system is municipal supply, i.e., domestic water and treated surface water are used for process water. Even when helper cooling towers are in operation, BFN operates in a once-through open cycle, returning nearly all of the water withdrawn back to the river. Water is not withdrawn from the river specifically for helper cooling tower makeup water, and the flow rate at the intake does not change due to helper cooling tower operation.

The water resources of Wheeler Reservoir are managed per the TVA *Reservoir Operations Plan*, in consultation with the U.S. Fish and Wildlife Service (USFWS) and USACE (TVA 2004). TVA controls releases from the upstream and downstream dams (Guntersville Dam and Wheeler Dam, respectively), to maintain required minimum flow in Wheeler Reservoir to meet specific system requirements for navigation, aquatic habitats, water quality, water supply, and waste assimilation (TVA 2004). Given that BFN consumptive water use averages only about 0.5 percent of the total withdrawal from the reservoir and that TVA controls these dam releases, neither water availability nor competing water demands in Wheeler Reservoir are adversely affected by BFN operation. Even in low-flow conditions, impacts on the aquatic community would be minimal, if discernible, because of the controls placed on water elevation in Wheeler Reservoir. The aquatic community has adapted to the normally fluctuating water levels and flow conditions of the reservoir. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would affect surface water use conflicts, and no new and significant information was identified. Therefore, TVA finds that impacts of BFN operation on surface water use and related impacts on aquatic resources during the proposed subsequent period of extended operation would be small, and further mitigation would not be warranted.

Conclusion – Aquatic Ecological Resources
Effects of BFN operation on aquatic ecological resources during the proposed subsequent period of extended operation would be small. Current 316(b) data support this conclusion. A viable and balanced aquatic community is present in the vicinity of BFN. Impacts to aquatic biota associated with the intake and discharge of cooling water and non-cooling water are minor and are not expected to adversely affect the balanced, indigenous, aquatic populations that currently exist in the vicinity of BFN. Mitigation measures other than those already in place would not be required. The incremental contribution of BFN operations during the proposed subsequent period of extended operation to cumulative impacts on aquatic ecological resources in the vicinity of BFN also would be small.

3.8. Terrestrial Ecology

This section characterizes existing terrestrial plants and wildlife as well as invasive species onsite and in the general vicinity of BFN, and it assesses potential impacts that may result from the implementation of the No Action and Action Alternatives.

3.8.1. Affected Environment – Terrestrial Ecology

According to the USEPA, BFN is located in the Interior Plateau ecoregion (Griffith et al. 2001). This ecoregion is dominated by oak-hickory and mesophytic forests. The historic bottomland hardwood forests common to the Interior Plateau have been mostly inundated by the impounded waters of the Tennessee River (Wheeler Reservoir) and other natural streams that cross the region. Wetlands in this ecoregion are most commonly associated with the floodplains of these streams and river systems; although springs and seepage wetlands occur as well. The Interior Plateau ecoregion has soils that are rich, deep, and intensively used for agriculture. The area surrounding BFN includes multiple fields that are used for row crop production.

3.8.1.1. Plants

Fragments of forest remain scattered across the BFN site. Approximately 30 acres of forest on BFN property were recently clear cut and mulched for security purposes. Forest fragments are mixed deciduous-evergreen or deciduous. Herbaceous areas are primarily mowed grass with a small amount of more variable vegetation on a wet section of ROW.

The BFN property includes 12,946 feet of Wheeler Reservoir shoreline. The riparian zone along the shoreline near the nuclear facility and helper cooling towers is stabilized with riprap and vegetated mainly by scattered plants such as black willow (*Salix nigra*), hackberry (*Celtis occidentalis*), sumac (*Rhus* spp.), privet (*Ligustrum* spp.), Japanese honeysuckle (*Lonicera japonica*), and trumpet creeper (*Campsis radicans*). The shoreline southeast of the facility is mostly mixed, upland forest that includes a few large oaks and loblolly pines. The plants associated with the upland forest areas on BFN include various tree species common in the area, such as black locust (*Robinia pseudoacacia*), sweetgum (*Liquidambar styraciflua*), sassafras (*Sassafras albidum*), cottonwood (*Populus deltoides*), elm (*Ulmus* spp.), hackberry, and black cherry (*Prunus serotina).* Vegetation common in the understory of the forested areas likely includes Chinese privet (*Ligustrum sinense*), spleenwort (*Asplenium* spp.), Virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicodendron radicans*). There are no uncommon or unusual plant communities on the property. To the northeast of BFN, the area is dominated by regularly maintained grassy areas as well as fields used for agricultural production of row crops.

The BFN site was and continues to be a highly altered and managed environment. With the construction and development of the facility, the introduction of non-native and potentially invasive species has occurred. Native plant communities have been converted to and are maintained as herbaceous, field habitats on much of the site. Among the non-native plant species likely to be present in these disturbed habitats are Chinese lespedeza (*Lespedeza cuneata*), Japanese honeysuckle, and multiflora rose (*Rosa multiflora*).

3.8.1.2. Wildlife

Mowed grass fields, which cover most of the undeveloped BFN property, generally offer limited habitat for wildlife species. Small, fragmented, forest areas such as those on the BFN property also are less likely to provide habitat for rare species than larger, interconnected forests. As most areas on BFN have been previously disturbed and provide limited wildlife habitat, the terrestrial wildlife species found at BFN are common and have widespread distributions. No uncommon wildlife communities or important terrestrial habitats are known to occur within or immediately adjacent to BFN.

Developed areas and areas otherwise previously disturbed by human activity, including the large areas of mowed fields, provide habitat that may be used by a number of common wildlife species, including the American robin (*Turdus migratorius*), American crow (*Corvus brachyrhynchos*), Canada goose (*Branta canadensis*), Carolina chickadee (*Poecile carolinensis*), European starling (*Sturnus vulgaris*), house finch (*Haemorhous mexicanus*), house sparrow (*Passer domesticus*), mourning dove (*Zenaida macroura*), Carolina wren (*Thryothorus ludovicianus*), northern cardinal (*Cardinalis cardinalis),* northern mockingbird (*Mimus polyglottos*), black vulture (*Coragyps atratus*), and turkey vulture (*Cathartes aura*) (National Geographic 2002). During a field survey, a colony of cliff swallow nests was observed around the outside of the reactor building. Mammals found in the disturbed community include the eastern gray squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*), and raccoon (*Procyon lotor*) (Whitaker 1996). Road-side ditches provide potential habitat for amphibians such as the American toad (*Anaxyrus americanus*) and upland chorus frog (*Pseudacris feriarum*). Reptiles potentially present include the eastern black kingsnake (*Lampropeltis getula nigra*) and gray rat snake (*Elaphe obsoleta*) (Gibbons and Dorcas 2005, Powell et al. 2016). Emergent wetlands and saturated wet weather conveyances within field settings provide habitat for common amphibians. Amphibians likely to be present include the American bullfrog (*Lithobates catesbeianus*), American toad, southern leopard frog (*Lithobates sphenocephallus*), spring peeper (*Pseudacris crucifer*), and upland chorus frog (Powell et al. 2016).

Forest fragments on BFN property may provide habitat for common birds such as the American robin, barred owl (*Strix varia*), blue-gray gnatcatcher (*Polioptila caerulea caerulea*), blue jay (*Cyanocitta cristata*), brown thrasher (*Taxostoma rufum*), Carolina wren, common yellowthroat (*Geothlypis trichas*), eastern bluebird (*Sialia sialis*), eastern phoebe (*Sayornis phoebe*), eastern towhee (*Pipilo erythrophthalmus*), eastern wood peewee (*Contopus virens*), gray catbird (*Dumetella carolinensis*), northern cardinal, northern flicker (*Colaptes auratus*), red-bellied woodpecker (*Melanerpes carolinus*), red-eyed vireo (*Vireo olivaceus*), red-shouldered hawk (*Buteo lineatus*), ruby-throated hummingbird (*Archilochus colubris*), scarlet tanager (*Piranga olivacea*), summer tanager (*Piranga rubra*), white-eyed vireo (*Vireo griseus*), and yellow-breasted chat (*Icteria virens*). Mammals likely to occur in these fragments include the nine-banded armadillo (*Dasypus novemcinctus*), raccoon, eastern chipmunk (*Tamias striatus*), eastern gray squirrel, Virginia opossum (*Didelphis virginiana*), and white-tailed deer (*Odocoileus virginianus*). Amphibians and reptiles likely to occur here include the eastern box turtle (*Terrapene carolina*), Fowler's toad (*Anaxyrus fowleri*), gray treefrog (*Dryophytes versicolor*), and gray rat snake.

Constructed channels around the cooling units and riparian areas along Wheeler Reservoir provide habitat for wading birds and waterfowl. Species observed in this area include the American black duck (*Anas rubripes*), Canada goose, great blue heron (*Ardea herodias*), double-crested cormorant (*Phalacrocorax auratus*), and mallard (*Anas platyrhynchos*).

3.8.2. Environmental Consequences – Terrestrial Ecology

This section addresses impacts to terrestrial ecology from the No Action and Action Alternatives.

<u>Alternative A – No Action Alternative</u>

Closure of BFN would eliminate the effects on terrestrial ecological resources from current operation. After shutdown, the elimination of operational effects generally would be expected to be small and beneficial for terrestrial resources at BFN.

However, TVA would need to replace the 3,900 MWe of BFN generation. A replacement generation facility constructed at an alternate greenfield site would result in potentially large land-use impacts. If a brownfield site is selected, potential impacts would be similar; however, the impacts would be smaller, or less intense. In addition to the acreage required for the facility itself, land may also be needed to support water lines and the potential construction of a railroad spur or barge dock to transport equipment during construction and operation. In addition, new transmission lines, pipelines, and other associated ROWs would be required as part of this alternative. A generation facility would integrate into TVAs existing transmission line system with the construction of new transmission lines from the plant site to the power grid system.

Direct impacts would likely occur to terrestrial plants and wildlife as a result of clearing and construction operations. These impacts could include important terrestrial habitats such as:

- Adjacent shorelines of open waters: ponds, lakes, and large bodies of water.
- Forests: hardwood, pine-hardwood, mixed hardwood, etc.
- Open fields: fallow fields, old fields, barren land, etc.
- Wetlands: forested, scrub shrub, emergent, etc.

- Riparian areas along streams.
- Native grass fields: pastures, agriculture, etc.

Impacts to terrestrial plants could be greater than impacts to wildlife because many wildlife species have the ability to relocate by their own means. Plant communities in the proposed construction footprint would be cleared to accommodate the new plant site, and wildlife would be displaced. Disturbed areas would be revegetated with native and/or non-invasive flora species to reduce the introduction and spread of exotic invasive plant species associated with ground disturbance and other construction activities. In addition, wildlife species that recolonize the area are expected to be suited for life in and around an industrial/urban environment.

Small indirect impacts would likely occur as a result of this alternative. Wildlife are expected to experience small indirect impacts due to displacement, local habitat loss, and fragmentation. Plant communities would also be expected to experience small indirect impacts due to habitat fragmentation and land-use conversion (e.g., forested and shrub areas converted into grassy areas, landscaped areas, or fields). Over time, these small changes may induce larger changes such as alterations in the pattern of land use in and around the new facility and human population density and growth rates that may affect terrestrial plants and wildlife and their habitats.

This alternative could result in small cumulative impacts to terrestrial plants and wildlife because of the potential collective habitat loss, habitat fragmentation, and decreased biological diversity. Construction of a new generation facility at an undetermined location along with associated transmission lines in the Tennessee Valley could result in small cumulative impacts to terrestrial vegetation and wildlife when combined with all of the past, present, and future construction in the region.

Potential effects would be evaluated in separate analyses once new generation construction project locations and technologies are specifically identified. Impacts on terrestrial resources from construction and operation of these new sources of energy likely would be small to moderate.

Alternative B – Proposed Action

Under Alternative B, the Proposed Action, current operational activities at BFN would continue on the existing site.

No refurbishment or changes to plant operational activities or in-scope transmission lines that would change effects on terrestrial resources would be expected to occur during the proposed subsequent period of extended operation. Wildlife and plant species on the developed parts of the BFN property are common species adapted to industrial sites and able to tolerate industrial noise and human activity. Any future activities that could impact the nesting colony of cliff swallows beyond their demonstrated level of tolerance would require coordination with state or federal agencies as appropriate. The characteristics of terrestrial communities on less intensively developed parts of the property have been influenced by years of BFN operations and maintenance activities occurring in close proximity.

No known sensitive terrestrial habitats currently exist within the BFN property boundaries, and operations and maintenance activities during the proposed subsequent period of extended operation would be expected to be similar to current activities. Furthermore, as a federal agency, TVA is subject to the requirements of federal laws and regulations, including NEPA and the Endangered Species Act (ESA), CWA, and Clean Air Act (CAA). Thus, environmental reviews under these and other regulations are carried out for all TVA actions in consultation and/or cooperation with other federal agencies. Pursuant to this process, applicable environmental requirements are identified for each proposed activity, and mitigation measures are considered. As a result, current operations and maintenance have had small impacts on terrestrial resources. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would alter impacts on terrestrial resources, and no new and significant information was identified. TVA concludes that continued operations and maintenance activities during the proposed subsequent period of extended operation would have small impacts on terrestrial resources and warrant no additional mitigation measures.

The 2021 REMP compared the radioactive material content in environmental monitoring samples to that in control station samples (TVA 2021b). Measured levels of radioactivity in the environmental samples at BFN were similar to expected background levels. There was no identified increase in exposure of terrestrial organisms to radionuclides from ingestion of plants or fish attributable to BFN operations. Doses to terrestrial organisms from continued operations and refurbishment associated with SLR are expected to be well below exposure guidelines developed to protect these organisms. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would impact terrestrial plants and animals, and no new and significant information was identified regarding this issue.

The helper cooling towers at BFN are normally operated only for a short period of time, mostly during the months of July and August, so fogging and icing have not been concerns. Because the helper cooling towers operate with fresh water, no salt deposition has been observed. Further, there have been no problems or complaints resulting from helper cooling tower operation. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would alter impacts on vegetation from the helper cooling towers, and no new and significant information was identified regarding this issue. TVA finds that the impacts on vegetation from helper cooling tower operation at BFN would be small.

Bird populations potentially could be impacted by collisions with structures at BFN. TVA currently complies with EO 13186: Responsibilities of Federal Agencies to Protect Migratory Birds, in accordance with the Migratory Bird Treaty Act (MBTA). Additionally, TVA is developing a memorandum of agreement with the USFWS that will include an Avian Protection Plan. The memorandum of agreement and Avian Protection Plan will be applicable TVA-wide, including at BFN. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would impact the potential for bird collisions with plant structures and transmission lines, and no new and significant information was identified regarding this issue.

The in-scope transmission lines are entirely within the BFN site. These lines run from the main transformers to the 500 kV and 161 kV switchyards located on the BFN site (Figure 1.2-4). There are no associated ROWs to be maintained onsite, and no refurbishment or other changes to plant structures or transmission lines are planned during the proposed subsequent period of extended operation. Most areas on the BFN site have been previously disturbed and provide limited terrestrial resources and negligible potential for exposure of biota to electric and magnetic fields in the vicinity of the in-scope transmission lines.

In conclusion, the impacts of BFN operation on terrestrial ecological resources during the proposed subsequent period of extended operation would be small. The evaluations above support this conclusion. Mitigation measures other than those already in place would not be required. The incremental contribution of BFN operations during the proposed subsequent period of extended operation to cumulative impacts on terrestrial ecological resources in the vicinity of BFN also would be small.

3.9. Endangered and Threatened Species

This section addresses species that have a status of endangered or threatened, or another special status, that provides them legal protection based on the following federal or state legislation:

Endangered Species Act (ESA) (16 U.S.C. 1531-1544, as amended): Section 7 of the federal ESA requires federal agencies to consider the effects of their actions on federally listed species and designated critical habitat, and to take steps to conserve and protect these species and habitats. The requirements of ESA Section 7 are administered by the USFWS, which principally has jurisdiction over terrestrial and freshwater aquatic species (as well as sea turtles when nesting onshore), and by National Oceanic and Atmospheric Administration (NOAA) Fisheries, which principally has jurisdiction over marine species (including sea turtles when in water).

Alabama Administrative Code, Alabama Department of Conservation and Natural Resources, Chapter 220-2-.92, Protected Nongame Species: This regulation makes it unlawful to take, capture, or kill any of the nongame wildlife species identified in the regulation, which include fish, amphibians, reptiles, birds, and mammals.

Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. Parts 668-668c): Although delisted under the federal ESA in 2007, the bald eagle (*Haliaeetus leucocephalus*) remains protected under the federal BGEPA. The BGEPA prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald eagles, which includes molesting or disturbing the birds or their nests or eggs.

Migratory Bird Treaty Act (MBTA): The federal MBTA makes illegal the killing, injury, or other taking of birds and their nests or eggs. It applies to essentially all native bird species that occur in the region, with the exception of certain non-migratory game birds that are managed by the states (e.g., quail, turkey, and grouse). Birds of conservation concern (BCC) are a subset of migratory birds identified by USFWS.

This section identifies species with a federal or state protected status and the potential to occur in the vicinity of BFN, and it evaluates potential impacts on those species from the alternatives.

3.9.1. Affected Environment – Endangered and Threatened Species

3.9.1.1. Terrestrial Species

Terrestrial species are considered to include those that are not obligately aquatic (i.e., breathe air rather than water). Their habitats may include uplands, wetlands, and water bodies.

Federal Status Species

Review of the TVA Natural Heritage Project Database indicated that one federal listed terrestrial animal species (gray bat) and one federal protected species (bald eagle) have reported occurrences within 3 miles of the BFN site in Limestone County, Alabama (TVA 2022i). In addition, based on the IPaC database query (USFWS 2022a), the USFWS has determined that the federal status Indiana bat, northern long-eared bat, tricolored bat, and monarch butterfly have the potential to occur in the vicinity of the BFN site (Table 3.9-1). No federal listed plant species have recorded occurrences within 5 miles of the BFN site, and critical habitat has not been designated for any federal listed species in the project vicinity (USFWS 2022a).

Table 3.9-1. Federal and State Status Terrestrial Animal Species with the Potential to Occur or Documented within 3 miles of the BFN Site

Common Name	Scientific Name	Federal Status[3]	State Status[3] (State Rank)[4]
Mammals			
Gray bat[2,5]	*Myotis grisescens*	E	SP(S2)
Indiana bat[2]	*Myotis sodalis*	E	SP(S2)
Northern long-eared bat[2]	*Myotis septentrionalis*	E	SP(S2)
Tricolored bat	*Perimyotis subflavus*	PE	--
Invertebrates			
Monarch butterfly[2,6]	*Danaus plexippus*	C	--
Birds			
Bald eagle[5]	*Haliaeetus leucocephalus*	DM	SP(S4B)
Osprey[1]	*Pandion haliaetus*	--	SP(S4)

[1] Source: TVA Regional Natural Heritage Database, extracted Feb. 2022 (TVA 2022i) – 3-mile buffer query
[2] USFWS Information for Planning and Consultation (IPaC) query (USFWS 2022a)
[3] Status Codes: E = Endangered; PE = Proposed Endangered; C = Candidate species for federal listing; DM = Delisted, recovered, and still being monitored; SP = State Protected.
[4] Alabama Natural Heritage Program State Ranks: S2 = Imperiled; S4 = Apparently Secure; S#B = Rank of breeding population.
[5] Species known from Limestone County, Alabama but not within 3 miles of the BFN site.
[6] Historically this species has not been tracked by natural heritage databases.

Gray bats roost in caves year-round and migrate between summer and winter roosts during spring and fall (Brady et al. 1982, TVA 2019d). Bats disperse over bodies of water at dusk where they forage for insects emerging from the surface of the water (Tuttle 1976). Two hibernacula for the gray bat are known in Limestone County, the closest of which is approximately 8.7 miles away. No caves are known within 3 miles of BFN. No mines or other gray bat roosting habitat on BFN property are known. Foraging habitat and sources of drinking water exist over streams, channels and wetlands on BFN property and over Wheeler Reservoir.

Indiana bats hibernate in caves in winter and use areas around them for swarming (mating) in the fall and staging in the spring, prior to migration back to summer habitat. During the summer, Indiana bats roost under the exfoliating bark of dead snags and living trees in mature forests with an open understory and a nearby source of water (Kurta et al. 2002, Pruitt and TeWinkel 2007). Indiana bats are known to change roost trees frequently throughout the season, while still maintaining site fidelity, returning to the same summer roosting areas in subsequent years (Pruitt and TeWinkel 2007). No caves are known within 3 miles of BFN, and no records of Indiana bats are known from Limestone County. The closest known record of this species is a historical record from 9.4 miles away in Lauderdale County.

The northern long-eared bat predominantly overwinters in large hibernacula such as caves, abandoned mines, and cave-like structures. During the fall and spring, they utilize entrances of caves and the surrounding forested areas for swarming and staging. In the summer, northern long-eared bats roost individually or in colonies beneath exfoliating bark or in crevices of both live and dead trees (typically greater than 3 inches in diameter). Roost selection by northern long-eared bat is similar to that of the Indiana bat; however, northern long-eared bats are thought to be more opportunistic in roost site selection. This species also roosts in abandoned buildings and under bridges. Northern long-eared bats emerge at dusk to forage below the canopy of mature forests on hillsides and near roads, and occasionally over forest clearings and along riparian areas (USFWS 2014). No caves are known within 3 miles of BFN. The closest known record of the northern long-eared bat is from 25.6 miles away in Bankhead National Forest.

The tricolored bat was proposed for listing as endangered under the ESA in September 2022 (87 FR 56373; September 14, 2022). Designating critical habitat for this species is not prudent according to USFWS. These bats hibernate in caves, mines, and rock crevices during winter. Tricolored bats in Alabama are often found roosting in road culverts and will forage on warm, winter nights. During spring, summer, and fall, the tricolored bat utilizes forested habitats, where it roosts in live or recently dead deciduous trees, primarily among leaves, and occasionally in human structures. It forages around forest edges and over waterways. This species is known or believed to occur in Limestone County, Alabama (Outdoor Alabama 2022b, USFWS 2022b).

No suitable winter roosting structures for the Indiana bat, northern long-eared bat, or tricolored bat exist on the BFN property. Review of the TVA Regional Natural Heritage Program database in February 2022 indicated that no caves exist within 3 miles of BFN. Thus, there are no suitable hibernacula for bats near BFN. Moderately suitable summer roosting habitat occurs in some scattered forest fragments across the BFN property. The least disturbed forest remains along the shoreline in the southeastern corner of the property. Based on aerial photos, it appears most other forested areas are regrowth after being cleared sometime before 1998. Remaining suitable habitat fragments consist of mature forests and/or areas with trees that have suitable cracks and crevices. Suitable foraging habitat includes the forest and forest edges as well as wetlands and water bodies, including the adjacent Wheeler Reservoir. Surveys performed using the 2020-2021 USFWS Indiana Bat Survey Guidelines identified 111 acres of forest fragments scattered across the BFN property that may offer potential habitat for summer roosting by the Indiana bat, northern long-eared bat, or tricolored bat. The monarch butterfly is a candidate for listing under the ESA. It is a highly migratory species, with eastern United States populations overwintering in Mexico. Monarch populations typically return to the eastern United States in April (Davis and Howard 2005). Summer breeding habitat requires milkweed plant species, on which adults exclusively lay eggs for larvae to develop and feed on. Adults will drink nectar from other blooming wildflowers when milkweeds are not in bloom (Alabama Public Health 2022). The early successional fields within the BFN property include several species of wildflowers and other flowering plants that provide suitable foraging habitat for adult monarchs. The overwhelming majority of areas with herbaceous vegetation on the BFN property are mowed grass fields. It is possible that small patches of flowering herbaceous plants may persist on the edges of fields where mowing has been infrequent, though none were documented.

The bald eagle formerly was federally listed under the ESA but has been de-listed by USFWS as it is now considered recovered. However, it remains protected under the BGEPA. The bald eagle is associated with larger, mature trees capable of supporting its massive nests. Nests are usually found near larger waterways where the eagles forage (USFWS 2007). Three bald eagle nests are known from Limestone County, the closest of which is 5.4 miles away. Wheeler Reservoir provides foraging habitat for the bald eagle. Suitable nesting trees occur throughout the forest fragment along Wheeler Reservoir in the southeastern corner of BFN; however, no bald eagle nests have been documented on the BFN site.

Most bird species in the BFN area are protected by the MBTA. (federal and state listed birds, and the bald eagle, are also protected under the MBTA.) The MBTA is the primary legislation in the United States established to conserve migratory birds. The MBTA prohibits the intentional taking, killing, or possessing of migratory birds unless permitted by regulation. EO 13186 (66 FR 3853–3856), *Responsibilities of Federal Agencies to Protect Birds*, provides a specific framework for federal agencies to comply with their MBTA obligations and aids in incorporating bird conservation planning into agency programs. For the purposes of the MBTA and EO 13186, migratory birds have been defined to include all native birds in the United States, except certain non-migratory game species managed by the states (e.g., quail, turkey, grouse, and ptarmigan). The BFN area includes habitats that are used by a variety of birds protected under the MBTA.

Migratory BCC are species that are of particular concern to USFWS. The Information for Planning and Consultation (IPaC) report for the BFN site contains a list of BCC that potentially could occur in the vicinity (USFWS 2022a). It includes BCC that could occur in the area during breeding season, wintering season, or year-round. The list includes nine BCC that could occur in the area during the breeding season (bobolink, brown-headed nuthatch, chimney swift, field sparrow, Kentucky warbler, prairie warbler, prothonotary warbler, red-headed woodpecker, and wood thrush) and two species that breed elsewhere (lesser yellowlegs and rusty blackbird).

State Status Species

State-protected animal species with recorded occurrences within 3 miles of the BFN site are shown in Table 3.9-1. The three bat species also have federal listing status and are discussed above. The two bird species are the bald eagle and osprey. The bald eagle is not a federal listed species but has federal protection under the BGEPA and is state protected in Alabama. It is discussed above.

The osprey has a status of state protected. In inland areas, the osprey occupies riparian habitats along bodies of water such as rivers, lakes, and reservoirs. It builds nests of sticks on trees or a variety of man-made structures (e.g., power transmission line structures, lighting towers) near water (Alabama Public Health 2022). Two osprey nests were documented on the BFN reservation during field reviews in September 2021. Due to maintenance issues with the cell tower one of the nests was on, it was removed a few weeks after the field surveys. The nest was not active at the time of removal. The remaining nest is on a TVA transmission tower.

The Alabama Natural Heritage Program does not assign a state status to plants but does rank species of conservation concern. The TVA Natural Heritage database does not include recorded occurrences of plants with a state rank within 5 miles of BFN, but it does include from Limestone County eight flowering plants with a state rank of S1 or S2 assigned by the Alabama Natural Heritage Program, as shown in Table 3.9-2 (TVA 2022i). The ranking does not confer legal protection.

Table 3.9-2. Plants with a State Rank of Imperiled and Occurring in Limestone County, Alabama

Common Name	Scientific Name	State Rank[1]
Lake-cress	*Armoracia lacustris*	S1
Waterweed	*Elodea canadensis*	S1
Duck River bladderpod	*Paysonia densipila*	S1
Alabama snow-wreath	*Neviusia alabamensis*	S2
Ragged fringe orchid	*Platanthera lacera*	S2
Mohr’s rosin-weed	*Silphium mohrii*	S1

Common Name	Scientific Name	State Rank[1]
Sessile trillium	*Trillium sessile*	S2
Northern prickly-ash	*Zanthoxylum americanum*	S1

Source: TVA Regional Natural Heritage Database, extracted Feb. 2022 (TVA 2022i) – recorded occurrences within Limestone County

[1] Alabama Natural Heritage Program ranking system:

S1 = Critically imperiled in Alabama because of extreme rarity (5 or fewer occurrences of very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation from Alabama.

S2 = Imperiled in Alabama because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from Alabama.

S3 = Rare or uncommon in Alabama (on the order of 21 to 100 occurrences)

3.9.1.2. Aquatic Species with Federal or State Status

Essential fish habitat (EFH) includes waters and substrate that are necessary for spawning, breeding, feeding, or growth to maturity of fish and shellfish that are federally managed species. EFH is identified and described by the National Marine Fisheries Service and regional fishery management councils, in accordance with the Magnuson-Stevens Act (16 U.S.C. 1801 et seq.). According to the National Marine Fisheries Service EFH Mapper, EFH has not been designated within Wheeler Reservoir (NOAA 2022).

The hydrologic units that make up the Wheeler Reservoir watershed contain numerous records of federal and state listed species (Table 3.9-3). Numerous records of listed mussel species also occur within a 10-mile radius of BFN (Table 3.9-3). In 1982, 12 mussel species were collected in Wheeler Reservoir in the vicinity of BFN. None of the species had a federal listing status or state protected status (TVA 2021e). In 1999, a survey collected 16 native mussel species in the vicinity of BFN, none of which were federal listed species (TVA 2020c). In July 2021, a mussel survey was conducted by TVA, in conjunction with the Alabama Department of Conservation and Natural Resources, to assess the current assemblage of mussels present in the portion of Wheeler Reservoir immediately adjacent to BFN. In the portion of the reservoir near BFN, the mussel community is composed of 11 common, widespread, silt-tolerant species, and no species of mussels or snails with federal or state status were found (Amaker 2021). Therefore, federal and state listed mussel species are not expected to occur near BFN for the following reasons: they are presumed to be extinct, they are presumed to be extirpated from the region, there are no recent records for the species in the region, there are no collection records for the species from pertinent locations, and/or the area near the BFN site does not contain suitable habitat for the species. Species that are federal or state listed and persist in Wheeler Reservoir occupy more suitable habitat that is located much farther upstream of BFN in the more riverine portion of the Tennessee River downstream from Guntersville Dam.

Table 3.9-3. Federal and State Status Aquatic Animal Species with Documented Occurrences or the Potential to Occur within Wheeler Reservoir

Common Name	Scientific Name	Federal Status[4]	State Status[5]	State Rank[6]
Fish				
Spring pygmy sunfish[1, 2]	*Elassoma alabamae*	T	SP	S1
Slackwater darter[1]	*Etheostoma boschungi*	T	SP	
Tuscumbia darter[1, 2]	*Etheostoma tuscumbia*	--	SP	S2
Snail darter	*Percina tanasi*	--[7]	SP[8]	S1[8]
Paddlefish[2]	*Polyodon spathula*	--	SP	S3

Common Name	Scientific Name	Federal Status[4]	State Status[5]	State Rank[6]
Mussels				
Mucket[1]	*Actinonaias ligamentina*	--	PSM	S2
Spectaclecase[1]	*Cumberlandia monodonta*	E	SP	S1
Dromedary pearlymussel[1, 2]	*Dromus dromas*	E, XN	SP	SX
Cumberlandian combshell[2]	*Epioblasma brevidens*	E, XN	SP	S1
Acornshell[2]	*Epioblasma haysiana*	--	PSM	SX
Tuberculed blossom pearlymussel[1]	*Epioblasma torulosa torulosa*	E	SP	SX
Cracking pearlymussel[2]	*Hemistena lata*	E, XN	SP	S1
Pink mucket[1, 2, 3]	*Lampsilis abrupta*	E	SP	S1
Pocketbook[1]	*Lampsilis ovata*	--	PSM	S2
White heelsplitter[1, 2]	*Lasmigona complanata*	--	PSM	S2
Birdwing pearlymussel[2]	*Lemiox rimosus*	E, XN	SP	S1
Hickorynut[1]	*Obovaria olivaria*	--	PSM	SX
Ring pink[1]	*Obovaria retusa*	E, XN	SP	SH
Orange-foot pimpleback[1]	*Plethobasus cooperianus*	E, XN	SP	SX
Sheepnose[1]	*Plethobasus cyphyus*	E	SP	S1
Ohio pigtoe[1, 2]	*Pleurobema cordatum*	--	PSM	S2
Rough pigtoe[1, 2, 3]	*Pleurobema plenum*	E, XN	SP	S1
Tennessee pigtoe[1]	*Pleuronaia barnesiana*	--	PSM	S1
Pink papershell[1]	*Potamilus ohiensis*	--	PSM	S3
Kidneyshell[1]	*Ptychobranchus fasciolaris*	--	PSM	S2
Fluted kidneyshell[2]	*Ptychobranchus subtentum*	E	SP	SX
Purple lilliput[1]	*Toxolasma lividus*	--	PSM	S2
Painted creekshell[1]	*Villosa taeniata*	--	PSM	S2

[1] Source: TVA Natural Heritage Database (TVA 2022i) – hydrologic unit code query
[2] Source: TVA Natural Heritage Database (TVA 2022i) – 10-mile buffer query
[3] Source: USFWS IPaC query (USFWS 2022a)
[4] Federal Status: E = Endangered; T = Threatened; XN = experimental population, nonessential (experimental reintroduced population)
[5] State Status: SP = State Protected; PSM = Partial Status Mussels
[6] State Rank: S1 = Critically imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently secure; S5 = Secure; SH = Historical (possibly extirpated); SX = Presumed extirpated in Alabama
[7] Source: 87 FR 60298-60313; October 5, 2022 – Removing the Snail Darter From the List of Endangered and Threatened Wildlife
[8] Source: (ALNHP 2021) – Current Tracking Lists, Version 2, October 2021.

The other group of aquatic animals with federal or state status and recorded occurrences in Wheeler Reservoir and/or within 10 miles of BFN are fish (spring pygmy sunfish, slackwater darter, Tuscumbia darter, and paddlefish). In 21 years (since 1993) of fish entrainment sampling by TVA in the vicinity of BFN, the paddlefish was collected in only 1 year (TVA 2020c). The spring pygmy sunfish, slackwater darter, and Tuscumbia darter were never collected and would not be expected to be present because they do not occur in lacustrine habitat such as that available in this portion of Wheeler Reservoir.

The snail darter was listed as endangered under the ESA in 1975, and its status was later changed to threatened. It was removed from the federal list of endangered and threatened species effective November 4, 2022 (87 FR 60298-60313; October 5, 2022). Although the snail darter has been federally delisted under the ESA, it currently remains a state listed species in Alabama. TVA has monitored for the presence of this species and has found populations in tributaries to the Tennessee River and in Tennessee River reservoirs. TVA sampling in all mainstem Tennessee River reservoirs from 2017 – 2020 found this species in five reservoirs, including Wheeler Reservoir. It is possible that larvae and adults could be present in Wheeler Reservoir near BFN. However, snail darters prefer clean gravel substrates, and this habitat is most common on the opposite side of Wheeler Reservoir from BFN.

3.9.2. Environmental Consequences – Endangered and Threatened Species

This section addresses potential impacts to threatened and endangered species under the No Action Alternative and the Proposed Action Alternative.

Alternative A – No Action Alternative

Closure of BFN would eliminate the effects on threatened and endangered species from operation. After shutdown, the elimination of operational effects generally would be expected to be small and beneficial for threatened and endangered species at or in the vicinity of BFN.

However, TVA would need to replace the 3,900 MWe of BFN generation. A replacement generation facility constructed at an alternate greenfield site would result in potentially large land-use impacts. If a brownfield site is selected, potential impacts would be similar; however, the impacts would be smaller, or less intense. In addition to the acreage required for the facility itself, land may also be needed to support water lines and the potential construction of a railroad spur or barge dock to transport equipment during construction and operation. In addition, new transmission lines, pipelines, and other associated ROWs would be required as part of this alternative. A generation facility would integrate into TVAs existing transmission line system with the construction of new transmission lines from the plant site to the power grid system.

Direct impacts may occur to threatened or endangered species as a result of clearing and construction operations. Impacts could occur to important threatened or endangered species habitats such as:

- Open waters (e.g., ponds, lakes and large bodies of water)
- Forests (e.g., hardwood, pine-hardwood, mixed hardwood, etc.0
- Waters of the US.
    - Wetlands: forested, scrub shrub, emergent, etc.
    - Streams: perennial, intermittent, ephemeral.

Small indirect impacts may occur as a result of this alternative. Over time, the small changes may induce larger changes such as alterations in the pattern of land use in and around the new facility, and human population density and growth rates that could alter threatened or endangered species and their habitats.

Small to large cumulative impacts may also occur to threatened or endangered species as a result of this alternative because of the potential habitat loss, habitat fragmentation, and decreased biological diversity. Construction of a new plant at an undetermined location and associated power lines in the Tennessee Valley could result in cumulative impacts when combined with all of the past, present, and future construction in the region.

Potential effects would be evaluated in separate analyses once new generation construction project locations and technologies are specifically identified. Measures to avoid, minimize, or mitigate potential impacts would be evaluated. TVA would comply with the ESA by engaging in Section 7 consultation as needed and other applicable regulations pertaining to federally listed and state-listed species.

Alternative B – Proposed Action

Under Alternative B, the Proposed Action, current operational activities at BFN would continue on the existing site. In addition, compliance with the ESA requires consultation with appropriate federal agencies to determine whether threatened or endangered species are present and whether they would be adversely affected by the continued operation of BFN, or refurbishment of facilities, during the proposed subsequent period of extended operation. The potential impacts of Alternative B on animal species with federal or state listing status are discussed below for terrestrial species and aquatic species. Plants with federal or state status or rank have not been recorded in the vicinity of BFN and would not be affected.

Terrestrial Species

Section 3.9.1 describes the special status terrestrial species with a potential to occur in the vicinity of the BFN site. Under the proposed action, TVA would continue to operate BFN according to license requirements, and terrestrial habitats would continue to be managed as they are currently. The species with a federal listing status and/or a state protected status and the potential to occur at BFN are the gray bat, Indiana bat, northern long-eared bat, tricolored bat, monarch butterfly, bald eagle, and osprey.

The gray bat roosts in caves year-round and may occur on BFN property and over Wheeler Reservoir only when foraging. Continued operation of BFN during the proposed subsequent period of extended operation would have no effect on the gray bat.

The Indiana bat (ESA listed as endangered), northern long-eared bat (ESA listed as endangered), and tricolored bat (proposed for listing as endangered under the ESA) roost in trees during the summer. If tree removal became necessary on the BFN property, they could be affected though impacts would be minimized if removal occurred in winter. No refurbishment or other changes to plant structures or activities would be associated with the SLR for BFN, and consequently, no tree removal is planned. The SLR for BFN would not impact any winter or summer roosting habitat for Indiana bat, northern long-eared bat, or tricolored bat. Therefore, the proposed action would not affect Indiana bat, northern long-eared bat, or tricolored bat. Should any tree removal become necessary in the future, those proposed actions would undergo an environmental review process to determine if the trees offer potentially suitable summer roosting habitat for the Indiana bat, northern long-eared bat, or tricolored bat. If the trees to be affected are determined to potentially provide suitable habitat, consultation under Section 7 of the ESA would be required. If the proposed activities fall under TVA's programmatic consultation for routine actions that may impact federal listed bats (completed in 2018), actions and appropriate use of take under the ESA would be documented and reported annually to USFWS. If proposed activities during the proposed subsequent period of extended operation fall outside of those covered under the programmatic consultation, a separate Section 7 consultation would be initiated with the USFWS by TVA to address potential adverse effects on listed (or proposed for listing) bat species. With ongoing implementation of these procedures in conjunction with continued operation of BFN during the proposed subsequent period of extended operation, potential effects on listed bat species would not be significant. The monarch butterfly currently is a candidate for listing under the ESA. As such, it is not subject to ESA Section 7 consultation. The eastern monarch population breeds throughout eastern North

America where milkweeds (*Asclepias* spp.) occur, including Alabama. Its breeding habitat is mainly prairies, meadows, and weedy fields with milkweeds. It is dependent on milkweeds for breeding habitat because they are the only food source for monarch larvae (caterpillars) (USFWS 2020a). Several species of milkweeds potentially could occur in field and wetland habitats at BFN. A wide variety of flowering plants that provide nectar for migrating monarchs also occur in the area. The SLR for BFN does not require any new construction or modifications beyond normal maintenance and minor refurbishment. Therefore, milkweed and nectar sources if present in these habitats would not be impacted by continued operation of BFN. Migrating adults are likely to transit the action area in the fall, but they are highly mobile and would not be affected by continued operation of BFN during the proposed subsequent period of extended operation. For these reasons, the proposed action would not significantly impact monarch populations, and its effects on the species would be small.

The bald eagle could forage in Wheeler Reservoir, and suitable nesting trees are present in the forest fragment along the reservoir in the southeastern corner of BFN, although no bald eagle nests have been documented on the BFN site. The National Bald Eagle Management Guidelines require the maintenance of a 660-foot buffer around bald eagle nest sites and coordination with USFWS to determine if mitigation measures are adequate (USFWS 2007). Bald eagle nests if established within this distance of the BFN site would be protected in accordance with the guidelines. With ongoing implementation of these measures in conjunction with continued operation of BFN during the proposed subsequent period of extended operation, potential effects on the bald eagle would be small.

The osprey is a state protected species and one of many native birds that occur in the vicinity of BFN that are protected by the MBTA. To avoid take under the MBTA, BFN grounds management practices would continue during the proposed subsequent period of extended operation, and activities that must occur within 660 feet of migratory bird nests while nests are active would be limited to bush hogs, mowers, and selective herbicides. If other actions cannot be modified to avoid nesting seasons, coordination with U.S. Department of Agriculture (USDA) Wildlife Services would be required for guidance to ensure compliance with the MBTA and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. With ongoing implementation of these procedures in conjunction with continued operation of BFN during the proposed subsequent period of extended operation, potential effects on the osprey and other migratory birds would be small.

Aquatic Species

Section 3.9.1 describes the special status aquatic species with a potential to occur in the vicinity of the BFN site. The TVA's Regional Natural Heritage Database (queried February 2022) included current or historical records of 15 aquatic species with a federal listing status within a 10-mile radius of BFN and/or within the hydrologic units of the Wheeler Reservoir watershed (Table 3.6-8). These include 13 mussel species federally listed as endangered and two fish species listed as threatened (spring pygmy sunfish and slackwater darter). These species also have a state protected status. An additional 11 mussel species and two fish species (Tuscumbia darter and paddlefish) identified in the query have only a state protected status. As described in Section 3.9.1, the snail darter has been delisted as a federal threatened species, but it still has state protected status and has recently been found to occur in Wheeler Reservoir. The historical and current data (based on surveys conducted in 1982, 1999, and 2021) indicate that rare mussel species with federal or state status do not occur in the portion of Wheeler Reservoir adjacent to and potentially affected by BFN. Therefore, SLR of the BFN operating license would have no effect on mussel species with federal or state status.

As discussed in Section 3.6.2.4, in 21 years (since 1993) of fish entrainment sampling by TVA in the vicinity of BFN, the paddlefish was collected in only 1 year, and the spring pygmy sunfish, slackwater darter, and Tuscumbia darter were never collected (TVA 2020c). The historical and current data indicate that these fish with federal or state status do not occur in the portion of Wheeler Reservoir adjacent to and potentially affected by BFN, and they would not be expected to be present because they do not occur in lacustrine habitat such as that available in this portion of Wheeler Reservoir (NatureServe Explorer 2022). The snail darter has recently been detected in Wheeler Reservoir. However, the only suitable habitat for this species that may be present in the vicinity of BFN is on the opposite side of Wheeler Reservoir from BFN. The snail darter was never collected in the 21 years of fish entrainment sampling at BFN, so its occurrence there is unlikely. Therefore, SLR of the BFN operating license would have no effect on fish species with federal or state status.

3.10. Managed and Natural Areas

This section describes the managed and natural areas that may be affected by the operation of BFN during the proposed subsequent period of extended operation. The areas were identified as potentially affected if located within 6 miles of BFN (Figure 3.10-1). Natural areas include managed areas such as wildlife management areas (WMAs), national wildlife refuges and habitat protection areas, ecologically significant sites, and nationwide rivers inventory streams. Managed areas include lands held in public ownership that are managed by a governmental entity (e.g., TVA, National Park Service, U.S. Forest Service, state or county government) to protect and maintain certain ecological and/or recreational features, but they may or may not have an onsite staff or developed facilities. Properties held in trust or owned by a management entity are the main criteria for their identification as a natural area or managed area.

3.10.1. Affected Environment – Managed and Natural Areas

These managed and natural areas have been recognized and are protected, to varying degrees, because they contain unique natural resources, scenic values, or public use opportunities. These managed and natural areas within 6 miles of BFN are briefly described below.

Mallard-Fox Creek State WMA

Mallard-Fox Creek WMA is located about 2.5 miles south of BFN on the south shore of Wheeler Reservoir in Lawrence County. This WMA covers 1,483 acres and contains habitat types that include hardwood forests, wildlife openings, grasslands, and agricultural fields. This WMA offers bird watching, hunting, canoeing, and fishing opportunities (Alabama Birding Trails 2021).

Swan Creek State WMA

This WMA is located in Limestone County approximately 5 miles southeast of the BFN site and includes 8,870 acres of land and water. Swan Creek WMA is managed for waterfowl and small game (Alabama Birding Trails 2022). Activities open to the public include hiking, boating, canoeing, fishing, and hunting. This area is a stopover for migrating shorebirds in the fall and passerine birds in both spring and fall.

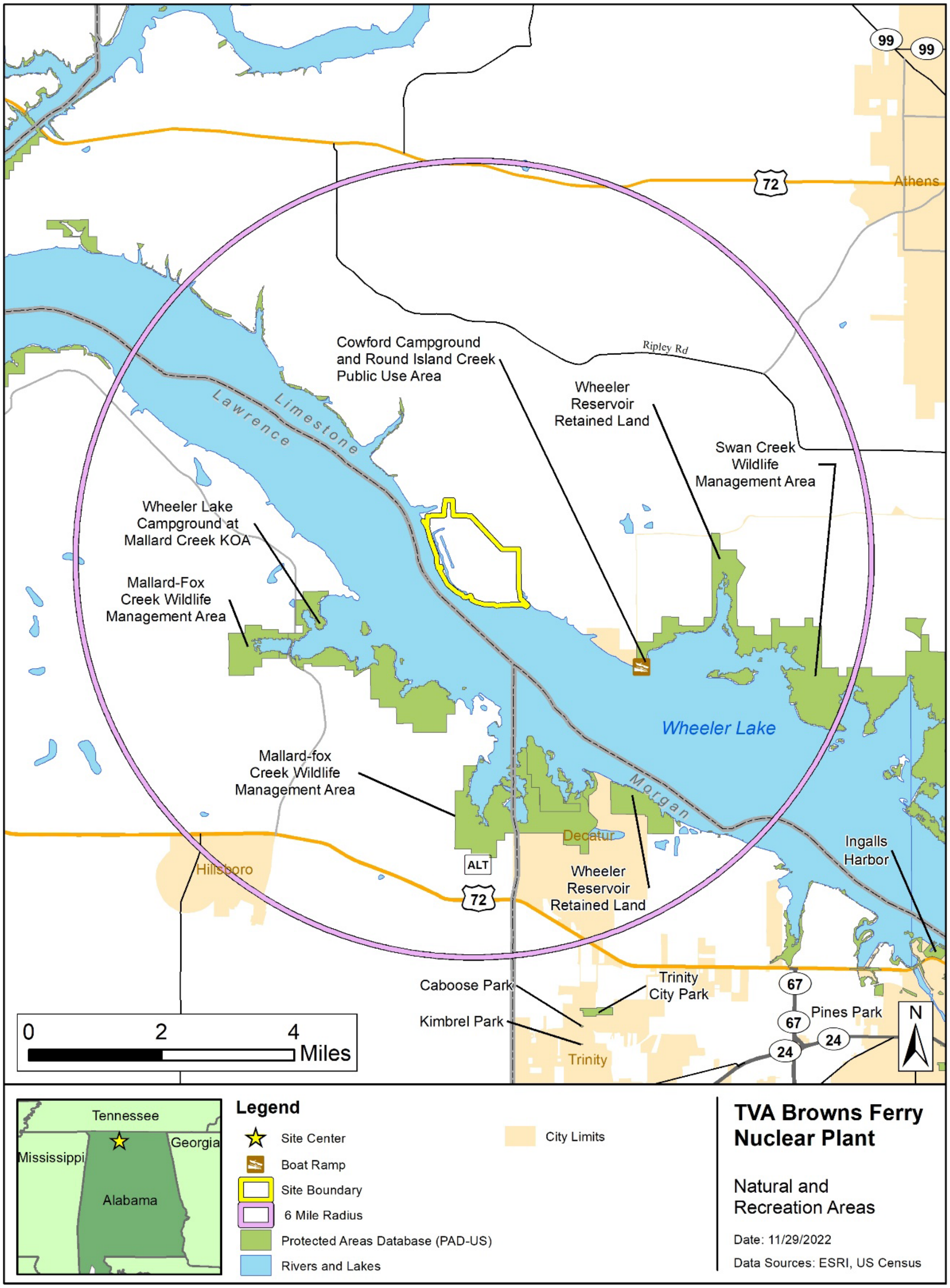


Figure 3.10-1. Managed and Natural Areas Within a 6-Mile Radius of BFN

<u>Wheeler Reservoir Public Land</u>

In 2017, TVA developed a Multiple Reservoir Land Management Plan to guide resource management and administration decisions on land around 46 reservoirs and identify the most suitable uses for the land under TVA's control. Two TVA-managed parcels designated as Zone 6 Developed Recreation, are present with 6 miles of the BFN site. One parcel, the Round Island Creek Recreation Area, is located in Limestone County approximately 4 miles southeast of the BFN site on the south shore of Wheeler Reservoir; it includes the lower portions of the Round Island Creek embayment. Habitats in the area include hardwood forest, patches of planted loblolly pine, and wetlands. This area provides opportunities for fishing, picnicking, and primitive camping. Another parcel immediately west of the Round Island Creek embayment features a mixture of scrub forest, loblolly pine plantation, agricultural fields and wetlands (forested, scrub-shrub, and emergent) with opportunities for fishing, hunting, primitive camping, and wildlife observation (TVA 2017c). A second parcel is located immediately east of the southern portion of the Mallard-Fox Creek WMA in Morgan County approximately 3 miles southeast of the BFN site on the south shore of Wheeler Reservoir (TVA 2017c).

3.10.2. Environmental Consequences – Managed and Natural Areas

This section addresses impacts to managed and natural areas from the No Action and Proposed Action Alternatives.

<u>Alternative A – No Action Alternative</u>

No impacts to managed and natural areas in the vicinity would be expected under this alternative. Closure of BFN would not directly affect managed and natural areas in the vicinity of BFN. However, TVA would need to replace the 3,900 MWe of BFN generation.

Under this alternative, land on greenfield, brownfield, or existing industrial sites would be improved to construct a generation facilities cumulatively equivalent to BFN. It is unlikely that direct impacts to natural areas would occur because of the importance of these resources to local city and county governments, the individual states, and the federal government. Avoidance planning would likely place any potential new generation plants at a safe distance from most natural areas. Small indirect impacts may occur as a result of this alternative. Some of the new generation options would require water for a cooling source as well as a plant discharge point. These typical power plant functions could potentially affect downstream aquatic natural areas with small changes in water flow, contamination, nutrient loads, etc. Over time, the small changes may induce larger changes such as alterations in the pattern of land use in and around the new facility, the population density, and population growth rates.

Small to large cumulative impacts may also occur to natural areas and any associated threatened or endangered species as a result of this alternative because of potential habitat loss, habitat fragmentation, and decreased biological diversity. Impacts of a new generation facility may occur at a considerable distance from many natural areas; however, the impacts could be compounded by other land improvements and development in the general area between the facility and any natural area. Construction of a new plant at an undetermined location and associated transmission lines in the Tennessee Valley could result in cumulative impacts when combined with all of the past, present, and future construction in the region.

Potential effects would be evaluated in separate analyses once new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

Under Alternative B, the Proposed Action, current activities would continue at the BFN site. No known managed or natural areas are immediately adjacent to the BFN site. The distance between existing managed areas and the BFN site provides ample buffer from any operational noise or other operational effects originating from BFN. The helper cooling tower plumes are temporary, seasonal, intermittent, and do not reach these managed areas. In addition, land-use changes in the vicinity would not occur as a result of this alternative. For these reasons, TVA concludes that the impacts on managed and natural areas during the proposed subsequent period of extended operation would be small and would require no mitigation measures beyond those already in place. Because impacts on these areas would be small, TVA concludes that the minor incremental contribution to cumulative impacts from the continued operation of BFN would also be small.

3.11. Recreation

This section describes recreation resources within the vicinity of BFN on the Wheeler Reservoir and in Limestone, Lawrence, and Morgan Counties. This section also addresses potential effects to recreation resources in association with the No Action Alterative and Proposed Action.

3.11.1. Affected Environment – Recreation

Wheeler Reservoir

TVA provides public lands for developed and dispersed recreational purposes through the reservoir. On Wheeler Reservoir, developed recreation opportunities include campgrounds, lodges, marinas, boat launches/ramps, parks, swimming pools, swimming beaches, fishing piers, and day use facilities. Dispersed recreation activities include picnicking, primitive camping, hiking, bank fishing, hunting, kayaking, and canoeing (TVA 2017c).

Wheeler Reservoir is an outdoor recreation resource attracting visitors from within and outside the region. Twenty-five parcels contain developed recreation areas on Wheeler Reservoir including public parks, commercial recreation operations and semi-private clubs. Many of these recreation areas are located on properties that TVA transferred, leased, or licensed for recreation development and use. Public parks developed on lands made available by TVA include Joe Wheeler State Park, Point Mallard Park, and Round Island Creek Recreation Area. Other public agencies, including the State of Alabama and Limestone County maintain boat-launching ramps at strategic locations on public land around the reservoir. Commercial recreation operations include the Ditto Landing Marina and Jay Landings Marina (TVA 2017c).

Stretching 60 miles from Guntersville Dam to Wheeler Dam, Wheeler Reservoir is home to quality fishing. While bass fishing is the most popular fishery in Wheeler Reservoir, the reservoir also provides excellent fishing opportunities for catfish, bream, crappie, and sauger. Part of the Alabama Bass Trail North Division and home to various bass fishing clubs and tournaments, Wheeler Reservoir provides a variety of fishing environments including stump flats, weed beds, creek channels, and steep banks. The return of the grass and a healthy bass population has produced a rebound in Wheeler Reservoir with largemouth bass, smallmouth bass, and spotted bass making the reservoir one of the best fisheries in Alabama (ABT 2022c). Reported catches for many teams during the Alabama Bass Trail May 2022 tournament ranged from 70 to 100 catches over the one-day event (ABT 2022a, ABT 2022b, ABT 2022c, Outdoor Alabama 2022a, Outdoor Alabama 2021).

Recreation Areas within a 6-mile radius of BFN are presented in Figure 3.10-1 and are discussed below.

Decatur/Wheeler Lake KOA Holiday

The Decatur/Wheeler Lake KOA Holiday is located in Lawrence County adjacent to Mallard-Fox Creek WMA approximately 2.2 miles west of BFN on the southern shore of Wheeler Reservoir. The KOA offers recreational vehicle (RV) and tent camping as well as boat rentals, playground, outdoor movie theater, a zipline and rope park, water activities, and biking (KOA 2021a, KOA 2021b, The Raptor Adventure 2021).

Round Island Recreation Area and Cowford Campground

Approximately 3.5 miles upstream of BFN is Round Island Recreation Area, developed and operated by TVA. It features facilities for camping, swimming, picnicking and boat launching. The reservoir in the vicinity of BFN is moderately utilized by recreational boaters and fishermen. Cowford Campground is located within Round Island Recreation Area. This site has 52 seasonal use campsites meant for RV and tent camping along with a boat ramp and fishing/boat pier (Limestone County 2021a). Cowford Campground is within the Round Island Creek Public use area and offers RV camping, swimming, fishing, and boating (Limestone County 2021a).

3.11.2. Environmental Consequences – Recreation

Alternative A – No Action Alternative

Under the No Action Alternative, cessation of BFN operation would not be anticipated to adversely affect recreational facilities or activities within 6 miles of BFN. Because shutdown of BFN would require construction of new replacement power either at BFN or elsewhere within the TVA system, potential effects to recreational resources could result from construction and operation. Those potential effects would be evaluated in separate analyses once new generation construction project locations and technologies are specifically identified. These separate analyses would investigate potential impacts to any national and state parks, public recreation, cultural and historic areas, and wild and scenic rivers. These locations would be assessed for potential adverse impacts that could result from construction and operation. Typically, these locations are considered avoidance areas; however, if a potential facility were sited near a recreational, scenic, or culturally significant area, then noise, dust, viewshed, and watershed impacts would be analyzed. Impacts could range from small to moderate. Some examples of potential mitigation methods could be the use of water to minimize dust, limiting noisy activities to specific times, and utilizing landscaping and painting techniques to limit viewshed impacts.

Alternative B – Proposed Action

Under Alternative B, the BFN SLR would result in no onsite or offsite changes that could potentially impact area recreation. In addition, no known reasonably foreseeable future actions are anticipated to result in land use or other changes within the 6-mile radius of BFN that would impact these recreation areas. Therefore, no cumulative impacts to recreational areas would be expected.

3.12. Meteorology, Air Quality, Climate Change and Greenhouse Gasses

3.12.1. Affected Environment – Meteorology, Air Quality, Climate Change, and Greenhouse Gasses

This section describes the existing air quality and climatic conditions of BFN.

3.12.1.1. Meteorology

The BFN site is adjacent to the Wheeler Reservoir impoundment of the Tennessee River which flows northwest at this location. There are no local physiographical features to cause significant climatological anomalies at the site, as the immediate terrain is flat or slightly undulating, with scattered 400- to 600-foot foothills and ridges located 20 to 25 miles to the east through south and southwest. At the BFN site, Wheeler Reservoir averages 1 to 1.5 miles in width. Normally, discontinuities in ambient thermal structure from differential surface heating between land and water should not cause detectable reservoir breeze circulation at the site area. Limited air mass modification may occur within the lower few hundred feet, particularly with southeast winds, when the over-water trajectory may approach 10 miles.

The climate at the BFN site is interchangeably continental and maritime in winter and spring, predominantly maritime in summer, and generally continental in fall. The mean annual temperature at Decatur, Alabama, is approximately 61.5 °F. In a typical year at Decatur, there are about 70 days with maximum temperatures equal to or greater than 90°F and about 57 days with minimum temperatures equal to or less than 32°F. The most extreme daily temperatures recorded occurred in June 1914 (108°F) and in February 1899 (-12°F).

Rainfall occurs relatively evenly throughout the year. The lowest monthly average is 3.0 inches in October. The highest monthly average is 5.1 inches in March. Major flood-producing storms are of two general types: the cool season, winter type and the warm season, hurricane type. Watershed snowfall is relatively light, averaging only about 14 inches annually. Individual snowfalls are normally light with an average of 13 snowfalls per year. Snowfall is not a factor in maximum flood determinations.

Much of the annual precipitation at BFN results from migratory storms in the winter and early spring (December through April). Most of the remaining precipitation is in June and July when air mass thundershower activity is common. Thunderstorms occur most frequently in July, August, June, and May.

BFN is located in an area occasionally traversed by cyclonic storms. Wind speeds in excess of 40 miles per hour (mph) are occasionally reported, but wind speeds in excess of 75 mph are rare. The estimated probability of a tornado occurrence at the BFN site in any one year is 6.979×10^{-4}, or about one occurrence in 1,433 years should be expected. In spite of the low probability, the plant is designed to withstand tornado forces.

Collection of onsite meteorological data at BFN commenced in February 1967 and continues at present. A BFN meteorological program has been developed to be consistent with the guidance given in NRC Regulatory Guide 1.23 (Revision 0) and the reporting procedures in Regulatory Guide 1.21 (Revision 1).

3.12.1.2. Air Quality

Air quality condition at a given location can be described by the concentration levels of various pollutants in the atmosphere. Under the CAA, the USEPA has established National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50) that specify maximum concentrations for carbon monoxide, particulate matter with aerodynamic diameters of 10 microns or less (PM_{10}), particulate matter with aerodynamic diameters of 2.5 microns or less ($PM_{2.5}$), ozone, sulfur dioxide, lead, and nitrogen dioxide. NAAQS are classified as primary or secondary. Primary standards protect against adverse health effects; secondary standards protect against welfare effects, such as damage to farm crops and vegetation and damage to buildings. Some pollutants have long-term and short-term standards. Short-term standards are designed to protect against acute, or short-term, health effects, while long-term standards were established to protect against chronic health effects.

Areas of the United States that are and have historically been in compliance with the NAAQS are designated by the USEPA as attainment areas. Areas that violate a federal air quality standard are designated by the USEPA as nonattainment areas. Areas that have transitioned from nonattainment to attainment are designated as maintenance areas and are required to adhere to maintenance plans to ensure continued attainment. The USEPA General Conformity Rule applies to federal actions occurring in nonattainment or maintenance areas when the total direct and indirect emissions of nonattainment pollutants (or their precursors) exceed specified thresholds. The emissions thresholds that trigger requirements for a conformity analysis are called de minimis levels. De minimis levels (in tons per year) vary by pollutant and also depend on the severity of the nonattainment status for the air quality management area in question. However, BFN is located in Limestone County, Alabama, which is an attainment area for all criteria pollutants, and therefore the general conformity rule does not apply.

In addition to the NAAQS for criteria pollutants, national standards exist for hazardous air pollutants (HAPs), which are regulated under Section 112 of the CAA. The *National Emission Standards for Hazardous Air Pollutants* regulate HAP emissions from stationary sources (40 CFR Parts 61 and 63).

The Title V of CAA requires states to administer a comprehensive permit program for the operation of stationary sources emitting air pollutants including HAPs. It applies to stationary sources of air pollution that exceed the major stationary source emission thresholds, as well as other non-major sources specified in a particular regulation. The air pollutant emission sources at BFN include the mechanical draft cooling towers, the auxiliary steam generators, the emergency diesel or propane fired generators, emergency pumps, and miscellaneous sources such as fuel storage facilities. BFN is not considered a major source of emissions and is therefore not required to obtain a Title V air permit (TVA 2020b). BFN operates under a synthetic minor source permit (Permit No. 708-0003-X005) issued on November 6, 2020 by ADEM (TVA 2020b). BFN tracks monthly operating hours for each equipment on a 12-month rolling basis. As of July 7, 2022, BFN has been operated in compliance of the synthetic minor source permit conditions (TVA, July 11, 2022).

The CAA, as amended, established Mandatory Class I Federal Areas where visibility is an important issue. No Class I areas exist within 62 miles of the BFN site (NPS 2021).

3.12.1.3. Climate Change and Greenhouse Gasses

Climate change refers to any significant change in measures of climate, such as temperature, precipitation, or wind lasting for an extended period (decades or longer). The Fourth National Climate Assessment concluded that global climate is projected to continue to change over this century and beyond (USGCRP 2018). More frequent and intense extreme weather and climate-related events, as well as changes in average climate conditions, are expected to continue to damage infrastructure, ecosystems, and social systems that provide essential benefits to communities. Future climate change is expected to further disrupt many areas of life, exacerbating existing challenges to prosperity posed by aging and deteriorating infrastructure, stressed ecosystems, and economic inequality.

Annual average temperature over the contiguous United States has increased by 1.8°F (1.0°C) for the period 1901–2016. Over the next few decades (2021–2050) and under all future climate scenarios evaluated, annual average temperatures are expected to rise by about 2.5°F for the United States relative to the recent past (average from 1976–2005) (USGCRP 2018).

Greenhouse Gases (GHGs) are emissions that trap heat in the atmosphere. These emissions occur from natural processes and human activities. Scientific evidence indicates a trend of increasing global temperature over the past century due to an increase in GHG emissions from human activities. The climate change associated with this global warming is predicted to produce negative economic and social consequences across the globe. Climate change is primarily a function of excessive carbon dioxide (CO_2) in the atmosphere. CO_2 is the primary GHG emitted through human activities. Activities associated with the proposed action that produce CO_2 are primarily related to emissions from fossil-fuel-powered equipment (e.g., bulldozers, loaders, haulers, trucks, generators) that may be used in support of any alternative.

Additional GHGs that contribute to climate change include hydrofluorocarbons used in refrigeration equipment; perfluorocarbons used as an etchant and cleaning agent in semiconductor manufacture, sulfur hexafluoride used as a gaseous dielectric medium for high-voltage (1-kV and above) circuit breakers, switchgears, and other electrical equipment; and methane. These gases can be released to the atmosphere through seal leaks, especially from older equipment, as well as during equipment manufacturing, installation, servicing, and disposal (DOE 2011).

The annual GHG emissions at BFN are below the GHG 25,000 tons per year reporting threshold and are not considered to generate appreciable GHG emissions to have potential impact on global climate change.

3.12.2. Environmental Consequences – Meteorology, Air Quality, Climate Change, and Greenhouse Gasses

This section addresses impacts to meteorology, air quality, climate change, and greenhouse gasses from the No Action and Action Alternatives.

Alternative A – No Action Alternative

Under the No Action Alternative, there would be no impact to meteorology. The impact on air quality from shutting down BFN would be a slightly beneficial. BFN would start decreasing the work force, which would reduce the emissions from the workers' vehicles. There would be less mobile and stationary equipment in use, which would decrease emissions. BFN would cease test operation of backup diesel generators, and other carbon-fueled plant equipment and the current operating air permit would be rescinded. Once the destruction and recycling of site structures and facilities began, there would be a brief period of increased pollutant emissions from construction-type activities resulting in temporary adverse air quality impacts.

Under the No Action Alternative, termination of the BFN operating license and shutdown of the plant would have little or no impact on GHG emissions, as the plant emits relatively small quantities of GHG. Because uranium fuel would no longer be needed, the GHG associated with the uranium fuel cycle for BFN would not be emitted.

Should TVA select the No Action Alternative, it would be necessary to also replace the 3,900 MWe of BFN generation. Prior to construction of a new generating plant, local meteorological conditions would be evaluated to model dispersion characteristics as well as the potential impact on the local air quality from the operation of the new facility. No new generation facility would be expected to adversely affect local meteorological conditions. Impacts from GHG emissions would be expected to be small for SMR and solar generation. A new natural gas-fired plant would contribute a substantial amount of GHG emissions for the life of the plant, but substantially less the GHG emissions from a comparably sized coal plant. The impacts are direct and indirect as well as potentially cumulative in the environment. The air emissions would meet all required regulations and would be expected to be small to moderate.

Constructing a new generation plant is similar to many large construction projects. Construction impacts to air quality come from several sources such as fugitive dust emissions, vehicular traffic emissions, heavy equipment emissions, and concrete batch plant emissions. BMPs would be used to control the sources of emissions, and the impacts would be small and of short duration. There would be small indirect impacts off site and no cumulative impacts due to construction.

Under the No Action Alternative, operation of a new SMR or solar plant(s) would not create a significant source of pollutants including GHG, because those facilities produce considerably less air pollutants when compared to fossil-fueled generation sources. Therefore, the environmental impact of a new SMR or solar plant(s) on air quality would be small. Under this alternative, operation of a new natural gas fired plant would increase some air pollutants. The amount of pollutants released is determined by the type of control equipment used in the plant design. The typical quantities of air pollutants released from a modern natural gas-fired turbine, such as the JSF gas turbine project, are small enough (for SO_2, NO_2, CO, and CO_2 emissions) that they would be operated with a small impact to air quality (TVA 2010c). Depending on the chosen location, typical combined-cycle combustion turbine gas-fired generation plants have small to moderate impacts on air quality, but would be designed and operated to meet all air quality standards. New processes are being developed to continue the decrease in pollutants released or sequestered.

The vehicular traffic of personnel commuting to work to any facility would produce small amounts of pollutants, and fugitive dust would occur from vehicles traveling on unpaved roads. With an operational work force of varying size depending on the nature of the new facility, the traffic due to commuting workers would be a small impact. Occasional trucks, diesel engines, and small-source engines would be used, but the impacts would be small. Fugitive dust would be a small impact.

Potential effects would be evaluated in separate analyses once new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

Under Alternative B, BFN would continue to operate under the current conditions. BFN is not a major source of pollutants and would continue to operate under a synthetic minor source air permit as the existing condition. Therefore, the impact of operation for an additional 20-year period would be small. The nuclear fission process produces substantially less air pollutants when compared to replacement fossil-fueled generation sources. The vehicular traffic of personnel commuting to work would produce small amounts of pollutants, and fugitive dust would occur from vehicles traveling on unpaved roads. SLR would support TVA meeting it's carbon-free emissions goals and likely provide a positive air quality impact when compared with other alternatives utilizing combustion sources for power generation. By using nuclear power, the amount of pollutants released into the air would be substantially less than that which may be released from alternative fossil fueled sources as described earlier. It is anticipated that the minimal air quality impacts under Preferred Alternative would be comparable to the renewable energy generation options such as solar.

Under Alternative B, the impacts from the climate change to Alternative B and GHG emissions from the BFN SLR would be expected to be small, similar to the existing condition. Because the duration of SLR is only 20 years, the permanent changes expected would be very small and for normal fluctuations in temperature of the water and air BFN would continue to operate within all thermal limits.

The only reasonably foreseeable local projects that could contribute with BFN to air quality impacts are transportation projects or development projects; however, construction and operation of these projects would be typically with potentially small negligible adverse impacts to air quality. The incremental contribution to cumulative impacts to air quality associated with the continued operation of BFN would be small.

3.13. Transportation

This section addresses non-radiological impacts to transportation in the vicinity of BFN. Transportation of nuclear fuel is discussed in Section 3.21.3.1.

3.13.1. Affected Environment – Transportation

3.13.1.1. Ground Transportation

BFN is located approximately 10 miles southwest of Athens, Alabama. The site is approximately 6 miles south of US Highway 72, which runs in an east-west direction passing through Huntsville, Athens, and Florence, Alabama. BFN is also approximately 9.3 miles and 10.5 miles west of US Highway 31 and Interstate 65, respectively, which both run in a north-south direction east of the site through Athens to the north and Decatur to the south (Figure 1.2-1). US Highway 72 and US Highway 31 are both high quality four-lane routes with good lane widths, alignments, turning lanes, and speed limits of 45 mph through Athens and increasing away from the city.

Employees commuting to and from BFN typically utilize the various paved, two-lane roads in the vicinity of the plant. Immediate road access to BFN is via County Road 20, which runs south from US Highway 72 as Shaw Road and continues east just north of BFN as Nuclear Plant Road, ultimately intersecting with US Highway 31. Browns Ferry Road is also a primary road to the site which runs northeast-southeast from Athens to Nuclear Plant Road near BFN (ALDOT 2022). Shaw Road, Nuclear Plant Road, and Browns Ferry Road are medium quality two lane roads with level alignment, some passing zones, and speed limits of 45 mph.

BFN currently has approximately 2,159 employees and is the primary traffic generator in the vicinity of the site. The employee population peaks at approximately 3,050 to 3,500 employees during refueling outages, which occur every 24 months (per unit) for approximately 35 days or less. Rural residences located along the county roads providing access to the site are also traffic generators in the area. As shown in Table 3.13-1, in 2021, the average daily traffic count on the roadways typically utilized by BFN employees ranged from 1,185 to 30,476 vehicles per day for Browns Ferry Road near BFN and for Interstate 65 near Athens, respectively (ALDOT 2022).

Table 3.13-1. Roadways in the BFN Vicinity and Average Number of Vehicles Per Day

Station ID	Road	2021 Average Daily Traffic Count
Limestone 916	Shaw Road	2,455
Limestone 917	Browns Ferry Rd	1,185
Limestone 119	Nuclear Plant Rd	2,302
Limestone 812	US Highway 72	15,746
Limestone 502	US Highway 31	18,871
Limestone 815	Interstate 65 (Athens)	30,476

Source: (ALDOT 2022)

3.13.1.2. Navigation

The Rivers and Harbors Act of 1899 (RHA) is the initial authority of the USACE regulatory permit program to protect navigable waters of the United States. Section 10 prohibits the unauthorized obstruction or alteration of any navigable water (USACE 2012b). Stretching from its mouth (TRM 0) to its head (TRM 651.1 and the confluence of the French Broad and Holston Rivers), the Tennessee River, which includes the Wheeler Reservoir, is an RHA Section 10 waterway. Regulatory control of Wheeler Reservoir is exercised by the USACE Nashville District (USACE 2022a, USACE 2022b).

Wheeler Reservoir is a navigable waterway used by commercial and recreational traffic. It is one of nine reservoirs that create a stairway of navigable water on the Tennessee River from Knoxville, Tennessee, to the mouth of the Tennessee River at the Ohio River in Paducah, Kentucky (TVA 2021l).

Barge traffic on Wheeler Reservoir has made it one of the major centers for shoreline industrial development on the Tennessee River system. Private industry has invested about $1.3 billion in the waterfront plants and terminals at Decatur, Alabama, the largest city on the Reservoir (TVA 2021l).

3.13.1.3. Air

The nearest airport, approximately 10-miles southeast of BFN is the Pryor Field Regional Airport in Decatur, a general aviation airport. Courtland Airport, a general aviation airport located approximately 13 miles southwest of the BFN, also serves the area. Huntsville International Airport is a full-service commercial airport located about 20 miles southeast of BFN. BFN has an onsite private-use helipad.

3.13.1.4. Railroad

There is an Amtrak station and a CSX Transportation, Inc (CSX) yard (CSX Oakworth Yard) in Decatur approximately 10 and 11 miles southeast of BFN, respectively. The Huntsville and Madison County Railroad Authority is a logistics service with Norfolk Southern (a Class I freight railroad) and CSX interchanges that operate on 13.25 miles of track (Huntsville and Madison County Railroad Authority 2021) 30 miles northeast of the site in Huntsville. The nearest Norfolk Southern station is about 10 miles south of BFN in Decatur.

3.13.2. Environmental Consequences – Transportation

This section addresses impacts to transportation from site construction and operation of the No Action and Proposed Action Alternatives.

Alternative A – No Action Alternative

Under the No Action Alternative, cessation of BFN operation would not adversely affect river navigation, railroad service, or air transportation in the vicinity of BFN. The loss of operation jobs would result in a decline of traffic on County Road 20 and other nearby roads. This could create an increase of available capacity for these area roads. While decommissioning efforts would provide moderate impacts to transportation, these impacts would be temporary. Repurposed use of the decommissioned site would probably provide transportation impacts similar to or less than impacts from the current BFN workforce. Overall, any decline in traffic due to plant closure would likely be partially offset should future housing subdivisions increase along these roads and should the anticipated population increases continue for Limestone County.

In addition, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system.

Construction and operation of a new generation facility would potentially impact the transportation infrastructure and traffic load on the roadways associated with a site. It is expected that a larger construction and operations work force would be required for a new SMR facility than would be required for a new solar facility. Factors that help determine transportation and traffic impacts from construction and operation of a new facility include:

- Number of construction and/or operational workers and expected vehicles on the road.
- Number of shift changes for construction and/or operational work force.
- Projected population growth rate in the region during the construction and operation period.
- Capacity and condition of existing roads.

Should a new power facility be constructed, the facility could be sited in a manner that would reduce or avoid transportation and traffic impacts. However, mitigation of potential transportation impacts due to the location of a facility may be necessary because of expected increases in construction and operation traffic. This mitigation may include need for extensive improvements to roadways and intersections (e.g., roadway widening, ramp improvements, and traffic signal installation) on state and local roads. Other mitigation actions could include employee carpooling or offsite parking with organized transportation, such as buses, to the site. Traffic generated as an outcome of construction activities would be temporary and short term. Scheduling for certain construction activities to occur during off-peak hours could also be an option to reduce conflict with normal traffic use on area roads. Traffic related to operation and maintenance at a potential site would utilize any mitigation improvements established during the construction phase. Impacts could range from small to moderate, depending on project and site-specific conditions.

Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

Under Alternative B, the SLR would not require major new construction, alterations, or refurbishment to BFN to maintain consistency with the current licensing basis. In addition, no change to operation at the plant or addition of operation personnel is anticipated. No resulting impacts to transportation are anticipated due to this action. Additionally, none of the transportation projects described in Section 1.5.1.3 are expected to contribute to cumulative impacts with respect to BFN due to their relatively short construction schedules, distance from the facility, and relative size.

3.14. Visual Resources

3.14.1. Affected Environment – Visual Resources

The terrain on either side of Wheeler Reservoir is relatively flat. Overall, the area surrounding BFN is rural and agricultural with single lane roads and forested areas. For the most part, residences are sparse and generally associated with agricultural fields or are in small shoreline neighborhoods to the northwest and southeast of BFN.

The majority of the BFN facility is visible in daylight from Wheeler Reservoir and the surrounding area located to the south and west. BFN is also visible at night due to exterior night lighting. The largest structures onsite are the reactor building, turbine building, and Cooling Tower 7; the tallest structure on the site is the off-gas stack. Additional structures visible from the south and west of BFN (on or across Wheeler Reservoir) include transmission towers and lines, the switchyard, parking areas, and Cooling Towers 1-6. Paradise Shores, a residential area to the north of the helper cooling towers, is buffered by a wooded areas that blocks the view of the site. When the helper cooling towers are in operation, steam plumes may be present and visible from nearby residences, but helper cooling towers are only used during the summer months as needed. The helper cooling towers, which create the steam plumes, operate only when needed to cool the plant water discharge to comply with the NPDES permit limits (ADEM 2018). During the remainder of the year, when the helper cooling towers are not operating, no plumes would be present.

Views from the west would be the most imposing as the scale of the plant is more obvious from water level and across Wheeler Reservoir. Although the plant contrasts as an industrial feature in an otherwise rural setting, it is not a dominant feature from most views due to its distance from residences and the presence of wooded areas around BFN. The land on the southern side of Wheeler Reservoir is forested and includes Mallard-Fox Creek WMA. The forested areas help shield the view of the facility from observers across the reservoir.

3.14.2. Environmental Consequences – Visual Resources

This section addresses impacts to visual resources from site construction and operation of the Action and No Action Alternatives.

<u>Alternative A – No Action Alternative</u>

Under No Action Alternative, no adverse impacts to visual resources would occur from the shutdown of BFN and with the shutdown of the helper cooling towers, there would be no steam plume; thus providing a beneficial visual impact. During and after decommissioning, objects currently visible to offsite persons may no longer remain or be visible. Visual impacts from repurposed use of the decommissioned site are anticipated to be similar to or less than visual impacts of the BFN site.

In addition, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system.

Under these alternatives, the impact on the visual resources of an area would be dependent upon the physical, biological, and cultural characteristics of the potential new generation site. Topographical relief, vegetative cover, proximity to the public, rural or urban location, construction and operation practices, facility visual features, and atmospheric conditions are all factors that would influence the perception of how a new facility would impact the visual resources of an area.

During the construction phase, there would be the potential for small, temporary small impacts to visual aesthetics in an area due to the staging of construction materials and site preparation, the introduction of construction cranes, and an increase of dust from additional traffic on local dirt roads. More permanent impacts to the viewshed during the operation phase could result from the cumulative effects of introducing cooling towers or exhaust stacks to the skyline, water vapor plume release, transmission lines, and visibility of other prominent facility features. The level of impact anticipated during construction and operation would range from small to moderate and vary depending upon viewer distance from the site, the abundance of trees, hilly terrain, and mitigation measures used, such as utilizing landscape materials on site, and painting techniques applied to facility structures.

Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

Under Alternative B, the BFN SLR would result in only small changes to the BFN site or operations, and to the landscape or area visual resources. In addition, land-use changes in the vicinity would not occur as a result of this alternative; therefore, no cumulative impacts to visual resources would be expected.

3.15. Noise and Vibration

3.15.1. Affected Environment – Noise and Vibration

Noise at BFN is generated by onsite equipment such as diesel generators, transformers, and helper cooling towers. The largest amount of noise from BFN which can periodically be heard offsite is from the helper cooling towers. The helper cooling towers operate most frequently during the summer months when neighborhood houses utilize air conditioning units, which would mask potential outside intrusive noise. Noise sources in the vicinity of BFN include river and lake traffic, road traffic, dogs barking, insects, and power line hum.

At high levels, noise can cause hearing loss, and at moderate levels, noise can interfere with communication, disrupt sleep, and cause stress. At relatively low levels, noise can cause annoyance. Noise is measured in decibels (dB), a logarithmic unit, so an increase of 3 dB is just noticeable, and an increase of 10 dB is perceived as a doubling of the sound level. Because not all noise frequencies are perceptible to the human ear, A-weighted decibels (dBA) that filter out sound in frequencies above and below human hearing are used for this assessment. Ambient environmental noise is usually assessed using the day-night sound level (DNL). The DNL is a weighted logarithmic 24-hour average with a 10-dB penalty added to noise between 10 p.m. and 7 a.m. to account for the potential for sleep disruption (USEPA 1974).

Community noise impacts are typically judged based on the magnitude of the increase above existing background sound levels. Although there are no federal, State of Alabama, or local municipal noise standards, regulations or ordinances that are applicable to the SLR, USEPA's noise control guideline recommended average annual equivalent DNL of 55 dBA to protect the health and well-being of the public can be used as a measure of annoyance from industrial noise in a noise sensitive neighborhood (USEPA 1974). Furthermore, as recommended by the Federal Interagency Committee on Noise (FICON), a 3-dBA or greater increase in DNL indicates a possible impact when the background is 60 dBA or less (FICON 1992).

A 24-hour ambient noise sample was collected at BFN on August 8, 2012, when six of the seven helper cooling towers were in operation and on September 6, 2012, when none of the helper cooling towers were operating (Ensafe 2012). The noise measurements on both dates were measured at the location of the nearest residence to BFN in the Paradise Shores Community, approximately 500 feet from the BFN property boundary. Based on the 24-hour noise measurements, the DNLs were calculated to be 61.9 dBA and 59.7 dBA with and without helper cooling towers operating, respectively (Ensafe 2012). Although the measured ambient background level without BFN helper cooling towers operating exceeded the EPA-defined 55 dBA threshold in DNL, the BFN helper cooling tower operations met the FICON guideline of an allowable 3-dBA or less increase in DNL at residences (FICON 1992).

A second 24-hour ambient noise assessment was conducted between July 30 and July 31, 2020 at the same sample location as in 2012, during which a DNL of 62.5 dBA was calculated (Cardno 2020). The most recent measurement collected at this location between August 1, 2022 and August 2 shows a 61.4 dBA in DNL (Cardno 2022) when helper cooling towers were in operation, which is slightly lower but comparable to the 2020 measurement. These measured sound levels were similar to the 2012 DNLs, indicating that ambient noise levels around the BFN have remained essentially unchanged over the years. Additionally, the USEPA noted that if a community is accustomed to the noise levels and the noise maker maintains a positive relationship with the community, then the day/night average sound level can be lowered by 5.0 dBA (USEPA 1974). After this correction, the average DNL measured most recently in August 2022 would be 57.5 dBA.

The results of these noise surveys, which focused on impacts to nearby residences (Cardno 2020, Ensafe 2012), indicate that the noise from the dominant sources at the BFN, i.e., operation of helper cooling tower(s) is barely noticeable by identified noise sensitive receptors in the vicinity.

3.15.2. Environmental Consequences – Noise and Vibration

This section addresses impacts to noise environment from the No Action and Action Alternatives.

<u>Alternative A – No Action Alternative</u>

Under the No Action Alternative, the shutdown of BFN and the resulting cessation of cooling tower operation, would ultimately result in a drop in industrial noise from the BFN site resulting in a small beneficial impact long-term. As the destruction and recycling of site structures and facilities began, there would be a brief period of noise increase from construction-type activities resulting in temporary and small noise impacts. In addition, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system.

<u>Construction</u>

The site of a new generation alternative is unknown. Noise impacts are dependent on the distance to the nearest critical receptor, so no specific dBA values for receptor locations can be determined. Noise for the construction of a new generation plant is expected to be small to moderate (depending on location and type of sensitive receptor) because most noise-producing construction activities are of short duration (minutes to hours per day) and the construction is temporary, likely being completed in approximately five to seven years (short-term), and there are numerous mitigation methods that can be implemented to limit the impact of noise.

Sources of noise in the construction of a new power generation facility are numerous and include large heavy equipment such as bulldozers, draglines, scrapers, and haulers to excavate earth, grade, and prepare for building placement. Other phases of construction would require the use of cranes, front loaders, graders, forklifts, man lifts, compressors, backhoes, dump trucks, a pier driller, and portable welding machines. It may also require the use of a concrete batch plant. These types of equipment would generate noise levels up to 98 dB at 50 feet (USDOT 1973). Construction noise of 98 dBA at 50 feet would be about 65 dBA at an approximate half-mile site boundary; a 6 dBA decrease each time the distance is doubled from the source (CERES 2009). This noise level would continue to decrease until reaching the nearest residence or noise-sensitive receptor location (hospital, library, nursing home, etc.). Noise at a sensitive receptor location at 1 mile would be below 60 dBA. Noise from construction equipment is expected to be audible over background noise levels, but it is not expected to cause a noticeable adverse impact. Mitigation measures might include noise shields around stationary equipment, limited hours of operation, properly maintained noise suppression equipment on machinery, and equipment operation limited to the day shift only.

Depending on site geology and soils, site preparation for the construction of a SMR or gas plant may require blasting, which would cause temporary noise impacts. Potential mitigation measures include, but are not limited to, the use of blasting blankets, notification of the surrounding receptors prior to blasting, and limiting blasting activities to daylight hours.

Traffic noise from the commuting of workers would be noticed and the impact would be small to moderate. Mitigation can be accomplished by using multiple shifts and encouraging car-pooling activities.

Construction noise associated with new transmission systems are expected to be small. The construction is usually of short duration, measured in days for each substation or tower location, while access roads and corridors may take a few weeks. The amount of heavy equipment needed to construct transmission systems is considerably less than a major construction site. Cranes and trucks are the major types of heavy equipment, whereas wood-clearing equipment such as chain saws and chippers may be used to clear vegetation. Out of safety concerns, construction activities for transmission systems are usually daytime-only projects, which helps limit the noise interfering with nighttime sleeping hours.

Based on projected noise levels and the temporary duration of construction activities, noise impacts from construction activities associated with this alternative are expected to be small for the surrounding communities, and small to moderate for the nearest residents. There is a direct impact on the construction site due to noise, but mitigation measures would be employed, and a formal worker hearing protection program would be implemented that would be similar to the current program in effect at BFN. Indirect impacts off site would be small and temporary during construction for surrounding animals. Some animals might avoid the area, but many would become accustomed to the noise.

Operation

The major noise source in the operation of a new SMR plant is normally the cooling tower, with noise level dependent on the type of cooling tower chosen. A reasonable expectation for a nuclear unit with mechanical draft cooling towers is approximately 85 dBA near the tower and 55 dBA at 1,000 feet from the towers. At the potential nearest residence (approximately 0.5 miles from the site boundary), noise from the cooling tower is expected to be well below 50 dBA, which is similar to rural background noise levels in a typical rural area. These levels would not exceed EPA's recommendation or HUD's guideline for residential areas.

The operational noise sources of motors, generators, pumps, trucks, and cars for any type of generation facility are typical of an operating industrial facility. The permanent work force would produce traffic noise during its commute to and from work. Offsite noise levels are in line with rural residential areas.

Based on the projected noise levels, noise impacts associated with the implementation of this alternative are expected to be small for the surrounding communities and the nearest residents. Direct impacts on site would require a formal hearing protection program as per Occupational Safety and Health Administration requirements (29 CFR Part 1910). There would not be any indirect impacts off site needing mitigation. Noise impacts are not normally cumulative and would not provide any cumulative impacts in the long term.

The operation of a new natural gas-fired plant would have noise sources similar to other large industrial facilities. Cooling towers, fans, pumps, compressors, boilers, etc. are usually on a smaller scale than nuclear or coal plants, but still produce noise as they are used to support plant operations. Natural gas-fired sites are usually smaller than coal or nuclear facilities, and may be located closer to residences or sensitive receptors due to the smaller area required to separate the site from the public. However, noise levels would still be expected to be within acceptable background noise levels at the nearest residence. Operational noise associated with a solar facility would be less than for a SMR or gas facility

Based on projected noise levels, noise impacts from the operation of this alternative are expected to be small for both the surrounding communities and for the nearest residents.

Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

<u>Alternative B – Proposed Action</u>

Under Alternative B, no new sources of noise would be introduced during the proposed subsequent period of extended operation. There are no plans for changes to the facility, procedures, or programs that could increase the noise generated from the BFN facility. Noise impacts associated with operation of BFN are small, even with the operation of the helper cooling towers. The noise sources of motors, generators, pumps, trucks, and cars are typical of an industrial facility. Offsite noise levels are currently similar to the noise levels in a rural residential area and would be expected to remain at the current levels. Additionally, there are no cumulative projects in the vicinity of BFN as discussed in Section 1.5.1.3 that would contribute to noise in the project area due to their distance from the site. Therefore, the noise impacts due to the SLR are expected to be small with no change from the current conditions.

3.16. Socioeconomics

This section describes socioeconomic conditions and evaluates the impacts associated with the proposed action and no action alternative related to population, employment and income, housing, local government revenues, and community services and schools in the vicinity of BFN.

3.16.1. Population

3.16.1.1. Affected Environment – Population

The socioeconomics region of influence around a nuclear power plant is defined by the counties where plant employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. Changes in nuclear power plant operations affect socioeconomic conditions in the regions surrounding them (NRC 2013).

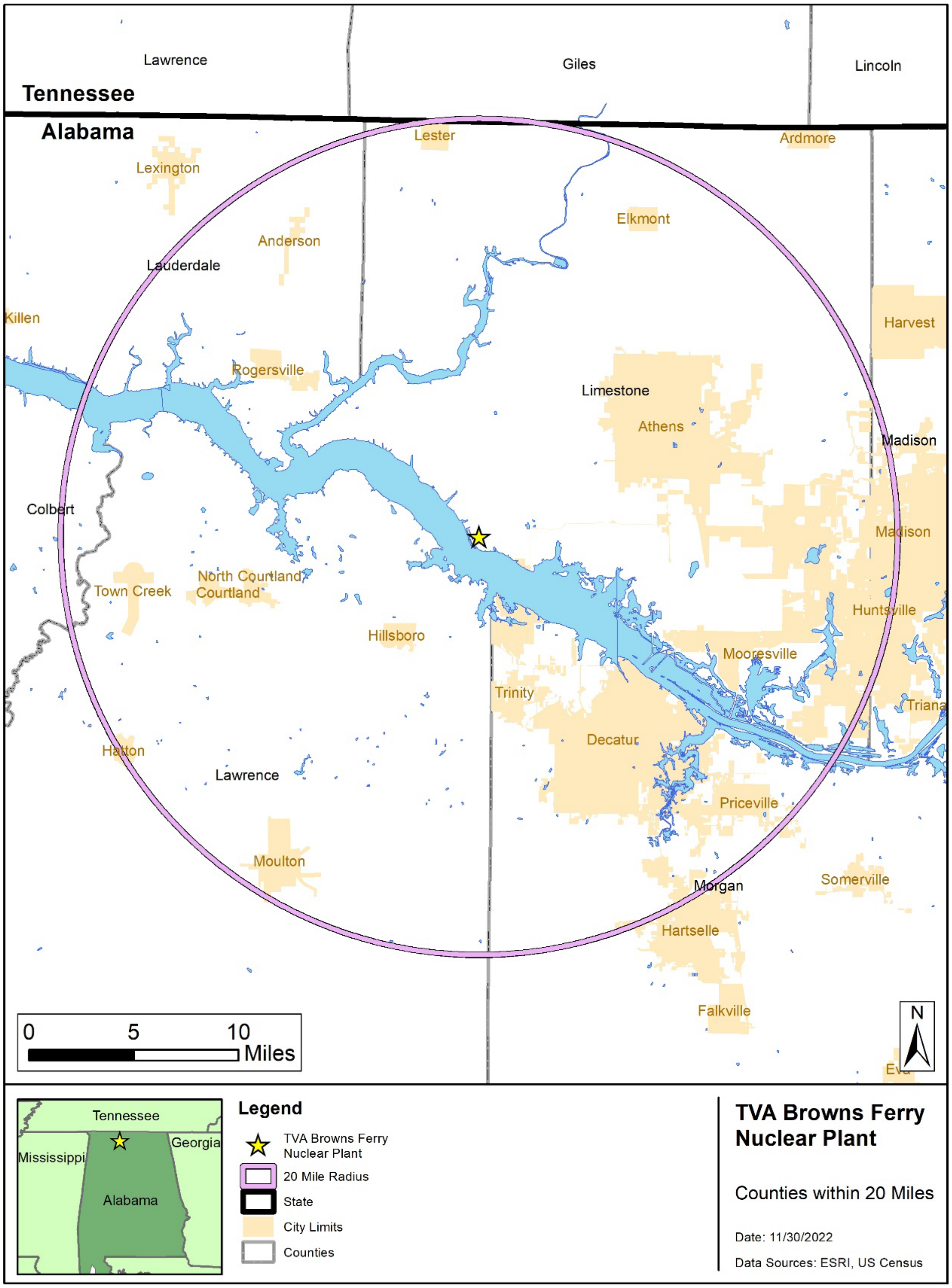
There are 21 counties within a 50-mile radius of the site, located in both Alabama and Tennessee (Figure 1.2-1). Of these, 14 counties are located in Alabama and seven counties are in Tennessee There are five cities in a 50-mile radius of BFN that have a population greater than 25,000. According to the 2020 decennial census, these cities are Athens city, Alabama (10.4 miles) with population of 25,406; Decatur city, Alabama (10.0 miles) with population of 57,938; Florence city, Alabama (32.6 miles) with population of 40,184; Huntsville city, Alabama (30.0 miles) with a population of 215,006; and Madison city, Alabama (20.8 miles) with a population of 56,933 (ArcGIS 2021, USCB 2020d). Three metropolitan areas are located largely or totally within the 50-mile zone: Decatur, Florence-Muscle Shoals, and Huntsville, all in Alabama (USCB 2021b).

As shown in Figure 3.16-1, there are seven counties within a 20-mile radius of the site. Six counties are located within Alabama (Colbert County, Franklin County, Lauderdale County, Lawrence County; Limestone County, Madison County and Morgan County) and one within Tennessee (Giles County). Three counties (Colbert, Madison and Giles) have only a very small edge or corner and very little population within the 20-mile zone (ArcGIS 2021).

Approximately 83.2 percent of the employees (contract workers and employees) live in Alabama, 7.0 percent live in Tennessee, and the remaining 9.8 percent is distributed across 35 other states. A majority of employees, approximately 1,681 (61.7 percent), live in three Alabama counties: Lauderdale (32.9 percent), Limestone (18.4 percent) and Colbert (10.4 percent). Thus, these three counties are considered the socioeconomic region of influence for this analysis and the following discussion specifically focuses on population growth in these three counties in relation to the State of Alabama.

As shown in Table 3.16-1, the population of Colbert, Lauderdale, and Limestone Counties, Alabama as reported in the 2020 decennial census was 57,227, 93,564 and 103,570 respectively (USCB 2020d). Population density per square mile in Colbert, Lauderdale and Limestone Counties was 96.5, 140.1 and 185.0 respectively (USCB 2022b).

Population projections for Alabama Counties were provided by the Alabama State Data Center, a partnership between the U.S. Census Bureau (USCB) and the State of Alabama. The projections, released in August 2022, utilized population data from the latest decennial census (2020) and provided a county population estimate every 5 years beginning with 2025 and ending in 2040. Because the proposed renewal of the BFN Units would extend plant operations to the year 2056 as described in Chapter 1, the population growth trend established in state-provided population projection data was extended out to include the years leading up to 2056. To project population to 2056, the actual growth rate of population change for each county was established for the years between 2020 and 2040 as presented by the state demographer. Those rates were then applied to the years 2041 through 2056 using a straight line method, as shown in Table 3.16-1 (ASDC 2022, USCB 2020d).



Source: (ArcGIS 2021)

Figure 3.16-1. Counties within 20 Miles of BFN

Table 3.16-1. Colbert, Lauderdale and Limestone County Projected Population Estimates and Growth Rates

	Colbert County		Lauderdale County		Limestone County	
Year	Projected Population	Average Annual Growth Rate (percentage per year)	Projected Population	Average Annual Growth Rate (percentage per year)	Projected Population	Average Annual Growth Rate (percentage per year)
2020[a]	57,227		93,564		103,570	
2025[b]	57,803	1.01	94,966	1.50	112,669	8.79
2030[b]	58,380	1.00	96,368	1.48	121,768	8.08
2035[b]	58,956	0.99	97,770	1.45	130,867	7.47
2040[b]	59,532	0.98	99,172	1.43	139,966	6.95
2041[c]	59,652	0.20	99,469	0.30	142,425	1.76
2042[c]	59,772	0.20	99,767	0.30	144,928	1.76
2043[c]	59,892	0.20	100,066	0.30	147,474	1.76
2044[c]	60,013	0.20	100,366	0.30	150,066	1.76
2045[c]	60,134	0.20	100,667	0.30	152,702	1.76
2046[c]	60,255	0.20	100,969	0.30	155,385	1.76
2047[c]	60,376	0.20	101,271	0.30	158,116	1.76
2048[c]	60,498	0.20	101,575	0.30	160,894	1.76
2049[c]	60,620	0.20	101,879	0.30	163,721	1.76
2050[c]	60,742	0.20	102,184	0.30	166,598	1.76
2051[c]	60,864	0.20	102,491	0.30	169,525	1.76
2052[c]	60,987	0.20	102,798	0.30	172,503	1.76
2053[c]	61,110	0.20	103,106	0.30	175,534	1.76
2054[c]	61,233	0.20	103,415	0.30	178,619	1.76
2055[c]	61,356	0.20	103,725	0.30	181,757	1.76
2056[c]	61,480	0.20	104,036	0.30	184,951	1.76

a USCB 2020 decennial census. Source: (USCB 2020d)
b Projected population values for 2025, 2030, 2035 and 2040. Source: (ASDC 2022)
c Projected population values for 2041 and thereafter are based on the extension of the population projection growth trend established from 2020 to 2040.

As shown in Table 3.16-1, the projection population for Colbert County is estimated to be 61,480 in the year 2056, a 3.3 percent increase from projected year 2040. The average projected annual growth rate between 2040 and 2056 is 0.20 percent per year. The projected population for Lauderdale County is estimated to be 104,036 in the year 2056, a 4.9 percent increase from projected year 2040. The average projected annual growth rate between 2040 and 2056 is 0.30 percent per year. The projected population for fast growing Limestone County is estimated to be 184,951, a 32.1 percent increase from projected year 2040. The average projected annual growth rate for this period is 1.76 percent. Projected population density per square mile in Colbert, Lauderdale and Limestone Counties for the year 2056 would be 103.7, 155.7 and 330.3 respectively (USCB 2022b).

Population was estimated from the BFN site out to 20-mile and 50-mile radii using the results of the USCB 2020 decennial census and geographic information system (GIS) software (ArcView) to determine demographic characteristics in the BFN vicinity. Block Groups not wholly within the area were allocated on the basis of the land area within the area. According to this analysis, 225,115 individuals live within 20 miles of the BFN site, for a population density of 179 persons per square mile (USCB 2020d). A total of 1,074,109 persons live within 50 miles of the site, for a population density of 136 persons per square mile (USCB 2022b).

3.16.1.2. Environmental Consequences – Population

<u>Alternative A – No Action Alternative</u>

Under the No Action Alternative, BFN operating licenses would not be extended, resulting in a shutdown of BFN and the resulting loss of jobs. The loss of employment for approximately 1,681 employees residing in Colbert, Lauderdale and Limestone Counties would have a negligible effect on the permanent population. As of 2020, the combined population of the Counties was greater than 250,000. These employees comprise less than one percent of the combined population. All counties project population growth; thus, any adverse impact to population as a result of plant shutdown would be short-term and small.

In addition, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. This may help offset the loss of jobs from BFN if some BFN employees were able to transfer to the new facility, it may also result in a corresponding small shift in population should the new facilities be constructed outside of the BFN vicinity. The level of impacts to population associated with construction and operation of a new generation facility would vary depending on the workforce requirements for that facility. During construction there may be a temporary influx of workers to the area. The operational workforce would likely relocate permanently to within commuter range of the new facility. Overall impacts to population associated with construction of a replacement generation facility would depend to a great extent on the size of the population around the site and the availability of housing and amenities. Potential effects from construction and operation of a new facility would be evaluated in separate analyses once the new power generation construction project locations and technologies are specifically identified. Impacts could range from small to moderate.

<u>Alternative B – Proposed Action</u>

With little or no change in employment at BFN during the proposed subsequent period of extended operation, no impacts to regional population would be anticipated as a result of continued power plant operations. Consequently, TVA concludes that there also would be no incremental contribution to cumulative impacts to population from the continued operation of BFN.

3.16.2. Employment and Income

3.16.2.1. Affected Environment – Employment and Income

Employment data by industry sector for 2020 are presented in Table 3.16-2. In 2020, total employment (number of jobs) in Alabama was 2,612,469. Lauderdale County had the highest number of jobs (42,760) which represented 1.6 percent of the total jobs in the state. Colbert and Limestone Counties had 30,948 (1.2 percent) and 38,080 (1.5 percent) respectively (BEA 2020).

Table 3.16-2. Top Employing NAICS Industry Categories

	Colbert, AL	Lauderdale, AL	Limestone, AL	Alabama
Total employment (number of jobs)	30,948	42,760	38,080	2,612,469
Farm employment	2.1%	3.1%	3.3%	1.6%
Construction	8.5%	6.5%	10.0%	5.8%
Manufacturing	18.5%	6.3%	11.1%	10.3%
Retail trade	11.7%	13.8%	12.9%	10.5%
Health care and social assistance	7.3%	12.1%	4.5%	9.6%
Accommodation and food services	5.5%	8.9%	5.2%	6.7%
Other services (except government and government enterprises)	6.4%	7.2%	7.5%	6.3%
Government and government enterprises	15.6%	13.3%	19.4%	15.5%

Source: (BEA 2020).

Generally, the dominant industry sectors in the Counties are similar to those of the state, which were Government and government enterprises (15.5 percent), retail trade (10.5 percent) and manufacturing (10.3 percent). The dominant industry sectors in Colbert County were manufacturing (18.5 percent), government and government enterprises (15.6 percent) and retail trade (11.7 percent). Lauderdale County had a greater percentage share of retail trade (13.8 percent) and health care and social assistance (12.1 percent) as compared to the state and the other counties but a smaller percentage of government and government enterprises (13.3 percent). The dominant industry sectors in Limestone County were government (19.4 percent), retail trade (12.9 percent) and manufacturing (11.1 percent) (BEA 2020). The Counties had a greater percentage share of farm employment as compared to the state.

In 2020, per capita income in the state was $46,479. Per capita income in Colbert and Lauderdale Counties was less than the state at $41,941 and $40,729 respectively. Per capita income in Limestone County ($47,695) was higher than the other Counties and the state (BEA 2022).

The 2020 unemployment rate for the Alabama was 6.5 percent. In comparison, Lauderdale, Limestone and Colbert Counties had 2020 unemployment rates of 5.5, 4.3, and 6.6 percent, respectively (BLS 2020a, BLS 2020b).

3.16.2.2. Environmental Consequences – Employment and Income

Alternative A – No Action Alternative

Under the No Action Alternative, BFN operating licenses would not be extended, resulting in a shutdown of operations and the resulting loss of jobs. As of 2020, there were over 110,000 jobs in the three-County area. BFN employment represents approximately 1.5 percent of employment in the three-County area. The level of impact to individual communities would depend on whether BFN employees would choose to continue to work within or near their current communities, or whether they would choose to find employment elsewhere. Therefore, any adverse impact to employment and income as a result of plant shutdown would be small.

In addition, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. The necessary construction workforce would likely come from local and regional sources, creating hundreds of new and indirect jobs for several years. The phasing out of construction personnel and phasing in of a smaller operational workforce has the potential to cause a boom and bust scenario, where a community might not only experience a subsequent drop in overall populations, but also the need for staffing certain indirect jobs. This could result in substantial employment impacts to local communities and counties near the new generation site(s). An incoming permanent workforce would help offset the loss of certain jobs and also create others. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. The overall impacts could range from small to moderate, depending on specific site conditions.

Alternative B – Proposed Action
With little or no change in employment at BFN expected during the proposed subsequent period of extended operation, employment and income would not be affected by continued power plant operations. Because no impacts are expected to employment and income, TVA concludes that there also would be no incremental contribution to cumulative impacts to employment and income from the continued operation of BFN.

3.16.3. Housing

3.16.3.1. Affected Environment – Housing
TVA refuels each nuclear unit on a 24-month cycle on a staggered basis. During these refueling outages, site employment increases by approximately 900 temporary workers for 28 to 35 days. Some temporary workers are from the BFN vicinity whereas others come into the area for temporary stays and may require accommodations which could impact the availability of housing.

Table 3.16-3 provides the number of housing units and housing unit vacancies for the years 2000, 2010 and 2020. Between 2010 and 2020 available housing units grew 7.4 percent in Colbert County (USCB 2000, USCB 2012, USCB 2020c). The 2020 vacancy rate was 11.7 percent. During the same period, available housing units grew 1.8 percent in Lauderdale County. The 2020 vacancy rate was 11.3 percent (USCB 2000, USCB 2012, USCB 2020c). Available housing units in fast growing Limestone County grew 22.1 percent. The 2020 vacancy rate was 7.8 percent (USCB 2000, USCB 2012, USCB 2020c, USCB 2020e).

Table 3.16-3. Housing Units and Housing Units Vacant (Available) by County – 2000, 2010 and 2020

	2000	2010	2020	Percent (%) Change 2000-2010	Percent (%) Change 2010-2020	Percent (%) Change 2000-2020
Lauderdale County						
Housing Units	40,424	43,791	44,585	8.3	1.8	10.3
Occupied Units	36,088	38,680	39,544	7.2	2.2	9.6
Vacant Units	4,336	5,111	5,041	17.9	-1.4	16.3
Vacant Units Percent (%) of Total Units	10.7	11.7	11.3	0.9	-0.4	0.6

	2000	2010	2020	Percent (%) Change 2000-2010	Percent (%) Change 2010-2020	Percent (%) Change 2000-2020
Limestone County						
Housing Units	26,897	34,977	42,692	30.0	22.1	58.7
Occupied Units	24,688	31,446	39,365	27.4	25.2	59.4
Vacant Units	2,209	3,531	3,327	59.8	-5.8	50.6
Vacant Units Percent (%) of Total Units	8.2	10.1	7.8	1.9	-2.3	-0.4
Colbert County						
Housing Units	24,980	25,758	27,666	3.1	7.4	10.8
Occupied Units	22,461	22,773	24,425	1.4	7.3	8.7
Vacant Units	2,519	2,985	3,241	18.5	8.6	28.7
Vacant Units Percent (%) of Total Units	10.1	11.6	11.7	1.5	0.1	1.6

Source: (USCB 2000, USCB 2012, USCB 2020c)

Each of these counties had vacancy rates greater than 5 percent in 2020, indicating the availability of housing. Available housing remained flat (decreased less than 1 percent) as compared to 2010 when approximately 11,627 units were available in those three counties combined (USCB 2000, USCB 2012, USCB 2020c).

3.16.3.2. Environmental Consequences – Housing

Alternative A – No Action Alternative

Under the No Action Alternative, the loss of operational jobs could have a dampening effect on the housing market. Housing costs may slightly decrease, as a result of additional available housing caused by the possible migration of operational workers to other locations. This migration and subsequent reduction in housing costs could have a small temporary impact, however, these effects would be short-lived in fast growing Limestone County and should also be of short duration in Colbert and Lauderdale counties as well.

In addition, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. Depending on a site's proximity to a large labor force and an area's economic characteristics, construction workers might choose to commute from their established residences, seek short-term rental facilities within commuter range, or acquire more permanent housing in a local area near a potential site. Operational workers would be expected to move into the area within a commuting distance from the site. Residential locations would depend on the availability of suitable housing facilities and local zoning codes and could be located anywhere within the labor market area. The strains on localized housing markets could lead to increased prices for some types of housing and/or a potential shortage of accommodations. The demand for housing would begin to diminish after the peak construction employment level is reached and essentially disappear by the end of the construction period. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. Impacts on housing would be expected to range from small to moderate if a facility were located in a sparsely populated area with readily available housing. Impacts could range to large if a potential site were located in a sparsely populated area with little or no available housing.

Alternative B – Proposed Action

With little or no change in employment at BFN expected during the proposed subsequent period of extended operation, and no impact expected to regional population, housing availability and values would not be affected by continued power plant operations. TVA concludes that there also would be no incremental contribution to cumulative housing impacts from the continued operation of BFN.

3.16.4. Local Government Revenues

3.16.4.1. Affected Environment – Local Government Revenues

TVA does not pay property taxes; however, in accordance with federal law, Section 13 of the TVA Act, 16 U.S.C. 8311, TVA makes payments in lieu of taxation to states and counties in which its power operations are carried on and in which it has acquired properties previously subject to state and local taxation. Under Section 13, TVA pays 5 percent of its gross power revenues to such states and counties. Only a very small share of the payments is paid directly by TVA to counties; most is paid to the states, which use their own formulas for redistribution of some or all of the payments to local governments. TVA's payments in lieu of taxes are apportioned among the states and counties according to a complex allocation formula, but in general, half of the money is apportioned based on power sales and half is apportioned based on the "book" value of TVA power property.

Title 40 Chapter 28 of the Alabama State Code, updated in 2010, specifies how the state of Alabama distributes TVA payments in lieu of taxes to its counties (Alabama Legislature 2012). The State of Alabama retains 17 percent for general fund purposes, allocates 78 percent to TVA-served counties based on a formula of TVA's book value of power property and power sales, and redistributes 5 percent to dry counties and municipalities that are not served by TVA (Alabama Legislature 2012). TVA-served counties share a portion of their payment with cities (based on a population ratio), school systems, and hospitals within their boundaries. In 2022, Alabama’s payment in lieu of taxes allocation from TVA was approximately $82.4 million.

Total TVA in-lieu-of taxes payments for 2021 were about $415.4 million, of which Alabama received $79 million. Estimated payments for 2022 are a total of $424.2 million. This amount would include an estimated $82.4 million to Alabama.

According to the Annual Report to the Tennessee General Assembly, Tennessee receives more than 67 percent of the total distributed by TVA’s formula based on gross power revenues. Title 67, Chapter 9, Part 1 of the Tennessee Code Annotated specifies how the payments in lieu of taxes are distributed to cities and counties with additional payments set aside for local governments in counties with TVA construction. Local governments receive more than 40 percent of the amount TVA allocates to Tennessee for distributes through the state’s formula (State of Tennessee 2022). Tennessee’s payments in lieu of taxes allocation from TVA was approximately $341.8 million in 2021.

3.16.4.2. Environmental Consequences – Local Government Revenues

Alternative A – No Action Alternative

Under the No Action Alternative, there would be a small impact on local government revenues due to the consequent change in TVA’s payments in lieu of taxes. As described in Section 3.16.4.1, TVA's payments in lieu of taxes are apportioned among the states and counties according to a complex allocation formula, but in general, half of the money is apportioned based on power sales and half is apportioned based on the "book" value of TVA power property. Therefore, changes in power sales at BFN would affect TVA’s payments in lieu of taxes to Alabama and the counties around BFN.

Additionally, construction and operation of replacement generation sources would result in a beneficial impact if the total amount of TVA-managed land in any individual county increased and if there were a change in power sales and the value of TVA power property in different areas of the Tennessee Valley. Revenue increases would be proportionally small. Any in-lieu-of-tax payment distribution to the local government(s) would be apportioned based on the specific state's legislative decision. Whether the local government's existing tax base is small or large, the disbursement would have a beneficial impact.

Alternative B – Proposed Action

With little or no change in regional population, operating employment levels at BFN, and payments in lieu of tax expected during the proposed subsequent period of extended operation, local government revenues would not be affected by continued power plant operations. Therefore, TVA also concludes that there would be no incremental contribution to cumulative impacts to local government revenue from the continued operation of BFN.

3.16.5. Police, Fire, and Medical Services

This section addresses impacts to police, fire, and medical services in the socioeconomic region of influence (Limestone, Lauderdale, and Colbert counties) where the majority of the BFN workforce resides. Additionally, Lawrence and Morgan counties which are located within the 6-milde vicinity of BFN are included due to their proximity to the plant and the possible need for emergency response support from these counties.

3.16.5.1. Affected Environment – Police, Fire, and Medical Services

If a situation evolves where outside emergency support becomes necessary at BFN, the plant communicates its need to a number of local and state emergency service agencies. Limestone, Lawrence, and Morgan Counties have a wide array of public safety agencies providing services to its residents, including a number of municipal police departments, sheriff's departments, volunteer and career community fire departments, emergency medical services, and area hospitals. Advance plans and arrangements have been made in conjunction with state and local authorities, where applicable, for warning the local populace of an emergency and possible evacuation response. Emergency response activities can include evacuating the area around the plant site, preventing entry of the public to affected areas, medical care of injured or exposed personnel, surveying affected areas for radioactivity, and restricting use of water supplies and foods. The following sections describe the police, fire, and medical services within the socioeconomic region of influence as well as within the 6-mile vicinity of BFN since they may need to respond to the facility in the event of an emergency due to proximity.

Limestone County

Limestone County has three police stations, two of which are associated with Athens (Limestone County 2021b). There are 27 fire departments in Limestone County, serving a population of 91,695 people in an area of 560 square miles, which is approximately one fire department per 3,396 people and one fire department per 20 square miles (CountyOffice.org 2021b). Unincorporated areas within the county are policed by the Limestone County Sheriff's Office which has several divisions including patrol, animal control, aviation, court security, and investigations (Limestone County 2021e). Limestone County also has two hospitals in Athens: Athens-Limestone Hospital and North Alabama Specialty Hospital (ALHA 2021).

Lawrence County

Lawrence County has five police stations associated with incorporated towns (Lawrence County 2021). There are 11 fire departments serving a population of 33,288 people in an area of 691 square miles. This is approximately one fire department per 3,026 people and one fire department per 62 square miles (CountyOffice.org 2021a). Unincorporated areas are served by the Lawrence County Sherriff's Office, whose divisions include administration, special services, civil processes, search and rescue, and patrol (Lawrence County 2022). Lawrence County also has one hospital in Moulton: Lawrence Medical Center (ALHA 2021).

Morgan County

Within Morgan County, the City of Decatur has six police zones (City of Decatur Alabama 2018). Additionally, the City of Priceville has its own police department (City of Priceville 2021). There are 46 fire departments in Morgan County, serving a population of 119,157 people in an area of 580 square miles. There is one fire department per 2,590 people and one fire department per 12 square miles (CountyOffice.org 2021c). The Morgan County Sheriff's Office duties include enforcement of all federal, state, and local laws; maintaining peace and order in the county; protecting property and personal safety; providing professional public safety dispatching services and generally assisting citizens in need. Other responsibilities include, providing a safe and secure jail, ensuring proper care, custody, treatment, supervision and discipline for all persons committed to the custody of the Sheriff, and to properly receive and execute any and all legal civil processes referred to the Office of the Sheriff (Morgan County Sheriff 2021). Morgan County also has three hospitals in Decatur: Decatur Morgan Hospital, Decatur Morgan Hospital – Parkway Campus, and Decatur Morgan West Behavioral Medical Center (ALHA 2021).

Colbert County

Colbert County has nine police departments including multiple stations in Muscle Shoals and Tuscumbia (CountyOffice.org 2022i). There are 22 fire departments in Colbert County serving a population of 54,435 people over an area of 593 square miles. With 15 volunteer fire departments and 7 dedicated fire departments, Colbert County has one fire department per 2,474 people or one per 26 square miles (CountyOffice.org 2022c). Headquartered in Tuscumbia, the Sheriff's Department includes 31 full-time sworn officers; providing patrol of unincorporated areas and areas not covered by municipal police as well as enforcing foreclosures and repossessions (CountyOffice.org 2022a). Colbert County has five hospitals with four in Sheffield and one in Muscle Shoals (Alabama Public Health 2022, CountyOffice.org 2022e).

Lauderdale County

Lauderdale County has 11 police departments including stations in Florence and Rogersville (CountyOffice.org 2022j). There are 32 fire departments in Lauderdale County serving a population of 92,590 people over an area of 668 square miles. With 18 volunteer fire departments and 14 dedicated fire departments, Lauderdale County has one fire department per 2,893 people or one per 20 square miles (CountyOffice.org 2022d). Headquartered in Florence, the Sheriff's Department includes 35 full-time sworn officers; providing patrol of unincorporated areas and areas not covered by municipal police as well as enforcing foreclosures and repossessions (CountyOffice.org 2022g). Lauderdale County has three hospitals, Shoals Hospital, Eliza Coffee Memorial Hospital, and North Alabama Medical Center a 263-bed general hospital, all located in Florence (Alabama Public Health 2022, CountyOffice.org 2022f).

3.16.5.2. Environmental Consequences – Police, Fire, and Medical Services

Alternative A – No Action Alternative

Shutdown of BFN would result in a phased reduction in the need for public safety services should operational staff relocate out of the country in the event of BFN shutdown. Additionally, the need for emergency personnel sourced from agencies and organizations that support emergency preparedness plans for BFN would be greatly reduced. As described in Sections 3.16.1 and 3.16.2, respectively, the counties in the vicinity of BFN have a growing population and a number of employment options. Therefore, it is likely that the reduced need for public safety services would be offset by continued growth in these counties.

Support from local emergency service providers would become a necessity during the construction and operation of new generation sources needed to replace BFN. Depending on the proximity to population centers and the availability of emergency services in the vicinity of these generation resources, the influx of construction workers could impact the ability of an area's police, fire, and medical facilities to provide support requiring additional resources. With workers leaving at the end of the construction phase, permanent investments made in the expansion of public safety services would support incoming operational staff and families expected to permanently move to the area, as well as other further county population growth. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. Overall, impacts on police, fire, and medical services would be expected to range from small to moderate.

Alternative B – Proposed Action

Under Alternative B, BFN License Renewal, little change in regional population and operating employment levels is anticipated during the proposed subsequent period of extended operation; thus, the impact to area's police, fire, and medical services would remain consistent with current impacts. Therefore, impacts of SLR to public safety would be small to moderate.

3.16.6. Schools

This section addresses impacts to schools most likely impacted by BFN. Because the bulk of BFN workers and their families reside in Lauderdale, Limestone, and Colbert Counties (approximately 33 percent, 18 percent, and 10 percent of workers, respectively), impacts to Lauderdale, Limestone, and Colbert Counties are addressed.

3.16.6.1. Affected Environment – Schools

Lauderdale County

Lauderdale County has 26 public schools and 4 private schools serving a population of 92,590 (CountyOffice.org 2022l, CountyOffice.org 2022n). Lauderdale County is also home to two universities, both in Florence, namely Heritage Christian University and the University of North Alabama. The former university, accredited by the Association for Biblical Higher Education, provides Associate, Baccalaureate, and Master's level biblical studies to a student body of 90. The latter is a comprehensive regional state university offering undergraduate and graduate degree programs to a student body of almost 7,100 (CountyOffice.org 2022b, Heritage Christian University 2022, ReviewSchools.org 2022).

Limestone County

Limestone County has one public school district with 17 schools in the district (Limestone County Schools 2022). There are three private schools in Limestone County serving a population of 91,695 people in an area of 560 square miles, which is approximately one private school per 186 square miles (CountyOffice.org 2021d). Athens City Schools is a K-12 public school district with seven schools and low student-to-teacher ratios (Athens City Schools 2021).

Limestone County also has two colleges. Calhoun Community College is Alabama's largest two-year college approximately 11 miles south of Athens in Tanner. The college offers a wide variety of associate degree programs and career/certificate programs and currently has over 12,000 students. Athens State University is located in downtown Athens and serves almost 2,800 graduates of state junior, community, and technical colleges and institutes (City of Athens 2021).

Colbert County

Colbert County has 28 public schools and 2 private schools serving a population of 54,435 (CountyOffice.org 2022k, CountyOffice.org 2022m). Colbert County is also home to Northwest Shoals Community College in Tuscumbia, Alabama (CountyOffice.org 2022h).

3.16.6.2. Environmental Consequences – Schools

Alternative A – No Action Alternative

Under the No Action Alternative, the loss of operational jobs could result in a loss of population in the counties surrounding BFN where a large percentage of BFN operational workers live (Section 3.16.3). This could have a dampening effect on school attendance if it results in out-migration of workers and their families, particularly in Colbert, Lauderdale, and Limestone counties where the majority of BFN workers currently live. There could also be a corresponding reduction in tax revenues and plant equivalent payments. However, as some operation workers and families could remain in the area and the population in the county is expected to grow, the overall impact is likely to be small.

In association with construction and operation of new replacement generation sources, it is expected that workers with accompanying family members would access available school facilities. For construction workers, the ability to find adequate housing and length of employment are two factors that could dictate whether they opt to have family members present during the time period when construction work is phasing out. It is expected that operational workers migrating to an area would be more likely to bring their families, resulting in an increased demand for school facilities. If a site were located in proximity to a populated metropolitan area with numerous schools, an influx of students would most likely be absorbed into a school system or enrollment would be spread among a number of school systems, thus having little impact on resources. Should a new generation facility be sited in a less populated area with fewer educational resources, the influx of new students from construction and operational worker families could cause a strain on a community’s educational infrastructures. The arrival of workers and the facility would bring new monies to a region through direct and indirect spending, and in the long run, the costs of providing education for additional students should be offset by the increase in tax revenues and plant equivalent payments, therefore impacts should be small.

Alternative B – Proposed Action

Under Alternative B, BFN SLR would result in no change to operating employment levels at the plant. No new impacts to schools would be anticipated through this action. Consequently, TVA concludes there also would be no incremental contribution to cumulative impacts to schools from the continued operation of BFN.

3.17. Environmental Justice

Regarding environmental justice, EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, issued on February 11, 1994, is designed to focus the attention of federal agencies on the human health and environmental effects of its programs, policies, and activities on minority and low-income communities (59 FR 7629). While TVA is not subject to this executive order, it evaluates potential environmental justice impacts as a matter of policy. The environmental justice review involves identifying potential offsite environmental impacts, their geographic locations, minority and low-income populations that may be affected, the significance of such effects, and whether they are disproportionately high and adverse compared to the population at large within the geographic area, and if so, what mitigative measures are available, and which would be implemented.

TVA used 2020 decennial census data from the USCB to determine the percentage of the total population within Alabama for each minority category and to identify the aggregate minority populations. Estimates from the 2016-2020 American Community Survey were used to identify the low-income population. TVA used ArcView® GIS software to combine 2020 USCB block group data with Environmental Systems Research Institute tract-boundary spatial data to determine the minority and low-income characteristics of populations in the 20-mile radius of BFN.

The Council on Environmental Quality (CEQ) guidance for performing environmental justice reviews defines a “minority” population as: Hispanic, Latino, or Spanish origin; American Indian or Alaskan Native; Asian; Black or African American; Native Hawaiian and Other Pacific Islander; or individuals who identified themselves on a census form as being a member of two or more races (CEQ 1997). The guidance indicates that a minority population exists if either of the two following conditions exists:

- Exceeds 50 Percent – the minority population of an impacted area exceeds 50 percent or
- Meaningfully Greater – the minority population percentage of the impacted area is meaningfully greater (for this analysis at least 10 percent) than the minority population percentage in the geographic area chosen for comparative analysis.

CEQ guidance defines “low-income” by using USCB statistical poverty thresholds (NRC 2013) The guidance indicates that a low-income population exists if either of the two following conditions exists:

- Exceeds 50 Percent – the low-income population of an impacted area exceeds 50 percent or
- Meaningfully Greater – the low-income population percentage of the impacted area is meaningfully greater (for this analysis at least 10 percent) than the low-income population percentage in the geographic area chosen for comparative analysis.

3.17.1. Affected Environment – Environmental Justice

This section describes minority and low-income populations within the 20-mile radius of BFN. As discussed in Socioeconomics (Section 3.16) and shown in Figure 3.16-1, there are seven counties within a 20-mile radius of the site. Six counties are located within Alabama (Colbert County, Franklin County, Lauderdale County, Lawrence County; Limestone County, Madison County and Morgan County) and one within Tennessee (Giles County) (ArcGIS 2021). This geographic area was chosen because of the influence of BFN activities and the BFN workforce on socioeconomic conditions in the surrounding vicinity. The geographic unit used in the analysis to identify environmental justice communities of concern is the census block group. The State (Alabama and Tennessee as applicable) is the geographic area chosen for comparative analysis. All block groups located wholly or partly within 20 miles of BFN were included in the analysis. The 20-mile radius includes 172 block groups. The following sections describe the minority and low-income populations found within the 20-mile radius.

3.17.1.1. Minority Population

Table 3.10-1 presents the number of census tracts within each county that exceed the threshold for determining the presence of a minority population. For each of the 172 census block groups within 20 miles of BFN, TVA calculated the percent of the population for the aggregate minority population as well for each minority group (Black, Latino, Asian, Native American, Native Hawaiian, other, multi-race) and compared the result to the corresponding threshold percent to determine whether a significant minority population exists. For Alabama, the presence of a significant minority population was found in four of six counties (66.7 percent) and in 52 of 169 block groups (30.8 percent). In Tennessee, only one county (Giles County) lies within the 20-mile radius, and contained no minority block groups (USCB 2020a, USCB 2020f).

The most prevalent minority population in Alabama was Black or African American. As shown in Table 3.10-1, Black or African American populations exist in 15 block groups. Hispanic minority populations are the second most common and exist in 31 block groups, all in Alabama(USCB 2020a, USCB 2020f). No minority block groups exist in Giles County, the only county in Tennessee included within the 20-mile radius.

Figure 3.17-1 shows the aggregate minority population block groups within 20 miles of BFN. Figure 3.17-2 shows the significant Hispanic and Black or African American Block Groups within a 20-mile radius of BFN which tend to be concentrated in urban areas.

3.17.1.2. Low-Income Population

Table 3.17-1 presents the number of census tracts within each state and county that exceed the threshold for determining the presence of low-income populations. The “meaningfully greater” threshold yields a more conservative estimate. Based on an analysis of U.S. Census Bureau ACS 2016-2020 population estimates, TVA determined the percent of low-income block groups within the 20-mile radius from BFN. In Alabama, 14.8 percent of blocks groups were low-income. In Tennessee, there were no low-income block groups within the 20-mile radius. Figure 3.17-3 shows the locations of significant low-income populations within the 20-mile radius (USCB 2020b).

3.17.2. Environmental Consequences – Environmental Justice

<u>Alternative A – No Action Alternative</u>

Under the No Action Alternative, the loss of operational jobs would not disproportionately impact the minority and low-income populations within the vicinity of BFN. As discussed in Section 3.16-2, the resulting loss of operational jobs would have a negligible effect on population, employment, and income. Housing costs may slightly decrease, as a result of additional available housing caused by the possible migration of operational workers to other locations. This migration and subsequent reduction in housing costs could have a small temporary beneficial impact, however, these effects would be short-lived in fast growing Limestone County and in other nearby also growing counties. The overall, impact to socioeconomic resources is expected to be short-term and small, and therefore, will not have a disproportionate impact to potential environmental justice communities of concern.

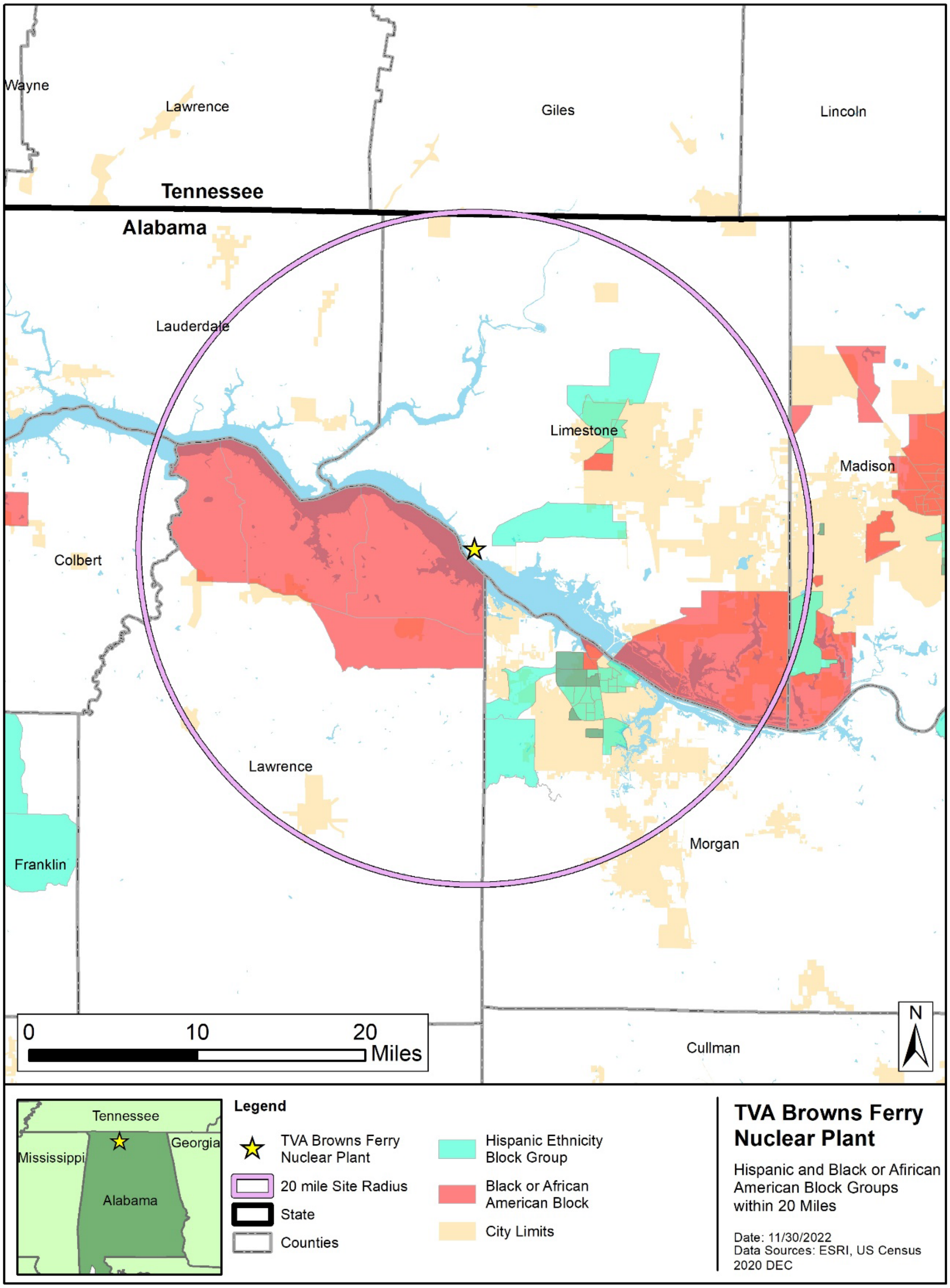


Figure 3.17-1. Minority Populations Within 20-Mile Radius of BFN

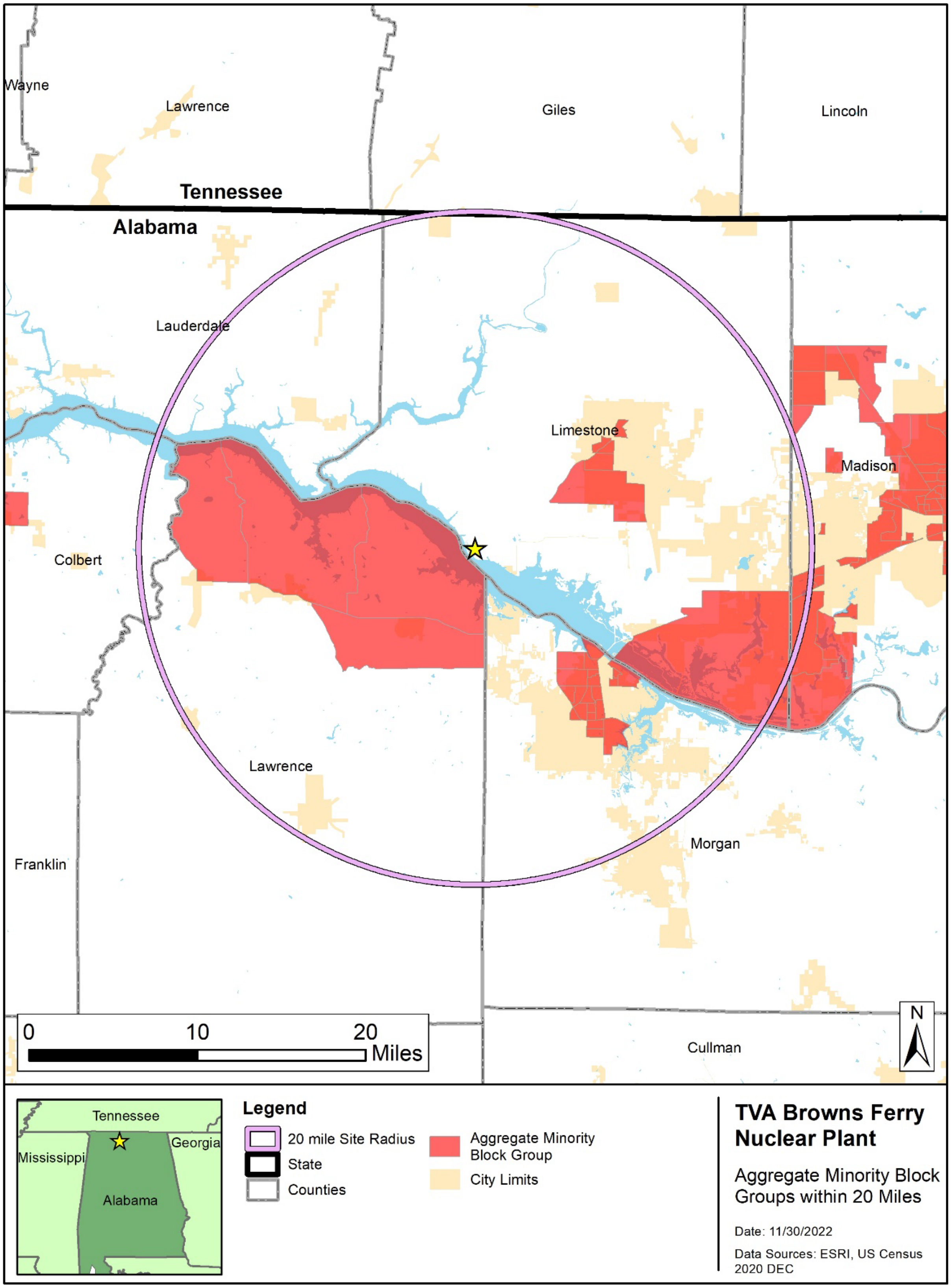


Figure 3.17-2. Aggregate Minority Populations Within 20-Mile Radius of BFN

Table 3.17-1. 2020 U.S. Census Race and Ethnicity Category and Low-Income Populations Within 20-Mile Radius

State / County	Total Number of Block Groups	Low-Income Block Groups	Minority Block Groups							
			Aggregate	Black or African American	American Indian or Native Alaskan	Asian	Native Hawaiian or Other Pacific Islander	Some Other Race	Multiracial	Hispanic
Alabama	**169**	**25**	**35**	**15**	**0**	**5**	**0**	**0**	**1**	**31**
Colbert	3	0	0	0	0	0	0	0	0	0
Lauderdale	10	0	0	0	0	0	0	0	0	0
Lawrence	27	4	4	4	0	0	0	0	1	0
Limestone	49	7	6	2	0	2	0	0	0	6
Madison	18	0	4	2	0	3	0	0	0	1
Morgan	62	14	21	7	0	0	0	0	0	24
Tennessee	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Giles	3	0	0	0	0	0	0	0	0	0

Source: (USCB 2020a, USCB 2020b, USCB 2020f)

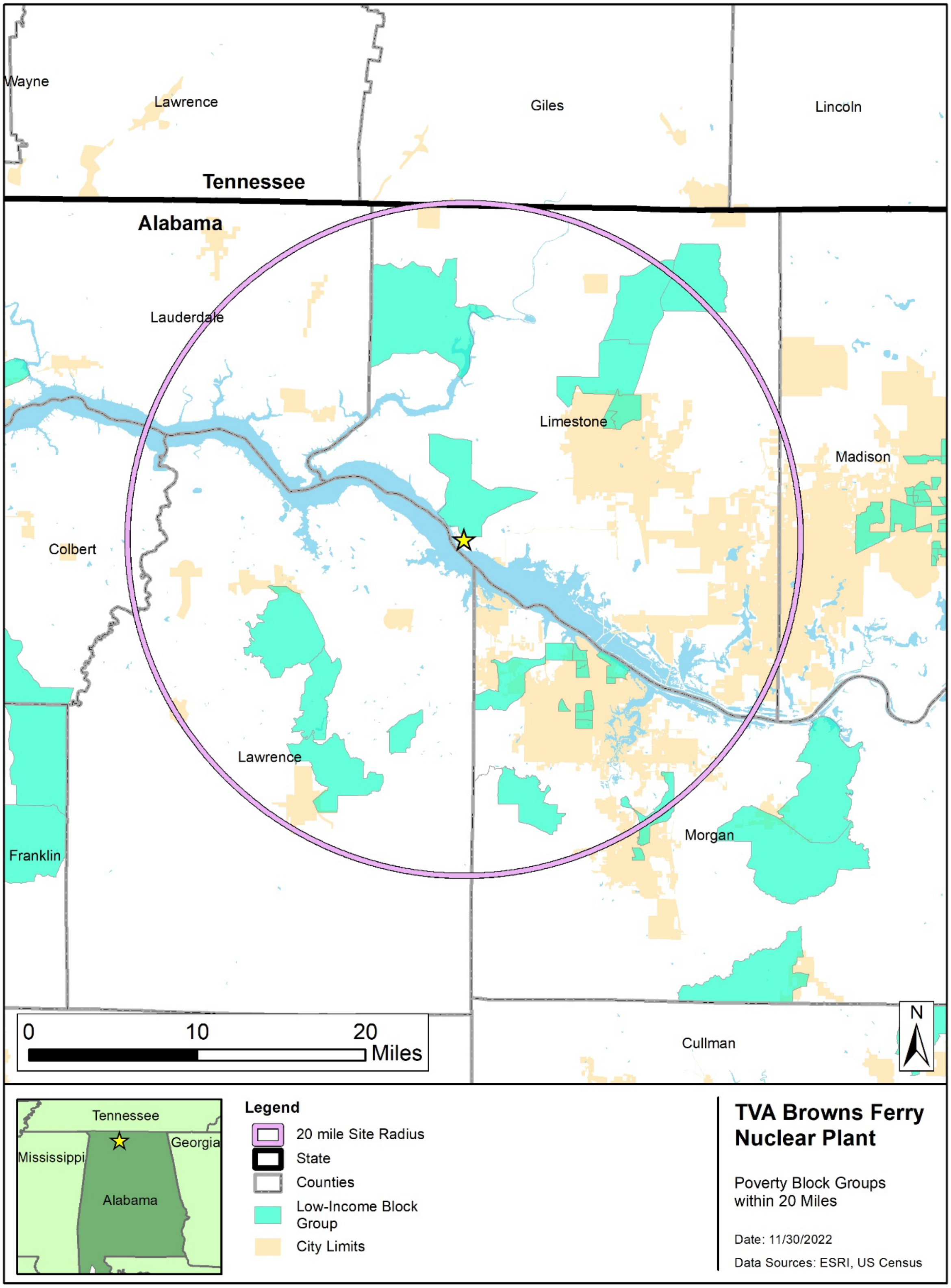


Figure 3.17-3. Low-Income Populations Within 20-Mile Radius of BFN

In addition, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. Environmental justice issues would depend on the proposed location. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. Potential impacts that might disproportionately impact minority or low-income communities include, for example, pressure on food and housing process, or increases in road congestion or noise near residential communities. The type and level of impact would vary depending upon proximity, mitigation measures, and general construction and operation practices. Impacts could range from small to moderate.

Alternative B – Proposed Action

The area of interest contains minority populations subject to consideration as potential environmental justice communities of concern. BFN SLR would result in no changes in operating employment levels at the plant. In its analysis of current conditions, TVA did not identify any location-dependent, disproportionately high and adverse impacts to minority and low-income populations resulting from continued operations of BFN. There would be beneficial impacts realized, such as sales taxes paid by TVA and BFN workers shopping in the vicinity of the plant. These in turn benefit local public services for the general population, including minority and low-income groups in the community. Based on the analysis of impacts for all resource areas presented, it is determined that there would be no significant adverse health impacts on members of the public or significant adverse environmental impacts on the physical environment (water, air, aquatic, and terrestrial resources) and socioeconomic conditions for continued plant operations. Therefore, there would be no disproportionately high and adverse environmental or economic effects on minority populations. Consequently, TVA concludes that there also would be no incremental contribution of the continued operation of BFN to the cumulative environmental justice conditions in the region during the proposed subsequent period of extended operation.

3.18. Archaeological and Historic Resources

As a federal agency TVA complies with Section 106 of the National Historic Preservation Act (NHPA) for TVA undertakings that have the potential to affect properties included or eligible for inclusion in the National Register of Historic Places (NRHP). As required by 36 CFR Part 800.1-13, TVA determines the undertaking's area of potential effects (APE), identifies appropriate consulting parties, and follows the processes for identifying historic properties, evaluating project effects, and resolving any adverse effects to historic properties. TVA follows these steps in consultation with the appropriate consulting parties including state historic preservation officers (SHPOs) and tribal governments. In addition, the Categorical Exclusion Checklist (for projects that do not require an Environmental Assessment [EA] or Environmental Impact Statement [EIS]) specifically includes consideration of actions which can potentially affect historic structures, historic sites, Native American religious or cultural properties, or archaeological sites.

BFN SLR qualifies as an undertaking with potential to affect historic properties (§800.16(y)) given that the project "may require maintenance actions or refurbishment to BFN to maintain consistency with the current licensing basis, as well as NRC and TVA requirements… [and that] plant improvements including intake structures, buried piping, and large external tanks would be expected upgrades for continued operation from 60 to 80 years." TVA has not yet identified plans for any such actions. However, if such actions were proposed in future, they could include modifications that have potential to alter the qualities that may lend historic significance to BFN, if BFN were determined eligible for inclusion in the NRHP, and could also include ground disturbing activities, which would have potential for effects to archaeological sites that may be eligible, or considered potentially-eligible, for inclusion in the NRHP. TVA determined the APE for the undertaking as BFN and all areas within the 880-acre reservation.

3.18.1. Affected Environment – Archaeological and Historic Resources

TVA has previously consulted with the Alabama SHPO regarding an undertaking that resulted in physical effects on BFN, the BFN Cooling Tower Additions Project, in 2010. TVA found that the cooling tower capacity upgrades would not appreciably alter the existing silhouette of BFN and would therefore have no visual effect (letter from Howard to Hathorn dated September 24, 2010). The Alabama SHPO agreed that the upgrades would not result in adverse effects to historic properties (letter from Brown to Howard dated October 25, 2010) but did not comment on BFN's NRHP eligibility. In informal email correspondence with AL SHPO in regards to the Thermal Performance Program EA, the SHPO clarified that "the 1974 cooling towers would not be National Register eligible due to age, the fact they were not part of the original design, and since they have lost their historic context" due to the replacement of five of BFN's six original cooling towers after 2010 (RE: TVA-Browns Ferry Nuclear Plant - Proposed cooling tower demo - section 106, email from Wofford to Cole dated March 6, 2020).

TVA completed an architectural assessment of the Browns Ferry Aquatic Research Facility (BFARF) in 2018 (Karpynec and Weaver 2018). Based on this assessment, TVA determined that the BFARF is eligible for the NRHP under the Secretary of the Interior's Criteria Consideration G of 36 CFR Part 60.4 ("A property achieving significance within the past 50 years if it is of exceptional importance") as a contributing resource to BFN, which although considered NRHP-eligible by TVA had not been determined eligible in consultation (Jones to Wofford May 21, 2018). The historic significance of the BFARF relates to TVA's efforts in the late twentieth century to study the environmental effects of heated water discharged from its nuclear-powered plants on regional aquatic life. The SHPO agreed by letter dated June 20, 2018. In consultation with SHPO, TVA proposed mitigation and prepared a draft Memorandum of Agreement (Jones to Wofford, September 19, 2018, October 12, 2018, and November 16, 2018), but TVA's plan to remove the BFARF was later cancelled, and the mitigation was not completed.

Because actions that may be completed by TVA in connection with the SLR could take place after BFN has reached or passed the 50-year age threshold for consideration as a historic property, TVA conducted a historic architectural inventory of BFN and assessment of BFN's eligibility for inclusion in the NRHP (Reynolds 2022) to identify historic properties in the APE as required by §800.4. Based on this study, TVA has determined that BFN currently is eligible for the NRHP under Criteria Consideration G as a historic district with a period of significance of 1966-1980. BFN will not meet the 50-year threshold for NRHP eligibility until 2023. However, given that the primary buildings and structures at BFN were completed between 1973 and 1976, they will soon meet the 50-year threshold to be eligible for the NRHP under Criteria A and C for their association with early nuclear energy development in Alabama and the TVA system, and as representative examples of nuclear energy engineering and architecture. The BFN historic district is comprised of 49 buildings and structures. The Unit 1, Unit 2, and Unit 3 Reactor Buildings are individually eligible, and 46 buildings/structures are eligible as contributing to the district. The contributing buildings/structures include, as examples: the Units 1-3 containment structures, multiple diesel generator buildings, the Intake Pumping Station, Turbine Buildings, Discharge Structure, BFARF, Meteorological Tower, Switchyard, and Warm Water Channel. Twenty structures within the boundaries of the district are considered non-contributing due to being built after 1980. The NRHP boundary is the BFN reservation boundary. Pursuant to the regulations implementing the NHPA, TVA provided this report (Reynolds 2022) to SHPO and invited their comments on the study and on the NRHP eligibility of BFN . The SHPO agreed with TVA’s findings and eligibility determination (Wofford to Osborne, November 14, 2022). Based on this finding, BRF is considered a historic property and TVA must the consider potential effects on BFN from any future undertaking that has potential for effects on historic properties. This would include formal evaluation of potential effects and additional consultation with the SHPO.

In 2021, TVA conducted a Phase I archaeological survey (Dison 2022) of undeveloped areas within the APE that had not been included in prior archaeological surveys meeting current survey standards, pursuant to Section 110 of the NHPA. The survey included systematic shovel testing and pedestrian survey of approximately 193 acres distributed across six separate areas. The survey revisited six previously-recorded archaeological sites (1LI24, 1LI284, 1LI286, 1LI287, 1LI856, and 1LI857) located within or adjacent to the survey area, and identified seven previously-unrecorded archaeological sites (1LI915, 1LI916, 1LI917, 1LI918, 1LI919, 1LI920, and 1LI921). Site 1LI24 is no longer extant, having been destroyed during construction of BFN. Site 1LI857 lacks intact deposits and is ineligible. Sites 1LI287 and 1LI856 have been combined into a single site (1LI287), and sites 1LI284 and 1LI286 also are combined into a single site (1LI284). TVA determined that sites 1LI284 and 1LI287 both have research potential and should be avoided by project activities, if possible. All seven newly recorded sites lack research potential and are ineligible for the NHRP. TVA consulted with the SHPO and federally-recognized Indian tribes who have an interest in Limestone County, Alabama (“Tribes”) regarding the study and eligibility determinations. The SHPO agreed, and none of the Tribes disagreed or identified additional resources of concern in the APE. With the combined areas of this survey and prior archaeological surveys in the APE (Dison 2022, Gage 2001, Gage and Hermann 2009, Marshall 2013, Stanton 2013) all areas within the APE that are not developed or subjected to heavy disturbance in the past (documented by construction drawings, historic photographs, or aerial imagery) have now been included in archaeological surveys meeting SHPO standards and TVA criteria for archaeological surveys. TVA has consulted with the SHPO and Tribes regarding each of these surveys, pursuant to §800.4. Besides sites 1LI284 and 1LI287, TVA and the SHPO have agreed that site 1LI535 also is potentially-eligible for the NRHP (Brown to Graham May 24, 2001).

When TVA acquired 880 acres of land in the 1960s for the construction of BFN, one historic cemetery, known as the Cox Cemetery, was located on the property. Soon after TVA’s acquisition of the property TVA survey crews identified seven graves belonging to individuals with the family names Cox, Lang, and Madrey. Burial dates range from 1836 to 1908. In 1966 TVA relocated all seven graves to a new location within the BFN reservation (Gage 2001). TVA does not consider the cemetery eligible for inclusion in the NRHP. However, TVA does consider the cemetery to be a sensitive cultural resource and has complied with Alabama state statutes regarding the treatment of human remains.

3.18.2. Environmental Consequences – Archaeological and Historic Resources

Alternative A – No Action Alternative

The No Action Alternative would result in the shutdown and decommissioning of BFN. TVA would anticipate continuing operations at BFN until the end of the current license period (2033, 2034, and 2036 for Units 1, 2, and 3 respectively). As described above, BFN will be eligible for the NRHP by 2023. Therefore, any decommissioning activities, including but not limited to demolition could result in adverse effects to the NRHP-eligible BFN historic district and contributing structures. Once decommissioning plans are available, TVA will review the plans, identify whether any of the contributing resources to the BFN historic district or potentially-eligible archaeological sites would be affected, and consult further with the appropriate consulting parties regarding TVA’s evaluation of effect. Should any activity related to decommissioning be proposed that would modify BFN or affect any of the potentially-eligible archaeological sites, TVA will follow the steps of §800.5 for assessing adverse effects and, if required, the steps of §800.6 for resolving adverse effects. Should future TVA plans have potential for adverse effects on any NRHP-eligible resources TVA will take the consulting parties' comments into consideration in developing ways to avoid, minimize, or mitigate any adverse effects. If adverse effects cannot be avoided, TVA will, in consultation with the appropriate consulting party(-ies), prepare a treatment plan including mitigation for the adverse effect, and will notify the Advisory Council on Historic Preservation. TVA will continue to avoid any activities that would disturb any of the graves in the relocated Cox Cemetery. Should TVA propose any activity that would physically affect the cemetery, TVA would voluntarily complete steps consistent with state statutes regarding cemeteries and human remains. With these mitigation measures and commitments, TVA finds there would be no effect to archaeological and historic resources at BFN as a result of the No Action Alternative.

Construction of new generation resources whether at BFN or elsewhere in the Tennessee Valley would constitute an undertaking under Section 106 of the NHPA. All lands involved in the undertaking would likely need an inventory and evaluation of cultural resources to identify historic properties and may require avoidance plans or other actions to mitigate adverse effects from proposed ground-disturbing actions and/or visual effects related to physical activities at the proposed site. The studies would likely be needed for all areas of potential disturbance at the proposed site(s) and along associated corridors where new construction would occur (e.g. roads, transmission and pipeline corridors, or other ROWs). The effects on cultural resources could, depending on the site, range from small to large. The anticipated NHPA Section 106 process would ensure that any historic properties would be properly identified and managed and that potential impacts would be considered and mitigation developed as appropriate. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

TVA has not identified specific actions with potential for effects on BFN or archaeological sites in the APE. Should such plans be developed in future, TVA will review the plans, identify whether any of the contributing resources to the BFN historic district or potentially-eligible archaeological sites would be affected, and consult further with the appropriate consulting parties regarding TVA's evaluation of effect. Should any activity related to SLR be proposed that would modify BFN or affect any of the potentially-eligible archaeological sites, TVA will follow the steps of §800.5 for assessing adverse effects and, if required, the steps of §800.6 for resolving adverse effects. Should future TVA plans have potential for adverse effects on any NRHP-eligible resources TVA will take the consulting parties' comments into consideration in developing ways to avoid, minimize, or mitigate any adverse effects. If adverse effects cannot be avoided, TVA will, in consultation with the appropriate consulting party(-ies), prepare a treatment plan including mitigation for the adverse effect, and will notify the Advisory Council on Historic Preservation. TVA will continue to avoid any activities that would disturb any of the graves in the relocated Cox Cemetery. Should TVA propose any activity that would physically affect the cemetery, TVA would voluntarily complete steps consistent with state statutes regarding cemeteries and human remains. With these mitigation measures and commitments, TVA finds there would be no effect to archaeological and historic resources at BFN as a result of the proposed period of subsequent operations.

3.19. Hazardous, Solid, and Low-Level Radioactive Wastes

Solid wastes generated in conjunction with operation of BFN include hazardous, non-hazardous, universal, and sanitary wastes. are managed in accordance with applicable federal and state regulations as implemented through corporate procedures. Spent nuclear fuel storage and disposal are discussed in Section 3.21.

3.19.1. Affected Environment – Hazardous, Solid, and Low-Level Radioactive Wastes

General Plant Trash

BFN generates municipal solid waste commonly known as “trash” or “garbage” consisting of food waste, plastic film, paper waste, and food product packaging waste. Solid wastes are disposed in permitted disposal facilities. General municipal solid waste is collected as part of routine plant operation activities and is contracted and managed through Republic Service. . Waste material is collected in dumpsters and transported to. Republic Service’s Morris Farms Landfill in Lawrence County, Alabama. BFN has an active recycling program that segregates and recycles scrap metal; cardboard; white, mixed, and office paper; food cans; wood pallets; plastic, glass, and aluminum containers; and batteries. The segregated materials are accepted for recycling by TVA-approved vendors.

Construction and Demolition Debris

BFN disposes of construction and demolition (C&D) solid waste at Republic Service’s Morris Farms Landfill in Lawrence County, Alabama. Produced directly or incidentally by construction and demolition at BFN, these C&D wastes include scrap lumber, bricks, sandblast grit, crushed metal drums, glass, wiring, non-asbestos insulation, roofing materials, building siding, scrap metal, concrete with reinforcing steel, nails, wood, electrical wiring, rebar, bricks, concrete, excavated dirt, tree stumps, and rubble.

Hazardous Waste

BFN generates small quantities of hazardous waste (including universal waste) during operation and refurbishment. Management of hazardous wastes generated, is strictly regulated by the USEPA or the responsible state agencies per the requirements of the Resource Conservation and Recovery Act (RCRA).

BFN maintains non-radioactive waste-related permits and licenses (ADEM NPDES Facility Permit No. AL0022080 and ADEM RCRA Regulated Waste Permit No. AL8640015410). A hazardous material coordinator ensures the proper sampling, packaging, storage, shipping analysis, and disposal of hazardous materials generated at BFN and is supported by corporate environmental services. BFN utilizes permitted and licensed vendors to transport and recycle or dispose of waste. Vendors and suppliers are managed and vetted at the corporate level.

Under RCRA standards, BFN is currently classified as a small quantity generator of hazardous waste with less than 2,200 pounds/month. BFN did not generate more than 1,323 pounds in any one month during the 2016 to 2021 period. As a result of two separate planned episodic generation events, BFN generated 6,376 and 3,468 pounds of hazardous waste in December 2020 and October 2021.

Hazardous and universal wastes are collected and recycled or disposed, as applicable, through firms listed on the Environmental Restricted Awards List. TVA has procedures in place for handling hazardous and universal wastes.

Used Oil

As defined in the RCRA regulations, used oil is not hazardous waste. Generated at BFN as a result of maintenance activities on plant equipment, all used oil at BFN is collected, stored on site, and shipped to an approved recycling center for energy recovery by an approved vendor.

Low-Level Radioactive Waste

LLRW and potentially radioactive wastes include spent resin material, filter sludges, contaminated rags, clothing, and paper products, contaminated reactor internal parts, and other processing media from the liquid radioactive waste disposal system. The contaminated reactor internal parts are removed from the core and either stored in an approved onsite storage facility or shipped offsite for storage and disposal. The spent resin materials and filter sludges are dewatered and temporarily stored onsite before being shipped offsite for storage and disposal based on radioactivity classification. The contaminated rags, clothing, and paper products are collected and packaged onsite before being shipped offsite for disposal.

BFN would continue to generate radioactive solid waste and ship it offsite for disposal during the proposed subsequent period of extended operation. BFN has sufficient existing capability to temporarily store all generated LLRW onsite. No additional construction of onsite storage facilities is necessary for LLRW storage during the proposed subsequent period of extended operation, as BFN has contracts in place with licensed waste haulers to transport LLRW offsite for disposal. It is processed and packaged for shipping, and subsequently shipped by truck in accordance with applicable U.S. Department of Transportation (DOT) regulations on county, state and federal roads and highways.

BFN ships LLRW to the following licensed disposal sites:

- EnergySolutions in Clive, Utah; and
- Waste Control Specialists in Andrews, Texas.

Routine plant operations, refueling outages, and maintenance activities that generate LLRW would continue during the proposed subsequent period of extended operation.

Mixed Waste

BFN infrequently generates small quantities of mixed waste [i.e., waste that contains both radioactive material and Toxic Substances Control Act-regulated items, e.g., PCBs, asbestos, and or RCRA-regulated items, e.g., listed or exhibits characteristic of hazardous wastes]. In accordance with TVA procedures, mixed waste generated at BFN is collected and stored based on its hazardous constituents and applicable RCRA waste storage time limits before being shipped offsite by trained and certified personnel to a permitted/licensed vendor. Environmental personnel ensure all applicable USEPA, state environmental agency, and DOT regulations are met.

3.19.2. Environmental Consequences – Hazardous, Solid, and Low-Level Radioactive Wastes

Alternative A – No Action Alternative

The decommissioning process would increase the volume of C&D and LLRW generated at BFN. All handling and disposal of non-radioactive and radioactive wastes during the decommissioning phase would be in accordance with applicable rules, regulations, and requirements of local, state, and federal laws. All waste would be properly disposed of in licensed landfills or processed by licensed vendors to recover as much waste as practicable. While the volumes of C&D waste and LLRW would increase during decommissioning, the total waste volumes from decommissioning of lands and structures contributes a small percentage of the filling up capacity at planned disposal sites. Special chemicals used for decontamination would be in accordance with all applicable permits, and personnel would be trained in handling hazardous materials. Therefore, the impact on the environment from waste generated during the period of decommissioning would be small.

The quantities and types of solid waste generated by the construction and operation of replacement generation resources would be determined primarily by the number of acres, the initial condition of the selected site(s), and the location and type of technology chosen. During construction, there would be large volumes of dirt, concrete, wood, metal, and packing materials to dispose of in appropriate landfills. Any construction and demolition wastes generated during the building and renovation process would be managed through the TVA waste disposal contracts to access the permitted disposal capacity or recycling facilities, as needed. Additionally, new generating capacity could require new, and potentially extensive, transmission lines. Construction of new transmission lines, structures, and development of ROWs has a potential to produce large volumes of solid waste; however, potential effects from construction and operation of replacement generation resources would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. Overall, impacts would be anticipated to be small.

Alternative B – Proposed Action

Under Alternative B , there would be no major construction activity and C&D waste generated as a result of normal plant operations would be minimal and would be disposed of in a state-approved landfill. Solid waste generation would continue as currently generated at BFN. BFN would keep its regulated waste permit for hazardous waste and retain its status as a small quantity generator. LLRW would continue to be generated during the proposed subsequent period of extended operation.

Waste would continue to be handled in accordance with TVA-approved procedures, which ensure that all federal regulations and limits pertaining to hazardous, solid, and LLRW are met. Therefore, impacts to the public and the environment resulting from processing, storage, and transportation of such waste are small, and would continue to be small during the proposed subsequent period of extended operation.

Waste generated from decommissioning would not be avoided under Alternative B; they would be delayed until the end of the proposed subsequent period of extended operation. As described for Alternative A, all decommissioning waste would be handled and disposed in accordance with all applicable rules, regulations, and requirements of local, state, and federal laws. Therefore, as under Alternative A, the impacts to the public and the environment from management of decommissioning derived waste would be small.

3.20. Radiological Effects of Normal Operations

This section discusses the potential radiological dose to the public during normal operations of BFN. To evaluate the radiological dose on the surrounding environment during normal operations of BFN, TVA has implemented a REMP in the vicinity of BFN since 1968 (TVA 2022b). Through this program, radiological impacts on non-radiological workers, the public and the environment are monitored, documented, and then compared to standards. The results from the REMP are reported in the Annual Radiological Environmental Operating Report (AREOR). BFN's 2021 AREOR documented that all doses to the public were within as low as reasonably achievable (ALARA) criteria established by 10 CFR Part 50, Appendix I. Additionally, there were no detectable increase in background direct radiation levels identified in areas surrounding BFN.

3.20.1. Affected Environment – Radiological Effects of Normal Operations

The estimated total natural background radiation dose to the public within 50 miles of BFN is approximately 332,000 person-rem/year. The natural background dose is based on an individual person dose of approximately 310 millirem per year (mrem/yr) (NRC 2020) and a population of 1,074,109 people within the 50 miles (USCB 2022b). Background radiation comes from a variety of sources such as cosmic radiation, soils and rocks, radon, weapons testing, medical x-rays, smoke detectors, and smoking. However, the specific estimate of 310 mrem/yr does not include medical or dental procedures such as x-rays.

3.20.1.1. Occupational

Occupational radiological impacts refer to radiation dose received by individuals in the course of their employment. Depending on work assignments, occupational radiation exposure is possible for workers who have received radiation safety training and are classified as radiological workers. NRC regulations in 10 CFR Part 20 require that occupational radiation exposures be kept ALARA with a limit on the annual total effective dose equivalent for individual radiation workers of 0.05 sieverts (5 rem) per year. Data from NRC indicate that BFN occupational radiation exposures fall within the range of those for other operating boiling water reactors with a 3-year average total effective dose equivalent per worker for 2018 through 2020 of 1.36 millisieverts (0.136 rem) (NRC 2022).

3.20.1.2. Public

Commercial nuclear power reactors, under controlled conditions, release small amounts of radioactive materials to the environment during normal operation. These releases result in radiation doses to humans that are small relative to doses from natural radioactivity. Nuclear power plant licensees must comply with NRC regulations (e.g., 10 CFR Part 20, Appendix I to 10 CFR Part 50, 10 CFR 50.36a, and 40 CFR Part 190) and conditions specified in the operating license. Radiation doses to the public from continued operations would be expected to continue at current levels and would be well below regulatory limits during the proposed subsequent period of extended operation. The BFN Annual Radioactive Effluent Release Reports for 2020 and 2021 were reviewed and the results indicated that the annual public dose is a fraction (less than one percent) of the regulatory limits and were in accordance with radiation protection standards identified (TVA 2020a, TVA 2021c).

Radiation Doses to Members of the Public

The ODCM reports the estimated doses to the maximally exposed individual and the general population during routine operations for both the radioactive liquid and gaseous effluent pathways. The maximally exposed individual is a hypothetical individual member of the public who would live continuously at the location that would allow him to receive the maximum dose by being exposed to the plant radioactive effluents.

Estimated doses to the maximally exposed member of the public due to radiological effluent releases from BFN are calculated on an annual basis. These dose values have consistently been very low, typically only a small fraction of applicable limits. For example, the maximum calculated whole-body dose for liquid releases in 2021 was 0.00263 mrem/year, or <1 percent of the applicable limit (10 CFR Part 50 Appendix I, 3 mrem/year) (TVA 2021c). The maximum calculated whole-body dose for gaseous releases in 2021 was 0.0431 mrem/year which represented 0.29 percent of the limit (10 CFR Part 50 Appendix I, 15 mrem/year) (TVA 2021c). The calculated annual total quantity dose from the pathway Beta Air for gaseous releases in 2021 was 2.81E-05 mrad or <1 percent of the applicable limit (10 CFR Part 50 Appendix I, 20 mrad/year for beta radiation). The calculated annual total quantity dose from the pathway

Gamma Air for gaseous releases in 2021 was 0.0002 mrad or <1 percent of the applicable limit (10 CFR Part 50 Appendix I, 10 mrad/year for gamma radiation).

Exposure Pathways

Evaluation of the potential impacts to the public from normal operational releases is based upon the probable pathways to individuals, populations, and biota near BFN. The exposure pathways are described in federal regulations of the NRC Regulatory Guides 1.109 and 1.111. There are two critical pathways by which radioactive materials can move through the environment to humans: air and water. The air pathway can be separated into two components: the direct (airborne) pathway and the indirect (ground or terrestrial) pathway. Human exposure through the water pathway may result from liquid effluents and from drinking water, eating fish, or by direct exposure at the shoreline.

The BFN Offsite Dose Calculation Manual (ODCM) specifies the requirements for monitoring specific exposure pathways. The ODCM is based on current conditions at the site and in the surrounding community so that monitoring and sampling can be altered as necessary. Dose calculations to members of the public are based on the guidance of the ODCM. The ODCM can be modified to include new pathways if needed or to exclude pathways if the conditions warrant.

TVA has monitored environmental impacts from BFN operations on the surrounding environs and the general public by implementing its REMP since 1968 (TVA 2022b). The REMP conducted for BFN is designed to monitor the primary pathways for exposure to humans. The BFN REMP includes measurement of direct radiation levels and collection and analysis of various sample types. Monitoring for the liquid pathway includes samples of fish, shoreline sediment and water from Wheeler Reservoir. The airborne pathway is monitored by direct sampling for air particulates and gaseous radioiodine and sampling of milk, soil, and food crops that could be affected by the deposition of airborne radionuclides.

The results from the REMP are reported in the AREOR. The data reported in the BFN AREOR demonstrate that the small amounts of radiological effluents released to the environment due to the operation of BFN have had no measurable impact on the environs around BFN. For example, the 2021 REMP states, “Only naturally occurring radioactivity was identified in all fish and local crop samples, as well air particulate, surface water and shoreline sediment samples” (TVA 2022b).

Exclusion Area Boundary

As defined in federal regulations of the NRC (10 CFR Part 100), the Exclusion Area Boundary (EAB) is the area surrounding the reactor in which TVA has the authority to determine all activities, including exclusion or removal of personnel and property from the area, and the boundary on which limits for the release of radioactive effluents are based. The EAB is shown as the site boundary in Figure 1.2-3. There are no residents living in this exclusion area. Access within the EAB is controlled by TVA, and no restricted areas within the EAB are accessible to members of the public. Areas outside the EAB are unrestricted in the context of federal regulations of the NRC (10 CFR Part 20) and open to the public. The nearest resident lives just east of the EAB about 0.9 miles from the center of the reactor building (TVA 2022b).

Radiological Doses Due to Liquid Effluents

The release of small amounts of radioactive liquid effluents are allowed for BFN as long as releases comply with the requirements specified in federal regulations of the NRC (10 CFR Part 20) and the ODCM (TVA 2019c). The liquid effluent exposure pathways given above were considered in the evaluation of radiation doses to the public resulting from radioactive liquid effluent releases. Current analyses of potential radioactive doses to members of the public due to releases of radioactivity in liquid effluents are calculated using the methodology provided in the ODCM.

The resulting calculated doses to an individual due to liquid effluents released from BFN for the years 2021 and 2020 are given in Table 3.20-1. The dose controls and limits of the ODCM, based NRC regulations (10 CFR Part 20, Appendix B, Table 2, Column 2 for concentrations of effluent releases and 10 CFR Part 50, Appendix I for any individual) are annual limits of 3 mrem or less to the total body and 10 mrem or less to any organ while the quarterly limits are 1.5 mrem or less to the total body and 5 mrem or less to any organ (TVA 2020a). The annual and quarterly limits are designed to assure that doses due to releases of radioactive material from nuclear power reactors to unrestricted areas are kept as low as practicable during normal conditions.

Table 3.20-1. Calculated Dose to Individuals From Liquid Effluents, 2021 and 2020

Year	Quarter	Age Group	Total Body Dose	Quarter Limit	% of Limit
2021	1	Adult	1.60E-03 mrem	5 mrem	< 1
2021	2	Adult	1.01E-03 mrem	5 mrem	< 1
2021	3	Adult	3.50E-06 mrem	5 mrem	< 1
2021	4	Adult	1.90E-05 mrem	5 mrem	< 1
2020	1	Child	1.30E-04 mrem	1.5 mrem	< 1
2020	2	Child	2.00E-04 mrem	1.5 mrem	< 1
2020	3	Adult	6.80E-04 mrem	1.5 mrem	< 1
2020	4	Adult	4.70E-04 mrem	1.5 mrem	< 1

Source: (TVA 2020a, TVA 2021c)

BFN submits annual reports to the NRC detailing the release of radioactive liquid effluents for the previous year. These annual radioactive effluent release reports include summations of all radioactive liquid releases and the resulting doses for individuals and the total population, as well as the quantities of radioactive nuclides released. The overall results expected from normal operations of BFN are as follows:

- Each unit meets the dose guidelines given in 10 CFR Part 50, Appendix I.
- The dose estimates to the public are a small fraction of the Appendix I guidelines.
- The analyses of the radiological impact to humans from liquid releases in TVA's REMP for BFN continue to conform to the ALARA criterion.
- The impact to members of the public resulting from normal liquid effluent releases is minor and presents minimal risk to the health and safety of the public.

Table 3.20-2 provides the calculated quarterly total body doses to the total population in the 50-mile radius of BFN for the years 2021 and 2020 from liquid and gaseous effluents released. The natural background radiation causes an estimated dose of 332,000 person-rem/year to the population within the 50-mile radius of BFN. Therefore, BFN is contributing a dose so minor that it cannot be distinguished from the variations in the natural background radiation dose, as was expected in TVA's REMP for BFN.

Table 3.20-2. Calculated Quarterly Total Population Doses (Liquid and Gaseous) to the Total Population in a 50-Mile Radius of BFN, 2021 and 2020

Year	Quarter	Total Population Dose by Quarter (person-rem) Liquids	Total Population Dose by Quarter (person-rem) Gases
2021	1	4.50E-02	1.93E-01
2021	2	6.90E-02	2.26E-01
2021	3	4.60E-05	2.68E-01
2021	4	2.40E-04	1.81E-01
2020	1	8.30E-03	2.39E-01
2020	2	1.20E-02	2.59E-01
2020	3	3.90E-02	2.65E-01
2020	4	2.00E-02	2.17E-01

Source: (TVA 2020a, TVA 2021c)

Radiological Impact of Gaseous Effluents

Gaseous effluents considered in the offsite dose calculation include fissions and activation gases and iodines and particulates with half-lives greater than eight days (TVA 2020a). TVA uses its offsite dose calculation manual to provide methods and procedures for calculating offsite doses and to demonstrate that releases do not exceed the dose limits of 10 CFR Part 50 Appendix I.

The current analyses of potential doses to members of the public due to releases of radioactivity in gaseous effluents are performed using the methodologies described in the BFN ODCM. The methods described are based on NRC guidance for determining the doses for releases of radioactive effluents from nuclear power plants into the atmosphere provided in Regulatory Guide 1.109, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, Revision 1* (NRC 1977).

The release of fission and activation gases is regulated by the dose limits of 10 CFR Part 50 Appendix I and BFN ODCM. The air dose to areas at and beyond the site boundary due to noble gases released in gaseous effluents per unit shall be limited during any calendar quarter to ≤ 5 millirad (mrad) for gamma radiation and ≤ 10 mrad for beta radiation; and during any calendar year to ≤ 10 mrad for gamma radiation and ≤ 20 mrad for beta radiation.

The release of radioiodines and particulates in gaseous effluent is regulated by the dose limits of 10 CFR Part 50 Appendix I and the BFN ODCM. The dose to a member of the public from radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than eight days in gaseous effluent released per unit to areas at and beyond the site boundary shall be limited to any organ during any calendar quarter to ≤7.5 mrem, and during any calendar year to ≤15 mrem. Table 3-20-3 provides a summary of gaseous effluent releases for the year 2021 and 2020.

Table 3.20-3. Gaseous Effluent Releases from BFN, 2021 and 2020

Year	Fission and Activation Gases (Ci)	Particulates (Ci [$T_{1/2}$ > 8 days])	Iodines (Ci)	Tritium (Ci)	Carbon14 (Ci)
2021 1st Quarter	< LLD	7.77E-04	2.63E-04	6.73E+01[a]	1.21E+01
2021 2nd Quarter	6.98E-01	3.79E-04	8.59E-04	9.83E+01	1.28E+01
2021 3rd Quarter	2.26E+00	3.66E-04	1.44E-03	7.82E+01	1.43E+01
2021 4th Quarter	4.28E+01	5.84E-04	2.16E-03	4.10E+01	1.42E+01
2020 1st Quarter	5.51E+01	5.22E-04	5.90E-04	1.62E+02	1.20E+01
2020 2nd Quarter	1.17E+01	6.76E-04	4.74E-04	1.23E+02	1.30E+01
2020 3rd Quarter	7.51E+00	4.14E-04	1.17E-03	1.04E+02	1.28E+01
2020 4th Quarter	2.35E+00	5.26E-04	4.21E-04	9.35E+01	1.20E+01

Source: (TVA 2020a, TVA 2021c)
LLD = lower limit of detection; Ci = curies
[a] Includes activity from abnormal releases. Dilution flow was not determined for abnormal releases.

Table 3.20-4 provide the gaseous doses calculated from the gaseous releases during the quarters in 2021 and 2020, demonstrating that the air dose calculated from the emissions in Table 3.20-3 are a small fraction on the allowed dose limits.

Table 3.20-4. Doses from Gaseous Effluents, 2020

Quarter	Pathway	Dose	QTR Limit	Percent of Limit
2021 1st Quarter	Gamma air	0.00E+00 mrad	5 mrad	< 1
	Beta air	0.00E+00 mrad	10 mrad	< 1
	Total body	0.00E+00 mrad	NA	NA
	Skin	0.00E+00 mrad	NA	NA
	Child/thyroid	8.79E-03 mrem	7.5 mrem	< 1
	Child/total body	8.82E-03 mrem	7.5 mrem	< 1
2021 2nd Quarter	Gamma air	6.00E-06 mrad	5 mrad	< 1
	Beta air	6.48E-07 mrad	10 mrad	< 1
	Total body	6.91E-06 mrad	NA	NA
	Skin	7.19E-06 mrad	NA	NA
	Child/thyroid	1.25E-02 mrem	7.5 mrem	< 1
	Child/total body	4.04E-02 mrem	7.5 mrem	< 1
2021 3rd Quarter	Gamma air	1.94E-05 mrad	5 mrad	< 1
	Beta air	2.10E-06 mrad	10 mrad	< 1
	Total body	2.23E-05 mrad	NA	NA
	Skin	2.33E-05 mrad	NA	NA
	Child/thyroid	1.38E-02 mrem	7.5 mrem	< 1
	Child/total body	1.36E-02 mrem	7.5 mrem	< 1
2021 4th Quarter	Gamma air	1.74E-04 mrad	5 mrad	< 1
	Beta air	2.54E-05	10 mrad	< 1
	Total body	1.98E-04 mrad	NA	NA
	Skin	2.10E-04 mrad	NA	NA
	Child/thyroid	8.68E-03 mrem	7.5 mrem	< 1
	Child/total body	8.22E-03 mrem	7.5 mrem	< 1

Quarter	Pathway	Dose	QTR Limit	Percent of Limit
2020 1st Quarter	Gamma air	1.11E-04 mrad	5 mrad	< 1%
	Beta air	4.18E-05 mrad	10 mrad	< 1%
	Total body	3.81E-04 mrad	NA	NA
	Skin	4.59E-04 mrad	NA	NA
	Child/thyroid	2.53E-02 mrem	7.5 mrem	< 1%
	Child/total body	2.51E-02 mrem	7.5 mrem	< 1%
2020 2nd Quarter	Gamma air	4.46E-05 mrad	5 mrad	< 1%
	Beta air	1.72E-05 mrad	10 mrad	< 1%
	Total body	3.53E-04 mrad	NA	NA
	Skin	4.15E-04 mrad	NA	NA
	Child/thyroid	1.41E-02 mrem	7.5 mrem	< 1%
	Child/total body	1.41E-02 mrem	7.5 mrem	< 1%
2020 3rd Quarter	Gamma air	3.97E-05 mrad	5 mrad	< 1%
	Beta air	1.30E-05 mrad	10 mrad	< 1%
	Total body	2.92E-04 mrad	NA	NA
	Skin	3.49E-04 mrad	NA	NA
	Child/thyroid	1.48E-02 mrem	7.5 mrem	< 1%
	Child/total body	1.45E-02 mrem	7.5 mrem	< 1%
2020 4th Quarter	Gamma air	7.24E-06 mrad	5 mrad	< 1%
	Beta air	2.55E-06 mrad	10 mrad	< 1%
	Total body	2.14E-04 mrad	NA	NA
	Skin	2.53E-04 mrad	NA	NA
	Child/thyroid	1.26E-02 mrem	7.5 mrem	< 1%
	Child/total body	1.25E-02 mrem	7.5 mrem	< 1%

Source: (TVA 2020a, TVA 2021c)
NA Not applicable, as air dose limits are only specified for gamma and beta radiation in areas at and beyond the Site Boundary due to noble gases released in gaseous effluents per unit.

Individual doses due to normal liquid and gaseous effluent releases from BFN are less than 1 percent of the applicable limits. The doses are well below the federal regulatory guidelines and standards (10 CFR Part 50 Appendix I and 10 CFR Part 20).

Total Dose (Liquid and Gaseous) From All Sources

Dose limits for individual members of the public are given in the ODCM Control 1.2.3. The annual (calendar year) dose or dose commitment to any member of the public, beyond the site boundary due to releases from uranium fuel cycle (UFC) sources, shall be limited to less than or equal to 25 mrem to the total body or any organ (except the thyroid, which shall be limited to less than or equal to 75 mrem). Table 3.20-5 provides results of the calculated cumulative total dose (total body or any other organ) from all sources for the years 2020 and 2021. Table 3.20-6 provides results of the calculated cumulative total dose (thyroid) from all sources for the years 2021 and 2020. These calculated doses are well within the limits specified in the ODCM. Therefore, it is concluded that normal operation of BFN presents minimal risk to the health and safety of the public.

Table 3.20-5. Cumulative Annual Total Dose (Total Body or Any Organ) From All Sources, 2021 and 2020

Year	Cumulative Total Dose (mrem)	Annual Dose Limit (mrem)	Percent Of Limit
2021	1.60E-01	25	< 1%
2020	1.46E-01	25	< 1%

Source: (TVA 2020a, TVA 2021c)

Table 3.20-6. Cumulative Annual Total Dose (Thyroid) From All Sources, 2021 and 2020

Year	Cumulative Total Dose (mrem)	Annual Dose Limit (mrem)	% Of Limit
2021	4.77E-02	75	< 1%
2020	7.05E-02	75	< 1%

Source: (TVA 2020a, TVA 2021c)

3.20.2. Environmental Consequences – Radiological Effects of Normal Operations

Alternative A – No Action Alternative

Under the No Action Alternative, the radioactive effects at BFN would change for the decommissioning process. The shutdown of BFN would stop the generation of new radioactive effluents being released to the environment. However, decommissioning activities associated with the dismantlement of the site structures would produce temporary radioactive air emissions and air emissions from dust, concrete, vehicle exhaust, and equipment. All releases for the decommissioning phase would still be in accordance with applicable regulations, and the impact from decommissioning effluent releases would be small.

Operation of replacement generation resources would only produce radiological effects if small modular reactors (SMRs) are implemented. There would be no radioactive effects during the construction of a new SMR plant(s) unless the construction takes place at the location of another operating nuclear plant, or there are multiple units being build and one unit becomes operational before the other(s). The radiological impacts from the construction of a new nuclear plant would be of small significance to the construction workers. Workers who would be in close proximity to the operating nuclear plant(s) would be tracked and monitored (radiation badge) as necessary to meet NRC requirements. Depending on the type of nuclear technology chosen, the radioactive effects of a new operating SMR plant(s) would be expected to be less than the BFN current effects. There would be no expected observable impacts from radioactive liquid or gaseous releases from a new SMR plant(s) during normal operations. The REMP would be set up for the new SMR plant(s) to ensure there are no measurable indirect or cumulative effects to the environment offsite of the new location or to the public. Potential effects from construction and operation of an SMR plant(s) would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. Overall, impacts would be anticipated to be small. There would be no radioactive impacts from the construction and operation of other potential generation resources.

Alternative B – Proposed Action

For this alternative, TVA does not anticipate any significant changes to radioactive dose to workers or to the public. No refurbishments or plant modifications are planned during the proposed subsequent period of extended operation that would affect public exposure to radiation. Radiological dose limits for protection of the public and workers have been developed by USEPA and NRC to ensure that the cumulative impacts of acute and long-term exposure to radiation and radioactive materials are small regardless of the source or sources. Operation of BFN during the proposed subsequent period of extended operation would comply with these dose limits. Because there is no reason to expect effluents to increase during the proposed subsequent period of extended operation, annual doses to the public from continued operation are expected to continue to be a small fraction of the regulatory limits. It is expected that radiation doses to the public from continued operations would continue at current levels and would be well below regulatory limits during the proposed subsequent period of extended operation. The incremental contribution of continued operation of BFN to cumulative radiation doses and associated health impacts to workers and the public from all sources would be small.

3.21. Uranium Fuel Cycle Effects

Nuclear power plants fueled by uranium produce radioactive wastes in various forms. This section discusses the management, storage, and transportation of radioactive wastes associated with the operation of BFN, including the handling and storage of spent fuel.

3.21.1. Radioactive Waste

3.21.1.1. Affected Environment – Radioactive Waste

The radioactive waste systems at BFN Units 1, 2, and 3 are designed to collect, process, and dispose of plant-produced radioactive wastes in a controlled and safe manner. These systems are designed to limit discharges in accordance with 10 CFR Part 50, Appendix I. The actual performance and operation of installed equipment, as well as reporting of actual offsite releases and doses, are controlled by the requirements of the ODCM and NPDES permit. The ODCM is subject to NRC inspection and describes the methods and parameters used for calculating offsite doses resulting from radioactive gaseous and liquid effluents and ensuring compliance with NRC regulations. The methods employed for the controlled release of those contaminants are dependent primarily upon the state of the material: liquid, solid, or gaseous.

This section describes the current radioactive waste systems and practices at BFN along with data showing current volumes and program results. Operation of BFN radioactive waste is handled by TVA-approved procedures, and the current methods of handling the waste would be continued during the proposed subsequent period of extended operation.

Liquid Radioactive Waste Treatment Systems

The Liquid Radioactive Waste Control System collects, treats, stores, and disposes of all potentially radioactive liquid wastes. These wastes are collected in sumps and drain tanks at various locations throughout the plant and then transferred to the appropriate collection tanks in the Radioactive Waste Building for treatment, storage, discharge, or disposal.

During normal operation, the liquid effluent treatment systems process and control the release of liquid radioactive effluents to the environment such that the doses to individuals offsite are maintained within the limits of 10 CFR Part 20 and ALARA dose standards in Appendix I to 10 CFR Part 50. The Liquid Radioactive Waste Management System is designed to process the waste and then recycle it within the plant as condensate, reprocess it through the radioactive waste system for further purification, or discharge it to the environment as liquid radioactive waste effluent in accordance with state and federal regulations.

Wastes to be discharged to the environment from the liquid radioactive waste management system are processed on a batch basis, with each batch being processed by such method(s) appropriate for the quality and quantity of materials determined to be present. Processed liquid wastes may be returned to the condensate system or discharged to the environs through the circulating water discharge channel. The liquid wastes in the discharge channel are diluted with condenser effluent circulating water to achieve a permissible concentration at the site boundary.

The low conductivity (high purity) liquid wastes are processed by filtration and ion exchange through the waste filter and waste demineralizer. After processing, the waste is pumped to a waste sample tank where it is sampled and then, if satisfactory for reuse, and there is sufficient available volume in the condensate storage tanks to accept the waste, it is transferred to the condensate storage tanks as makeup water.

High-conductivity (low purity) liquid wastes are processed through a filter and are collected in a floor drain sample tank because they have low concentrations of radioactive impurities. If the concentration after dilution is less than or equal to the applicable limits, the filtered liquid may be discharged.

An alternate method of processing low and high conductivity liquid is the use of vendor-supplied skid-mounted equipment, interconnected to the permanent radioactive waste system. Depending on effluent quality and plant needs, the water can be sent to either the waste sample tank or floor drain sample tank. Processing from the waste sample tank or floor drain sample tank is identical as described above.

The processing equipment is located within concrete buildings to provide secondary enclosures for the wastes in the event of leaks or overflows. Tanks and equipment which contain wastes with high radioactive concentrations that could be determined to result in increased dose to personnel are shielded. Except where flanges are required for maintenance, most pipe connections are welded to reduce the probability of leaks. Process lines which penetrate shield walls are routed to prevent a direct radiation path from the tanks or equipment. Control of the waste system is from local panels in the Radioactive Waste Building.

Protection against accidental discharge of liquid radioactive waste is provided by valve redundancy, instrumentation for detection of alarms of abnormal conditions, procedural controls, interlocks, and radiation monitor controlled valves.

TVA procedures are used to ensure shipments of radioactive material and radioactive wastes from BFN meet TVA Nuclear requirements, waste processor requirements, burial site requirements, state regulations, and federal regulations.

Table 3-21.1 provides a summary of radioactive liquid releases for the years 2020 and 2021. The resulting total dose for each year is less than 1 percent of the allowed dose limit.

Table 3.21-1. Annual Radioactive Liquid Releases, 2020-2021

Year	**Fission and Activation** Gases (Curies)	**Tritium (Curies)**	**Dissolved and Entrained Gases (Curies)**	**Total Volume Released (Liters)**	**Total Body Dose From Liquids (mrem)**
2021	1.10E-01	1.51E+01	9.49E-06	3.34E+06	2.63E-03
2020	3.63E-02	4.83E+01	1.57E-04	5.41E+06	1.48E-03

Source: (TVA 2020a, TVA 2021c)

Gaseous Radioactive Waste Treatment Systems

The Gaseous Radioactive Waste Management System collects and processes gaseous radioactive wastes from the main condenser air ejectors, the startup vacuum pumps, condensate drain tank vent, and the steam packing exhauster, and controls their release to the atmosphere through the plant stack so that the total radiation exposure to persons outside the controlled area is as low as reasonably achievable and does not exceed applicable regulations.

Table 3-20.2 provides a summary of quarterly gaseous total body dose for the years 2020 and 2021. The resulting quarterly total dose for each year is less than 1 percent of the allowed dose limit.

Table 3.21-2. Quarterly Gaseous Total Body Dose, 2020-2021

Year	Total Body 1st QTR (mrem) (Limit=7.5 mrem/QTR)	Total Body 2nd QTR (mrem)	Total Body 3rd QTR (mrem)	Total Body 4th QTR (mrem)
2021	8.82E-03	1.25E-02	1.36E-02	8.22E-03
2020	2.51E-02	1.41E-02	1.45E-02	1.25E-02

Source: (TVA 2020a, TVA 2021c)
QTR = quarter

Table 3-20.3 provides a summary of total (individual) annual dose from all sources (liquids and gases) for the years 2020 and 2021. The resulting total annual dose for each year is less than 1 percent of the allowed dose limit. Therefore, the impact from all radioactive effluent releases from BFN is small and would continue to be small during the proposed subsequent period of extended operation.

Table 3.21-3. Total Dose From All Sources, 2020-2021

Year	Total Dose (mrem)	% of Limit (limit=25 mrem)
2021	1.60E-01	<1%
2020	1.46E-01	<1%

Source: (TVA 2020a, TVA 2021c)

Solid Radioactive Systems

Within the Solid Radioactive Waste Management System, solid radioactive wastes are collected, processed, stored, packaged, and prepared for shipment. Solid radioactive wastes include dry and dry solid wastes and wet solid wastes.

Dry Solid Wastes

Dry solid wastes include contaminated rags, paper, clothing, spent filter elements, laboratory apparatus, small parts and equipment, and tools. Items of dry solid waste are collected in suitable containers located throughout the plant. Spent elements which may have a high-radiation level are packaged in accordance with applicable burial site requirements prior to being transported for processing, burial, or approved onsite storage. Low-radiation level solid wastes may be stored onsite in approved storage areas. In such instances, a maximum curie inventory of 325 curies will not be exceeded. After a period of storage, the containers are removed from the storage area and prepared for disposal. Shielded containers are provided for offsite shipment of high-activity waste if required.

Wet Solid Wastes

Wet solid wastes consist of spent powdered ion exchange resins, filter aid sludge, and bead-type ion exchange resins. Spent powdered ion exchange resin and filter aid sludge are accumulated and stored in phase separator tanks. Successive batches of slurried materials are accumulated, and supernatant liquid decanted, until the desired settled slurry volume has been reached. High-activity-level sludge from the reactor water cleanup filter-demineralizers is stored in three cleanup phase-separator tanks. Bead-type ion exchange resins from the waste demineralizer are stored in the spent resin tank. The spent resin remains in that tank until operations personnel determine it needs to be transferred. From that tank the spent resin is transferred to the phase separator tanks where it is mixed with other sludges. After mixing it is sent to the packaging area.

Sludge from the condensate, the fuel pool filter-demineralizers, and the waste and floor drain filters are stored in six condensate phase-separator tanks. Sludge from the various sources may be either mixed in the six tanks or segregated. Each cleanup phase-separator tank and condensate phase-separator tank has decant outlets, a bottom outlet that lead to the suction of a sludge transfer pump, and an overflow outlet leading to the Radioactive Waste Building equipment drain sump. After an appropriate decay period, the sludge is reslurried and pumped to the packaging area.

The packaging system is designed to permit the use of several different types of containers, including disposable tanks (liners) in reusable shields constructed of carbon steel or high-density polyethylene plastic. Prior to a packaging run, a container is positioned at one of two dewatering systems, either in a shipping cask or in a shielded enclosure. For a condensate phase-separator, hoses are connected and the sludge pump and air-operated spargers are used to stir up the settled sludge in the phase-separator and bring it into suspension. For a cleanup phase-separator, eductors are used to mix the slurry instead of air spargers. The slurry then is pumped to the loading station and back to the phase-separator tank. A portion of the slurry is drawn off into the waste package until the package is nearly filled. Water is withdrawn through the built-in filter elements via the portable dewatering system(s) and drained into the waste package drain tank. This process is repeated until the package is nearly full of dewatered slurry. Then the portable dewatering system hoses are disconnected, package penetrations are plugged, and the package is prepared for onsite storage or offsite shipment.

3.21.1.2. Environmental Consequences – Radioactive Waste

This section updates and compares the potential for environmental effects from plant construction and operations regarding radioactive waste for actions of the viable alternatives: Alternative A No Action Alternative, and Alternative B BFN SLR.

<u>Alternative A – No Action Alternative</u>

If Alternative A were to be selected, TVA would allow the current BFN operating licenses to expire at the end of their terms, shutting down each unit no later than the current license expiration dates: December 20, 2033, for Unit 1, June 28, 2034, for Unit 2, and July 2, 2036, for Unit 3.

For alternative A, radioactive waste would continue to be produced in the manner and annual volumes currently generated at BFN. There would be no change in the types or rates of liquid, gaseous, or solid wastes generated during the remaining operating period. The total cumulative volumes of each type of radioactive waste would increase until permanent plant shutdown and decommissioning activities commenced. The management, handling, storage, and shipping of radioactive waste would remain consistent with current practice. All applicable federal regulations would be followed. BFN would continue to release radioactive liquids and gases to the environment in accordance with, and below the limits of, federal regulation. Solid radioactive waste would continue to be handled in accordance with TVA-approved procedures, which ensure that all federal regulations and limits pertaining to solid radioactive waste are met.

Upon shutdown, generation of routine operational radioactive waste would cease. During decommissioning, the plant would ship all stored radioactive material to be processed or to its final disposal. The life-time volume of radioactive waste shipped would be larger at the end of the 20-year period than it would be should the licenses not be renewed. The radioactive waste from activated components (piping, valves, reactor vessel, etc.) and structures (activated rebar, concrete, etc.) that would be removed during decommissioning would be approximately the same whether it were at the end of the current license or the end of the proposed subsequent period of extended operation.

Because shutdown of BFN would require construction of new replacement power either at BFN or elsewhere within the TVA system, the potential for radioactive waste generation would depend on the source and specific technology of the replacement power generation facility. If new nuclear generation were selected, the approved design would be subject to the same requirements for handling and processing radioactive waste at BFN. Similar to BFN, the environmental impacts associated with radioactive waste handling, storage, and transportation would be expected to be small. If new technology allowed for reduced radioactive waste volumes due to advancements in design, equipment, and programs in the new nuclear facility, the impacts associated with operation of a new nuclear generation facility may even be less than that at BFN.

For any non-nuclear electrical power generation facility, radioactive waste is not generated during construction or operation. Therefore, there would be no environmental impact related to radioactive waste during the construction or operation of any non-nuclear power generation facility. Potential effects from construction and operation of any replacement generation resource would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. Overall, impacts would be anticipated to be small.

Alternative B – Proposed Action

Under Alternative B, radioactive waste would continue to be produced in the manner and annual volumes currently generated at BFN. There would be no change in the types or rates of liquid, gaseous, or solid wastes generated during the proposed subsequent period of extended operation. The management, handling, storage, and shipping of radioactive waste would remain consistent with current practice. All applicable federal regulations would be followed. BFN would continue to release radioactive liquids and gases to the environment in accordance with, and below the limits of, federal regulation. Impacts to the environment from releases of radioactive liquids and gases are small and would continue to be small throughout the period of extended operation. Solid radioactive waste would continue to be handled in accordance with TVA-approved procedures, which ensure that all federal regulations and limits pertaining to solid radioactive waste are met. The increased volume of radioactive waste generated during the 20-year period would result in a greater volume disposed of in a licensed landfill. The additional volume would remain a small impact on the available landfill capacity, and would not result in large cumulative impacts on licensed landfills. BFN would continue to comply with annual public dose rate and environmental emission limitations. Therefore, impacts to the public and the environment resulting from processing, storage, and transportation of solid radwaste, including cumulative effects of waste storage from BFN are small, and would continue to be small during the proposed subsequent period of extended operation.

When BFN finally shuts down at end of the current license or the end of the proposed subsequent period of extended operation, generation of routine operational radioactive waste would cease. During decommissioning, the plant would ship all stored radioactive material to be processed or to its final disposal. The life-time volume of radioactive waste shipped would be larger at the end of the 20-year period than it would be should the licenses not be renewed. The radioactive waste from activated components (piping, valves, reactor vessel, etc.) and structures (activated rebar, concrete, etc.) that would be removed during decommissioning would be approximately the same whether it was at the end of the current license or the end of the proposed subsequent period of extended operation.

3.21.2. Spent Fuel Storage

3.21.2.1. Affected Environment – Spent Fuel Storage

BFN has two ISFSI storage pads used to safely store spent fuel in licensed and approved dry cask storage containers on site. The ISFSI is licensed separately from BFN Units 1, 2, and 3 Renewed Facility Operating Licenses and would remain in place until the DOE takes possession of the spent fuel and removes it from the site for permanent disposal or processing. Expansion of the onsite spent fuel storage capacity would be required in the future if a national storage solution for the permanent storage of spent fuel does not become available during the proposed subsequent period of extended operation if the DOE does not take responsibility for the permanent storage and disposal of the onsite spent fuel. Should this be necessary, the impacts associated with this expansion would be assessed under a licensing process separate from that of BFN Units 1, 2, and 3 Renewed Facility Operating Licenses, consequently it would also be reviewed under a separate NEPA evaluation. As described in Section 1.5.1.3, expansion of the ISFSI is addressed as a reasonably foreseeable future action and considered with regard to cumulative impacts.

3.21.2.2. Environmental Consequences – Spent Fuel Storage

<u>Alternative A – No Action Alternative</u>

For the No Action Alternative, there would be no additional spent fuel generated after permanent plant shutdown. The BFN ISFSI would continue operation under its separate general license until the DOE takes possession of the spent fuel from the BFN ISFSI, and it can be decommissioned in a separate project. The current ISFSI storage pads are projected to be filled on or before year 2036. Under the existing licenses and assuming decommissioning at the end of the current license periods, an additional 274 dry fuel storage casks will be needed to support operations and decommissioning.

Because shutdown of BFN would require construction of new replacement power either at BFN or elsewhere within the TVA system, the potential for impacts related to nuclear spent fuel would depend on the source and specific technology of the replacement power generation facility. If new nuclear generation were selected, the approved design would be subject to the same requirements for handling and storage of spent fuel as BFN. For a new nuclear generating facility, spent fuel typically would be stored in a spent fuel pool. It is not expected that an ISFSI would be included in the initial construction. Once a new nuclear generating facility is operating, spent fuel would be produced in processes similar to BFN. The environmental impacts of a new nuclear generating facility may be reduced relative to those at BFN due to advancements in technology, design, and programs. The expected environmental impacts associated with spent fuel storage at any new nuclear generation facility would be expected to be small.

For any non-nuclear electrical power generation facility, spent nuclear fuel is not generated during construction or operation. Therefore, there would be no environmental impact related to spent nuclear fuel during construction or operation of any non-nuclear power generation facility. Potential effects from construction and operation of any replacement generation resource would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

Under Alternative B, spent fuel assemblies would continue to be produced during the proposed subsequent period of extended operation at BFN in quantities and rates consistent with that seen for current plant operation. For alternative B, additional ISFSI storage capacity would be required beyond that described in Alternative A if DOE does not take possession of spent fuel. The addition of a third ISFSI storage pad to further increase storage capacity needed for the proposed subsequent period of extended operation is under consideration, but plans are in the conceptual stage and no installation schedule has been established. The BFN site has adequate space onsite to accommodate the construction of an additional ISFSI pad if necessary. Construction and operation of an additional storage pad to support the SLR is expected to have only small cumulative impacts, including small direct impacts from radiation doses from the ISFSI for onsite workers and people in the surrounding area. The resulting indirect and cumulative dose impacts would be small. The impacts associated with ISFSI expansion would be assessed under a licensing process separate from that of BFN Units 1, 2, and 3 subsequent renewed operating licenses. Dose limits would be maintained in compliance with federal regulations.

3.21.3. Transportation of Radioactive Materials

3.21.3.1. Affected Environment - Transportation of Radioactive Materials

Transportation of radioactive materials is required to operate any nuclear facility. BFN transports radioactive materials currently and would continue to do so during the proposed subsequent period of extended operation if SLR is approved by the NRC.

Table S-4 in 10 CFR 51.52 includes the NRC evaluation of the environmental effects of transportation of fuel and waste to and from light water reactors. Note "1" of Table S-4 states that data for the table come from the Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Plants in WASH-1238, December 1972, and Supplement 1 NUREG-75/038, April 1975, Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, and the table states that the radiological risk due to effects of accidents in transportation was determined to be small.

The table addresses two categories of environmental considerations: (1) normal conditions of transport and (2) accidents in transport. (10 CFR Part 51) Subparagraphs 10 CFR 51.52(a) (1) through (5) delineate specific conditions the reactor licensee must meet to use Table S-4 as part of its environmental evaluation to determine impacts. The conditions in paragraph (a) of 10 CFR 51.52 establishing the applicability of Table S-4 relate to:

- Reactor core thermal power (not to exceed 3,800 megawatt thermal)
- Fuel form, fuel enrichment (Sintered uranium dioxide pellets with uranium-235 enrichment not exceeding 4 percent by weight)
- Fuel encapsulation (encapsulated in zircaloy rods)
- Average fuel irradiation (does not exceed 33,000 megawatt-days per metric ton)
- Time after discharge of irradiated fuel before shipment (no irradiated fuel assembly is shipped until at least 90 days after it is discharged from the reactor)
- Mode of transport for unirradiated fuel (truck)
- Mode of transport for irradiated fuel (truck, rail, or barge)

- Radioactive waste form and packaging (with the exception of spent fuel, all radioactive waste shipped from the reactor is packaged and in a solid form, by truck or rail)
- Mode of transport for radioactive waste other than irradiated fuel

Transportation of Unirradiated Fuel
10 CFR 51.52 requires that unirradiated fuel be shipped to the reactor site by truck. Table S-4 includes a separate condition requiring that the truck shipments be limited to 73,000 pounds or less. New fuel assemblies are transported to BFN by truck in accordance with DOT and NRC regulations.

Transportation of Irradiated Fuel
Packaging of irradiated fuel for offsite shipment would comply with applicable DOT and NRC regulations for transportation of radioactive material. If transportation is to a DOE repository, by law, DOE is responsible for the transportation of spent fuel from reactor sites to a repository, as shown in the Nuclear Waste Policy Act of 1982, Section 302, and DOE makes the decision on the transport mode.

BFN meets the conditions and provisions of paragraph (a) of 10 CFR 51.52. Therefore, the environmental impact and risks of transporting radioactive materials as a result of continued operation of BFN would be bound by the impacts shown in Summary Table S-4 (10 CFR 51.52).

3.21.3.2. Environmental Consequences - Transportation of Radioactive Materials

Alternative A – No Action Alternative
Alternative A would be bound by the same transportation criteria for radioactive wastes that currently applies to BFN operation. Because shutdown of BFN would require construction of new replacement power either at BFN or elsewhere within the TVA system, the potential for impacts related to transportation of radioactive materials would depend on the source and specific technology of the replacement power generation facility. If new nuclear generation were selected, the approved design would be subject to the same requirements for radioactive material transportation as BFN, and any impact would be expected to remain small. For non-nuclear power generation, the need for radioactive material transportation would not be expected. As such, environmental impacts associated with radioactive material transportation would be small for the No Action Alternative. Potential effects from construction and operation of any replacement generation resource would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action
The risks of transporting radioactive materials are bound by Table S-4 (10 CFR 51.52). Since BFN would continue to meet the requirements of Table S-4 during the proposed subsequent period of extended operation, the environmental impact of any transportation of irradiated fuel would be small. Transportation impacts of all types of radioactive waste would be expected to be small.

3.22. Nuclear Plant Safety and Security

This section assesses the environmental impacts of postulated accidents involving radioactive materials at BFN and plant security, including protection against intentional and destructive acts. It is divided into three subsections that addresses Design Basis Accidents (DBAs), severe accidents, and plant security.

- DBAs (Section 3.22.1)
- Severe Accidents (Section 3.22.2)
- Plant Security (Section 3.22.3)

3.22.1. Design-Basis Accidents

3.22.1.1. Affected Environment – Design-Basis Accidents

The potential consequences of postulated accidents are determined based on the use of a set of DBAs that are representative of the reactor designs. 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 CFR Part 50 and 10 CFR Part 100. The DBAs considered include Loss of Coolant Accidents, Refueling, Control Rod Drop, and Steam Line Break (AEC 1972).

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. The results of these evaluations are found in license documentation such as the NRC staff's safety evaluation report and the licensee's updated final safety analysis report. 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 SLR, the environmental impacts as calculated for DBAs should not differ significantly from initial licensing assessments over the life of the plant, including the proposed subsequent period of extended operation. Accordingly, the design of the plant relative to DBAs during the extended period is considered to remain acceptable.

TVA is not aware of any new and significant information associated with the renewal of the BFN operating licenses. Information included in the BFN License Renewal Supplemental EIS (2005) concluded that there are no impacts of DBAs during the proposed subsequent period of extended operation beyond those discussed in the GEIS, which were determined to be of small significance because all plants were designed to successfully withstand these design basis accidents.

A high degree of protection against the occurrence of postulated accidents is provided through quality design, manufacture, and construction, which ensure the high integrity of the reactor system and associated safety systems. Deviations from normal operations are handled by protective systems and design features that place and hold the plant in a safe condition. It is conservative to postulate that serious accidents may occur, even though they are extremely unlikely. Engineered safety features are installed to prevent and mitigate the consequences of postulated events that are judged credible. The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental impact standpoint have been analyzed using best estimates of probabilities, realistic fission product releases, and realistic transportation assumptions.

Personnel with specific duties and responsibilities in the BFN radiological emergency plan program receive instruction in the performance of their duties and responsibilities during accidents and emergencies. Drills and exercises are conducted regularly to develop and maintain the key skills required for emergency response by these highly trained personnel. Drills are performed regularly for such accident conditions as fire, medical emergencies, radiological protection, and emergency communications.

3.22.1.2. Environmental Consequences – Design-Basis Accidents

Alternative A – No Action Alternative

Under the No Action Alternative, TVA would continue to properly maintain all equipment and facilities at BFN and ensure the high integrity of the reactor system and associated safety systems until all systems are shutdown and through decommissioning as appropriate. Emergency plans would continue to be maintained and implemented as needed, and personnel would continue to receive training and participate in drills and exercises until those are no longer necessary at the appropriate point in decommissioning. Because shutdown of BFN would require construction of new replacement power either at BFN or elsewhere within the TVA system, the potential for impacts related to design basis accidents would depend on the source and specific technology of the replacement power generation facility. If new nuclear generation were selected, the approved design integrates the requirements to design against and protect from a series of potential DBAs. The new nuclear plant would be designed specifically for the new technology chosen by TVA and that technology would meet all DBA criteria and be approved by the NRC. The environmental impacts of a new nuclear generating facility may be reduced relative to those at BFN due to advancements in technology, design, and programs implemented. The expected environmental impacts associated with design basis accidents at any new nuclear generation facility would be expected to be small. For any non-nuclear electrical power generation facility, there would be no applicable environmental impact related to DBAs. Potential effects from construction and operation of any replacement generation resource would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

In all DBA cases considered, radiological impacts remain below the regulatory dose limits. If a DBA occurred, the impacts would be small and limited by plant design and the trained emergency actions of BFN personnel. It is concluded that the environmental risks due to postulated radiological accidents are small. Continued operation of BFN during the proposed subsequent period of extended operation does not change the analysis of accidents and the potential impacts of postulated accidents would remain small.

3.22.2. Severe Accidents

3.22.2.1. Affected Environment – Severe Accidents

The term “accident” refers to any unintentional event (i.e., outside the normal or expected plant operation envelope) that results in a release or the potential for a release of radioactive material to the environment. The NRC categorizes accidents as either design basis or severe. DBAs, described in Subsection 3.22.1, are those for which the risk is great enough that the NRC requires plant design features and procedures to prevent unacceptable accident consequences. Severe accidents are defined as accidents with substantial damage to the reactor core and degradation of containment systems. Because the probability of a severe accident is very low, the NRC considers them too unlikely to warrant normal design controls to prevent or mitigate the consequences. Severe accident analyses consider both the frequency of a severe accident and the offsite consequences to determine the public risk.

The risk of nuclear power plant severe accidents is normally determined by a plant-specific probabilistic safety assessment that provides a systematic and comprehensive methodology for determining the risks associated with severe accidents due to the operation of the nuclear power plant.

3.22.2.2. Environmental Consequences – Severe Accidents

Alternative A – No Action Alternative

If the BFN operating license was not extended for the additional 20-year period, BFN would shut down and the potential impacts from postulated severe accidents would no longer be applicable.

Because shutdown of BFN would require construction of new replacement power either at BFN or elsewhere within the TVA system, the potential for impacts related to severe accidents would depend on the source and specific technology of the replacement power generation facility.

If new nuclear generation were selected, the approved design would be analyzed for the risk of a severe accident occurring, and the consequences to the onsite and offsite environment evaluated. The impacts would be required to be small and of no significance for the plant to gain approval for construction and operation. The new plant would be specifically analyzed based on the selected technology, and that technology would necessarily require approval by the NRC prior to construction and operation. The environmental impacts of a new nuclear generating facility may be reduced relative to those at BFN due to advancements in technology, design, and programs implemented. The expected environmental impacts associated with severed accidents at any new nuclear generation facility would be expected to be small and of no significance.

For any non-nuclear electrical power generation facility, there would be no applicable environmental impact related to severe radiological accidents. Potential effects from construction and operation of any replacement generation resource would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

The environmental impacts related to potential severe accidents are within the requirements specified for BFN. Severe accident analyses considered both the risk of a severe accident occurring and the onsite and offsite consequences if the accident did occur to determine the significance. The risk results for continued operation of BFN for the proposed subsequent period of extended operation are not significant, and environmental impacts associated with postulated severe accidents would be expected to be small.

3.22.3. Plant Security

3.22.3.1. Affected Environment – Plant Security

TVA has in place detailed sophisticated security measures to prevent physical intrusion into all its nuclear plant sites, including BFN, by hostile forces seeking to gain access to plant nuclear reactors or other sensitive facilities or materials. TVA security personnel are trained and retrained to react to and repel hostile forces threatening TVA nuclear facilities. TVA's security measures and personnel are inspected and tested by the NRC. It is highly unlikely that a hostile force could successfully overcome these security measures and gain entry into sensitive facilities, and even less likely that they could do this quickly enough to prevent operators from putting plant reactors into safe shutdown mode. However, the security threat that is more frequently identified by members of the public or in the media are not hostile forces invading nuclear plant sites, but attacks using hijacked jet airliners, the method used on September 11, 2001, against the World Trade Center and the Pentagon. The likelihood of this now occurring is equally remote in light of today's heightened security at airports, but this threat has been carefully studied.

The Nuclear Energy Institute (NEI) commissioned the Electric Power Research Institute (EPRI) to conduct an impact analysis of a large jet airliner being purposefully crashed into sensitive nuclear facilities or containers including nuclear reactor containment buildings, spent fuel storage pools, spent fuel dry storage facilities, and spent fuel transportation containers. Using conservative analyses, EPRI concluded that there would be no release of radionuclides from any of these facilities or containers because they are already designed to withstand potentially destructive events. Nuclear reactor containment buildings, for example, have thick concrete walls with heavy reinforcing steel and are designed to withstand credible earthquakes, overpressures, and hurricane force winds. The EPRI analysis used computer models in which a Boeing 767-400 was crashed into containment structures representative of all United States nuclear power containment types. The containment structures suffered some crushing and chipping at the maximum impact point, but were not breached. The results of this analysis are summarized in an NEI paper titled "Deterring Terrorism: Aircraft Crash Impact Analyses Demonstrate Nuclear Power Plant's Structural Strength" (NEI 2002).

The EPRI analysis is fully consistent with research conducted by the NRC. When the NRC considered such threats, Commissioner McGaffigan observed (NRC 2007):

> Today the NRC has in place measures to prevent public health and safety impacts of a terrorist attack using aircraft that go beyond any other area of our critical infrastructure. In addition to all the measures the Department of Homeland Security and other agencies have put in place to make such attacks extremely improbable (air marshals, hardened cockpit doors, passenger searches, etc.), NRC has entered into a Memorandum of Understanding with NORAD/NORTHCOM to provide real-time information to potentially impacted sites by any aircraft diversion.
>
> As NRC has said repeatedly, our research showed that in most (the vast majority of) cases an aircraft attack would not result in anything more than a very expensive industrial accident in which no radiation release would occur. In those few cases where a radiation release might occur, there would be no challenge to the emergency planning basis currently in effect to deal with all beyond-design-basis events, whether generated by mother nature, or equipment failure, or terrorists. (NRC 2007)

Notwithstanding the very remote risk of a terrorist attack affecting operations, TVA increased the level of security readiness, improved physical security measures, and increased its security arrangements with local and federal law enforcement agencies at all of its nuclear generating facilities after the events of September 11, 2001. These additional security measures were taken in response to advisories issued by NRC. TVA continues to enhance security at its plants in response to NRC regulations and guidance. The security measures TVA has taken at its sites are complemented by the measures taken throughout the United States to improve security and reduce the risk of successful terrorist attacks. This includes measures designed to respond to and reduce the threats posed by hijacking large jet airliners.

In the very remote likelihood that a terrorist attack would successfully breach the physical and other safeguards at BFN resulting in the release of radionuclides, the consequences of such a release are reasonably captured by the consideration of the impacts of severe accidents discussed above in this section.

Nuclear plant security is applicable to BFN until it is decommissioned and all spent fuel is removed from the site, regardless of the date of the decommissioning.

3.22.3.2. Environmental Consequences – Plant Security

Alternative A – No Action Alternative

As noted above, nuclear plant security requirements would continue to apply at BFN until decommissioning has been completed and all spent fuel has been removed from the site. Environmental impacts associated with a plant security event occurring during plant operation or during decommissioning activities can be reasonably expected to be bound by the severe accident scenarios considered above and would be expected to be small.

Because shutdown of BFN would require construction of new replacement power either at BFN or elsewhere within the TVA system, the potential for impacts related to plant security would depend on the source and specific technology of the replacement power generation facility. If new nuclear generation were selected, any new nuclear plant would be designed and constructed to meet all security design considerations and regulations. Any environmental impact, as noted above, would be bound by the severe accident scenarios and would be expected to remain small. For any non-nuclear electrical power generation facility, nuclear plant security regulations are not applicable. Potential effects from construction and operation of any replacement generation resource would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified.

Alternative B – Proposed Action

As discussed for Alternative A, environmental impacts related to any plant security event associated with facility operation or during decommissioning activities are reasonably expected to be small and bound by the severe accident scenarios considered in Section 3.22.2. As such, any plant security event-related environmental impact resulting from the proposed subsequent period of extended operation would be expected to be small.

3.23. Non-radiological Public Health and Safety

Located in Limestone County on the northern shore of Wheeler Reservoir across from Lawrence and Morgan Counties, BFN impacts public health and safety in all three counties. As discussed in Section 3.16, an array of police, fire, and medical services are available in the region. Law enforcement agencies in all three counties promote public safety by preventing and stopping crimes, providing criminal investigations, and responding to emergencies (ASA 2022). Dedicated and volunteer fire departments in Alabama provide fire protection and other emergency services including emergency response to motor vehicle accidents, hazardous material incidents, and rescue operations. Hospitals provide emergency medical care along with diagnostic services, treatment, and recovery services.

If a situation evolves where outside emergency support becomes necessary at BFN, the plant communicates this need to local and state emergency service agencies. Advance plans and arrangements have been made in conjunction with state and local authorities, where applicable, for warning the local populace of an emergency and possible need for evacuation. Safety measures may include preventing public entry to affected areas, providing medical care of injured or exposed personnel, surveying affected areas for radioactivity, and restricting use of water and food supplies (TVA 2021a, TVA 2022d).

Non-radiological public health and safety concerns at BFN include electric shock hazards and microbiological hazards in the form of thermophilic (increased temperature adapted) microorganisms.

3.23.1. Affected Environment – Non-Radiological Public Health and Safety

Electric Shock Hazards

Flowing charges create a magnetic field, and a magnetic field induces a current of electric charge in conductive objects. Transmission lines, and all electric wiring, create magnetic fields that induce a current of electric charge. The strength of the induced current and charge is dependent on the magnitude of the current through the transmission line, the design of the transmission line, the distance to the charged object, the conductive nature of the charged object, and whether the conducting object is grounded. Induced currents and charges can cause shocks under certain conditions (TVA 2019e).

Transmission lines and right of ways are designed to minimize the potential for such shocks. Stationary conductive objects, including metal fences and guardrails, with proximity to the transmission lines allowing a possible charge to develop have been grounded; thus, preventing a probable source for shocks. In addition, by precluding direct public access to transmission line towers, transmission lines are designed to preclude direct contact shock hazards to the public (TVA 2019e).

The in-scope BFN transmission lines are located on the BFN site. TVA is the owner and operator of the transmission lines connecting BFN to the transmission grid. All TVA transmission lines are designed to meet or exceed the medium loading requirements of the National Electrical Safety Code (NESC) and are designed to surpass the short-circuit NESC safety requirement. And, thus, the public is precluded from accessing the site and from direct contact with these transmission lines. Further, any induced current from these lines would be 5 milliamperes or less.

Microbiological Hazards

Discharge of thermal effluents into Wheeler Reservoir has the potential to promote the growth of thermophilic microorganisms, some of which can cause adverse effects on human health. Microorganisms of particular concern for their potential to impact the health of the plant workers and the public include bacteria such as *Legionella* spp. as well as free-living amoebae of the genera *Naegleria*. These microorganisms can grow in warm waters that can occur at nuclear power plants in cooling towers and cooling water discharges (Tyndall 1981, Tyndall 1983, Tyndall et al. 1985).

Bacteria pathogenic to humans usually thrive at temperatures above 30ºC (86ºF) and are ubiquitous in the environment. During the summer months, temperatures in Wheeler Reservoir are at their highest, which is when there is the most concern for human pathogens. In terms of hydrothermal impacts on Wheeler Reservoir, operation of the circulating water system is regulated by the State of Alabama under NPDES permit number AL0022080 (ADEM 2018). BFN operates within the parameters of the permit using the helper cooling towers as needed for additional cooling and by reducing the power/heat generated to remain in compliance.

Legionella bacteria are responsible for Legionnaires' disease, with the onset of pneumonia in the first two weeks following exposure through inhalation. Risk groups for serious effects from *Legionella* include the elderly, cigarette smokers, persons with chronic lung disease or an immunocompromising disease, and persons receiving immunosuppressive drugs (CDC 2021a, CDC 2021b). A temperature range of 77°F to 113°F is favorable for *Legionella* growth (CDC 2021a, CDC 2021b). Exposure to *Legionella* from plant operations is a potential problem for workers who dislodge biofilms during the cleaning of condenser tubes or cooling (CDC 2021a). TVA has performed rigorous sampling of cooling tower basins, cooling tower water, and surrounding areas with the potential for growth of *Legionella.* Sampling results identified levels of *Legionella* that were lower than the standard threshold that could potentially impact workers' or the public's health.

Naegleria fowleri (*N. fowleri*) is a free-living pathogenic amoeba that occurs naturally in surface waters and is the main cause of primary amoebic meningoencephalitis (PAM). *N. fowleri* is thermophilic and can grow in heated plant effluent and become a hazard to recreational water users. Amoebic meningoencephalitis is an extremely rare disease that results from the nasal intake of water containing the amoeba. Primary affected groups are individuals of all ages, but groups with the greatest risk of severe disease include infants, the elderly, and those with compromised immune systems. *N. fowleri* is commonly present in freshwaters in the United States; however, infections are rare. From 1962 through 2021 there were only 154 reported cases of *N. fowleri* infection in the United States. Of those 154 cases, 36 were reported between 2011 and 2021 (CDC 2021b). Alabama has not reported any cases of *N. fowleri* infection (CDC 2021a). No data currently exist to accurately estimate the true risk of PAM, and low infection rates make epidemiological studies difficult (CDC 2020). No method currently exists to accurately measure the numbers of amoebae in water, making it unclear how to set standards to protect human health (CDC 2017).

3.23.2. Environmental Consequences – Non-Radiological Public Health and Safety

This section addresses impacts to non-radiological public health and safety from the No Action and the BFN SLR Alternatives. Initiation of decommissioning activities for each BFN unit is required prior to the expiration of each unit's operating license.

Alternative A – No Action Alternative

With the closure of BFN, the in-scope transmission lines would no longer be necessary. The 500-kV transmission lines connected into TVA's 500-kV transmission system would no longer conduct electric charge from the closed BFN. With the closure of BFN, the possibility of electric shock hazard from in-scope BFN transmission lines is nullified.

In addition, with the closure of BFN, the cooling systems would no longer discharge plant effluent into Wheeler Reservoir; no longer heating the waters for thermophilic microorganism growth. In addition, with the closing of BFN, additional cooling from the helper cooling towers would no longer be required, and a possible source for *Legionella* would be eliminated. Impacts to public health would be small and beneficial.

However, under the No Action Alternative, the shutdown of BFN would require construction of replacement power either at BFN or elsewhere within the TVA system. Potential effects from construction and operation would be evaluated in separate analyses once the new generation construction project locations and technologies are specifically identified. These separate analyses would investigate potential impacts to non-radiological public health and safety issues including electric shock hazards and microbiological hazards. The type and level of impact would vary depending upon proximity, mitigation measures, and general construction and operation practices. Impacts could range from small to moderate.

Alternative B – Proposed Action

Under Alternative B, no changes are anticipated to the current plant operations and maintenance procedures and the proper safety protocols protecting the health of the employees and the public would remain in place.

All TVA transmission lines are designed to meet or exceed NESC medium loading requirements and short-circuit safety requirements. Also, the public is precluded from accessing the site and from direct contact with in-scope transmission lines. As a result, any induced current from these lines would be 5 milliamperes or less and the possible shock hazard to the public is small.

Further, operation of BFN Units 1, 2, and 3 and their cooling systems are not expected to change substantially during the proposed subsequent period of extended operation, and there is no reason to believe that discharge temperatures would increase or that disinfection would be discontinued Compliance with the current NPDES permit would continue to protect against high temperatures in the BFN discharge mixing zone that might result in human health impacts from microbiological organisms. From 2015 to 2020, average water temperatures from the cooling water discharge during the warmest months of the year did not exceed 90°F. Maximum temperatures recorded during those months and years did not exceed 91°F. These temperatures are below the range at which *N. fowleri* is typically found, and the low levels of *Legionella* found in onsite sampling of waters favorable for its growth indicate that conditions in the reservoir are unlikely to support its growth there. No new impacts to public health would be anticipated through this action.

3.24. Decommissioning

Regulatory guidance for the consideration of environmental impacts associated with decommissioning is provided in of NUREG-1437 (NRC 2013). The regulatory options and environmental impacts associated with decommissioning BFN are discussed below.

Regulatory Options for Decommissioning

Under all of the alternatives, TVA is required to begin decommissioning each BFN unit no later than the expiration of its operating license. Decommissioning decisions and actions would have to be made sooner under the No Action Alternative than under the BFN SLR Alternative.

The same decommissioning options apply to each alternative. When TVA proposes a decommissioning option, appropriate environmental reviews would be conducted as decommissioning is a separate licensing action. A description of decommissioning options is provided below. TVA currently has no preference among decommissioning options and is not proposing one now. However, the base assumption is that relicensing would not unreasonably increase the amount of radioactive or nonradioactive equipment to be disposed of at decommissioning.

To decommission a nuclear power plant, radioactive material on the site must be reduced to levels that would permit termination of the NRC license. This involves removing the spent fuel from the reactor and spent fuel pools, dismantling any systems or components containing activated materials (such as the reactor vessel and primary loop piping), and cleaning up or dismantling contaminated materials. Activated materials cannot be decontaminated and would have to be removed from the facility and shipped to a waste processing, storage, or disposal facility. Contaminated materials may either be cleaned of contamination on site or removed and shipped to a waste processing, storage, or disposal facility. TVA would decide how to decontaminate material based on the amount of contamination present, the ease with which it can be removed, and the costs and risks to remove the contamination versus the cost and risks to ship the contaminated material to a waste processing, storage, or disposal facility.

The NRC has evaluated the environmental impacts of three methods for decommissioning nuclear power facilities: DECON, SAFSTOR, and ENTOMB (see definitions below) (NRC 2013). NRC regulations state that decommissioning and license termination must be completed within 60 years of permanent cessation of operations. However, existing nuclear power plant decommissioning projects are demonstrating that decommissioning can be completed decades before the 60-year requirement needs to be considered. The choice of decommissioning options and the decommissioning timeline is strongly influenced by uncertainties in LLRW disposal costs and other economic factors.

DECON calls for the timely removal of radioactive material and radioactive contamination to permit unrestricted release of the reactor site. Equipment and structures are decontaminated to levels that meet NRC-approved release criteria or removed and disposed as LLRW.

The advantages of DECON include the following (NRC 2000):

- The operating license is terminated and the facility and site become available for other purposes more quickly than with the other options.
- Availability of the operating work force that is knowledgeable of the facility.
- Elimination of the need for long-term security, maintenance, and surveillance of the facility, which would be required for the other decommissioning options.
- Greater certainty about the availability of low-level waste disposal facilities to accept the LLRW.
- Lower estimated costs compared to the SAFSTOR alternative, largely as a result of future price escalation. Most activities that occur during DECON would also occur during the SAFSTOR period, only at a later date. However, it is anticipated that the later the date for completion of decommissioning the greater the cost. Some of these increases may be offset by technological advances during the SAFSTOR period.

The disadvantages of DECON may include the following (NRC 2000):

- Higher worker and potentially public doses. There is less benefit from radioactive decay that would occur in the SAFSTOR option.
- A larger near-term commitment of disposal site space than the SAFSTOR option.

SAFSTOR is a deferred decontamination strategy that takes advantage of the natural decay of a significant portion of the radiation. After all fuel assemblies, nuclear source material, radioactive liquid wastes, and stored solid wastes are removed from the plant, the remaining structure would then be placed in a safe and secure state. Monitoring systems would be used throughout the SAFSTOR period and a full-time security force would be maintained. The facility would later enter a DECON phase so the license could be terminated within the required 60-year timeframe. This option makes the site unavailable for alternate uses for an extended period, but there could be a reduced need for radioactive waste disposal.

The advantages of SAFSTOR include the following (NRC 2000):

- A substantial reduction in radioactivity as a result of the radioactive decay during the storage period.
- A reduction in worker dose when compared to DECON.
- A potential reduction in public exposure from fewer shipments of radioactive waste as compared to DECON.

- A potential reduction in the amount of radioactive waste disposal space required as compared to DECON.
- Lower cost during the years immediately following permanent cessation of operations.
- More time to benefit from growth through investment of the decommissioning trust fund prescribed by NRC regulations (10 CFR Part 50).

The disadvantages of SAFSTOR include (NRC 2000):

- Shortage of personnel familiar with the facility at the time of deferred dismantlement and decontamination.
- Site unavailable for alternate uses during the extended storage period.
- Uncertainties regarding the availability of LLRW disposal sites and disposal costs in the future.
- Continuing need for maintenance, security, and surveillance.
- Higher total cost for the subsequent decontamination and dismantlement period (assuming typical price escalation during the time the facility is stored); however, this could be partially offset by reduced radioactive waste disposal volumes resulting from radioactive decay and growth of the decommissioning trust fund.

For the ENTOMB option, radioactive structures, systems, and components are encased in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license.

The advantages of the ENTOMB option are (NRC 2000):

- Encasing materials generally provide radiation shielding resulting in reduced worker dose while decontaminating and dismantling other parts of the facility.
- A potential reduction in public exposure from fewer shipments of radioactive waste.
- The ENTOMB option may have a relatively low cost compared to the DECON and SAFSTOR options.

The disadvantages of ENTOMB include (NRC 2000):

- Because most power reactors will have radionuclides in concentrations exceeding the limits for site release even after 100 years, this option may not be feasible under current regulations. This option may be acceptable for reactor facilities that can demonstrate that radionuclide levels will decay to levels that will allow release of the site.
- Although several small reactors have been entombed or partially entombed, no NRC licensees have proposed the ENTOMB option for a power reactor undergoing decommissioning. Therefore, there is virtually no industry experience to provide a source of lessons learned regarding this option for decommissioning commercial nuclear power plants.

Environmental Impacts Associated with Decommissioning

Discontinuing operation of BFN and the initiation of decommissioning may allow some other commercial or industrial use of part of the site in the future. This would mitigate to some extent the negative socioeconomic impacts of loss of employment. This may include use of the site for electric power generation. Any such future use would require its own environmental review. New, improved decommissioning technologies and efficiencies may be available by the time TVA considers making a decommissioning decision.

Environmental issues associated with decommissioning that result from continued plant operation during the license renewal period are discussed in the GEIS (NRC 2013). These issues are assigned either a Category 1 or a Category 2 designation. For all Category 1 issues, no additional plant-specific analysis is required by the NRC, unless new and significant information is identified. Category 2 issues are those that do not meet one or more of the criteria of Category 1; therefore, additional plant-specific review for these issues is required. There are no Category 2 issues related to decommissioning at BFN.

In summary, neither of the alternatives would result in eliminating any decommissioning option or result in any environmentally unacceptable conditions. Delaying decommissioning of the BFN reactors as a result of the proposed subsequent period of extended operation would have small beneficial and negative impacts when compared to the alternative. However, the net impact of either alternative would be similarly small.

3.25. Unavoidable Adverse Environmental Impacts

This section describes principal unavoidable adverse environmental impacts for which mitigation measures are either considered impractical, do not exist, or cannot entirely avoid the adverse impact. Specifically, this section considers unavoidable adverse impacts that would occur for either the No Action Alternative (Alternative A) or SLR of BFN Units 1, 2, and 3 (Alternative B). The unavoidable construction and operational effects are identified in Tables 3.25-1 and 3.25-2.

Table 3.25-1. Construction-Related Unavoidable Adverse Environmental Impacts

Resource, Alternative	Unavoidable Adverse Impacts
Land Use Alternative A	Construction of new generating assets to replace the 3,900 MWe generating capacity of BFN would require clearing and disturbing of land. The amount of land that would be disturbed is not known at present due to the different combination of generating assets that could be utilized to replace BFN. If greenfield sites are uses, all the land may be changed from the “as found” land use designation while a brownfield site may not change the land-use designation but would require clearing and disturbing activities of the same nature. There would potentially be a long-term commitment of land for the potential new transmission corridors if they are needed and not already present. Some land used as landfills could be dedicated to long-term disposal of construction debris and not available for other uses.
Land Use Alternative B	No major refurbishments or plant modifications are planned during the proposed subsequent period of extended operation. The potential future expansion of the ISFSI is on land already designated for BFN and does not represent any change in land use. Additionally, should a new ISFSI become necessary, impacts would be evaluated in subsequent NEPA and licensing documents.

Resource, Alternative	Unavoidable Adverse Impacts
Hydrologic and Water Use Alternative A	A small amount of water is consumed during construction activities. The impact would vary based on the source of water (groundwater vs surface water) and the combination of generating assets that would be constructed to replace the generating capacity of BFN.
Aquatic Ecology Alternative A	Any construction for the new generating assets that would take place at the waterbody's edge or dredging activities may cause direct, short-term, and small loss of some organisms and temporary degradation of habitat. New transmission lines that cross streams may cause a small disruption of some organisms and degradation of habitat.
Terrestrial Ecology Alternative A	Any construction for the new generating assets would cause small to large alterations to habitat and the species that inhabit them. Construction, clearing, and grading of a new site could directly harm or displace animals. These impacts would be intermittent and continue throughout the construction phases.
Socioeconomics and Environmental Justice Alternative A	Construction workers and local residents would experience elevated levels of traffic through the course of the construction phases needed to build the new generating assets to replace BFN. The locations of the new sites would determine the level of impact on the surrounding community. Rural areas would potentially experience a greater impact than urban locations. The influx of a construction work force would cause short-term, small to large effects on local housing, infrastructure, land use, and community services such as fire or police protection. In the short term, there may be school crowding. Increased tax revenue would mitigate some of this impact. Construction workers and local residents would be exposed to elevated levels of dust, exhaust emissions, and noise from construction and equipment. These constitute small unavoidable impacts. No unavoidable adverse construction impacts to environmental justice populations are anticipated.
Hazardous and Solid, Waste Alternative A	The potential impacts of waste depend on the combination of generating assets that would be constructed to replace BFN. The quantities and types of solid waste generated would be determined primarily by the number of acres, the initial condition of the selected site, and the location and type of technology chosen. Waste would be generated through operation activities. However, impacts would be small as waste would be disposed of in accordance with procedures and applicable regulations.

Table 3.25-2. Operations-Related Unavoidable Adverse Environmental Impacts

Resource, Alternative	Unavoidable Adverse Impacts
Land Use Alternative A	Various amounts of land would be needed in order to construct new generating assets to replace BFN. Land use at offsite locations for these new generating assets would be a long-term commitment. There would be a long-term commitment of land for the required transmission corridors and supporting structures and facilities of the new generating assets. Potential for unanticipated disturbances to historic, cultural, or paleontological resources would be mostly or entirely mitigated. Additional land Could be used for long-term disposal of general trash and hazardous waste normally associated with large industrial facilities. The viewscape of the new generating assets and supporting facilities would be adversely affected over the operational period.
Land Use Alternative B	The BFN site is approximately 880 acres. The majority of the land use is classified as hay/pasture and developed. Land use would continue to be primarily hay/pasture and developed until the plant is shut down and decommissioned. After decommissioning, the site may be used for a different purpose. The ISFSI would remain until the DOE takes possession of the spent fuel, and the ISFSI land would be used for a different purpose. If necessary, the BFN site has adequate space onsite to accommodate the construction of a third ISFSI pad. Impacts associated with this expansion would be assessed under a licensing process separate from that of BFN Units 1, 2, and 3 Subsequent Renewed Facility Operating Licenses. The viewscape of the BFN site and transmission facilities would continue to be impacted over the operational period, but no more than at the present.
Hydrologic and Water Use Alternative A	Water use would vary depending on the generating assets that would be constructed and operated to replace the generating capacity of BFN. All facilities would be operated in compliance with NPDES permits, applicable water quality standards, storm water pollution and SPCC plans would ensure that the impacts would be small.
Hydrologic and Water Use Alternative B	Normal plant operations result in discharge of small amounts of chemicals and radioactive effluents to Wheeler Reservoir throughout the life of BFN. Compliance with the NPDES permit; applicable water quality standards; storm water pollution prevention and SPCC plans; and discharge of radioactive effluents in compliance with applicable regulatory standards would ensure adverse impacts would be small. Discharge of cooling water results in a thermal plume in Wheeler Reservoir throughout the operational life of a BFN unit. The differences between plume temperature and ambient water temperature are maintained within limits set in the NPDES permit. When in service, helper cooling towers release much of the heat to the atmosphere that would otherwise be discharged to the reservoir. Water lost to evaporation represents consumption of water that would not be available for other uses. The consumptive use of surface water, which would continue throughout the operational life of the plant, is less than 0.2 percent of the available surface water. Water use would remain similar to that of current operations during the proposed subsequent period of extended operation

Resource, Alternative	Unavoidable Adverse Impacts
Aquatic Ecology Alternative B	Entrainment or impingement results in a loss of fish and other aquatic organisms. BFN operates in an open mode and uses helper cooling towers when needed to remain in compliance with the NPDES permit, typically a few months during the hottest part of the summer (usually July and August). The impacts of entrainment or impingement on aquatic species would continue to be small.
Socioeconomics and Environmental Justice Alternative A	The loss of operational jobs and potential relocation of employees would have a negligible effect on the permanent population of Lauderdale, Limestone, and Colbert Counties, but the loss of operational jobs could have a dampening effect on the housing market, specifically in Limestone County. The loss of operational jobs could result in a loss of population in Limestone County where a large percentage of BFN operational workers live. The sizeable operational work force needed for the new generating assets would likely come from local and regional sources, creating new jobs for several years. The impact of an influx of workers on a smaller community or city located near the selected site could result in substantial strain on public services and housing. The impacts on the minority or low-income populations would be proportional to their proximity to the new generation facilities. Acquiring adequate housing would be necessary for workers that would relocate to the area for any of the generating asset projects. Upgrading existing or building new infrastructure, water, and wastewater facilities could be required, particularly with the creation of new housing subdivisions. Small unavoidable adverse impacts are expected over the life of the operation of the new generating assets that would be needed to replace BFN.
Radiological Alternative A and B	Small radiological doses to workers and members of the public from radioactive liquid and gaseous effluent releases to air and surface water would occur over the operational life of this project. Releases are well below regulatory limits. While employees are potentially exposed over the long term, adherence to applicable regulatory standards, radiological safety procedures, work plans and safety measures reduce this to a small impact. The potential impacts of radioactive waste and spent fuel are reduced through specific plant design features in conjunction with a waste minimization program. Potential impacts are further reduced through employee safety training programs and work procedures, and by strict adherence to applicable regulations for storage, treatment, transportation, and ultimate disposal of this waste in a geological repository, or reprocessing. These mitigation measures reduce the risk of radioactive impacts, but there remains some small residual risk. Waste disposal constitutes a long-term commitment of land.

Resource, Alternative	Unavoidable Adverse Impacts
Hazardous, Solid, and Low-Level Radioactive Waste Alternative A	The potential impacts of waste depend on the combination of generating assets that would be constructed to replace BFN. The quantities and types of solid waste generated would be determined primarily by the number of acres, the initial condition of the selected site, and the location and type of technology chosen. Waste would be generated through operation activities. However, impacts would be small as waste would be disposed of in accordance with procedures and applicable regulations. Should SMRs be used as for replacement generation, LLRW would be stored, treated, and disposed. Disposal of these materials represents a long-term commitment of land. The impacts of low-level radioactive and nonradioactive hazardous waste are reduced through waste minimization programs, employee training programs, and strict adherence to work procedures and applicable regulations.
Hazardous, Solid, and Low-Level Radioactive Waste Alternative B	LLRW would be stored, treated, and disposed. Disposal of these materials represents a long-term commitment of land. The impacts of low-level radioactive and nonradioactive hazardous waste are reduced through waste minimization programs, employee training programs, and strict adherence to work procedures and applicable regulations.
Atmospheric and Meteorological Alternative A	Atmospheric and meteorological impacts would vary and depend on the combination of generating assets that would be constructed to replace BFN. There would be impacts from the operation of some of these options. All facilities would be required to meet all air quality standards and the impacts would be small to moderate. Should SMRs be used as a replacement generation source, any emissions would be maintained within limits established in permits. Air emissions from diesel generators, equipment, and vehicles would have a small impact on workers and local residents over the operational life of this project. A small amount of radioactive emissions would occur from the SMR plant(s) during normal operations. Compliance with permit limits and regulations for installing and operating air emission sources and monitoring of those air emissions would result in little or no adverse impacts. Should cooling towers be used they could emit a plume of water vapor resulting in a limited obstructed view of the sky. The plumes present little environmental effect on humans or biota.
Atmospheric and Meteorological Alternative B	Although emissions would be maintained within limits established in permits, air emissions from diesel generators, equipment, and vehicles would have a small impact on workers and local residents over the operational life of this project. A small amount of radioactive emissions would occur from nuclear plants during normal operations. Compliance with permit limits and regulations for installing and operating air emission sources and monitoring of those air emissions would result in little or no adverse impacts. Helper cooling towers would emit a plume of water vapor resulting in a limited obstructed view of the sky. The plumes present little environmental effect on humans or biota.

3.26. Relationship Between Short-Term Versus Long-Term Productivity of the Human Environment

This section focuses on and compares the significant short-term benefit (e.g., principally generation of electricity) and uses of environmental resources which have long-term consequences on environmental productivity. Table 3.26-1 summarizes the proposed action's short-term uses and benefits versus the long-term consequences on environmental productivity. For the purposes of this section, the term "short-term" is the period of time during which continued power generation activities would take place for BFN (years of 2033 – 2056), including prompt decommissioning for Alternative B. This discussion applies to the general ramifications of implementing any of the proposed alternatives.

Table 3.26-1. Summary of BFN – Alternative B Principal Short-Term Benefits Versus the Long-Term Impacts on Production

Alternative B – BFN Subsequent License Renewal	Short-Term Uses and Benefits	Relationships to Maintenance and Enhancement of Long-Term Environmental Productivity
Land Use	Continued commitment of land for industrial use until the plant is shut down and decommissioned.	No permanent loss as the land could be released for other uses or returned to its natural state after decommissioning.
Aquatic Ecology	Entrainment and impingement of aquatic biota will continue, but the impacts will continue to be small.	No large permanent detrimental disturbance to biota or their habitats.
Socioeconomic Growth	For continued operation of BFN, the impacts to local socioeconomic conditions would be expected to remain unchanged and of small impact. When BFN is required to shut down and go into decommissioning, the short-term impacts to the local economy would be expected to be small.	Payments in lieu of taxes, plant expenditures, and employee spending leads to some long-term direct and secondary growth in the local economy, infrastructure, and services that may continue after BFN is decommissioned.
Irradiated Spent Fuel	Provides a short-term supply of clean carbon-free energy.	Managed as radioactive waste and either reprocessed or isolated from the biosphere for thousands or tens of thousands of years. Long-term commitment of the local ISFSI storage area and the underground geological repository.
Other Radioactive Waste	The radioactively contaminated reactor vessel and equipment are required for the short-term production of nuclear energy.	Contaminated waste would be moved offsite and must be managed and isolated from the biosphere for hundreds or thousands of years depending on the level of radiotoxicity and half-life.

Alternative B – BFN Subsequent License Renewal	Short-Term Uses and Benefits	Relationships to Maintenance and Enhancement of Long-Term Environmental Productivity
Potential for Accident	Potential consequences of a reactor accident could range from small to large. However, the probability or likelihood of a severe accident is calculated to be very remote. Because the probability of such an event is so small, the overall risk of a nuclear accident is, likewise, considered to be so small as not to constitute a potentially significant impact upon the human environment.	In the advent of an accident, the impacts could be long-term and large. Affected areas would be remediated, and would eventually be returned to industrial or other purposeful life.
Depletion of Natural Resources	As a reactor fuel, the uranium provides a short-term supply of clean carbon-free energy.	Continued operation of BFN would contribute to the long-term cumulative depletion of the global supply of uranium.
Offset Usage of Finite Fossil Fuel Supplies	During operation, BFN would avoid the consumption of fossil fuels, with some increase in the use of uranium. Consumption of fossil fuels in the uranium fuel cycle is substantively less than would occur for equivalently sized fossil-fuel based generation.	Reduces the cumulative long-term depletion of global fossil fuel supplies.
Materials, Energy, and Water	BFN generates far more electrical power than is used to operate the plant. A small amount of materials are used during plant operation. A relatively small quantity of cooling water is lost through evaporation and drift from cooling systems.	Operation of BFN contributes to the cumulative long-term irretrievable use of materials, energy, and water. However, BFN provides far more energy than is consumed.
Air Pollution	Operation of BFN avoids air pollutants that would likely be produced by fossil-fueled plants if the reactor operation was not extended into the period of extended operation.	Operation of BFN results in a long-term cumulative avoidance of greenhouse emissions that would likely be produced by fossil-fueled plants.
Social Changes	Operation of BFN through the proposed subsequent period of extended operation would produce little change from the current social characteristics of the local area.	Payments made in lieu of taxes by TVA, and wages spent by the operational staff, would inject large revenues into the local economy that have long-lasting economic growth and development effects, which would continue after BFN is decommissioned.

The principal short-term benefit from the continued operation of BFN through the proposed subsequent period of extended operation would be the production of a clean and reliable form of electrical energy. Alternative A would also supply clean and reliable electrical energy, although the natural gas-fired combined cycle (CC) and combustion turbine (CT) generation would be the least clean (air quality) of all the replacement generation options. The short-term beneficial impacts of usage outweigh the adverse impacts on long-term environmental productivity.

With respect to long-term benefits, nuclear energy (Alternative B and the SMR option within Alternative A) avoids CO_2 emissions that may have a large long-term detrimental effect on global climate. Nuclear energy also reduces the depletion of fossil fuels. Sections 3.21 describes effects associated with uranium fuel use. Impacts associated with Alternative A SMR(s) and Alternative B include radioactive waste, spent fuel storage, and transportation of radioactive materials. Section 3.25.1 and Section 3.25.2 describe the effects of mining, conversion, enrichment of uranium, fabrication of nuclear fuel, use of fuel, and disposal of the spent fuel as applicable to Alternatives A (SMRs) and B. Effects of natural gas-fired production (i.e., CC and CT facilities as part of Alternative A).

There are two key long-term adverse impacts on productivity of importance to the nuclear alternatives. Both of these environmental impacts are governed by the half-lives of the respective radioisotopes. The first involves long-term radioactive contamination of the reactor vessel, equipment, and other material exposed to radioactive isotopes. The second involves irradiated spent fuel that must be safeguarded and isolated from the biosphere for thousands of years or reprocessed for use as fuel.

3.26.1. Short-Term Uses and Benefits

There are a number of short-term benefits derived from the continued operation of BFN during the proposed subsequent period of extended operation. The proposed subsequent period of extended operation of BFN stands out as the best choice of the two alternatives. Table 3.27-1 presents a summary of BFN’s principal short-term benefits versus the long-term impacts on productivity. These short-term uses and benefits, as summarized below include the following:

- Electricity generation.
- Fuel diversity.
- Avoidance of air pollution and greenhouse gas emissions.
- Land use.
- Aquatic Biota.
- Socioeconomic changes and growth.

The principal short-term benefit of the proposed subsequent period of extended operation of BFN would be the continued base load generation to meet the demand for electricity in TVA’s power service area. Energy diversity is also fundamental to the objective of achieving a reliable and affordable electrical power supply system. Over-reliance on any one fuel source leaves consumers vulnerable to price spikes and supply disruptions. Continued operation of BFN supports the goal of a diversified mix of electrical generating sources. TVA’s goal is to reduce the carbon emissions of the TVA generating system, and Alternative A or B supports that goal. However, Alternative A would not be as effective as there is potential for the construction of natural gas facilities.

BFN would not require changes to the transmission system to maintain the short-term and long-term capacity and reliability of the power supply in TVA’s service area. Alternative A would potentially require extensive new infrastructure for transmission lines and pipelines depending on the location and type of new generation resources.

There would be no major construction or refurbishments during the proposed subsequent period of extended operation. Therefore, no additional impacts to terrestrial resources would occur. Land use would not change at the site until decommissioning has occurred. The land may be released for other uses or returned to its natural state after BFN has been decommissioned. Alternative A would potentially require extensive land-use changes for the construction of the new plants and infrastructure, resulting in large impacts to the terrestrial resources.

BFN would not experience any major construction or refurbishments during the proposed subsequent period of extended operation, and impacts to flora and fauna have already occurred and would be expected to remain stable at the site. Alternative A would potentially cause small to large impacts to flora and fauna due to the construction of new generating assets. Aquatic biota impacts have been determined to be of small impact due to impingement and entrainment during operation of BFN. Alternative A would have an even smaller impact due reduced amounts of nuclear generating assets.

The eventual decommissioning of BFN would result in small to moderate short-term impacts to local communities due to the loss of jobs, decreased tax revenue, people moving out of the area, school enrollment decreasing, and impacts on fire, police, and public services. Secondary impacts to local businesses and communities would be expected to be short-term and small. Decommissioning impacts would occur either at the end of the proposed subsequent period of extended operation or at the time the current licenses would expire.

3.26.2. Maintenance and Enhancement of Long-Term Environmental Productivity

Potential long-term effects on the productivity of the human environment are described in this section and summarized in Table 3.26-1. The assessment of long-term productivity impacts does not include the short-term effects related to the continued operation of BFN or the construction and operation of new generating assets needed to replace BFN.

Some of the adverse environmental impacts would remain after practical measures to avoid or mitigate them have been taken.

Land Use

The BFN site land use would continue to be designated as industrial through the proposed subsequent period of extended operation. A new solar, battery storage, and nuclear or natural gas-fired plant site land use would have to be designated for construction and operation of the new facilities.

After any of the generating plants considered under Alternatives A and B are shut down and decommissioned, the land-use designation could be changed as appropriate for the new use of the land. After BFN, or SMR (Alternative A), is shut down and decommissioned to NRC standards, the land would be available for other industrial or non-industrial uses. Decommissioned natural gas-fired plants or solar facilities are not subject to NRC standards, but the land would be available for a multitude of potential land uses.

Therefore, land-use impacts are not expected to preclude long-term productivity. Similarly, after decommissioning, there would be no long-term effects related to air emissions, water effluents, and other resources described in Chapter 3.

Exposure to Hazardous and Radioactive Materials and Waste

Under Alternatives A (SMR facilities) and B, workers may be exposed to low doses of radiation and trace amounts of hazardous materials and waste. Workplace exposures are carefully monitored to ensure that radioactive exposure is within regulatory limits. Local non-workers also receive a very small incremental dose of radiation. Radiological monitoring and impacts related to the operation of BFN or an SMR are described in Chapter 2. The persistence of radionuclides depends on the half-life of the radionuclides. The doses are in compliance with applicable regulatory standards and permits and do not substantially affect humans, biota, or air and water resources.

Potential for Nuclear Accident
Under Alternative A (SMR facilities) and Alternative B, the risk of a potential accident at BFN or from SMRs would be the product of the potential consequences, and the probability or likelihood that an event would occur. The potential consequences of an accident could range from small to large. However, the probability or likelihood of a large accident is very remote. Therefore, the overall risk of a nuclear accident is likewise so small as not to constitute a potentially significant impact upon the human environment. The results of analysis in Section 3.22 indicate that the environmental risks due to postulated accidents are small.

Uranium Fuel Cycle and Depletion of Uranium or Natural Gas
The principal use of uranium is as a fuel for nuclear power plants. With approximately 440 nuclear reactors operating worldwide, these plants currently produce approximately 16 percent of the world's electrical power generation. Global uranium fuel consumption is increasing as nuclear power generation continues to expand worldwide. Continuing to operate BFN through the proposed subsequent period of extended operation would contribute to a small incremental increase in the depletion of uranium.

The operation of a new natural gas-fired plant would contribute to the depletion of the limited global supply of natural gas, although currently natural gas supplies in the United States appear to be increasing as a result of the development of natural gas shale formations.

Offset Usage of Finite Fossil Fuel Supplies
Fossil fuels represent a finite geological deposit, the use of which constitutes a cumulative irreversible commitment of a natural energy resource. The continued operation of BFN or the construction and operation of solar facilities or SMRs helps offset the cumulative depletion of this limited resource.

Use of Materials, Energy, and Water
Construction and operation of BFN have already resulted in the long-term, irreversible use of materials and energy for the completion of BFN. Construction and operation of SMRs, solar facilities, battery storage, or natural gas-fired plants would result in the long-term, irreversible use of materials and energy for the construction and operation of the new generation facilities. However, over the term of operation, BFN, solar facilities, SMRs, or natural gas-fired plants would provide far more energy than is consumed in their construction. A small amount of water is consumed in the construction of any new electrical generation plant. During operation of nuclear power plants, a relatively modest quantity of cooling water is also consumed as loss to the atmosphere through evaporation and drift.

3.27. Irreversible and Irretrievable Commitments of Resources

This section describes anticipated irreversible and irretrievable commitments of environmental resources that would occur in either the continued operation of BFN or the construction and operation of generating assets needed to replace the generating capacity of BFN. The irreversible and irretrievable commitments are summarized in Table 3.27-1 below.

For the purposes of this analysis, the term “irreversible” applies to the commitment of environmental resources (e.g., permanent use of land) that cannot by practical means be reversed to restore the environmental resources to their former state. In contrast, the term “irretrievable” applies to the commitment of material resources (e.g., irradiated steel, petroleum) that, once used, cannot by practical means be recycled or restored for other uses.

Table 3.27-1. Summary of Irreversible and Irretrievable Commitments of Environmental Resources

Environmental and Material Resources Issues	Irreversible	Irretrievable
Socioeconomic Changes Alternatives A and B	Alternative A decommissioning and construction of new generating assets would result in both short-term and long-term small changes in the population, nature, and character of the local community, and local socioeconomic structure. Alternative B would also undergo decommissioning which would result in both short-term and long-term small changes in the population, nature, and character of the local community, and local socioeconomic structure	None.
Disposal of Hazardous and Radioactively Contaminated Waste Alternatives A and B	Alternatives A (i.e., SMRs as part of the replacement facilities for BFN) and B result in the generation of radioactive, hazardous, and nonhazardous waste that would be disposed of in licensed landfills or disposal repositories. Alternative A (i.e., construction and operation of the various generating assets) also results in hazardous and nonhazardous waste that would be disposed of in licensed landfills. Land committed to the disposal of radioactive, hazardous, and nonhazardous wastes is an irreversible impact because it is committed to that use, and is largely unavailable for other purposes.	None.
Commitment of Underground Geological Resources for Disposal of Radioactive Spent Fuel Alternatives A and B	Spent nuclear fuel is isolated from the biosphere for thousands or tens of thousands of years in a deep underground geological repository. This long-term commitment makes the surrounding geological resources unusable for thousands of years.	None.
Destruction of Geological Resources during Uranium Mining and Fuel Cycle and Natural Gas Production Alternatives A and B	None.	Uranium mining can result in contamination and destruction of geological resources, and pollution of lakes, streams, underground aquifers, and the soil. Natural gas production can result in contamination and destruction of geological resources and pollution of lakes, streams, underground aquifers, and the soil.

Environmental and Material Resources Issues	Irreversible	Irretrievable
Contaminated and Irradiated Materials Alternatives A and B	None.	Some of the materials used as components and structures in the operation of BFN or new SMR facility are radioactively contaminated or irradiated over the life of the plant. This material cannot be reused or recycled and must be isolated from the biosphere for hundreds or thousands of years.
Land Use Alternatives A and B	None.	The range of available land uses for the BFN site or alternative new generation facilities and associated transmission line ROWs would be restricted for the life of the plant and transmission lines, resulting in irretrievable lost production or use of renewable resources such as timber, agricultural land, or wildlife habitat during the period the land is used.
Water Consumption Alternatives A and B	None.	Relatively small amounts of potable water are used during operation of BFN. A small fraction of the cooling water taken from Wheeler Reservoir is lost through evaporation. The combination of generating assets that could be constructed could use small amounts of potable water during operation. The impact to surface water is small relative to available resources, but the volume used is a natural resource that is no longer readily available for use.
Consumption of Energy Alternative A and B	None.	Nonrenewable energy in the form of fuels (gas, oil, and diesel) and electricity is consumed in construction and to a lesser extent, operation of BFN or in the construction and operation of new power generation facilities. Alternative A would consume large amounts of natural gas to fuel CC and CT facilities if these were chosen to help replace the generating capacity of BFN.

Environmental and Material Resources Issues	Irreversible	Irretrievable
Consumption of Uranium Fuel and Natural Gas Alternatives A and B	None.	BFN or a new SMR would contribute a relatively small increase in the depletion of uranium used to fuel the reactors. A new natural gas-fired plant would contribute to the depletion of natural gas used to fuel the plant.

3.27.1. Irreversible Environmental Commitments

Irreversible environmental commitments resulting from the continued operation of BFN or operation of a new nuclear in the form of SMRs would relate primarily to those of the UFC: (1) land disposal of equipment and materials contaminated by hazardous and LLRW, (2) UFC effects that include commitment of underground geological resources for disposal of radioactive waste and spent fuel, and (3) destruction of geological resources during uranium mining.

Implementation of Alternatives A and B (at decommissioning) would result in both short-term and long-term small changes in the population, the nature and character of the local community, and the local socioeconomic infrastructure.

Uranium Fuel Cycle

The UFC is defined as the total of those options and processes associated with the provision, utilization, and ultimate disposition of fuel for nuclear power reactors.

Environmental effects are contributed from uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, use of the fuel, possible future reprocessing of irradiated fuel, transportation of radioactive materials, disposal of used (spent) fuel and management of wastes.

BFN or SMR plants would generate radioactive, hazardous, and nonhazardous wastes that require disposal. This waste is disposed of in permitted hazardous, mixed, or radioactive landfills or disposal facilities. Land committed to the disposal of radioactive and hazardous wastes represents an irreversible impact because it is committed to that use and can be used for few other purposes.

Emissions for fuel production or storage of spent fuel would be considered irreversible. The analysis of these environmental effects results in the finding that all resource impacts were small. The UFC effects from either Alternative A or B impacts would be only small effects.

In June 2008, the DOE submitted to the NRC a license application to build a deep geologic repository for used nuclear fuel and other high-level radioactive waste at Yucca Mountain, Nevada, a remote desert location. A year later, President Obama announced plans to discontinue the Yucca Mountain project and empanel a blue ribbon commission to provide recommendations for long-term management of high-level radioactive waste. The DOE announced formation of the commission on January 29, 2010. TVA believes that a geologic repository will ultimately be the permanent storage solution.

3.27.2. Irretrievable Environmental Commitments

Irretrievable environmental commitments resulting from the continued operation of BFN or the construction and operation of new power generation plants include the following:

- Construction and irradiated materials.
- Water consumption.
- Consumption of energy.
- Consumption of uranium fuel or natural gas.
- Land use.
- Destruction of geological resources during uranium mining and fuel cycle or natural gas production.

Construction and Irradiated Materials

Common irretrievable commitments of materials comprising the components and structures used either for operation of BFN or construction and operation of SMRs include such items as concrete, rebar, structural steel, power cable, small bore piping, and large bore piping. A portion of these materials becomes contaminated or irradiated over the life of nuclear operation. This material cannot be reused or recycled and must be isolated from the biosphere for hundreds or thousands of years. However, because some of this material may be reused (if uncontaminated) or decontaminated for future use, the recycled portion does not constitute an irretrievable commitment of resources.

While the amount of construction materials is large, use of such quantities in large-scale construction projects such as nuclear reactors, hydroelectric and coal-fired plants, and many large industrial facilities (e.g., refineries and manufacturing plants) represents a relatively small incremental increase in the overall use of such materials. Even if this material is eventually disposed of, use of construction materials in such quantities has a small impact with respect to the national or global consumption of these materials. An additional irretrievable commitment of resources includes materials used during normal plant operations, some of which are recovered or recycled.

Construction of a natural gas-fired plant, solar farm, or battery storage facility would require fewer materials and would not be subject to irradiation or contamination, resulting in almost no irretrievable commitment of resources. Construction of transmission lines and infrastructure for Alternative A would require the irretrievable commitment of fossil fuels (diesel and gasoline), oils, lubricants, and other consumables used by construction equipment and workers commuting to the site. Other materials used for construction of the proposed facilities would be committed for the life of the facilities. Some of these materials, such as ceramic insulators and concrete foundations, may be irretrievably committed, while the metals used in conductors, supporting structures, and other equipment could be and would likely be recycled. The useful life of the transmission structures is expected to be at least 60 years. Natural gas pipelines require maintenance that involves irretrievable commitment of fossil fuels as well and have a finite lifetime.

Water Consumption

Relatively small amounts of potable water are used during the operation of BFN and small amounts would be needed for the construction and operation of new generating assets.

Some of the cooling water taken from Wheeler Reservoir for BFN would be lost through the helper cooling towers by way of drift and evaporation. The impact to surface water resources is relatively small, but represents a natural resource that may no longer be available for use.

Energy Used in Construction or Operation of New Power Generation Plants
Nonrenewable energy in the form of fuels (gas, oil, and diesel) and electricity are consumed in the construction and, to a much smaller extent, operation of all power generation plants. Beyond ancillary (e.g., vehicles, equipment) usage, nuclear reactors do not consume fossil fuels such as petroleum or coal, but a natural gas-fired plant would consume large quantities of natural gas resources.

The total amount of energy consumed during construction or operation of a modern electrical generation plant is very minor in comparison to the total amount consumed within the United States. On net balance, the nuclear reactor produces far more energy (as measured in BTUs) than is consumed in its construction and operation. For this reason, one of the key considerations related to irreversible and irretrievable requirements is that operation of BFN or construction of an SMR or Solar Facility helps conserve or avoid the consumption of finite fossil fuel supplies.

Land Use
The land that would be used for ROWs for pipelines and transmission lines for Alternative A (i.e., CC or CT, solar, storage, and/or SMRs and associated infrastructure) would constitute an irretrievable commitment of onsite resources, such as wildlife habitat and forest resources, for the length of time the pipeline and transmission lines are in place. However, the approximate previous land use and land cover could be returned upon retirement of these facilities.

Uranium Fuel Cycle and the Depletion of Uranium and Natural Gas
Global uranium fuel consumption is increasing as nuclear power generation continues to expand worldwide. Sources of uranium include primary mine production as well as secondary sources. Continued operation of BFN would contribute a relatively small increase in the depletion of uranium. Under Alternative A, BFN would close and the decrease in the depletion of uranium would be offset by SMRs that would be constructed to aid in replacing BFN.

Operation of the CC or CT plants would result in the irretrievable loss of natural gas, which would be used to fuel the CCs or CTs. In addition, the materials used for the construction of the proposed site would be committed for the life of the facilities. However, these fossil fuels and building materials are not in short supply at this time and their use would not have an adverse effect upon continued availability of these resources.

3.27.3. Energy Resources and Conservation Potential
The total amount of energy consumed during continued operation of BFN or the construction or operation of the various generating facilities under Alternatives A is very small in comparison to the total amount consumed within the United States. Considering the resulting net balance of energy, a reactor or CC or CT gas turbine would produce far more energy (as measured in BTUs) than would be consumed in its construction or operation. Operation of a nuclear plant helps conserve or avoid the consumption of finite fossil fuel supplies. A CC gas turbine is more efficient than a simple cycle gas turbine and also consumes less fossil fuel than a coal plant.

Nonrenewable energy in the form of fuels (gas, oil, and diesel) and electricity would be consumed in construction of any plant, and to a much smaller extent, in the operation of either BFN or other generating assets that would be constructed to replace the generating capacity of BFN.

Processing of nuclear fuel is, however, an energy-intensive activity. Existing uranium enrichment facilities are large and each facility services several nuclear generating plants. For comparative purposes, the energy required to process or enrich uranium sufficient to fuel a single 1,000 MW pressurized boiling water reactor nuclear plant would approximate that of the output from a 50 MW fossil-fuel (coal-fired) facility operating at 75 percent capacity factor. Newer technologies (e.g., centrifuge or atomic vapor laser isotope separation) currently, or becoming, commercially available for enrichment utilize significantly less power than older technologies. As it is anticipated that these new, less energy intensive technologies will eventually become the norm for production of nuclear fuel, the processing portion of the UFC would likely use even less energy and become even more "carbon-friendly" in the future.

DOE formally announced in a June 29, 2009, Federal Register notice (74 FR 31017) that the department had decided to no longer pursue the prior administration's domestic Global Nuclear Energy Partnership program and that the department would focus on long-term research and development of technologies with the potential to produce beneficial changes to the manner in which nuclear waste is managed. This announcement effectively ended DOE efforts to pursue design and construction of spent nuclear fuel recycling facilities, either at a commercial or engineering scale.

CHAPTER 4 – SUBMITTED ALTERNATIVES, INFORMATION AND ANALYSIS

The Supplemental Environmental Impact Statement (SEIS) includes a summary that identifies all alternatives, information, and analyses submitted by State, Tribal, and local governments, in Section 1.5, and other public commenters during the scoping process for consideration in developing the SEIS (40 Code of Federal Regulations 1502.17). During the scoping period, comments pertained to safety, aging infrastructure, alternatives, general environmental concerns, air quality, water quality and stormwater, wetlands and streams, waste disposal, climate, and environmental justice. The comments related to Tennessee Valley Authority's (TVA's) proposed action are included in Appendix D of the Scoping Report (Appendix A of this SEIS).

Based on the scoping process, reviews, and assessments of the proposed action, TVA determined that the scope of the SEIS should include the following topics:

- Land Use
- Geology and Soils
- Surface Water Resources, Hydrology, and Water Quality
- Groundwater Resources
- Floodplains and Flood Risk
- Wetlands
- Aquatic and Terrestrial Ecology
- Endangered and Threatened Species
- Managed and Natural Areas
- Recreation
- Air Quality, including Meteorology
- Global Climate Change and Greenhouse Gases
- Transportation
- Visual Resources
- Noise and Vibration
- Socioeconomics, including Environmental Justice
- Archaeological Resources and Historic Structures
- Hazardous, Solid, and Low-Level Nuclear Waste
- Radiological Effects of Normal Operations
- Uranium Fuel Cycle Effects
- Nuclear Plant Safety and Security
- Decommissioning

CHAPTER 5 – LIST OF PREPARERS

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CHAPTER 6 – LITERATURE CITED

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Appendix A
Scoping Report

Document Type: SEIS–Administrative Record
Index Field: SEIS Scoping Report
Project Name: BFN Subsequent License Renewal
Project Number: 534475 (2021-11)

FINAL

BROWNS FERRY NUCLEAR (BFN) PLANT

SUBSEQUENT LICENSE RENEWAL ENVIRONMENTAL IMPACT STATEMENT

PUBLIC SCOPING REPORT

Prepared by:

Tennessee Valley Authority
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October 2021

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Symbols, Acronyms, and Abbreviations

ADEM	Alabama Department of Environmental Management
BFN	Browns Ferry Nuclear
CWA	Clean Water Act
EA	Environmental Assessment
EIS	Environmental Impact Statement
EJ	Environmental Justice
EO	Executive Order
EPU	Extended Power Uprate
GEIS	Generic Environmental Impact Statement
MWe	Megawatts electric
NEPA	National Environmental Policy Act
NOI	Notice of Intent
NRC	Nuclear Regulatory Commission
PNNL	Pacific Northwest National Laboratory
SEIS	Supplemental Environmental Impact Statement
SLR	Subsequent License Renewal
TVA	Tennessee Valley Authority
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Browns Ferry Nuclear (BFN) Plant
Supplemental Environmental Impact Statement (SEIS)

Public Scoping Report

July 2021

The Tennessee Valley Authority (TVA) proposes to submit a Subsequent License Renewal (SLR) Application to the Nuclear Regulatory Commission (NRC) requesting renewal of the Browns Ferry Nuclear (BFN) Plant operating licenses. Renewal of the NRC operating licenses will authorize the plant to continue to operate for an additional 20 years beyond the current 20 -year renewed operating licenses expiration dates of 2033, 2034, and 2036 for Units 1, 2, and 3, respectively. Subsequent NRC license renewal for the operating BFN facilities does not involve new major construction or modifications beyond normal maintenance and refurbishment. However, there are other proposed projects such as spent fuel storage expansion that is not directly related to NRC license renewal that are connected to, or could affect, license renewal. Therefore, TVA is initiating the preparation of a Supplemental Environmental Impact Statement (SEIS) pursuant to the National Environmental Policy Act (NEPA) to assess the environmental impacts of the proposed action.

Background

TVA operates BFN Units 1, 2, and 3 consistent with its mission as charged under the TVA Act of 1933. BFN consists of three General Electric boiling water reactors and associated turbine generators that collectively supply approximately 3,900 Megawatts electric (MWe) to the TVA transmission and distribution system.

In March 2002, TVA issued a Final SEIS followed by a Record of Decision in June 2002 for the operating license renewal of BFN. TVA submitted a License Renewal Application to the NRC in December 2003 for a 20-year extension of the operating licenses for each BFN unit. NRC prepared its own SEIS in consideration of TVA's license application. NRC's Final SEIS concluded that the impacts of license renewal would not be adverse and issued Supplement 21 regarding Browns Ferry Nuclear Plant Units 1, 2, and 3, to the Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants (NUREG-1437) in June 2005. The NRC issued renewed operating licenses for Units 1, 2, and 3 in May 2006, allowing operation of the three BFN units until 2033, 2034, and 2036, respectively.

TVA submitted a license amendment request for extended power uprate (EPU) of approximately 15 percent for all three units in September 2015. The NRC issued a Draft Environmental Assessment (EA) in the Federal Register in December 2016 for public comment. In May 2017, the NRC issued the Final EA and Finding of No Significant Action related to the EPU license amendment. NRC issued the license amendment in August 2017. BFN Unit 3 reached EPU in Summer 2018, Unit 1 reached EPU in December 2018, and Unit 2 reached EPU in Spring 2019.

TVA's Objectives

The purpose of the proposed action is to help provide continued generation of baseload power from the BFN site between 2033 and 2056 by obtaining NRC license renewals to operate all three BFN units. BFN's current generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan, by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation. Renewal of the current NRC operating licenses would allow BFN to continue supplying approximately 3,900 MWe of safe, clean, reliable, and cost-effective baseload power for an additional 20 years. BFN license renewal is a key component of meeting TVA's goal of a net-zero carbon emissions generating system by 2050.

TVA must decide whether to submit a SLR Application to the NRC to extend the operating licenses of the three units for an additional 20 years beyond their current license terms. TVA is preparing an SEIS to inform TVA decision-makers and the public about the environmental consequences of the proposed action.

Proposed Alternatives

Several alternatives will be analyzed in addition to the continuing operation of BFN by license renewal for the generating capacity and energy needed to provide approximately 3,900 MWe of base load power between 2033 and 2053. Potential options for meeting TVA's purpose and need include the range of supply-side and demand-side actions identified in TVA's Integrated Resource Plan. While development of alternatives is a continuing process, preliminary internal scoping by TVA has identified the following four possible alternatives,

- **Alternative A: No Action** – TVA would not submit an application to NRC for SLR. The existing licenses would expire in 2033, 2034, and 2036 and TVA would begin the process of evaluating and planning for the necessary decommissioning of all three BFN units. The 3,900 MWe baseload generation would no longer produced by BFN.
- **Alternative B: BFN NRC Subsequent License Renewal** – TVA would submit a SLR Application to NRC for renewal of BFN Units 1, 2, and 3 licenses until 2053, 2054, and 2056 respectively.
- **Alternative C: Use of Existing Generating Assets** – TVA would cease operations at BFN, and BFN's generating baseload electricity would be replaced using existing generating assets, including natural gas, coal, hydro, nuclear, and storage.
- **Alternative D: Use of Existing and Construction of New Generating Assets** – TVA would cease operations at BFN, and BFN's generating baseload electricity would be replaced using a mix of existing and newly constructed generating assets, including solar, natural gas, nuclear, battery and hydro storage, etc.

Environmental Review Process

NEPA requires the identification and analysis of potential environmental effects of proposed federal actions and alternatives before those actions take place. The NEPA review process is intended to help federal agencies make decisions that are based on an understanding of the action's environmental impacts and, if necessary, to take actions that protect, restore, and enhance the environment. NEPA also requires that federal agencies provide opportunities for public involvement in the decision-making process.

TVA is initiating the preparation of this SEIS to assess the environmental impacts of the proposed action and a reasonable range of alternatives. An EIS is the most intense level of NEPA review. A supplement is prepared to update a previous EIS; in this case the 2002 SEIS for BFN License Renewal. During the completion of this SEIS, the public and environmental and permitting agencies will have opportunities to provide input on the development of the environmental review. After considering input from the scoping period, TVA will develop and publish a Draft SEIS that will be provided to the public and intergovernmental agencies for additional comment. During the Draft SEIS public comment period, TVA plans to conduct a public meeting. TVA will consider all the comments received during the public review of the Draft SEIS, make revisions as appropriate, and publish a Final SEIS stating a preferred alternative. Subsequently, TVA will publish a Record of Decision documenting its final decision regarding the proposed action.

TVA estimates that the Draft SEIS will be published in Fall 2022, the Final SEIS would be published in Early 2023, and a final decision would be made in Spring 2023.

Public Outreach During Scoping Period

The purpose of the scoping period is to present TVA's project objectives and initial alternatives for input from the public and interested stakeholders.

On June 1, 2021, TVA published a Notice of Intent (NOI) in the Federal Register announcing plans to prepare a SEIS to address the potential environmental effects associated with extending the operation of BFN Units 1, 2, and 3 for an additional 20 years (see Appendix A). The NOI initiated a 30-day public scoping period, which concluded on July 1, 2021. In addition to the NOI in the Federal Register, TVA published notices regarding this effort in two local newspapers: The Decatur Daily which serves the Decatur and the Tennessee Valley in northern Alabama and the News Courier which serves Limestone County. TVA also issued a news release to media and posted the news release on the TVA Web site (See Appendix B).

To accommodate social distancing guidelines and public health recommendations related to the COVID-19 pandemic, TVA created a virtual meeting room that was available for the duration of the scoping period. The URL link to the virtual meeting room was included in the NOI and can be accessed through TVA's website (https://www.tva.com/environment/environmental-stewardship/environmental-reviews/nepa-detail/browns-ferry-nuclear-plant-subsequent-license-renewal) through the completion of the EIS process. The virtual scoping meeting room contains information on the NEPA process and the proposed action, as well as links to TVA and NRC websites related to the project. The virtual scoping meeting room also allows the public to submit a comment or feedback on the project during open comment periods (scoping and draft SEIS review). Posterboards and screenshots from the virtual scoping meeting room are included in Appendix C.

Summary of Public Scoping Feedback

TVA received a total of 23 comments regarding the SLR of BFN Units 1, 2, and 3 from five commenters. Of the five comment submissions, two were from federal entities (U.S. Environmental Protection Agency [USEPA] and U.S. Geological Survey [USGS]) and three were from members of the public. Nine of the 23 comments received were in regard to safety and aging infrastructure. The remaining comments received pertained to alternatives, general environmental concerns, air quality, water quality and stormwater, wetlands and streams, waste disposal, climate, and environmental justice. The comments related to TVA's proposed action are provided below. Original comment submissions are included in Appendix D.

Public Scoping Comments

Safety and Aging Infrastructure

Comment 1: There is no evidence these installations will remain safe for an additional 20 years. I ask that all systems be thoroughly inspected and investigated before these extensions are considered and the results made public. (Commenter: Steve Sondheim)

Comment 2: Commenters noted the collapse of the Surfside, Florida condo building as an example that older structures are vulnerable to a variety of aging factors. Aging, stressed components are more likely to fail the longer they are in service. A link to an article was included. (Commenters: Steven Sondheim and Don Safer)

Comment 3: The Supplemental Environmental Impact Statement should reevaluate fundamental assumptions of safety that have been used to justify previous SLRs of other nuclear power reactors in the US. (Commenter: Don Safer)

Comment 4: The SEIS should include the effects of a catastrophic accident and massive radiation release at one or more of these aging reactors that were designed to operate for 40 years. Extending operation to 80 years demands an exhaustive study of the aging management. The longer these reactors run, the greater the risk of a devastating accident. (Commenter: Don Safer)

Comment 5: The Browns Ferry reactors are Fukushima style GE Mark 1 reactors, a design that has a long, controversial history, with many questioning the lack of robustness in the containment system and foreshadowing the three reactor melt-downs, hydrogen explosions, resulting containment breeches, and release of massive amounts of radiation at Fukushima. Links to four articles were included to support this comment. (Commenter: Don Safer)

Comment 6: The Browns Ferry reactors have a history of mechanical problems and other issues resulting in six separate shut-downs of longer than a year including the longest shutdown of any US reactor (Unit 1 from 1985 to 2007) and the second and third longest shutdowns (Unit 3 from 1985 to 1995 and Unit 2 from 1984 to 1991). In 2011 they received one of only 4 “Red finding” safety warnings from the NRC for extended safety performance deficiencies. Safety concerns have plagued these reactors throughout their lives. Links to three articles were included to support this comment. (Commenter: Don Safer)

Comment 7: The BFN spent fuel pools locations are over 40 feet off the ground and with only sheet metal roofing overhead and these pools contain an enormous amount of deadly radiation. The SEIS should consider deficiencies in the BFN spent fuel pools and the environmental effects of a failure of one or more of these pools and the resulting release of radiation. Links to three articles were included to support this comment. (Commenter: Don Safer)

Comment 8: The commenter states that “reasonable assurance” of reactor safety during the proposed SLR period is far from certain. The safety of this license extension is wholly unproven. The NRC and the nuclear reactor operators have taken a “don’t look, don’t want to know” approach to verification of continued integrity of inner reactor critical components that are subject to the intense conditions in a nuclear reactor (heat, neutron bombardment, pressure, extreme temperature swings in SCRAM events, etc.). The commenter also provided a quote from former NRC Commissioner Victor Gilinsky and the link to the story from which the comment was taken, noting the absence of validity of the NRC’s SLR process. (Commenter: Don Safer)

Comment 9: The commenter stated that SEIS should consider the wide range of critical knowledge gaps in the age-related material degradation process in General Electric Mark 1 boiler water reactors and the management of that degradation over 60 or 80 years. The SEIS should also provide an evidence basis on materials safety and systems reliability to make informed, scientifically qualified decisions in regulatory review of longer license extensions of nuclear power plants. Harvesting and material testing of nuclear plant components and compiling an evidence basis to assess age-related degradation management are necessary for “reasonable assurance,” which is an explicit NRC requirement for license extension. The commenter provided a link to a Department of Energy Pacific Northwest National Laboratory (PNNL) Technical Letter Report published in December 2017 in which PNNL was instructed to identify knowledge gaps and recommended harvestings and analysis of materials in decommissioning. He noted that a revised report (PNLL-27120, Rev. 1) was republished in April 2019 having removed scores of references to critical knowledge gaps and recommendations to require decommissioning harvesting and analysis for reasonable assurance in NRC safety and environmental review and approval process of license extension applications. Without scientifically founded “reasonable assurance,” the NRC lacks a legal basis for granting Subsequent License Renewal. (Commenter: Don Safer)

Alternatives
Comment 10: Nuclear power is not needed if renewable energy is adequately deployed by 2035-40. (Commenter: Steven Sondheim)

Comment 11: The No Action Alternative (A) should be chosen, and a new process started that focuses on alternative (E): Replacement of BFN Generating Capacity with Renewable Energy Sources. TVA should bring on board renewables, energy efficiency and additional storage with urgency. Renewable energy is the fastest growing energy resource in the world and the United States. The commenter provide links to two articles. (Commenter Don Safer)

General Environmental Concerns
Comment 12: The SEIS should comprehensively cover all conceivable environmental impacts of continued operation of the BFN reactors. It should consider the fundamental environmental, health and environmental justice problems inherent in nuclear power at every step in the nuclear fuel chain: uranium mining, milling, fuel fabrication, operations, radioactive waste, and decommissioning. (Commenter: Don Safer)

Air Quality
Comment 13: Limestone County is in attainment with the Clean Air Act National Ambient Air Quality Standard. (Commenter: USEPA)

Water Quality and Stormwater
Comment 14: Based on NEPA, the proposed project may be located within a mile of an impaired stream Round Island Creek/Round Island Creek (Wheeler Lake). TVA should consider implementing best management practices during maintenance for areas greater than one acre per the Clean Water Act’s (CWA) National Pollutant Discharge Elimination System Permit for stormwater, where applicable, to ensure that water quality impairments are not exacerbated. (Commenter: USEPA)

Wetlands and Streams
Comment 15: The EPA recommends that TVA collaborate with Alabama Department of Environmental Management (ADEM) and US Army Corps of Engineers (USACE) to determine any potential impacts from the hydraulic and hydrological design associated with thermal discharges to the Tennessee River that may impact terrestrial and/or aquatic species, including both flora and fauna. TVA in collaboration with USACE may wish to include CWA Section 404(b)(1) documents in the SEIS to support any wetland and stream mitigation decisions and to help ADEM evaluate potential stream impact requirements for the CWA Section 401 Water Quality permit. Providing adequate wetland and stream information within the NEPA process can help to streamline the final environmental review and permitting processes for these

resources. According to NEPAssist, there are five approved mitigation or conservations banks in the facility vicinity - Flint River Mitigation Bank Phase I (1042), Wheeler Pointe Mitigation Bank (1044). ADOT Town Creek (1198) and ADOT Crow Creek (1199) and Robinson Spring Mitigation Bank (930) should mitigation be required. (Commenter: USEPA)

Waste Disposal
Comment 16: The SEIS should indicate if there will be any changes in the generation of waste including low-level radioactive waste, mixed low-level radioactive waste, transuranic waste, and hazardous and Toxic Substance Control Act wastes over the life of the program. The SEIS should indicate where TVA will send the spent nuclear fuel and spent fuel debris for storage pending long-term disposal options. (Commenter: USEPA)

Climate
Comment 17: Climate change may impact the proposed project, posing threats to aging infrastructure, worker health and safety and the environment. We recommend that the SEIS include an evaluation of climate-related impacts including discussions of frequency and severity of major storm events, wildfires, or drought that could lead to power disruptions or increased cooling demands in summer months. Efforts that TVA is taking at BFNP to address and adapt to potential climate impacts should be discussed in the SEIS. (Commenter: USEPA)

Comment 18: [The SEIS] should consider the growing threats to nuclear power reactor operation and safety posed by the ever-growing effects of climate change. (Commenter: Don Safer)

Environmental Justice
Comment 19: The SEIS should include an analysis that is consistent with the Environmental Justice (EJ) Executive Order (EO) 12898. The analysis should indicate whether minority, low income or other overburdened populations reside within the vicinity of the proposed project area. If so, the EPA recommends that the communities with EJ concerns should be meaningfully involved throughout the decision-making process to help identify potential benefits and burdens associated with relicensing and permitting decisions. Adaptive and innovative approaches to both public outreach and community involvement regarding project issues should take place during the project planning. It would also be helpful to include a current map depicting the population demographics near the BFNP facility. EPA's EJSCREEN can be used a preliminary screen to help identify potential issues. (Commenter: USEPA)

General Comments
Comment 20: The USGS has no comment at this time. Thank you. (Commenter: USGS)

Comment 21: Renew the licenses. Keep the plant running. We need it. (Commenter: Jack Keeling)

Comment 22: I highly object to the extension of licenses to the Browns Ferry Nuclear Power reactors from 60-80 years which is 40 years beyond the original license. (Commenter: Steven Sondheim)

Comment 23: The subsequent license renewal (SLR) of the three Browns Ferry (BFN) Reactors should be rejected. (Commenter: Don Safer)

Appendix A: Federal Register Notice of Intent

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• 20 CFR 404.1740(b)(8) and 416.1540(b)(8)—This regulatory section requires representatives to disclose to SSA whether the representative is or has been disqualified from participating in or appearing before any Federal program or agency, including instances in which a Federal program or agency took administrative action to disqualify the representative in lieu of disciplinary proceedings. If the disqualification occurs after the appointment of the representative, the representative will immediately disclose the disqualification to SSA; and;

• 20 CFR 404.1740(b)(9) and 416.1540(b)(9)—This regulatory section requires representatives to disclose to SSA whether the representative has been removed from practice or suspended by a professional licensing authority for reasons that reflect on the representative's character, integrity, judgment, reliability, or fitness to serve as a fiduciary. If the removal or suspension occurs after the appointment of the representative, the representative will immediately disclose the removal or suspension to SSA.

A representative's obligation to report these events is ongoing, and SSA requires representatives to report any time one or more of these events occurs. We consider this information essential to ensure the integrity of our administrative process and to safeguard the rights of all claimants. SSA requires representatives to notify SSA in writing, but there is no prescribed format for these reports. The respondents are individuals appointed to represent claimants before SSA.

Type of Request: Extension of an OMB-approved information collection.

Regulation section	Number of respondents	Frequency of response	Average burden per response (minutes)	Estimated annual burden (hours)	Average theoretical hourly cost amount (dollars) *	Total annual opportunity cost (dollars) **
404.1740(b)(5)/416.1540(b)(5)	43,600	1	5	3,633	* $26.45	** $96,093
404.1740(b)(6)/416.1540(b)(6)	2	1	5	0	* 69.86	** 0
404.1740(b)(7)/416.1540(b)(7)	50	1	5	4	* 69.86	** 279
404.1740(b)(8)/416.1540(b)(8)	10	1	5	1	* 69.86	** 70
404.170(b)(9)/416.1540(b)(9)	10	1	5	1	* 69.86	** 70
Totals	43,672			3,639		96,512

* We based this figure on average hourly wages for paralegals/legal assistants and lawyers as posted by the U.S. Bureau of Labor Statistics (*https://www.bls.gov/oes/current/oes_nat.htm*).

** These figures do not represent actual costs that SSA is imposing on representatives to complete the required disclosures; rather, these are theoretical opportunity costs for the additional time representatives or their employees and associates will spend to complete the required disclosures. *There is no actual charge to representatives to complete the required disclosures.*

Dated: May 25, 2021.

Naomi Sipple,

Reports Clearance Officer, Social Security Administration.

[FR Doc. 2021–11421 Filed 5–28–21; 8:45 am]

BILLING CODE 4191–02–P

TENNESSEE VALLEY AUTHORITY

Supplemental Environmental Impact Statement—Browns Ferry Nuclear Site Subsequent License Renewal

AGENCY: Tennessee Valley Authority.

ACTION: Notice of intent.

SUMMARY: The Tennessee Valley Authority (TVA) intends to prepare a Supplemental Environmental Impact Statement (SEIS) to address the potential environmental effects associated with obtaining subsequent license renewals (SLR) for the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3 located in Limestone County, Alabama. Renewal of the operating licenses would allow the plant to continue to operate for an additional 20 years beyond the current operating licenses expiration dates of 2033, 2034, and 2036 for Units 1, 2, and 3, respectively. TVA plans to evaluate a variety of alternatives including a no-action alternative. Public comments are invited to identify other potential alternatives, relevant information, and analysis related to the proposed action.

DATES: The public scoping period begins with the publication of this Notice in the **Federal Register** and comments on the scope of the SEIS must be received or postmarked by July 1, 2021. To accommodate social distancing guidelines and public health recommendations related to the COVID–19 pandemic, TVA will have a virtual meeting room available for the duration of the scoping period. Visit *https://www.tva.com/nepa* to obtain more information.

ADDRESSES: Comments may be submitted in writing to J. Taylor Cates, NEPA Specialist, 1101 Market Street, BR 2C–C, Chattanooga, TN 37402. Comments may also be submitted online at: *https://www.tva.com/nepa* or by email to *nepa@tva.gov.* Due to COVID–19 teleworking restrictions, electronic submission of comments is encouraged to ensure timely review and consideration.

FOR FURTHER INFORMATION CONTACT: Other related questions should be sent to Tennessee Valley Authority, J. Taylor Cates, NEPA Specialist, 1101 Market Street, BR 2C–C, Chattanooga, TN 37402, or 423–751–2732/*jtcates@tva.gov.*

SUPPLEMENTARY INFORMATION: This Notice is provided in accordance with the Council on Environmental Quality's (CEQ) regulations for implementing the National Environmental Policy Act (NEPA) at 40 CFR parts 1500–1508 and Section 106 of the National Historic Preservation Act (NHPA), and its implementing regulations (36 CFR part 800). The SEIS will be prepared consistent with the 2020 CEQ regulations for implementing NEPA at 40 CFR parts 1500–1508 (85 FR 43304–43376, Jul. 16, 2020). The regulations of the Nuclear Regulatory Commission (NRC) in 10 CFR part 54 set forth the applicable license extension requirements.

TVA Power System

TVA is a corporate agency and instrumentality of the United States, created by and existing pursuant to the TVA Act of 1933 (16 U.S.C. part 831), and created to, among other things, foster the social and economic welfare of the people of the Tennessee Valley region and promote the proper use and conservation of the Valley's natural resources. TVA generates and distributes electricity for business customers and local power distributors, serving more than 10 million people in parts of seven southeastern states. TVA is fully self-financed without Federal appropriations, and funds virtually all operations through electricity sales and power system bond financing. In addition to operating and investing its revenues in its electric system, TVA provides flood control, navigation and management for the Tennessee River system, and assists local power companies and state and local governments with economic development efforts.

Dependable electrical capacity on the TVA power system is about 33,000 Mega Watts Electric (MWe). TVA's current generating assets include one pumped-storage facility, one diesel generator site, three nuclear plants, five coal plants, nine combustion turbine plants, eight combined cycle plants, 14 solar energy sites, 29 hydroelectric dams, and several small renewable generating facilities. A portion of delivered power is obtained through long-term power purchase agreements. About 13 percent of TVA's annual generation is from hydro; 14 percent is from coal; 27 percent is from natural gas; 41 percent is from nuclear; and the remainder is from wind and solar. TVA also gains available capacity through its energy efficiency programs. TVA transmits electricity from these facilities over almost 16,000 miles of transmission lines. Like other utility systems, TVA has power interchange agreements with utilities surrounding the Tennessee Valley region, and routinely buys and sells power.

Background

TVA operates BFN Units 1, 2, and 3 in Limestone County, Alabama. BFN is located on an 840-acre tract on the north shore of Wheeler Reservoir at Tennessee River Mile (TRM) 294, approximately 10 miles northwest of Decatur, Alabama, and 10 miles southwest of Athens, Alabama. BFN consists of three General Electric boiling water reactors (BWRs) and associated turbine generators that collectively supply approximately 3,900 MWe of electric power to the TVA transmission and distribution system.

In March 2002 and June 2002, TVA issued a Final SEIS (FSEIS) and a Record of Decision (ROD) for the operating license renewal of BFN. TVA submitted a License Renewal Application (LRA) to the NRC in December 2003 for a 20-year renewal of the operating licenses for each BFN unit. The environmental conclusions of the NRC FSEIS did not differ from the TVA FSEIS conclusions, and the NRC issued Supplement 21 regarding Browns Ferry Nuclear Plant Units 1, 2, and 3, to the Generic EIS (GEIS) for License Renewal of Nuclear Plants (NUREG–1437) in June 2005. The NRC issued operating license renewals for Units 1, 2, and 3 in May 2006, allowing continued operation of the three BFN units until 2033, 2034, and 2036, respectively.

In September 2015, TVA submitted a license amendment request (LAR) for extended power uprate (EPU) of all three units. The NRC issued a draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) in the **Federal Register** on December 1, 2016 for public comment. On May 22, 2017 the NRC issued the Final EA and FONSI related to the EPU license amendment.

Project Purpose and Need

The purpose of the proposed action is to help provide continued generation of baseload power between 2033 and 2053 by obtaining license renewals to operate BFN Units 1, 2, and 3. BFN is considered baseload power because the plant generally runs at close to maximum output. BFN's current baseload generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation capacity. Renewal of the current operating licenses would allow BFN to continue supplying approximately 3,900 MWe capacity of baseload power.

TVA needs to generate sufficient electricity to supply the Tennessee Valley with increasingly clean, reliable, and affordable electricity for the foreseeable future for the region's homes and businesses, working with local power companies to keep service steady and reliable. By renewing the licenses, TVA would maximize use of existing assets to support TVA's goals of generating electricity at the lowest feasible cost for the people of the Tennessee Valley. BFN's carbon-free generating capacity supports TVA's goal of a net-zero carbon emissions generating system by 2050.

Preliminary Proposed Action and Alternatives

TVA proposes to submit a Subsequent LRA (SLRA) to the NRC requesting renewal of BFN operating licenses. Renewal of the current operating licenses would permit operation for an additional 20 years past the current operating license terms, which expire in 2033, 2034, and 2036 for Units 1, 2, and 3, respectively. This SEIS is being prepared to provide the public and TVA decision-makers an assessment of the environmental impacts of renewing BFN Unit 1, 2, and 3 operations, as well as provide the public an opportunity to participate in the SEIS process. License renewal does not require any new construction or modifications beyond normal maintenance and minor refurbishment. However, there are other proposed projects not directly related to SLR that are connected to, or could affect, license renewal.

The SEIS proposes to address a range of alternatives (A–D) including: (A) The No-Action Alternative; (B) BFN Subsequent License Renewal; (C) Use of Existing Generating Assets; and (D) Use of Existing and Construction of New Generating Assets. Two additional alternatives, (E) Replacement of BFN Generating Capacity Entirely with Renewable Energy Sources and (F) Replacement of BFN Generating Capacity Entirely with Purchase Power, were considered but eliminated.

Anticipated Environmental Impacts

The SEIS will include a detailed evaluation of the environmental, social, and economic impacts associated with implementation of the proposed action. Resource areas to be addressed in the SEIS include, but are not limited to: Air quality; aquatics; botany; climate change; cultural resources; emergency planning; floodplains; geology and groundwater; hydrothermal; land use; navigation; noise and vibration; radiological safety; soil erosion and surface water; socioeconomics and environmental justice; threatened and endangered species; transportation; visual; waste; water use; wetlands; and wildlife. Measures to avoid, minimize, and mitigate adverse effects will be identified and evaluated in the SEIS.

In preparing this SEIS, TVA will consider the analysis within the NRC's Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants (NUREG–1437, Revision 1), where the NRC generically considered the environmental effects of renewing nuclear power plant operating licenses for a 20-year period (results are codified in 10 CFR part 51). The GEIS identified 78 environmental issues and reached generic conclusions on environmental impacts for 59 of those issues that apply to all plants or to plants with specific design or site characteristics. The GEIS' generic assessment is relevant to the assessment of impacts of the proposed action at BFN. Generic information from the NRC GEIS that is related to the current assessment would be incorporated by reference, generally following the tiering process described in 40 CFR 1501.11, with the SEIS providing a more narrow analysis relevant to the specific aspects of this proposed project. Additional plant-specific review would be conducted for impacts not covered by the GEIS and which are encompassed by the range of resource issue areas identified above.

Anticipated Permits and Other Authorizations

TVA anticipates consulting with the required authorities including, but not limited to: The Endangered Species Act; Bald and Golden Eagle Protection Act; Rare Species Protection and Conservation Act; National Historic Preservation Act; Clean Air Act; and Federal Clean Water Act.

TVA anticipates seeking required permits or authorizations as appropriate, from the following governmental entities: The Nuclear Regulatory Commission; US Army Corps of Engineers; US Coast Guard; US Environmental Protection Agency; Alabama Department of Environment and Conservation; US Fish and Wildlife Service; Alabama State Historic Preservation Officer; and Tribal Historic Preservation Officers. This is not an exhaustive list, other permits or authorizations may be sought as required or appropriate.

Public Participation and Scoping Process

TVA seeks comment and participation from all interested parties for the proposed action, including, but not limited to, assisting TVA in determining the scope of issues for analysis in the SEIS. Information about this project is available at *https://www.tva.com/nepa,* which includes a link to an online public comment page. TVA invites the public to identify other alternatives, and analysis relevant to the proposed action. Comments must be received or postmarked no later than July 1, 2021. Federal, state, local agencies, and Native American Tribes are also invited to provide comments.

Please note that any comments received, including names and addresses, will become part of the project administrative record and will be available for public inspection.

To accommodate social distancing guidelines and public health recommendations related to the COVID–19 pandemic, TVA will have a virtual meeting room available for the duration of the scoping period that includes a range of information on the proposed action. Visit *https://www.tva.com/nepa* to obtain more information about the virtual open house.

SEIS Preparation and Schedule

TVA will consider comments received during the scoping period and develop a scoping report which will be published at *https://www.tva.com/nepa.* The scoping report will summarize public and agency comments that were received and identify the projected schedule for completing the SEIS process. Following completion of the environmental analysis for SLR, TVA will post a Draft SEIS for public review and comment on the project web page. TVA anticipates holding a public open house, which may be virtual, after releasing the Draft SEIS. Open house details will be posted on TVA's website in conjunction with the Draft SEIS. TVA expects to release the Draft SEIS in mid-2022.

TVA will consider comments received on the Draft SEIS, as well as cost, engineering, risk and other applicable evaluations before selecting one or more alternatives as preferred in the Final SEIS. TVA projects completing a Final SEIS in early 2023. A final determination on proceeding with the preferred alternative will be documented in a ROD.

Authority: 40 CFR 1501.9.

Rebecca Tolene,

Vice President, Environment.

[FR Doc. 2021–11557 Filed 5–28–21; 8:45 am]

BILLING CODE 8120–08–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Notice of Intent To Release Certain Properties From All Terms, Conditions, Reservations and Restrictions of a Quitclaim Deed Agreement Between City of Tallahassee and the Federal Aviation Administration for the Tallahassee International Airport, Tallahassee, FL

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Request for public comment.

SUMMARY: The FAA hereby provides notice of intent to release certain airport properties 44.66 acres at the Tallahassee International Airport, Tallahassee, FL from the conditions, reservations, and restrictions as contained in a Quitclaim Deed agreement between the FAA and the City of Tallahassee, dated March 14, 1990. The release of property will allow the City of Tallahassee to dispose of the property for non-aeronautical purposes. The City of Tallahassee requests the release of a 44.66 acre tract located along Capital Circle SW in Tallahassee, Florida to facilitate the widening of State Road 263 for municipal development. This capital improvement project is funded by the Florida Department of Transportation. The parcel is currently designated as aeronautical property. The property will be released of its federal obligations given the land is no longer required by The City of Tallahassee. The Fair Market Value (FMV) of this parcel has been determined to be $2,020,050.00.

Documents reflecting the Sponsor's request are available, by appointment only, for inspection at the Tallahassee International Airport and the FAA Airports District Office.

SUPPLEMENTARY INFORMATION:

Section 125 of The Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR–21) requires the FAA to provide an opportunity for public notice and comment prior to the "waiver" or "modification" of a sponsor's Federal obligation to use certain airport land for non-aeronautical purposes.

DATES: Comments are due on or before July 1, 2021.

ADDRESSES: Documents are available for review at the Tallahassee International Airport, 3300 Capital Circle SW, Suite One, Tallahassee, FL 32310–8732 and the FAA Airports District Office, 8427 SouthPark Circle, Suite 524, Orlando, FL 32819–9058. Written comments on the Sponsor's request must be delivered or mailed to: Stephen Wilson, Program Manager, Orlando Airports District Office, 8427 South Park Circle, Suite 524, Orlando, FL 32819–9058.

In addition, a copy of any comments submitted to the FAA must be mailed or delivered to Mr. Eric Houge, Airport Engineer, Tallahassee International Airport, 3300 Capital Circle SW, Suite One, Tallahassee, FL 32310–8732.

FOR FURTHER INFORMATION CONTACT: Stephen Wilson, Program Manager, (407) 487–7229, Orlando Airports District Office, 8427 SouthPark Circle, Suite 524, Orlando, FL 32819–9058.

Issued in Orlando, FL on May 26, 2021.

Bartholomew Vernace,

Manager, Orlando Airports District Office, Southern Region.

Revision Date 11/22/00.

[FR Doc. 2021–11435 Filed 5–28–21; 8:45 am]

BILLING CODE 4910–13–P

Appendix B: Newspaper Advertisements and Media Release

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Free beer, other new incentives for Biden's 'vaccine sprint'

By Zeke Miller
The Associated Press


Biden

WASHINGTON Dangling everything from sports tickets to a free beer, President Joe Biden is looking for that extra something anything that will get people to roll up their sleeves for COVID 19 shots when the promise of a life saving vaccine by itself hasn't been enough.

Biden on Wednesday announced a "month of action" to urge more Americans to get vaccinated before the July 4 holiday, including an early summer sprint of incentives and a slew of new steps to ease barriers and make getting shots more appealing to those who haven't received them. He is closing in on his goal of getting 70% of adults at least partially vaccinated by Independence Day essential to his aim of returning the nation to something approaching a pre pandemic sense of normality this summer.

"The more people we get vaccinated, the more success we're going to have in the fight against this virus," Biden said from the White House. He predicted that with more vaccinations, America will soon experience "a summer of freedom, a summer of joy, a summer of get togethers and celebrations. An All American summer."

The Biden administration views June as "a critical month in our path to normal," Courtney Rowe, the director of strategic communications and engagement for the White House COVID 19 response team, told the AP.

Biden's plan will continue to use public and private sector partnerships, mirroring the "whole of government" effort he deployed to make vaccines more widely available after he took office. The president said he was "pulling out all the stops" to drive up the vaccination rate.

Among those efforts is a promotional giveaway announced Wednesday by Anheuser Busch, saying it will "buy Americans 21+ a round of beer" once Biden's 70% goal is met.

"Get a shot and have a beer," Biden said, advertising the promotion even though he himself refrains from drinking alcohol.

Additionally, the White House is partnering with early childhood centers such as KinderCare, Learning Care Group, Bright Horizons and more than 500 YMCAs to provide free childcare coverage for Americans looking for shots or needing assistance while recovering from side effects.

The administration is also launching a new partnership to bring vaccine education and even doses to more than a thousand Black owned barbershops and beauty salons, building on a successful pilot program in Maryland.

They're the latest vaccine sweeteners, building on other incentives like cash giveaways, sports tickets and paid leave, to keep up the pace of vaccinations.

"The fact remains that despite all the progress, those who are unvaccinated still remain at risk of getting seriously ill or dying or spreading the disease to others," said Rowe.

Aiming to make injections even more convenient, Biden is announcing that many pharmacies are extending their hours this month and thousands will remain open overnight on Fridays. The White House is also stepping up its efforts to help employers run on site vaccination clinics.

Biden will also announce that he is assigning Vice President Kamala Harris to lead a "We Can Do This" vaccination tour to encourage shots. It will include first lady Jill Biden, second gentleman Doug Emhoff and Cabinet officials. Harris' travel will be focused on the South, where vaccination rates are among the lowest in the country, while other officials will travel to areas of the Midwest with below average rates.

To date 62.9% of the adult U.S. population have received at least one dose of a COVID 19 vaccine and 133.9 million are fully vaccinated. The rate of new vaccinations has slowed to an average below 555,000 per day, down from more than 800,000 when incentives like lotteries were announced, and down from a peak of nearly 2 million per day in early April when demand for shots was much higher.

The lengths to which the U.S. is resorting to convince Americans to take a shot stands in contrast to much of the world, where vaccines are far less plentiful. Facing a mounting U.S. surplus, the Biden administration is planning to begin sharing 80 million doses with the world this month.

"All over the world people are desperate to get a shot that every American can get at their neighborhood drugstore," Biden said.

Thanks to the vaccinations, the rate of cases and deaths in the U.S. are at their lowest since the beginning of the pandemic last March, averaging under 16,000 new cases and under 400 deaths per day.

As part of the effort to drive Americans to get shots, the White House is borrowing some tools from political campaigns, including phone banks, door knocking and texting. The administration says more than 1,000 such events will be held this weekend alone. Additionally, it is organizing competitions between cities and colleges to drive up vaccination rates.

Other new incentives include a $2 million commitment from DoorDash to provide gift cards to community health centers to be used to drive people to get vaccinated. CVS launched a sweepstakes with prizes including free cruises and Super Bowl tickets. Major League Baseball will host on site vaccine clinics and ticket giveaways at games. And Kroger will give $1 million to a vaccinated person each week this month and dozens of people free groceries for the year.

The fine print on the Anheuser Busch promotion reveals the benefits to the sponsoring company, which will collect consumer data and photos through its website to register for the $5 giveaway. The company says it will hand out credits to how ever many people qualify.

COVID-19

From Page A1


Cole Smith receives a Moderna variant vaccine shot from clinical research nurse Tigisty Girmay on March 31 at Emory University's Hope Clinic in Decatur, Ga. [AP PHOTO/BEN GRAY, FILE]

appear effective against worrisome virus mutants, at least for now.

Scientists do not yet know what's called the correlate of protection, the level below which antibodies cannot fend off the coronavirus with out additional help.

Dr. Anthony Fauci, the U.S. government's leading infectious disease expert, told a Senate subcommittee last week that vaccine protection would not be infinite.

"I would imagine we will need, at some time, a booster," Fauci said. "What we're figuring out right now is what that interval is going to be."

To date, 62.8% of the adult U.S. population has received at least one dose of a COVID 19 vaccine and 133.6 million, or more than 40 percent, are full vaccinated. The rate of new vaccinations has slowed to an average below 600,000 per day, according to the Centers for Disease Control and Prevention. That's closing in on President Joe Biden's goal of 70% with at least one inoculation by July 4.

Infections and deaths continue to fall. The nation's seven day average for daily new cases fell to less than 17,300 on Tuesday, down from more than 31,000 two weeks ago. Daily deaths declined to 588, down from 605, according to data from Johns Hopkins University. In all, the virus has killed more than 595,000 people in the U.S.

So called long lived plasma cells are one of the body's backups. Immunologist Ali Ellebedy at Washington University in St. Louis found that nearly a year after people recovered from mild COVID 19, those plasma cells had migrated to the bone marrow where they were continuing to secrete antibodies. That's why although antibodies do diminish with time, they have not disappeared.

Now Ellebedy is hunting for the same cells in vaccine recipients, and while the research isn't finished, he's finding hints that they're forming.

An even more important backup system comes in the form of memory B cells. If existing antibodies are not enough to stop the coronavirus, memory B cells are poised to churn out large numbers of new antibodies, Ellebedy explained. Numerous studies have found those memory cells after COVID 19 vaccination.

And if the virus makes it past those defenses, yet another immune branch the memory T cells jumps in to eliminate infected cells and prevent severe illness.

With different coronaviruses that cause common colds, people tend to get re infected every two to five years, Wherry noted.

Based on natural immunity against those related viruses, "we are sort of expecting our immunity may decline," he said. "But we don't know. For these mRNA vaccines, we may be doing better than nature, better than a natural infection."

So far, health authorities agree that the most common COVID 19 vaccines in the U.S. and Europe protect against the virus mutations that are currently circulating, though not as strongly as they guard against the original virus.

Why? The vaccines mimic the protein that covers the outer surface of the coronavirus, and only certain spots of that protein are mutating, said FDA vaccine chief Dr. Peter Marks. The mRNA vaccines in particular make antibody levels sky rocket after the second dose. Those levels are so high that they offer some protection even when the vaccine and the variant are not a perfect match.

With so many people still unvaccinated, opportunities abound for more mutations to occur. The biggest sign that a booster might be necessary would be a jump in COVID 19 cases in fully vaccinated people, especially severe illnesses and especially if the infections are caused by a new variant.

To get ready, people vaccinated a year ago as part of the first Pfizer and Moderna vaccine trials now are being enrolled in studies of additional shots either a third dose of the original or versions that have been updated to match a variant that first emerged in South Africa. Moderna says preliminary findings are promising. More results are due this summer.

The National Institutes of Health also just began testing a system in which patients are given a different brand of booster than their original vaccination, to see if it is effective.

Most of the world's population has yet to receive a first dose. With different countries using different kinds of vaccines, decisions on booster shots may vary widely. Already, the United Arab Emirates has offered a third dose to recipients of a Chinese made shot, the first formal introduction of any kind of booster.

If boosters eventually are called for, they will not be needed all at once because antibodies fade gradually rather than disappearing suddenly.

"Even if we require boosters or get to the point where we see immunity waning a little bit, we still are going to be far better off than we were a year ago," Wherry said.

LIMESTONE LEDGER

SATURDAY

Guided nature walk
Damien Simbeck will guide a free nature walk starting 8 a.m. Saturday, June 5, at Marbut Bend Walking Trail in West Limestone. Participants can learn about the area and the wildlife who live there. Binoculars, comfortable walking shoes, sun screen and insect repellent are appreciated. The trail is handicapped-accessible.

Coffee call
The Alabama Veterans Museum & Archives' Coffee Call, sponsored by Vietnam Veterans Chapter 511 and Lyle Sadler, will take place 8 a.m. Saturday, June 5, at the museum's new facility, 114 W. Pryor St., Athens.

Family fun day
TLC Pediatrics will host a family fun day from 9 a.m. until noon Saturday, June 5, to celebrate their one-year anniversary. All invited. Games, treats, prizes and more available.

Addiction Eviction Rally
The 3rd annual Addiction Eviction Rally is set for 10:30 a.m.–7 p.m. Saturday, June 5, at Swan Creek Park, 98 U.S. 31, Athens. Free meals, school supplies, hygiene bags and food boxes available. School supply and diaper donations accepted. Three scholarships will be awarded. More information: Lori Masonia, 256-374-3202

Earth Day & Outdoor EXPO
Keep Athens-Limestone Beautiful will host its annual Earth Day & Outdoor EXPO from 11 a.m. to 2 p.m. Saturday, June 5, in Big Spring Memorial Park. Vendors will be located throughout the park with activities for kids, earth-friendly products, information and more. Steve Trash will perform at 11:30 a.m., 12:30 p.m. and 1:30 p.m. More information: KALB 256-233-8000; KALBCares@gmail.com

TUESDAY

Cooking contest
The Alabama Farmers Federation Women's Committee will accept entries for the annual Heritage Cooking Contest 10 a.m. Tuesday, June 8, at the ALFA office, 524 U.S. 72 West, Athens (across from Hobbs Jewelry). The category is candy. Copy of recipe required with registration and entry. Cash prizes available. Must be an ALFA member to enter. More information: 256-233-0938

WEDNESDAY

Childcare class
Limestone County Kids and Kin will host a free child-rearing class from 10 a.m. until noon Wednesday, June 9, at The Haven, 810 N. Malone St., Athens. The class is designed for those raising a relative's child and will focus on "Tails and Tales, Part 1." More information: Tammie Hill, 256-724-2554

UPCOMING

Community appreciation day
Women Empowering Women of Alabama and FreshWind Church will host a community appreciation day 11 a.m.–3 p.m. Saturday, June 12, at 17200 Lucas Ferry Road, Athens. Food, clothing and door prizes will be given away. All ages welcome. More information: Janice Williams, 256-233-5995

Mitchell reunion
Descendants of the Cross Key community's Mitchell family are invited to a family reunion starting 11 a.m. Saturday, June 12, at Swan Creek Park Pavilion #3, U.S. 31 in Athens. Food will be served at noon. More information: Louis, 256-232-7783

Beans and rice
Beans and rice will be given away 9–11 a.m. Saturday, June 19, by volunteers at Saint Timothy's Episcopal Church, 207 E. Washington St., Athens. No names taken; no ID required. More information: 256-232-2567; sttimothy.athens@gmail.com

Juneteenth Festival
A Juneteenth Festival will be held 10 a.m.–7 p.m. Saturday, June 19, on The Square in Athens. Food, vendors, live music, art and more available. Free admission.

Childcare class
Limestone County Kids and Kin will host a free child-rearing class from 10 a.m. until noon Wednesday, June 23, at The Haven, 810 N. Malone St., Athens. The class is designed for those raising a relative's child and will focus on "Tails and Tales, Part 2." More information: Tammie Hill, 256-724-2554

Kiddie Carnival opening
The Athens Lions Club Kiddie Carnival will start the 2021 season 6:30–9:30 p.m. Thursday, June 24, at 309 E. Forrest St., Athens. The carnival will open at those hours Thursdays, Fridays and Saturdays through July 31. Rides, concessions and games available. Free admission to carnival. Ride tickets 50 cents each. More information: "Athens Lions Club Kiddie Carnival" on Facebook

Day of Caring
Limestone County Churches Involved will host a Day of Caring from 9 a.m.–noon Saturday, June 26, at the facility on Jefferson Street in Athens. LCCI will offer food and general assistance to Limestone County residents, including help with rent or utilities for those who qualify. More information: the Rev. Thom Porter, 256-262-0671

ONGOING

Summer feeding program
Women Empowering Women of Alabama, in partnership with FreshWind Church, is offering free meals for children 1-18 years old. Meals available 10 a.m.–1 p.m. Mondays through Fridays from Monday, June 7, until Friday, July 23.

Bill assistance
Community Action Partnership of Huntsville-Madison and Limestone County Inc.'s LIHEAP Cooling Season will begin June 1. Elderly and/or disabled residents and parents of children 18 or younger who meet the income qualifications can apply for assistance with their cooling bills. Call 256-907-1550 to schedule an appointment. More information: www.caa-htsval.org/services/utilities.html

Walk-in vaccine clinic
The Athens-Limestone Hospital COVID-19 vaccine clinic will accept walk-ins for the Pfizer COVID-19 vaccine on a first-come, first-serve basis for ages 12 and older. Clinic hours are 8 a.m.–3 p.m. Mondays through Fridays at Emmanuel Baptist Church, 1917 U.S. 72 West, Athens. More information: ALH COVID-19 hotline, 256-262-6188

New library hours
The Houston Memorial Library and Museum has extended its hours. Patrons can now visit 10 a.m.–4 p.m. Mondays, Wednesdays, Thursdays and Fridays; 10 a.m.–7 p.m. Tuesdays; and 10 a.m.–4 p.m. on the first Saturday of each month. Book sale room also now open. Additional changes may be announced later. Masks and social distancing requested. More information: 256-233-8770

Vaccine rides
The Limestone County NAACP is offering free rides at 12:30 and 3:30 p.m. Mondays through Fridays for those wishing to receive their COVID-19 vaccine at the Athens-Limestone Hospital clinic. More information: 256-227-8489; 256-216-5668

Food giveaway
Ebenezer Missionary Baptist Church's food pantry will be open 11 a.m.–1 p.m. on the third Saturday of each month at 1911 Hine St., Athens. Patrons must provide proof of at least one of the following: eligibility to receive supplemental food assistance (SNAP/food stamps); eligibility for Temporary Assistance to Needy Families; eligibility to receive Supplemental Security Income; income at or below 130% of the federal poverty level; or special circumstances (fire, flood, illness, injury, etc.). Eligibility forms provided at distribution site. Must have valid ID card or driver's license. Only one distribution per household while supplies last. Monetary and food donations accepted. More information: 256-424-5403

Used book sale
Friends of the Athens-Limestone Public Library host a used book sale from 10:15 a.m.–2:15 p.m. each Tuesday and first Saturday of each month at the library, 603 S. Jefferson St., Athens. More information: 256-232-1233

Virtual exercise class
Limestone County Council on Aging presents virtual exercise class 2–3 p.m. Mondays and Fridays via Zoom. The classes are called S.A.I.L., which stands for Stay Active and Independent for Life. More information: 256-233-6412

Corruption hotline
The Alabama Attorney General's Office and the Federal Bureau of Investigation are asking residents with knowledge of public corruption in Limestone County to email details to reportcorruption@ago.state.al.us or call the tip line at 844-404-TIPS

CHURCH EVENTS

Sermon series
Alabama Fork CPCA will host a two-part virtual sermon series titled "Thirsting for More" 9 a.m. Sunday, June 6, and Sunday, June 13. More information: 256-431-7926; sundaymorningseminary.org

Gospel singing
Berea Baptist Church will host a Southern gospel singing with the Hogan family starting 6 p.m. Sunday, June 13, at 16779 Lucas Ferry Road, Athens. Love offering will be received. More information: Gary Wilson, 256-497-9763

CEMETERY CLEANUP

Reunion Cemetery
Reunion Cemetery will host decoration day with a chicken and goat stew fundraiser Saturday, June 5. Attendees are asked to bring their own container. Donations made payable to the Reunion Cemetery Fund should be sent to Nicole Collins, 25172 Alabama 127, Elkmont, AL 35620.

New Garden Cemetery
New Garden Cemetery will host a cleanup day Saturday, June 5, with the annual decoration day held Sunday, June 6. Donations are needed for upkeep and can be made both days at the cemetery. Those who cannot attend in person can mail donations to Harold Atkinson, 20321 Sandlin Road, Elkmont, AL 35620; or to Harold Robinson, 14016 Robinson Lane, Elkmont, AL 35620

City cemeteries
The City of Athens reminds residents and families of the following regarding its cemeteries: No flowers or decorations allowed on the ground between April 1 and Oct. 31, unless following a funeral; flower placement acceptable year-round on monuments, at their base or at foot markers; fresh flowers will be removed one week after a funeral; silk flowers will be removed 21 days after a funeral; approval by cemetery superintendent required before planting flowers, shrubs, trees or sod; city personnel will remove all trees or shrubs deemed detrimental to adjacent lots or grave openings; and worn, tattered or damaged U.S. flags will be removed and disposed of properly.

MEETINGS

- **Legion.** American Legion Post 49 will meet 7 p.m. Thursday, June 3, at the Disabled American Veterans building, 25396 Airport Road, Athens. More information: Rod Huffman, 256-233-3023

Limestone Ledger is a community calendar in which non-profit organizations can notify the public of events. Publication of donation requests or services offered should not be considered an endorsement by this newspaper. The News Courier encourages residents to research organizations before donating or accepting services. All items will run as space allows until the day of the event and should be submitted at least one week prior to the event for best results. Ongoing items run for up to one month but can be resubmitted regularly. Email submissions to newscouriersoundoff@gmail.com, fax to 256-233-7753 or bring to The News Courier, 410 W. Green St., Athens.

TVA

TVA MEDIA ADVISORY

TVA Requests Input on Browns Ferry Nuclear Subsequent License Renewal

ATHENS, Ala. – The Tennessee Valley Authority is asking for public comment on its Notice of Intent to prepare a Supplemental Environmental Impact Statement on proposed actions associated with obtaining U.S. Nuclear Regulatory Commission license renewals for the Browns Ferry Nuclear Plant Units 1, 2 and 3 in Limestone County, Alabama.

The NRC license renewals would authorize the Browns Ferry Nuclear Plant Units 1, 2, and 3 to continue operation for an additional 20 years beyond the current NRC operating licenses expiration dates of 2033, 2034, and 2036, respectively. TVA plans to evaluate a variety of alternatives including a no-action alternative.

TVA has a virtual meeting room available from June 1 through July 1, 2021. Access the virtual meeting and other details at https://www.tva.com/nepa under the section titled Open for Public Comment.

Comments must be received or postmarked by July 1, 2021, and may be submitted in writing to J. Taylor Cates, NEPA Specialist, 1101 Market Street, BR 2C-C, Chattanooga, TN 37402; online at https://www.tva.com/nepa; or by email to nepa@tva.gov. Due to COVID-19 teleworking restrictions, electronic submission of comments is encouraged to ensure timely review and consideration.

All comments received, including names and addresses, will become part of the administrative record and available for public inspection.

For more information about TVA and its 88-year mission of service to the Tennessee Valley, click here.

# # #

Media Contact: Malinda Hunter, Chattanooga, 423-718-9245
TVA Public Relations, Knoxville, 865-632-6000
http://www.tva.com/newsroom
Follow TVA news on Facebook, Twitter and Instagram

(Distributed: June 2, 2021)

TVA TENNESSEE VALLEY AUTHORITY

TVA Requests Input on Browns Ferry Nuclear Subsequent License Renewal

Jun 2, 2021

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Contact

Malinda Hunter
Public Relations
mhunter@tva.gov
423-718-9245

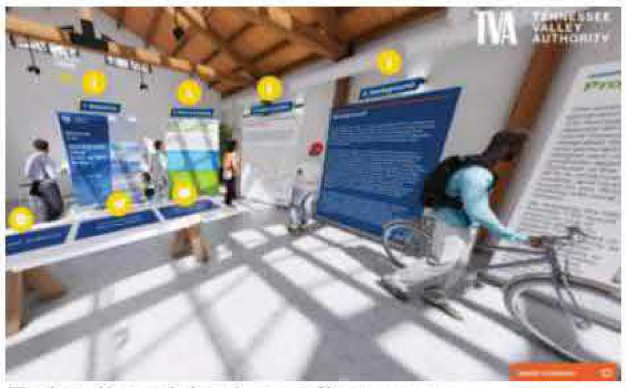
TVA Media Line

Our media staff is available 24 hours a day. If you cannot reach the contact above, please call our media line at 865-632-6000.

TVA TENNESSEE VALLEY AUTHORITY

Browns Ferry Nuclear Plant Subsequent License Renewal

Virtual Public Meeting



Enter the virtual meeting room

Notice of Intent to Prepare a Supplemental Environmental Impact Statement

On June 1, 2021, TVA published a Notice of Intent (NOI) to prepare a Supplemental Environmental Impact Statement (SEIS) to address the potential environmental effects associated with obtaining US Nuclear Regulatory Commission (NRC) subsequent license renewals (SLR) for the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3 located in Limestone County, Alabama. Renewal of the current operating licenses would permit operations for an additional 20 years past the current operating license terms, which expire in 2033, 2034, and 2036 for Units 1, 2, and 3, respectively. The SEIS is being prepared to provide the public and TVA decision-makers with an assessment of the environmental impacts related to the aforementioned NRC license renewal, as well as provide the public an opportunity to participate in the SEIS process. The NRC license renewal would not require any new construction or modifications beyond normal maintenance and minor refurbishment. However, there are other proposed projects not directly related to the NRC SLR that are connected to, or could affect, license renewal.

BFN is considered baseload power because the plant generally runs at close to maximum output. BFN's current baseload generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation capacity. Renewal of the current operating licenses would allow BFN to continue supplying approximately 3,900 MWe capacity of baseload power.

TVA needs to generate sufficient electricity to supply the Tennessee Valley with increasingly clean, reliable, and affordable electricity for the foreseeable future for the region's homes and businesses, working with local power companies to keep service steady and reliable. By renewing the licenses, TVA would maximize use of existing assets to support TVA's goals of generating electricity at the lowest feasible cost for the people of the Tennessee Valley. BFN's carbon-free generating capacity supports TVA's goal of a net-zero carbon emissions generating system by 2050.

The SEIS proposes to address a range of alternatives (A-D) including: (A) the No-Action Alternative; (B) BFN Subsequent License Renewal; (C) Use of Existing Generating Assets; and (D) Use of Existing and Construction of New Generating Assets. Two additional alternatives, (E) Replacement of BFN Generating Capacity Entirely with Renewable Energy Sources and (F) Replacement of BFN Generating Capacity Entirely with Purchase Power, were considered but eliminated.

The NOI is provided in accordance with the Council on Environmental Quality's (CEQ) regulations for implementing the National Environmental Policy Act (NEPA) at 40 CFR parts 1500-1508 and Section 106 of the National Historic Preservation Act (NHPA), and its implementing regulations (36 CFR Part 800). The PEIS will be prepared consistent with the 2020 CEQ regulations for implementing NEPA at 40 CFR parts 1500-1508 (85 FR 43304-43376, Jul. 16, 2020).

Public Involvement

Public scoping was open from June 1, 2021 – July 1, 2021.

TVA is interested in an open process and wants input from the community. The public was invited to submit comments on the scope of this SEIS, alternatives being considered, and environmental issues.

Related Documents:

Notice of Intent

Contact

More information on this environmental review can be obtained from:

TENNESSEE VALLEY AUTHORITY

423-751-2732
1101 Market Street, 2C-C
Chattanooga, TN 37402

Appendix C: Virtual Scoping Meeting Room Materials

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Virtual Scoping Meeting Room Posterboards

TVA TENNESSEE VALLEY AUTHORITY

Welcome
to the

BFN SLR SEIS Virtual Scoping Open House

June 1 – July 1, 2021

The National Environmental Policy Act (NEPA) and Scoping

NEPA requires the identification and analysis of potential environmental effects of major proposed federal actions and alternatives before those actions take place. NEPA's intent is to protect, restore, or enhance the environment through well-informed federal decisions. Public involvement is integral to the federal decision-making process and is required by NEPA.

The purpose of this virtual open house is to inform the public of TVA's intent to prepare a Supplemental Environmental Impact Statement (SEIS) pursuant to NEPA to assess the environmental impacts associated with obtaining subsequent license renewals (SLR) for the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3. Additionally, TVA invites early input from the public regarding the development of the scope, alternatives being considered, and environmental issues related to the proposed action.

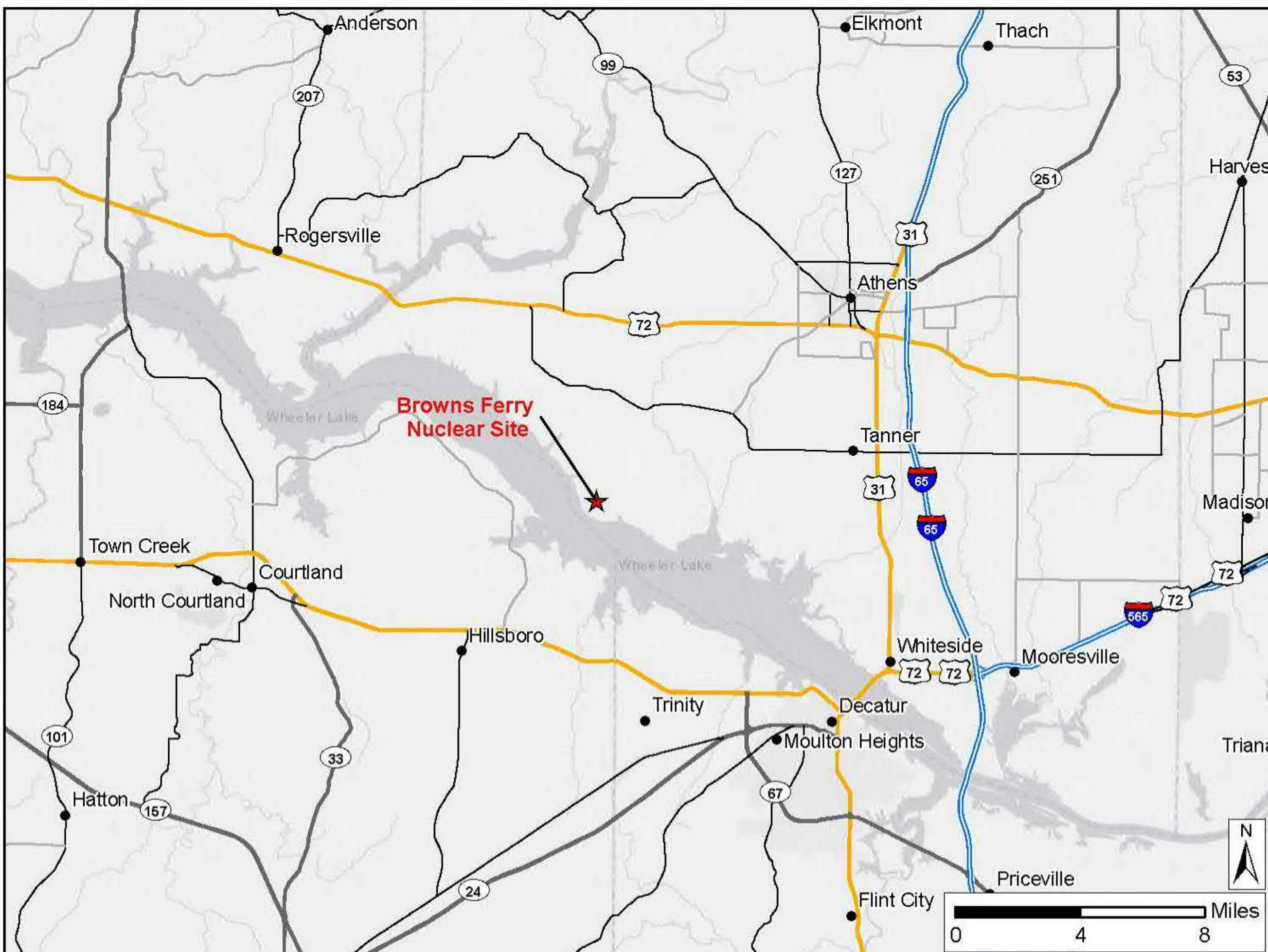
Questions to consider:

- What environmental resources should the SEIS consider?
- What potential impacts should be evaluated?
- Are there any additional alternatives that should be considered?
- Can you recommend any additional sources of information?
- What organizations should TVA be coordinating with?

TVA TENNESSEE VALLEY AUTHORITY

Project Location

The Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) is located on an 840-acre tract on the north shore of Wheeler Reservoir at Tennessee River Mile (TRM) 294, approximately 10 miles northwest of Decatur, Alabama, and 10 miles southwest of Athens, Alabama.



TVA TENNESSEE VALLEY AUTHORITY

Background

TVA operates BFN Units 1, 2, and 3 consistent with its mission as charged under the TVA Act of 1933. BFN consists of three General Electric boiling water reactors (BWRs) and associated turbine generators that collectively supply approximately 3,900 Megawatts electric (Mwe) of electric power to the TVA transmission and distribution system.

In March 2002, TVA issued a Final SEIS (FSEIS) followed by a Record of Decision (ROD) in June 2002 for the operating license renewal of BFN. TVA submitted a License Renewal Application (LRA) to the Nuclear Regulatory Commission (NRC) in December 2003 for a 20-year extension of the operating licenses for each BFN unit. The environmental conclusions the NRC FSEIS did not differ from the TVA FSEIS conclusions and the NRC issued Supplement 21 regarding Browns Ferry Nuclear Plant Units 1, 2, and 3, to the Generic EIS (GEIS) for License Renewal of Nuclear Plants (NUREG-1437) in June 2005. The NRC issued operating license renewals for Units 1, 2, and 3 in May 2006, allowing continued operation of the three BFN units until 2033, 2034, and 2036, respectively.

TVA submitted a license amendment request (LAR) for extended power uprate (EPU) of approximately 15% for all three units in September 2015. The NRC issued a draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) in the Federal Register in December 2016 for public comment. In May 2017, the NRC issued the Final EA and FONSI related to the EPU license amendment. The NRC issued the license amendment in August 2017.

Project Purpose and Need

The purpose of the proposed action is to help provide continued generation of baseload power between 2033 and 2053 by obtaining US Nuclear Regulatory Commission (NRC) license renewals to operate BFN Units 1, 2, and 3. BFN's current generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation. Renewal of the current NRC operating licenses would authorize BFN to continue supplying approximately 3,900 MWe of safe, clean, reliable, and cost-effective baseload power for the foreseeable future for the Tennessee Valley region's homes and businesses, working with local power companies to keep service steady and reliable.

By renewing the NRC licenses, TVA would maximize use of existing assets to support TVA's goals of generating electricity at the lowest feasible cost for the people of the Tennessee Valley. BFN's carbon-free generating capacity supports TVA's goal of a net-zero carbon emissions generating system by 2050.

TVA TENNESSEE VALLEY AUTHORITY

Preliminary Proposed Action

TVA proposes to submit a Subsequent License Renewal Application to the NRC requesting renewal of the BFN operating licenses.

- Renewal of the NRC operating licenses will authorize the plant to continue to operate for an additional 20 years beyond the current 20-year renewed operating licenses expiration dates of 2033, 2034, and 2036 for Units 1, 2, and 3, respectively.
- Subsequent NRC license renewal for the operating BFN facilities does not involve new major construction or modifications beyond normal maintenance and refurbishment.
- There are other proposed projects not directly related to NRC license renewal that are connected to, or could affect, license renewal.

TVA TENNESSEE VALLEY AUTHORITY

Alternatives

The SEIS proposes to address a range of alternatives including:

- Alternative A: No-Action Alternative
- Alternative B: BFN NRC Subsequent License Renewal
- Alternative C: Use of Existing Generating Assets
- Alternative D: Use of Existing and Construction of New Generating Assets

Two additional alternatives were considered but eliminated:

- Alternative E: Replacement of BFN Generating Capacity Entirely with Renewable Energy Sources
- Alternative F: Replacement of BFN Generating Capacity Entirely with Purchase Power

TENNESSEE VALLEY AUTHORITY

Anticipated Environmental Impacts

The SEIS will include a detailed evaluation of the environmental, social, and economic impacts associated with implementation of the proposed action and alternatives. Measures to avoid, minimize, and mitigate potential adverse effects will also be identified and evaluated in the SEIS.

Resource areas to be addressed in the SEIS include, but are not limited to:

- Air Quality
- Aquatics
- Botany
- Climate Change
- Cultural Resources
- Emergency Planning
- Floodplains
- Geology and Groundwater
- Hydrothermal
- Land Use
- Navigation
- Noise and Vibration
- Radiological Safety
- Soil Erosion and Surface Water
- Socioeconomics and Environmental Justice
- Threatened and Endangered Species
- Transportation
- Visual Resources
- Waste
- Water Use
- Wetlands
- Wildlife

TVA TENNESSEE VALLEY AUTHORITY

SEIS and GEIS

In preparing this SEIS, TVA will review the GEIS for License Renewal of Nuclear Plants, NUREG-1437, in which the NRC considered the environmental effects of renewing nuclear power plant operating licenses for a 20-year period (codified in 10 CFR Part 51).

The GEIS identified 78 environmental issues and reached generic conclusions on environmental impacts for 59 of those issues that apply to all plants or to plants with specific design or site characteristics.

The GEIS' generic assessment is relevant to the assessment of impacts of the proposed action at BFN. Generic information from the NRC GEIS that is related to the current assessment would be incorporated by reference, generally following the tiering process described in 40 CFR 1501.11, with the SEIS providing a more narrow analysis relevant to the specific aspects of this proposed project.

Additional plant-specific review would be conducted for impacts not covered by the GEIS and which are encompassed by the range of resource issue areas identified on the Anticipated Environmental Impacts poster.

TVA TENNESSEE VALLEY AUTHORITY

Anticipated Permits and Other Authorizations

TVA anticipates consulting with the required authorities including, but not limited to:

- Endangered Species Act
- Bald and Golden Eagle Protection Act
- Rare Species Protection and Conservation Act
- National Historic Preservation Act
- Clean Air Act
- Federal Clean Water Act

TVA anticipates seeking or renewing required permits or authorizations, from the following governmental entities:

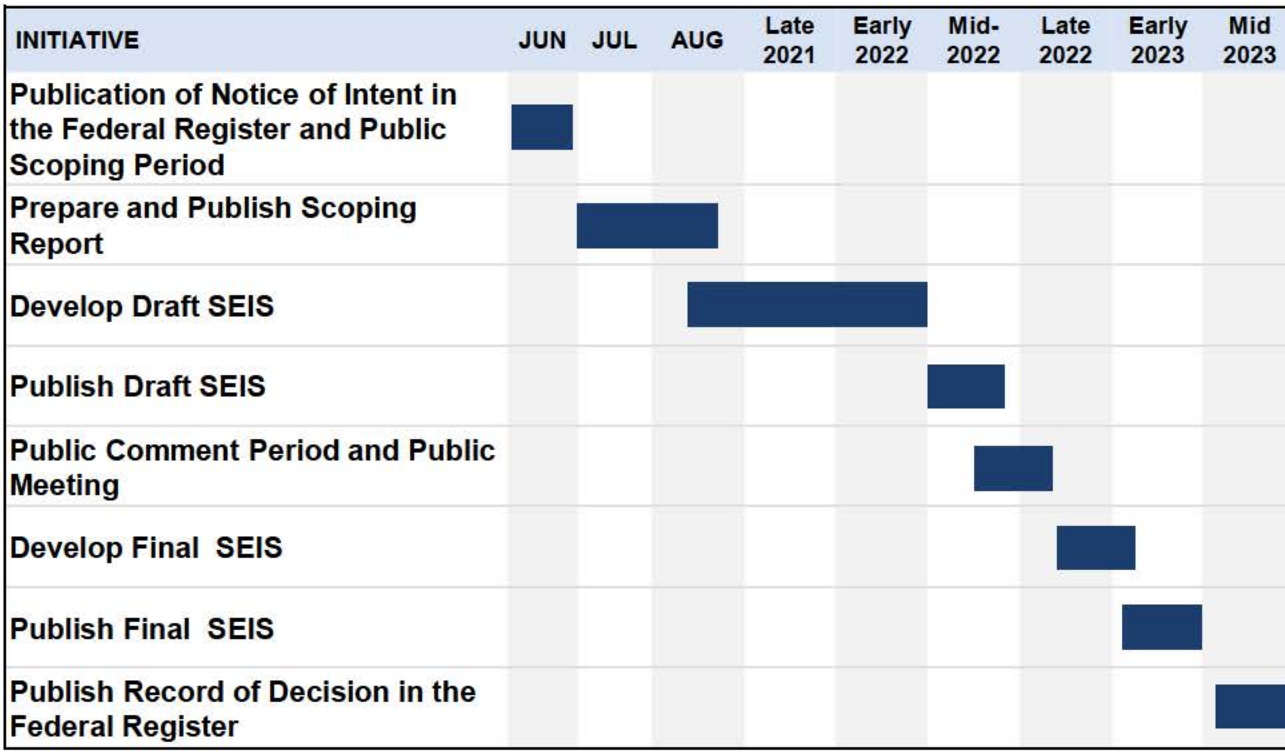
- Nuclear Regulatory Commission
- US Army Corps of Engineers
- US Coast Guard
- US Environmental Protection Agency
- Alabama Department of Environment and Conservation
- US Fish and Wildlife Service
- Alabama State Historic Preservation Officer
- Tribal Historic Preservation Officers

Other permits or authorizations may be sought as required or appropriate.

TVA TENNESSEE VALLEY AUTHORITY

SEIS Preparation and Schedule

TVA will consider comments received during the scoping period and develop a scoping report which will be published at https://www.tva.com/nepa. The scoping report will summarize public and agency comments that were received and identify the projected schedule for completing the SEIS process.



Following completion of the SLR environmental analysis, TVA will post a Draft SEIS for public review and comment on the project web page. TVA anticipates holding a public open house, which may be virtual, after releasing the Draft SEIS. Open house details will be posted on TVA's website in conjunction with the Draft SEIS. TVA expects to release the Draft SEIS in mid-2022.

TVA will consider comments received on the Draft SEIS, as well as cost, engineering, risk and other applicable evaluations before selecting one or more alternatives as preferred in the Final SEIS. TVA projects completing a Final SEIS in early 2023. A final determination on proceeding with the preferred alternative will be documented in a Record of Decision.

TVA TENNESSEE VALLEY AUTHORITY

How to Submit Comments

TVA invites the public to submit comments on the scope of this SEIS, alternatives being considered, and analysis relevant to the proposed action. Federal, state, local agencies, and Native American Tribes are also invited to provide comments.

Comments are encouraged and must be received or postmarked no later than July 1, 2021.

Due to COVID-19 teleworking, TVA recommends that the public submit comments electronically to ensure their timely review and consideration.

Please note that any comments received, including names and addresses, will become part of the project administrative record and will be available for public inspection.

Comments can be provided by:

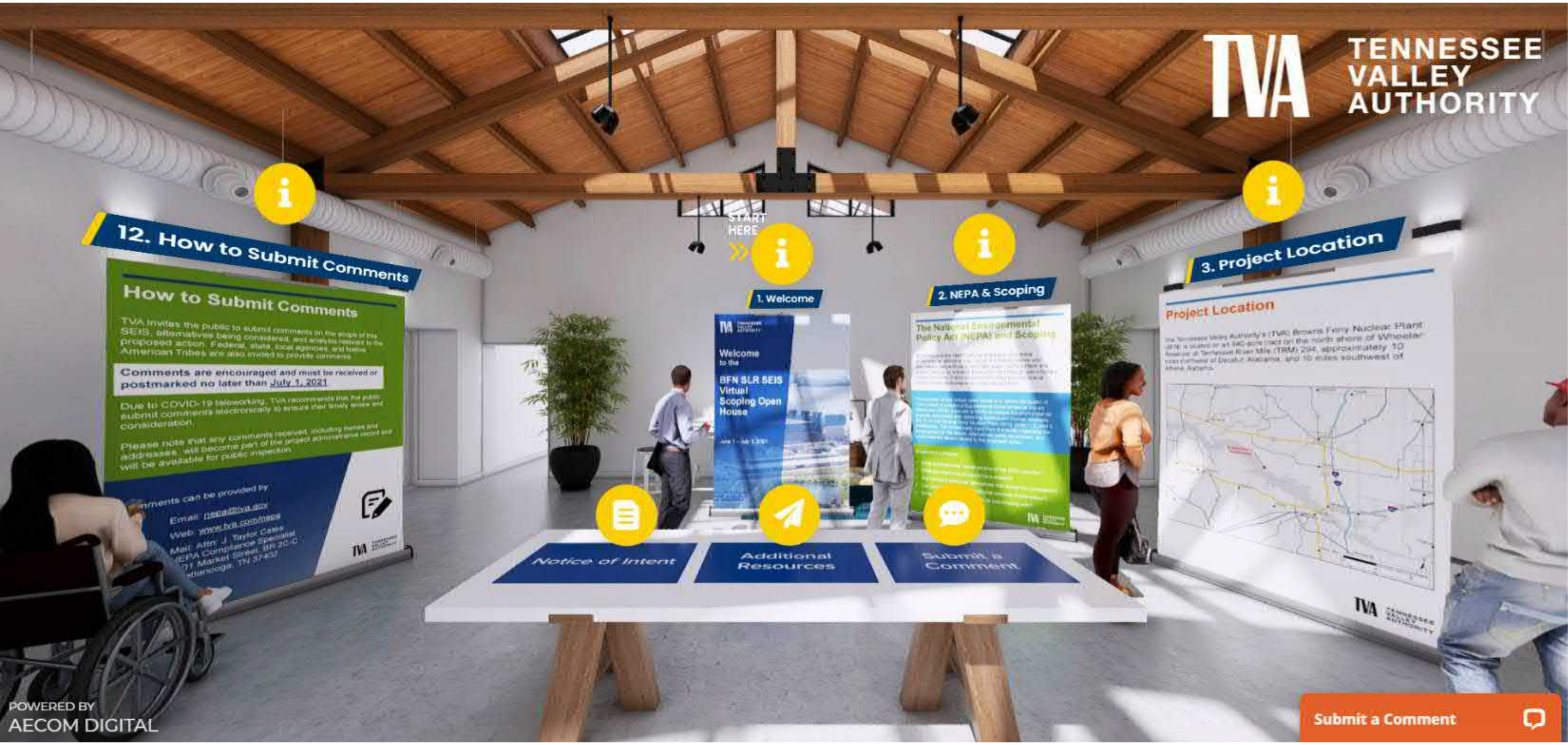
Email: nepa@tva.gov

Web: www.tva.com/nepa

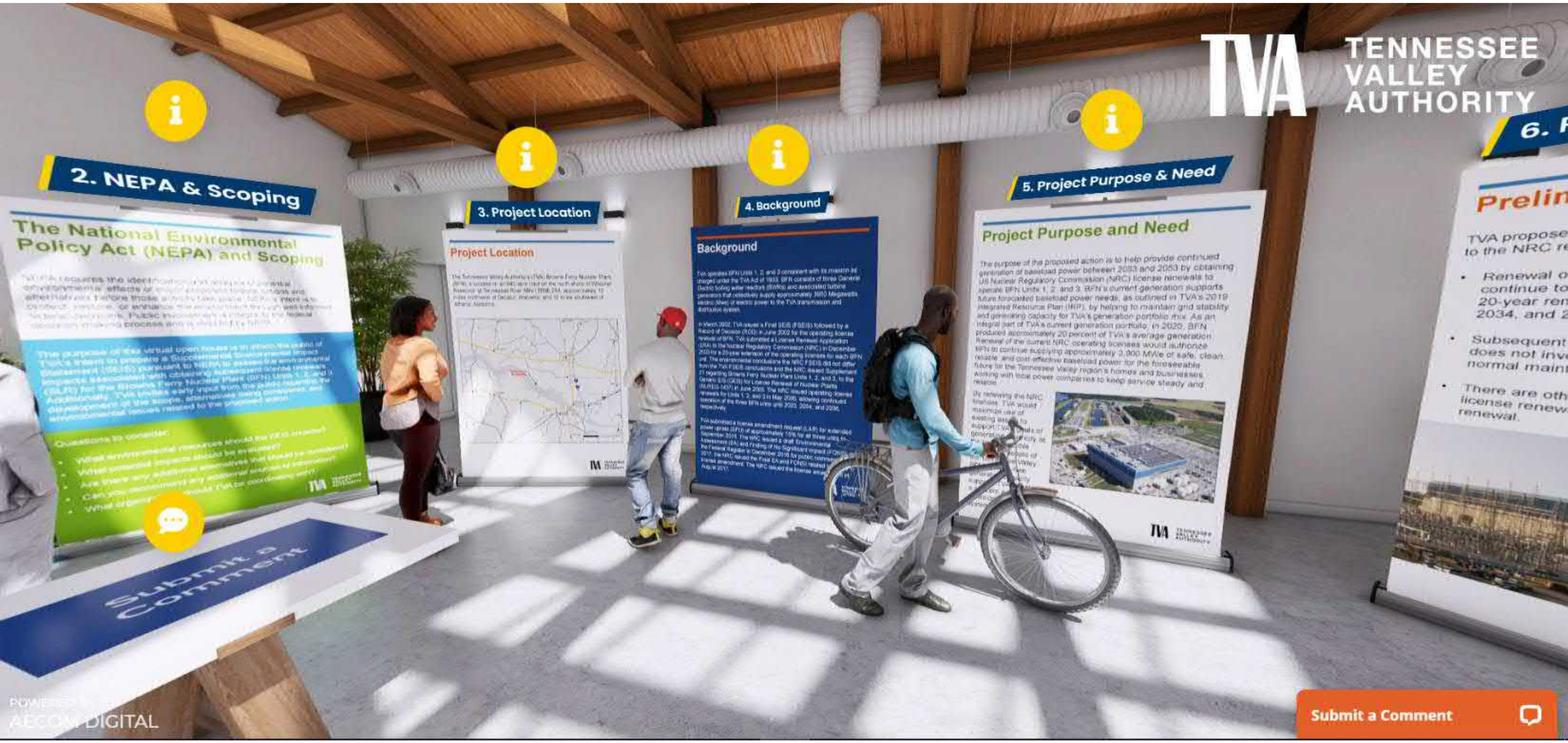
Mail: Attn: J. Taylor Cates
NEPA Compliance Specialist
1101 Market Street, BR 2C-C
Chattanooga, TN 37402

TVA TENNESSEE VALLEY AUTHORITY

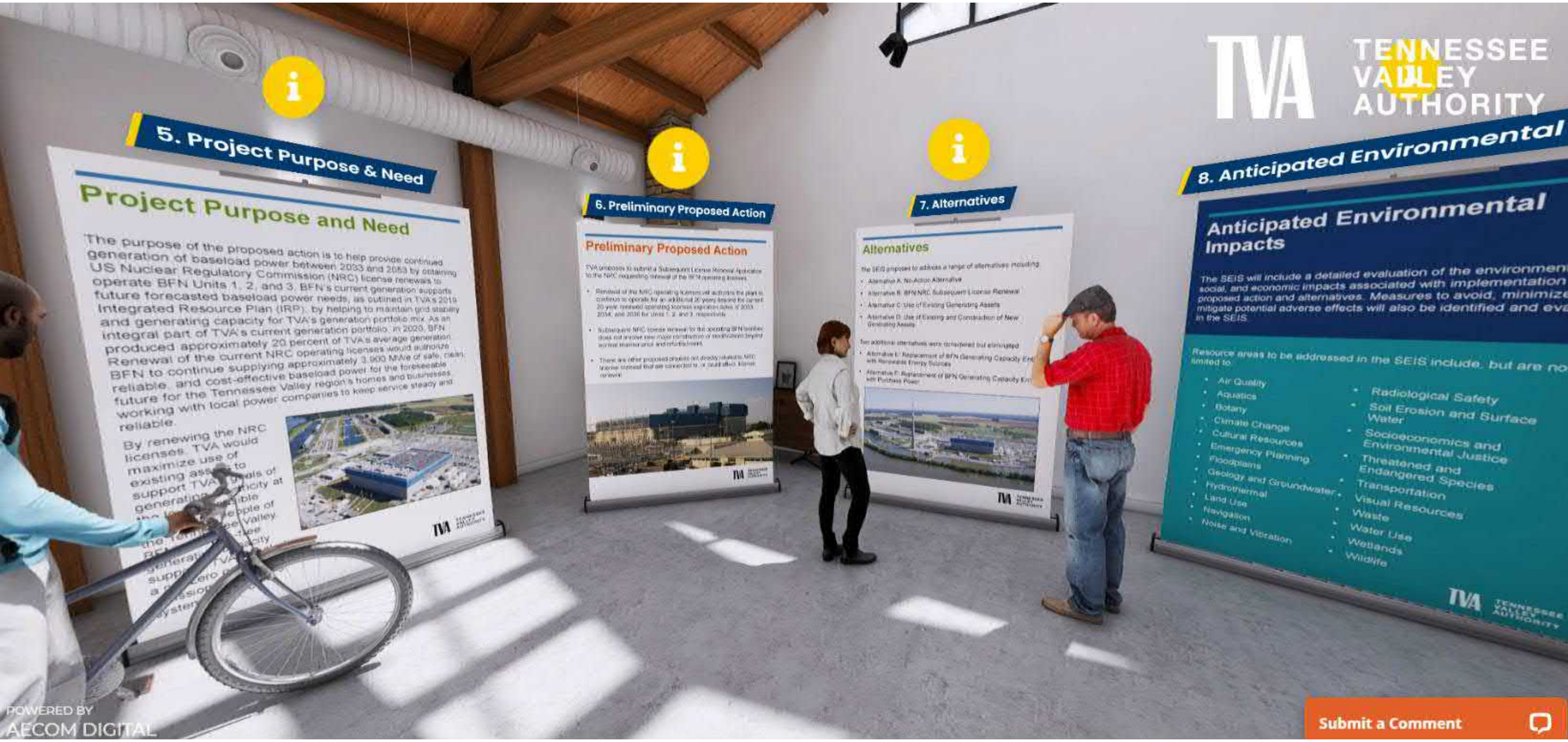
Virtual Scoping Meeting Room Screenshots



TVA
TENNESSEE VALLEY AUTHORITY
12. How to Submit Comments
How to Submit Comments
Comments are encouraged and must be received or postmarked no later than July 1, 2021
START HERE
1. Welcome
Welcome to the
BFN SLR SEIS Virtual Scoping Open House
2. NEPA & Scoping
3. Project Location
Project Location
Notice of Intent
Additional Resources
Submit a Comment
POWERED BY
AECOM DIGITAL
Submit a Comment



TVA
TENNESSEE
VALLEY
AUTHORITY
2. NEPA & Scoping
The National Environmental Policy Act (NEPA) and Scoping
3. Project Location
Project Location
4. Background
Background
5. Project Purpose & Need
Project Purpose and Need
Submit a Comment
Submit a Comment
AECOM DIGITAL



TVA TENNESSEE VALLEY AUTHORITY
5. Project Purpose & Need
Project Purpose and Need
The purpose of the proposed action is to help provide continued generation of baseload power between 2033 and 2053 by obtaining US Nuclear Regulatory Commission (NRC) license renewals to operate BFN Units 1, 2, and 3. BFN's current generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation. Renewal of the current NRC operating licenses would authorize BFN to continue supplying approximately 3,900 MWe of safe, clean, reliable, and cost-effective baseload power for the foreseeable future for the Tennessee Valley region's homes and businesses, working with local power companies to keep service steady and reliable.
6. Preliminary Proposed Action
Preliminary Proposed Action
7. Alternatives
Alternatives
8. Anticipated Environmental
Anticipated Environmental Impacts
Resource areas to be addressed in the SEIS include, but are not limited to:
Air Quality
Aquatics
Botany
Climate Change
Cultural Resources
Emergency Planning
Floodplains
Geology and Groundwater
Hydrothermal
Land Use
Navigation
Noise and Vibration
Radiological Safety
Soil Erosion and Surface Water
Socioeconomics and Environmental Justice
Threatened and Endangered Species
Transportation
Visual Resources
Waste
Water Use
Wetlands
Wildlife
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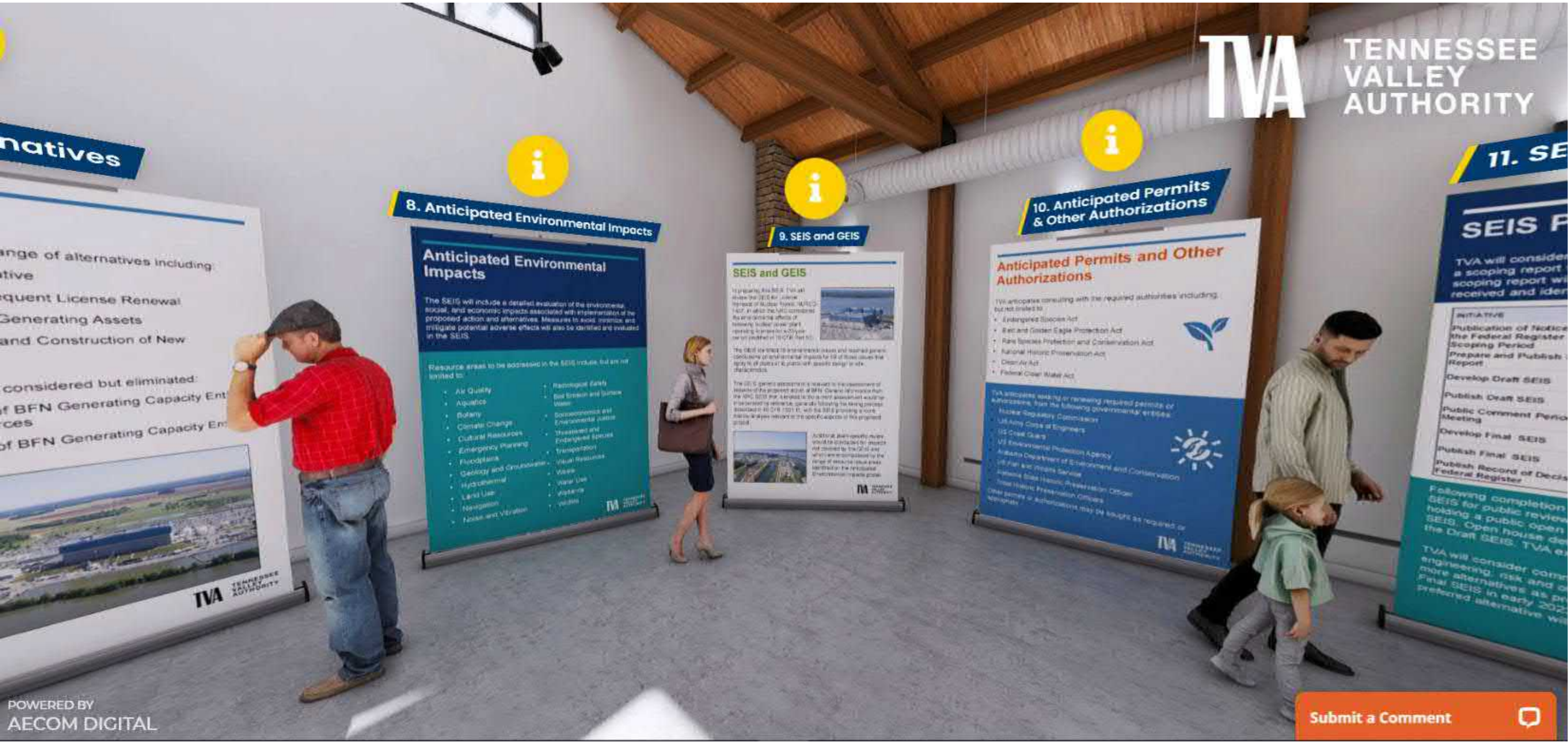
Submit a Comment



TENNESSEE
VALLEY
AUTHORITY
8. Anticipated Environmental Impacts
Anticipated Environmental Impacts
9. SEIS and GEIS
SEIS and GEIS
10. Anticipated Permits & Other Authorizations
Anticipated Permits and Other Authorizations
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Submit a Comment

10. Anticipated Permits & Other Authorizations
Anticipated Permits and Other Authorizations
TVA anticipates consulting with the required authorities including, but not limited to:
Endangered Species Act
Bald and Golden Eagle Protection Act
Rare Species Protection and Conservation Act
National Historic Preservation Act
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TVA anticipates seeking or renewing required permits or authorizations, from the following governmental entities:
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US Fish and Wildlife Service
Alabama State Historic Preservation Officer
Tribal Historic Preservation Officers
Other permits or authorizations may be sought as required or appropriate.
11. SEIS Preparation & Schedule
SEIS Preparation and Schedule
12. How to Submit Comments
How to Submit Comments
TENNESSEE VALLEY AUTHORITY
1. Welcome
Welcome to the
BFN SLR SEIS Virtual Scoping Open House
June 1 – July 1, 2021
Notice of Intent
Additional Resources
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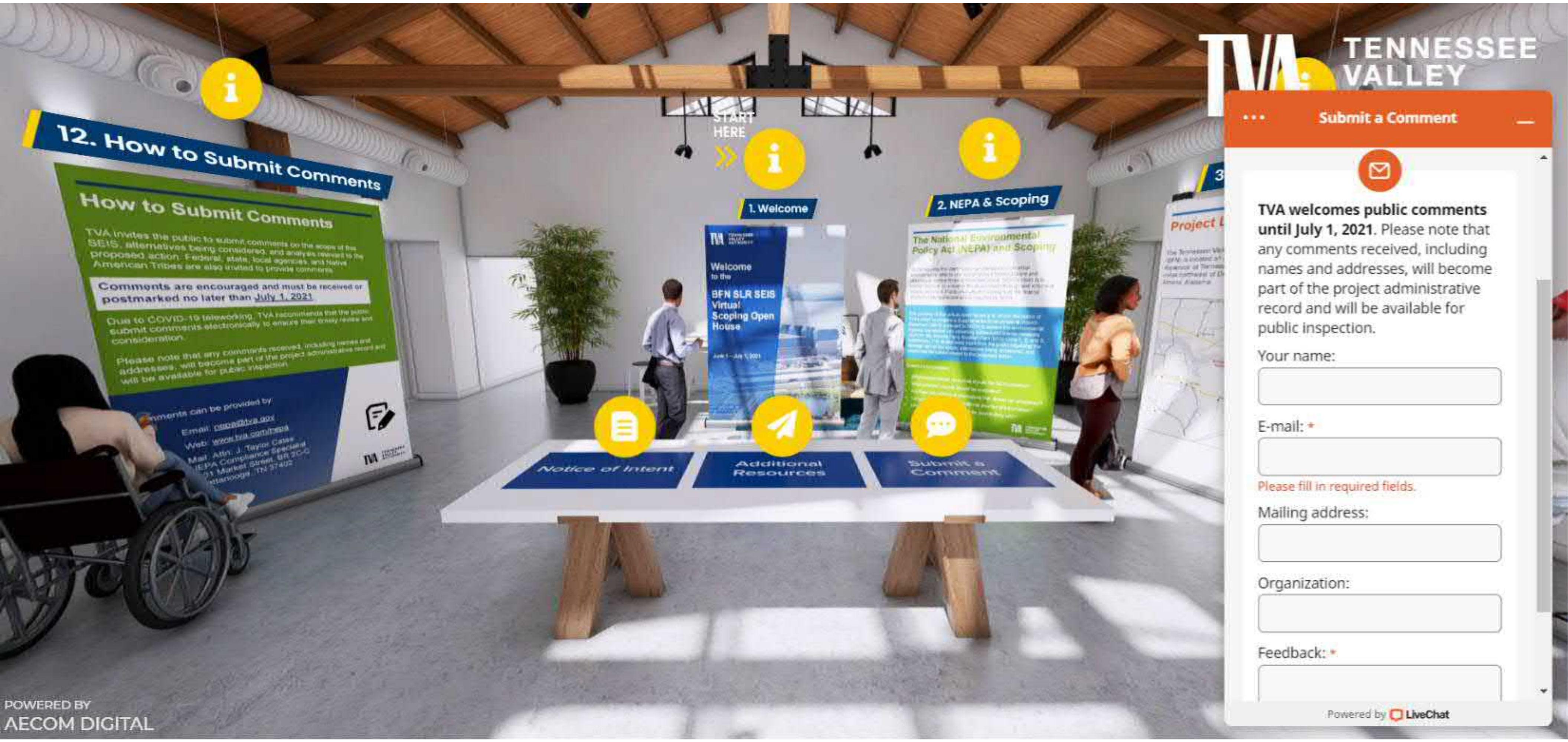
Submit a Comment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START HERE
1. Welcome
Welcome to the BFN SLR SEIS Virtual Scoping Open House
2. NEPA & Scoping
The National Environmental Policy Act (NEPA) and Scoping
Notice of Intent
Additional Resources
Submit a Comment
TVA TENNESSEE VALLEY
Submit a Comment
TVA welcomes public comments until July 1, 2021. Please note that any comments received, including names and addresses, will become part of the project administrative record and will be available for public inspection.
Your name:
E-mail: *
Please fill in required fields.
Mailing address:
Organization:
Feedback: *
Powered by LiveChat
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Appendix D: Public and Agency Comments

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From: Long, Larry
To: Cates, J. Taylor
Cc: Kajumba, Ntale
Subject: Browns Ferry NOI comments
Date: Friday, June 25, 2021 1:45:09 PM

J. Taylor Cates
Tennessee Valley Authority
NEPA Specialist
1101 Market Street, BR 2C-C
Chattanooga, TN 37402

RE: Notice of Intent to prepare a Supplemental Environmental Impact Statement for the subsequent license renewal for Browns Ferry Nuclear Plant Units 1, 2, and 3.

Dear Mr. Cates:

The U.S. Environmental Protection Agency (EPA) has reviewed Tennessee Valley Authority's (TVA) Notice of Intent (NOI) to prepare a Supplemental Environmental Impact Statement (SEIS) that addresses the environmental effects associated with obtaining relicense renewals (SLR) for the Browns Ferry Nuclear Plant (BFNP) Units 1, 2, and 3 in Limestone County, Alabama. Renewal of the operating licenses would allow the plant to continue to operate for an additional 20-years beyond the current operating licenses of 2033, 2034, and 2036 for the three units. The BFNP Units 1, 2, and 3 are located on 840-acres tract on the north shore of Wheeler Reservoir. The TVA plant consists of three General Electric boiling water reactors and associated turbine generators.

According to the NOI, TVA indicates that the SLR would not require any new construction or modifications beyond normal maintenance and minor refurbishment. However, there are other proposed projects that are connected to or could affect license renewal. We recommend that TVA evaluate the effects of the other proposed projects and describe efforts to address potential impacts in the SEIS.

Air Quality**.** Limestone County is in attainment with the Clean Air Act National Ambient Air Quality Standard.

Water Quality/Stormwater -Based on NEPA, the proposed project may be located within a mile of an impaired stream Round Island Creek/Round Island Creek (Wheeler Lake). TVA should consider implementing best management practices during maintenance for areas greater than one acre per the CWA's National Pollutant Discharge Elimination System Permit for stormwater, where applicable, to ensure that water quality impairments are not exacerbated

Wetlands and Streams - The EPA recommends that TVA collaborate with Alabama

Department of Environmental Management (ADEM) and US Army Corps of Engineers (USACE) to determine any potential impacts from the hydraulic and hydrological design associated with thermal discharges to the Tennessee River that may impact terrestrial and/or aquatic species, including both flora and fauna. TVA in collaboration with USACE may wish to include Clean Water Act (CWA) Section 404(b)(1) documents in the SEIS to support any wetland and stream mitigation decisions and to help ADEM evaluate potential stream impact requirements for the CWA Section 401 Water Quality permit. Providing adequate wetland and stream information within the NEPA process can help to streamline the final environmental review and permitting processes for these resources. According to NEPAssist, there are five approved mitigation or conservations banks in the facility vicinity - Flint River Mitigation Bank Phase I (1042), Wheeler Pointe Mitigation Bank (1044). ADOT Town Creek (1198) and ADOT Crow Creek (1199) and Robinson Spring Mitigation Bank (930) should mitigation be required.

Waste Disposal - The SEIS should indicate if there will be any changes in the generation of waste including low-level radioactive waste, mixed low-level radioactive waste, transuranic waste, and hazardous and Toxic Substance Control Act wastes over the life of the program. The SEIS should indicate where TVA will send the spent nuclear fuel and spent fuel debris for storage pending long-term disposal options.

Climate - Climate change may impact the proposed project, posing threats to aging infrastructure, worker health and safety and the environment. We recommend that the SEIS include an evaluation of climate-related impacts including discussions of frequency and severity of major storm events, wildfires, or drought that could lead to power disruptions or increased cooling demands in summer months. Efforts that TVA is taking at BFNP to address and adapt to potential climate impacts should be discussed in the SEIS.

Environmental Justice - The SEIS should include an analysis that is consistent with the Environmental Justice (EJ) Executive Order (EO) 12898. The analysis should indicate whether minority, low income or other overburdened populations reside within the vicinity of the proposed project area. If so, the EPA recommends that the communities with EJ concerns should be meaningfully involved throughout the decision-making process to help identify potential benefits and burdens associated with relicensing and permitting decisions. Adaptive and innovative approaches to both public outreach and community involvement regarding project issues should take place during the project planning. It would also be helpful to include a current map depicting the population demographics near the BFNP facility. EPA's EJSCREEN can be used a preliminary screen to help identify potential issues.

Thank you for the opportunity to review the proposed project. If you have any questions, feel free to contact Mr. Larry Long, of the NEPA Section, at (404) 562-9460, or by e-mail at long.larry@epa.gov.

Larry Long
Regional Mining Expert
Physical Scientist/Sr. Principle Reviewer
NEPA Section/Strategic Programs Office
Office of the Regional Administrator
61 Forsyth Street, SW

Atlanta, GA 30303
404-562-9460
404-562-9598(FAX)
long.larry@epa.gov

Intelligence does not always define wisdom, but adaptability to change does

From:	Kopec, Brett A
To:	nepa
Cc:	Janowicz, Jon A
Subject:	Fw: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER21/0210 - NOI TVA to Prepare Supplemental Environmental Impact Statement (SEIS) for the Browns Ferry Nuclear Site Subsequent License Renewal, Units 1, 2, and 3 located in Limestone County, Ala...
Date:	Monday, June 7, 2021 8:29:35 AM

Brett Kopec
USGS
Administrative Operations Assistant

From: Gordon, Alison D <agordon@usgs.gov>
Sent: Friday, June 4, 2021 5:00 PM
To: Kopec, Brett A <bkopec@usgs.gov>
Cc: Janowicz, Jon A <jjanowicz@usgs.gov>
Subject: Fw: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER21/0210 - NOI TVA to Prepare Supplemental Environmental Impact Statement (SEIS) for the Browns Ferry Nuclear Site Subsequent License Renewal, Units 1, 2, and 3 located in Limestone County, Ala...

The USGS has no comment at this time. Thank you.

From: oepchq@ios.doi.gov <oepchq@ios.doi.gov>
Sent: Tuesday, June 1, 2021 7:33 AM
To: Reddick, Virginia <Virginia_Reddick@ios.doi.gov>; Treichel, Lisa C <Lisa_Treichel@ios.doi.gov>; Alam, Shawn K <Shawn_Alam@ios.doi.gov>; Braegelmann, Carol <carol_braegelmann@ios.doi.gov>; Kelly, Cheryl L <cheryl_kelly@ios.doi.gov>; ERs, FWS HQ <FWS_HQ_ERs@fws.gov>; Runkel, Roxanne <Roxanne_Runkel@nps.gov>; Stedeford, Melissa <Melissa_Stedeford@nps.gov>; Hamlett, Stephanie R <shamlett@osmre.gov>; Janowicz, Jon A <jjanowicz@usgs.gov>; Gordon, Alison D <agordon@usgs.gov>; oepchq@ios.doi.gov <oepchq@ios.doi.gov>; Stanley, Joyce A <Joyce_Stanley@ios.doi.gov>
Subject: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER21/0210 - NOI TVA to Prepare Supplemental Environmental Impact Statement (SEIS) for the Browns Ferry Nuclear Site Subsequent License Renewal, Units 1, 2, and 3 located in Limestone County, Alabama

This e-mail alerts you to a Environmental Review (ER) request from the Office of Environmental Policy and Compliance (OEPC). This ER can be accessed here.
To access electronic ERs visit the Environmental Assignments website: https://ecl.doi.gov/ERs.cfm. For assistance, please contact the Environmental Review Team at 202-208-5464.
Comments due to Agency by: 07/01/21

From:	Wufoo
To:	nepa
Subject:	NEPA Comments - Browns Ferry Nuclear Plant [#1]
Date:	Wednesday, June 2, 2021 11:29:16 AM

This is an EXTERNAL EMAIL from outside TVA. THINK BEFORE you CLICK links or OPEN attachments. If suspicious, please click the "Report Phishing" button located on the Outlook Toolbar at the top of your screen.

Name	Jack Keeling
City	CHATTANOOGA
State	Tennessee
Organization	None
Email	[redacted]
Phone Number	[redacted]
Please provide your comments by uploading a file or by entering them below. *	Renew the licenses. Keep the plant running. We need it.

From: [redacted]
To: Cates, J. Taylor
Subject: Comments on extending licenses
Date: Thursday, July 1, 2021 7:12:59 PM

This is an EXTERNAL EMAIL from outside TVA. THINK BEFORE you CLICK links or OPEN attachments. If suspicious, please click the "Report Phishing" button located on the Outlook Toolbar at the top of your screen.

July 1 was the deadline. Today is July 1. Please submit these comments on my behalf. And please let me know if the comments will be submitted.

Steven Sondheim
[redacted]
Memphis 38117

I highly object to the extension of licenses to
The Browns Ferry Nuclear Power Reactors from 60-80 years which is 40 years beyond the original license.

Besides this power not being needed if renewable energy is adequately deployed by 2035-40, there is no evidence these installations will remain safe for an additional 20 years.

I ask that all systems be thoroughly inspected and investigated before these extensions are considered and the results made public. As the following article points out, older structures are vulnerable to a variety of aging factors.

https://readersupportednews.org/opinion2/277-75/70146-rsn-collapsed-florida-condo-sends-a-giant-nuke-warning

Sent from my iPhone

rsn

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print this page   go to original   add comment   send to friend

search... go


A man prays Friday near where search and rescue operations are ongoing at the partially collapsed 12-story Champlain Towers South condo building in Surfside, Fla. (photo: Joe Raedle/Getty Images)

Collapsed Florida Condo Sends a Giant Nuke Warning

By Harvey Wasserman, Reader Supported News
28 June 21

The horrifying collapse of a south Florida condo should alarm us all about the next reactor catastrophe.

The owners of that 13-story condo were warned years ago that it could implode. They were apparently getting ready for repairs, but in the interim did nothing.

The owners of America's 93 licensed reactors have been warned for decades that they could both implode and explode. They have also done nothing.

More than 150 people may have died in this avoidable Florida disaster. The death toll from the next avoidable reactor disaster could stretch into the millions, with property damage in the trillions, a blow from which our economy and ecosystems might never recover.

South Florida authorities have now ordered inspections of large buildings over forty years old. Nearly all US reactors – including four on the ocean in South Florida – are also now around forty years old.

They all must be immediately shut for rigorous inspection. To wait is to invite a radioactive version of what just happened to that condo.

The argument is not about nuclear power. It's about basic sanity.

The industry is currently pushing "new" designs based on fusion, thorium, breeder technologies, molten salt, small modular, and more. None have been proven safe or effective in fighting climate chaos. Nor can they compete with renewables. None have a reasonable prospect of coming online before being completely left in the radioactive dust by accelerating advances in wind, solar, batteries, and LED efficiency.

All are certain to consume huge quantities of public money, pouring into private pockets (like those of Bill Gates) before failing utterly.

But they pale in importance alongside the 93 US reactors (there are some 430 worldwide) now plummeting toward certain catastrophe.

None of these reactors can get private liability insurance against an apocalyptic disaster. Most were designed in the pre-digital 1950s and '60s. Many were built with inferior materials and understanding.

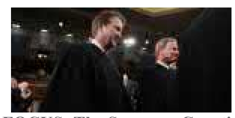
Critical welds at California's Diablo Canyon, for example, contain metal components long since banned. But Unit One continues to operate.

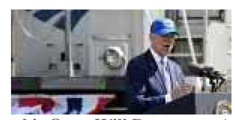
Critical concrete at New Hampshire's Seabrook and Ohio's Davis-Besse is crumbling. Fort Calhoun in Nebraska was flooded. Intake pipes at South Texas froze. Reactors in Ohio and Virginia have been damaged by earthquakes. Diablo is surrounded by earthquake faults set to deliver seismic shocks which a Nuclear Regulatory Commission resident inspector has said it can't withstand. The owners of San Onofre want to bury their high-level wastes ONE HUNDRED FEET from the tide line. Meaningful evacuation planning is nonexistent at sites where nearby population centers have exploded since the original siting approval.

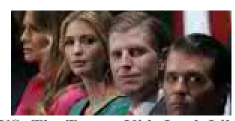
All these old reactors contribute to climate chaos with emissions of heat, radiation, and carbon. They suck up billions of gallons of precious water, then dump it or evaporate it with chemical, radioactive, and thermal pollution. In every case, our planet would benefit from their shutdown.

Virtually all US reactors are almost certainly embrittled, meaning emergency cooling water poured into the core to quell a meltdown would shatter critical components, resulting in apocalyptic hydrogen and possibly fission explosions, as at Chernobyl and Fukushima.


FOCUS: Ex-Dam CEO And West Point Grad Convicted In Murder Of Berta Cáceres
Democracy Now!
06 July 2021

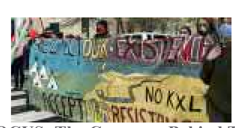

FOCUS: The Supreme Court's Conservatives Have Laid The Groundwork For The Devastation To Come
Dahlia Lithwick and Mark Joseph Stern, Slate
06 July 2021

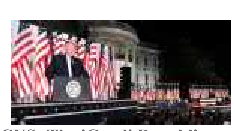

Break's Over. Will Democrats Act?
Katrina vanden Heuvel, The Washington Post
06 July 2021


FOCUS: The Trump Kids Look Likely To Turn On Their Dad – And I Suspect Ivanka Will Go First
Arwa Mahdawi, Guardian UK
07 July 2021


Republicans' Effort To Deny The Capitol Attack Is Working - And It's Dangerous
David Smith, Guardian UK
06 July 2021


Meet The Consulting Firm That's Staffing The Biden Administration
Jonathan Guyer and Ryan Grim, The Intercept
07 July 2021


FOCUS: The Company Behind The Keystone XL Pipeline Would Like $15 Billion Of Your Money, Please
Charles Pierce, Esquire
07 July 2021


FOCUS: The 'Good' Republicans Are Bad, And The Bad Ones Are Batshit
Molly Jong-Fast, The Daily Beast
08 July 2021

To put it most simply: no embrittled reactor has a workable set of brakes. Yet states like California, and the NRC itself, refuse to conduct relatively cheap and simple open inspections.

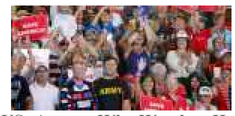
Thus embrittlement, pipe cracking, component degradation, technical obsolescence, an aging workforce, rampant incompetence, and worse define the reality of virtually every operating atomic reactor, here and around the planet.

So when we look in horror at that collapsed south Florida condo, with all those innocent souls buried in the rubble, we must remember that later today, parallel pictures could show a mega-hot runaway reactor spewing Chernobyl/Fukushima levels of radiation throughout the ecosphere.

Thankfully, the Solartopian realities of fast-accelerating wind, solar, battery, and efficiency technologies give us the leeway to shut them all NOW.

Let’s do it before it’s too late!!

Harvey Wasserman co-convenes the weekly Election Protection 2024 ZOOM. His People's Spiral of US History *is at www.solartopia.org.*



FOCUS: Anyone Who Wonders How We Got Here Is A Liar Or A Fool
Charles Pierce, Esquire
08 July 2021

Comments

We are concerned about a recent drift towards vitriol in the RSN Reader comments section. There is a fine line between moderation and censorship. No one likes a harsh or confrontational forum atmosphere. At the same time everyone wants to be able to express themselves freely. We'll start by encouraging good judgment. If that doesn't work we'll have to ramp up the moderation.

General guidelines: Avoid personal attacks on other forum members; Avoid remarks that are ethnically derogatory; Do not advocate violence, or any illegal activity.

Remember that making the world better begins with responsible action.

- The RSN Team

Steppen-Wolf 2021-06-28 14:42 **-8**

Face it, people, we live in an evil, mass-insane world run by people who care more about money and profit(s) than lives. Contrary to their claims that such is supposedly not the case, they don't care if masses of people die. Their lord and master is Satan, who hates humanity and wants us all dead. What else besides evil explains the level of greed at the expense of lives and the well-being of the entire planet? I'll tell you the answer: Nothing. So, if you don't want to believe in evil, especially evil at the level(s) that it exist(s) today, too bad, because it clearly exists, and the massively-evil people who run things clearly exist as well. Many of them even (falsely) claim to be "Christians", and/or part of other "benevolent" religions.

What does facing all of this point to? It makes it abundantly-clear that our only hope is God through Jesus the Christ (John 14:6). The evil and insane people who run things aren't going to stop endangering and mass-murdering us for profit(s), including those of them who are religious people. Please don't depend on such people to save the day, even the minority of them who claim to mean well. Against the juggernaut that is the majority of such people, they stand little or no chance. Laws may be passed that make it appear we will be protected, but when the crap hits the fan to a completely-overwhelming extent, we will be left high and dry by them. We can only depend on God to save us, not the whims of evil people.

davehaze 2021-06-29 15:54 **+6**

I dont know Steppen, depending on God has had mixed results. Depending on Christians has been disastrous. Let's make humans without excuses responsible. Try that.

mbrenman 2021-06-28 17:37 **-13**

Bizarre comparison, and shameful to use this tragedy for political ax grinding.

laborequalswealth 2021-06-29 12:16 **+9**

"None of these reactors can get private liability insurance against an apocalyptic disaster."

THAT tells you ALL you need to know. GD right it's POLITICAL. What's wrong with YOU?

Texas Aggie 2021-06-29 13:59 **+11**

Not bizarre at all. Both examples are structures made of concrete that deteriorates over time and are located in places where their failure will cause damage to life and property.

davehaze 2021-06-29 14:39 **+5**

mb

That's the way the concrete crumbles-- without thought or concern of consequence, people crushed or nuclear core melted.

johnescher 2021-06-29 16:49 **+1**

Why, Wulfie, does Satan want everybody dead? Wouldn't He prefer people to stay alive the better to roast slowly as the globe warms?

elizabethblock 2021-06-28 18:39 **+16**

Bob Bossin, Canadian musician, said a long time ago that building a nuclear reactor without a safe way to dispose of nuclear waste is like building an outhouse without digging a hole first.
And in seventy years, we have not figured out a safe way to dispose of nuclear waste. I don't think we ever will.

NAVYVET 2021-06-28 19:55 **+14**

Browns Ferry Nuclear Subsequent License Renewal Scoping Comments for SEIS

The subsequent license renewal (SLR) of the three Browns Ferry (BFN) Reactors should be rejected: the collapse of the Champlain Towers South condo in Surfside, Florida reminded us of the vulnerability of aging infrastructure. Aging, stressed components are more likely to fail the longer they are in service. The No-Action Alternative (A) should be chosen, and a new process started that focuses on alternative (E): Replacement of BFN Generating Capacity with Renewable Energy Sources. TVA should bring on board renewables, energy efficiency and additional storage with urgency. Renewable energy is the fastest growing energy resource in the world: https://www.npr.org/2021/05/11/995849954/renewable-energy-capacity-jumped-45-worldwide-in-2020-iea-sees-new-normal. Renewable energy is the fastest growing in the US as well: https://www.c2es.org/content/renewable-energy/.

The Supplemental Environmental Impact Statement should reevaluate fundamental assumptions of safety that have been used to justify previous SLRs of other nuclear power reactors in the US.

The SEIS should comprehensively cover all conceivable environmental impacts of continued operation of the BFN reactors. It should consider the fundamental environmental, health and environmental justice problems inherent in nuclear power at every step in the nuclear fuel chain: uranium mining, milling, fuel fabrication, operations, radioactive waste, and decommissioning. It should consider the growing threats to nuclear power reactor operation and safety posed by the ever-growing effects of climate change.

The SEIS should include the effects of a catastrophic accident and massive radiation release at one or more of these aging reactors that were designed to operate for 40 years. Extending operation to 80 years demands an exhaustive study of the aging management. The longer these reactors run, the greater the risk of a devastating accident.

The Browns Ferry reactors are Fukushima style GE Mark 1 reactors, a design that has a long, controversial history, with many questioning the lack of robustness in the containment system and foreshadowing the three reactor melt-downs, hydrogen explosions, resulting containment breeches, and release of massive amounts of radiation at Fukushima. Please include the articles at these and all links in the SEIS scoping process: https://www.environews.tv/091117-ges-mark-1-nuclear-reactor-recalled-worldwide-like-faulty-unsafe-auto-pt-5/; https://www.nytimes.com/2011/03/16/world/asia/16contain.html;

https://abcnews.go.com/Blotter/fukushima-mark-nuclear-reactor-design-caused-ge-scientist/story?id=13141287; https://www.nirs.org/boiling-water-reactors/.

The Browns Ferry reactors have a history of mechanical problems and other issues resulting in six separate shut-downs of longer than a year including the longest shutdown of any US reactor (Unit 1 from 1985 to 2007) and the second and third longest shutdowns (Unit 3 from 1985 to 1995 and Unit 2 from 1984 to 1991). In 2011 they received one of only 4 "Red finding" safety warnings from the NRC for extended safety performance deficiencies. Safety concerns have plagued these reactors throughout their lives: https://www.nirs.org/wp-content/uploads/factsheets/brownsferryfactsheet.pdf. A whistleblower's story illuminates these concerns:
https://www.al.com/wire/2013/07/browns_ferry.html ;
https://www.al.com/wire/2013/07/browns_ferry_engineer_never_ex.html .

This 2013 study highlights more issues: https://www.bredl.org/pdf4/AL_BFN_Report_2013-final-digit.pdf including the spent fuel pools locations over 40 feet off the ground and with only sheet metal roofing overhead. Safety concerns: https://allthingsnuclear.org/dlochbaum/susquehanna-spent-fuel-pool-concerns-and-how-i-ended/ . These pools contain an enormous amount of deadly radiation. The SEIS should consider deficiencies in the BFN spent fuel pools and the environmental effects of a failure of one or more of these pools and the resulting release of radiation:
https://nautilus.org/uncategorized/risks-of-densely-packed-spent-fuel-pools/ .

The "reasonable assurance" of reactor safety during the proposed SLR period is far from certain. The safety of this license extension is wholly unproven. The NRC and the nuclear reactor operators have taken a "don't look, don't want to know" approach to verification of continued integrity of inner reactor critical components that are subject to the intense conditions in a nuclear reactor (heat, neutron bombardment, pressure, extreme temperature swings in SCRAM events, etc).

The SEIS should consider the wide range of critical knowledge gaps in the age-related material degradation process in GE Mark 1 BWRs and the management of that degradation over 60 or 80 years. It is therefore critical that the scoping process fill those gaps and provide an evidence basis on materials safety and systems reliability to make informed, scientifically qualified decisions in regulatory review of longer license extensions of civilian NPPs. Critical reactor systems, structures, and components must be strategically harvested from decommissioning similar design nuclear power plants and studied in labs by materials scientists, rather than disposing of them as is done now. This would include and not be limited to harvesting and analysis of base metals and weld materials from irreplaceable reactor pressure vessels, concrete from reactor containment structures and spent fuel pools, reactor internal components, and sections of electrical cable. These components provide a unique opportunity for real-world analysis of the effects of NPPs' harsh operational environment and the outcomes of licensees' age management programs. Essentially the only way to access, extract and study these materials is in the decommissioning process.

The DOE's Pacific Northwest National Laboratory, under contract with NRC Office of Research, published a Technical Letter Report in December 2017 entitled "Criteria and Planning Guidance for Ex-Plant Harvesting to Support Subsequent License Renewal" (PNNL-27120). The contract explicitly instructed PNNL to identify the "knowledge gaps" and make recommendations. PNNL recommended harvesting and analysis of these materials in decommissioning. The report can be found here:
http://static1.1.sqspcdn.com/static/f/356082/28026831/1542303608657/autopsy_PNNL-27120_harvesting_Dec2017.pdf?token=m0Gx1ULrrWdHLvN%2BE3yET8AfdLw%3D

The report was publicly posted for nine months on the government websites of PNNL, DOE Office of Scientific and Technical Information (OSTI) and the IAEA International Nuclear Information System (INIS), before the NRC Office of Nuclear Reactor Regulation removed it from government websites in September 2018. It was republished (only on the NRC website) as PNNL-27120 Rev.1 in April 2019. The revised version removed scores of references to critical "knowledge gaps" and recommendations to "require" decommissioning harvesting/analysis as necessary for reasonable assurance in NRC safety and environmental review and approval process of license extension applications. Without scientifically founded "reasonable assurance," the NRC lacks a legal basis for granting Subsequent License Renewal.

PNNL's recommendations from December 2017 remain well founded. Harvesting and material testing of nuclear plant components and compiling an evidence basis to assess age-related degradation management are necessary for "reasonable assurance" (which is an explicit NRC requirement for license extension). They are therefore prerequisites for approving long license extensions and are critical to fulfilling the NRC's mission of protecting public safety and the environment.

Former NRC Commissioner Victor Gilinsky has noted the absence of validity of the NRC's SLR process: "The so-called license extension safety review is a scandal. Although the whole thing is bureaucratically elaborate, and a bonanza for industry consultants and lawyers, the only question the NRC safety reviewers address is whether the plant owners have a plan for dealing with aging equipment so that the plant can meet its current “licensing basis”. The NRC reviewers are specifically forbidden by regulation from questioning that licensing basis, that is, the basis on which safety depends, even though it was set many decades ago when less was known about, say, for example, seismic events, and in the light of current information may well be out of date.” From a comment sent to the Bulletin of Atomic Scientists on the story at this link: https://thebulletin.org/2020/09/with-climate-change-aging-nuclear-plants-need-closer-scrutiny-turkey-point-shows-why/ . Please include that entire article in these comments.

Submitted by,

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Nashville, TN 37205

July 1, 2021

ENERGY

Renewable Energy Growth Rate Up 45% Worldwide In 2020; IEA Sees 'New Normal'

May 11, 2021 · 11:51 AM ET

BILL CHAPPELL

Workers next to solar panels in an integrated power station in Yancheng, China, in October. An unprecedented amount of renewable power came online in the fourth quarter of 2020, according to a new report from the International Energy Agency. China alone added more than 92 gigawatts of capacity, more than triple the amount it added in the fourth quarter of 2019.

Hector Retamal / AFP

Despite the pandemic, the growth rate in the world's renewable energy capacity jumped 45% in 2020, part of "an unprecedented boom" in wind and solar energy, according to a new report from the International Energy Agency. It's the largest annual rate of increase since 1999.

"An exceptional 90% rise in global wind capacity additions led the expansion," the report states. It also cites a 23% expansion in new solar power installations.

In 2020, renewable power was "the only energy source for which demand increased ... while consumption of all other fuels declined," says the IEA, whose mission is to make the world's energy supply more reliable, affordable and sustainable.

The IEA predicts large capacity gains in renewable energy will become the "new normal" in 2021 and 2022, with increases similar to 2020's record total.

An unprecedented amount of renewable power came online in the fourth quarter of 2020, the report states. China alone added more than 92 gigawatts of capacity – more than triple the amount it added in the fourth quarter of 2019. The U.S. added 19 gigawatts, a sharp gain over the 13.7 it added in the same quarter of the previous year.

Despite the gains in renewable energy, experts warn that a "substantial gap" persists between emissions from continued fossil fuel use and the lower levels needed to meet temperature limits in the Paris Agreement on climate change by the end of the decade.

"A massive expansion of clean electricity is crucial to enable the world to reach its net zero goals," IEA head Fatih Birol said on Tuesday, calling on governments to build on the momentum of the past year to invest more in solar, wind and other renewables, along with bolstering their electrical grid infrastructures.

Global coal consumption of coal, a key source of greenhouse gas emissions that contribute to global climate change, fell by 4% in 2020 – the biggest drop since World War II, the IEA said earlier this year. But demand has been building anew since late last year, driven by Asia's economies that were among the first to start bouncing back from the COVID-19 pandemic.

Another factor: even as China invests in "green" energy, the country has also continued to build new coal power plants. China is responsible for about a third of the world's annual coal consumption – and it's expected to hit a new record high in 2021, the IEA said in April.

The U.S. relies on coal-fired power plants for about 20% of its electricity generating capacity, according to the federal Energy Information Administration, citing figures from the end of 2020. The largest share of the country's power comes from natural gas-fired plants, which account for 43% of U.S. capacity, the agency says.

The IEA says it revised its U.S. renewable energy forecast after Congress extended federal tax credits for solar and wind projects, as part of the spending bill lawmakers approved in late 2020.

The sector could rise further if Congress passes legislation that is based on President Biden's infrastructure plan, the Paris-based agency says.

The U.S. approved a large offshore wind project on Tuesday, advancing a plan to build a turbine installation some 12 nautical miles offshore from Martha's Vineyard, Mass. This photo shows the first offshore wind project in America: the Block Island Wind Farm, off the shores of Block Island, R.I., as seen in 2016.

Don Emmert/AFP via Getty Images

The U.S. approved a large offshore wind project on Tuesday, advancing a plan to build a turbine installation some 12 nautical miles offshore from Martha's Vineyard, Mass. The 800-megawatt project would produce enough electricity to power 400,000 homes and businesses, the Biden administration says.

The IEA's Renewable Energy Market Update identifies several countries as driving the phenomenal growth in renewable energy last year, including China, the U.S. and Vietnam. All three countries were facing policy deadlines that spurred renewable energy projects to completion.

For the first time, China accounted for 50% of the world's growth in renewable energy capacity, the report says. The country is expected to add slightly less renewable power capacity in 2021, as it phases out some subsidies for wind and solar projects.

Despite those changes, solar energy development "will continue to break records," the IEA says, predicting that annual capacity additions will hit 162 gigawatts by the end of next year – almost 50% higher than the solar capacity gains in the pre-pandemic era of 2019.

Renewable energy sources "are expected to account for 90% of total global power capacity increases" this year and next, according to the agency, citing support from government policies and investments.

The Paris-based IEA was founded during the energy crisis of the early 1970s. It has 30 members, including the U.S., along with eight "association countries," such as China and India.

Correction

May 13, 2021

The original version of this story incorrectly said global renewable energy capacity increased 45% in 2020. The 45% increase was in the annual rate of increase of global renewable energy capacity.

renewable energy

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Renewable Energy

At-a-glance

- Renewable energy is the fastest-growing energy source in the United States, increasing 100 percent from 2000 to 2018.
- Renewables made up more than 17 percent of net U.S. electricity generation in 2018, with the bulk coming from hydropower (7.0 percent) and wind power (6.6 percent).
- Solar generation (including distributed) is projected to climb from 11 percent of total U.S. renewable generation in 2017 to 48 percent by 2050, making it the fastest-growing electricity source.
- Globally, renewables made up 24 percent of electricity generation in 2016, much of it from hydropower (16 percent).
- Renewable ethanol and biodiesel transportation fuels made up over 12 percent of total U.S. renewable energy consumption in 2018, up from 7 percent in 2006.

Renewable Supply and Demand

Renewable energy is the fastest-growing energy source globally and in the United States.

Globally:

- Eighteen percent of the energy consumed globally for heating, power, and transportation was from renewable sources in 2017 (see figure below). Nearly 60 percent came from modern renewables (i.e., biomass, geothermal, solar, hydro, wind, and biofuels) and the remainder from traditional biomass (used in residential heating and cooking in developing countries).
- Renewables made up 26.2 percent of global electricity generation in 2018. That's expected to rise to 45 percent by 2040. Most of the increase will likely come from solar, wind, and hydropower.

The International Energy Agency notes that the development and deployment of renewable energy technologies will depend heavily on government policies and financial support to make renewable energy cost-competitive.

Estimated Global Renewable Energy Share of Total Final Energy Consumption (2017)

SOURCE

Renewable Energy Policy Network for the 21st Century, p. 31. (2019)

In the United States:

- Eleven percent of the energy consumed across sectors in the United States was from renewable sources in 2018 (11.5 quadrillion Btu out of a total of 101.1 quadrillion Btu). U.S. consumption of renewables is expected to grow over the next 30 years at an average annual rate of 1.8 percent, higher than the overall growth rate in energy consumption (0.2 percent per year) under a business-as-usual scenario.
- Renewables made up 17.1 percent of electricity generation in 2018, with hydro, wind, and biomass making up the majority. That's expected to rise to 24 percent by 2030. Most of the increase is expected to come from wind and solar. Non-hydro renewables have increased their share of electric power generation from less than 1 percent in 2005 to nearly 10.1 percent at the end of 2018 while demand for electricity has remained relatively stable.

In the transportation sector, renewable fuels, such as ethanol and biodiesel, have increased significantly during the past decade. E85 (ethanol transportation fuel) is expected to be the fastest growing renewable energy type, growing at an average annual rate of 9.7 percent over the next 30 years, although it starts from a very low base.

In the industrial sector, biomass makes up 98 percent of the renewable energy use with nearly 60 percent derivec ass wood, 32 percent from biofuels, and nearly 7 percent from biomass waste.

Uncertainty about federal tax credits, fuel prices, and economic growth will influence the pace of U.S. renewable energy source development.

Renewable Energy Drivers

Factors affecting renewable energy deployment include market conditions (e.g., cost, diversity, proximity to demand or transmission, and resource availability), policy decisions, (e.g., tax credits, feed-in tariffs, and renewable portfolio standards) as well as specific regulations. Nearly all countries had renewable energy policy targets in place at the end of 2018.

Businesses with sustainability goals are also driving renewable energy development by building their own facilities (e.g., solar roofs and wind farms), procuring renewable electricity through power purchase agreements, and purchasing renewable energy certificates (RECs).

Policy Drivers

Two federal tax credits have encouraged renewable energy in the United States:

- The production tax credit (PTC), first enacted in 1992 and subsequently amended, was a corporate tax credit available to a wide range of renewable technologies including wind, landfill gas, geothermal, and small hydroelectric. For eligible technologies, the utility received a 2.2 ¢/kWh ($22/MWh) credit for all electricity generated during the first 10 years of operation. The PTC is currently being phased out; facilities beginning construction after December 31, 2019 will no longer be able to claim this credit.
- The investment tax credit (ITC) is earned when qualifying equipment, including solar hot water, photovoltaics, and small wind turbines, is placed into service. The credit reduces installation costs and shortens the payback time of these technologies. The Consolidated Appropriations Act (2016) extended the ITC for three years. It will phase down to 10 percent in 2022 (from 30 percent in 2019).

States offer added incentives, making renewables even easier to implement from a cost perspective.

A renewable portfolio standard requires electric utilities to deliver a certain amount of electricity from renewable or alternative energy sources by a given date. State standards range from modest to ambitious, and qualifying energy sources vary. Some states also include "carve-outs" (requirements that a certain percentage of the portfolio be generated from a specific energy source, such as solar power) or other incentives to encourage the development of particular resources. Although climate change may not be the prime motivation behind these standards, they can deliver significant greenhouse gas reductions and other benefits, including job creation, energy security, and cleaner air. Most states allow utilities to comply with the renewable portfolio standard through tradeable credits that utilities can sell for additional revenue.

In states with a renewable portfolio standard, utilities consider cost, intermittency and resource availability in choosing technologies that satisfy this requirement.

In the U.S. transportation sector, The Energy Policy Act of 2005 created a Renewable Fuel Standard that required 2.78 percent of gasoline consumed in the United States in 2006 to be renewable fuel.

The Energy Independence and Security Act of 2007 created a new Renewable Fuel Standard, which increased the required volumes of to 36 billion gallons by 2022, or about 7 percent of expected annual gasoline and diesel consumption above a business-as-usual scenario.

Types of Renewable Energy

Renewable energy comes from sources that can be regenerated or naturally replenished. The main sources are:

- Water (hydropower and hydrokinetic)
- Wind
- Solar (power and hot water)
- Biomass (biofuel and biopower)
- Geothermal (power and heating)

All sources of renewable energy are used to generate electric power. In addition, geothermal steam is used directly for heating and cooking. Biomass and solar sources are also used for space and water heating. Ethanol and biodiesel (and to a lesser extent, gaseous biomethane) are used for transportation.

Renewable energy sources are considered to be zero (wind, solar, and water), low (geothermal) or neutral (biomass) with regard to greenhouse gas emissions during their operation. A neutral source has emissions that are balanced by the amount of carbon dioxide absorbed during the growing process. However, each source's overall environmental impact depends on its overall lifecycle emissions, including manufacturing of equipment and materials, installation as well as land-use impacts.

Water

Large conventional hydropower projects currently provide the majority of renewable electric power generation. With about 1,132 gigawatts (GW) of global capacity, hydropower produced an estimated 4,210 terawatt hours (TWh) of the 26,700 TWh total global electricity in 2018.

The United States is the fourth-largest producer of hydropower after China, Brazil, and Canada. In 2011, a much wetter than average year in the U.S. Northwest, the United States generated 7.9 percent of its total electricity from hydropower. The Department of Energy has found that the untapped generation potential at existing U.S. dams designed for purposes other than power production (i.e., water supply, flood control, and inland navigation) represents 12 GW, roughly 15 percent of current hydropower capacity.

Hydropower operational costs are relatively low, and hydropower generates little to no greenhouse gas emissions. The main environmental impact is that a dam to create a reservoir or divert water to a hydropower plant changes the ecosystem and physical characteristic of the river.

Waterpower captures the energy of flowing water in rivers, streams, and waves to generate electricity. Conventional hydropower plants can be built in rivers with no water storage (known as "run-of-the-river" units) or in conjunction with reservoirs that store water, which can be used on an as-needed basis. As water travels downstream, it is channeled down through a pipe or other intake structure in a dam (penstock). The flowing water turns the blades [illegible], generating electricity in the powerhouse, located at the base of the dam.

Other Hydroelectric Power Generation

Small hydropower projects, generally less than 10 megawatts (MW), and micro-hydropower (less than 1 MW) are less costly to develop and have a lower environmental impact than large conventional hydropower projects. In 2016, the total amount of small hydro installed worldwide was 78 GW. China had the largest share at 51 percent.

China, Italy, Japan, Norway and the United States are the top five small hydro countries by installed capacity. Many countries have renewable energy targets that include the development of small hydro projects.

Hydrokinetic electric power, including wave and tidal power, is a form of unconventional hydropower that captures energy from waves or currents and does not require dam construction. These technologies are in various stages of research, development, and deployment. In 2011, a 254 MW tidal power plant in South Korea began operation, doubling the global capacity to 527 MW. By the end of 2018, global capacity was about 532 MW.

Low-head hydro is a commercially available source of hydrokinetic electric power that has been used in farming areas for more than 100 years. Generally, the capacity of these devices is small, ranging from 1kW to 250kW.

Pumped storage hydropower plants use inexpensive electricity (typically overnight during periods of low demand) to pump water from a lower-lying storage reservoir to a storage reservoir located above the power house for later use during periods of peak electricity demand. Although economically viable, this strategy is not considered renewable since it uses more electricity than it generates.

Hydroelectric Power Generation

SOURCE

Environment Canada, 2012

Wind

Wind was the second largest renewable energy source (after hydropower) for power generation. Wind power produced more than 5 percent of global electricity in 2018 with 591 GW of global capacity (568.4 GW is onshore). Capacity is indicative of the maximum amount of electricity that can be generated when the wind is blowing at sufficient levels for a turbine. Because the wind is not always blowing, wind farms do not always produce as much as their capacity. With around 210 MW, China had the largest installed capacity of wind generation in 2018. The United States, with 96.5 GW, had the second-largest capacity; Texas, Oklahoma, Iowa, and Kansas provide more than half of U.S. wind generation.

Although people have harnessed the energy generated by the movement of air for hundreds of years, modern turbines reflect significant technological advances over early windmills and even over turbines from just 10 years ago. Generating electric power using wind turbines creates no greenhouse gases, but since a wind farm includes dozens or more turbines, widely-spaced, it requires thousands of acres of land. For example, Lone Star is a 200 MW wind farm on approximately 36,000 acres in Texas.

Average turbine size has been steadily increasing over the past 30 years. Today, new onshore turbines are typically in the range of 2 – 5 MW. The largest production models, designed for off-shore use can generate 12 MW; some innovative turbine models under development are expected to generate more than 14 MW in offshore projects in the coming years. Due to higher costs and technology constraints, off-shore capacity, approximately 22.6 GW in 2018, is only a small share (about 4 percent) of total installed wind generation capacity.

Wind Turbine Sizes

SOURCE

GE, Vox, 2019

Solar

Solar energy resources are massive and widespread, and they can be harnessed anywhere that receives sunlight. [illegible]t of solar radiation, also known as insolation, reaching the Earth's surface every hour is more than all the energy currently consumed by all human activities each year. A number of factors, including geographic location, time of day, and weather conditions, all affect the amount of energy that can be harnessed for electricity production or heating purposes.

Solar photovoltaics are the fastest growing electricity source. In 2018, around 100 GW of global capacity was added, bringing the total to about 505 GW and producing a bit more than 2 percent of the world's electricity.

Solar energy can be captured for electricity production using:

- A solar or photovoltaic cell, which converts sunlight into electricity using the photoelectric effect. Typically, photovoltaics are found on the roofs of residential and commercial buildings. Additionally, utilities have constructed large (greater than 100 MW) photovoltaic facilities that require anywhere from 5 to 13 acres per MW, depending on the technologies used.
- Concentrating solar power, which uses lenses or mirrors to concentrate sunlight into a narrow beam that heats a fluid, producing steam to drive a turbine that generates electricity. Concentrating solar power projects are larger-scale than residential or commercial PV and are often owned and operated by electric utilities.

Solar hot water heaters, typically found on the roofs of homes and apartments, provide residential hot water by using a solar collector, which absorbs solar energy, that in turn heats a conductive fluid, and transfers the heat to a water tank. Modern collectors are designed to be functional even in cold climates and on overcast days.

Electricity generated from solar energy emits no greenhouse gases. The main environmental impacts of solar energy come from the use of some hazardous materials (arsenic and cadmium) in the manufacturing of PV and the large amount of land required, hundreds of acres, for a utility-scale solar project.

Concentrating Solar Power

NOTES

Solar collectors (i.e., parabolic troughs) capture and concentrate sunlight to heat a synthetic oil called therminol, which then heats water to create steam. The steam is piped to an onsite turbine-generator to produce electricity, which is then transmitted over power lines. On cloudy days, the plant has a supplementary natural gas boiler.

SOURCE

U.S. Department of Energy, 2019

Biomass

Biomass energy sources are used to generate electricity and provide direct heating, and can be converted into biofuels as a direct substitute for fossil fuels used in transportation. Unlike intermittent wind and solar energy, biomass can be used continuously or according to a schedule. Biomass is derived from wood, waste, landfill gas, crops and alcohol fuels. Traditional biomass, including waste wood, charcoal and manure, has been a source of energy for domestic cooking and heating throughout human history. In rural areas of the developing world, it remains the dominant fuel source. Globally in 2017, traditional biomass accounted for about 7.5 percent of total energy consumption. The growing use of biomass has resulted in increasing international trade in biomass fuels in recent years; wood pellets, biodiesel, and ethanol are the main fuels traded internationally.

In 2018, global biomass electric power capacity stood at 130 GW. In 2018, the United States had 16 GW of installed biomass-fueled electric generation capacity. In the United States, most of the electricity from wood biomass is generated at lumber and paper mills using their own wood waste; in addition, wood waste is used to generate the heat for drying wood products and other manufacturing processes. Biomass waste is mostly municipal solid waste, i.e., garbage, which is burned as a fuel to run power plants. On average, a ton of garbage generates 550 to 750 kWh of electricity. Landfill gas contains methane that can be captured, processed and used to fuel power plants, manufacturing facilities, vehicles and homes. In the United States, there is currently more than 2 GW of installed landfill gas-fired generation capacity at more than 600 projects.

In addition to landfill gas, biofuels can be synthesized from dedicated crops, trees and grasses, agricultural waste and algae feedstock; these include renewable forms of diesel, ethanol, butanol, methane and other hydrocarbons. Corn ethanol is the most widely used biofuel in the United States. Roughly 38 percent of the U.S. corn crop was diverted to the production of ethanol for gasoline in 2018, up from 20 percent in 2006. Gasoline with up to 10 percent ethanol (E10) can be used in most vehicles without further modification, while special flexible fuel vehicles can use a gasoline-ethanol blend that has up to 85 percent ethanol (E85).

Closed-loop biomass, where power is generated using feedstocks grown specifically for the purpose of energy production, is generally considered to be carbon dioxide neutral because the carbon dioxide emitted during combustion of the fuel was previously captured during the growth of the feedstock. While biomass can avoid the use of fossil fuels, the net effect of biopower and biofuels on greenhouse gas emissions will depend on full lifecycle emissions for the biomass source, how it is used, and indirect land-use effects. Overall, however, biomass energy can have varying impacts on the environment. Wood biomass, for example, contains sulfur and nitrogen, which yield air pollutants sulfur dioxide and nitrogen oxides, though in much lower quantities than coal combustion.

Geothermal

Geothermal provided an estimated 175 TWh globally in 2018, one half in the form of electricity (with an estimated 13.3 GW of capacity) and the remaining half in the form of heat. (Total global electricity generation in 2018 was 26,700 TWh).

In the United States, 16 billion kWh of geothermal electricity was generated in 2018, making up about 4 percent of non-hydroelectric renewable electricity generation, but only 0.4 percent of total electricity generation. Seven states generated electricity from geothermal energy: California, Hawaii, Idaho, Nevada, New Mexico, Oregon and Utah. Of these, California accounted for 80 percent of this generation.

Traditional geothermal energy exploits naturally occurring high temperatures, located relatively close to the Earth’ some areas, to generate electric power and for direct uses such as heating and cooking. Geothermal areas are generally located near tectonic plate boundaries, where there are earthquakes and volcanoes. In some places, hot springs and geysers have been used for bathing, cooking and heating for centuries

Generating geothermal electric power typically involves drilling a well, perhaps a mile or two in depth, in search of rock temperatures in the range of 300 to 700°F. Water is pumped down this well, where it is reheated by hot rocks. It travels through natural fissures and rises up a second well as steam, which can be used to spin a turbine and generate electricity or be used for heating or other purposes. Several wells may have to be drilled before a suitable one is in place and the size of the resource cannot be confirmed until after drilling. Additionally, some water is lost to evaporation in this process, so new water is added to maintain the continuous flow of steam. Like biopower and unlike intermittent wind and solar power, geothermal electricity can be used continuously. Very small quantities of carbon dioxide trapped below the Earth's surface are released during this process.

Enhanced geothermal systems use advanced, often experimental, drilling and fluid injection techniques to augment and expand the availability of geothermal resources.

Geothermal Power Station

SOURCE

BBC Science

Renewable Energy Indicators, 2018

SOURCE

Renewable Energy Policy Network for the 21st Century (REN21), 2019

U.S. Renewable Resource Availability

The following maps from the DOE National Renewable Energy Laboratory depict the relative availability of renewable energy resources throughout the United States.

- Wind resources are abundant in the Great Plains, Iowa, Minnesota, along the spine of Appalachian Mountains, in the Western Mountains and many off-shore locations.
- Solar photovoltaic and concentrating solar power resources are the highest in the desert Southwest and diminish in intensity in a northward direction.
- The best biomass resources are in the upper central plains (corn) and forests of the Pacific Northwest.
- Traditional geothermal resources are concentrated in the Western United States.

U.S. Wind Resource Map

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U.S. National Renewable Energy Laboratories

U.S. Photovoltaic Solar Resources

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Should GE's Mark 1 Nuclear Reactor Be Recalled Worldwide Like a Faulty Unsafe Automobile? (Pt. 5)

bureau EnviroNews DC News Bureau | by Josh Cunnings | on September 11, 2017 | 1 Comment

(EnviroNews DC Bureau) — **Editor's Note:** *TheAfollowingAnewsApieceArepresentsAtheAfifthAinAaA15-partAmini-seriesAtitled,A*Nuclear Power in Our World Today, *featuringAnuclearAauthority,A engineerAandAwhistleblowerAArnieAGundersen.ATheAEnviroNewsAUSAAspecialAencompassesAaA wideAspanAofAtopics,ArangingAfromAManhattan-eraAmadnessAtoAtheAcontinuously-unfoldingA crisisAonAtheAgroundAatAFukushimaADaiichiAinAeasternAJapan.ATheAtranscriptAisAasAfollows:A*

Josh Cunnings (Narrator): Good evening and thanks for joining us at the *EnviroNewsAUSAA* news desk for the fifth segment in our 15-part mini series, *NuclearAPowerAinAOurAWorldAToday*. In our previous episodes, we explored several Manhattan-era messes in the United States, but tonight, we begin by discussing the troublesome situation on the ground at the Fukushima Daiichi power plant on Japan's eastern coast.

Now, if you trace Japan's troubles back far enough, then once again, you're going to find yourself right back here in the good old U S of A – in the state of California – during the 1970s – with General Electric at the helm.

The project that we're referring to was the development of the Mark 1 boiling water nuclear reactor – the very same model which melted entirely in units 1, 2 and 3 at Fukushima.

Now, when it comes to people who are qualified to talk about the many issues and problems surrounding the Mark 1, few could be more capable than former nuclear reactor operator and engineer Arnie Gundersen. As a matter of fact, the distinguished expert is all too familiar with the ins and outs of the design.

So, without further ado, here's another excerpt from this simply fantastic interview with Arnie Gundersen by *EnviroNews USA* Editor-in-Chief Emerson Urry. Take a listen.

Urry: And so speaking about these reactors and the technical components – you were actually involved with the Mark 1. And I remember reading that some of the engineers that worked on that project had resigned way back then in 1972, yet General Electric was still apparently willing to pimp this reactor out essentially, all over the planet. What can you tell us about the Mark 1 reactor, and your understanding of what happened back then with these engineers, and how General Electric has been able to spread this reactor to all corners of the globe, with really no consequence. We saw Greenpeace had started a petition to make General Electric and Hitachi, and maybe a couple others of the service providers, actually pay for the damage there, but has there been any culpability? **[Editor's Note: Urry intended to say "1976" not "1972" in this passage]**

Gundersen: Fukushima Daiichi has four units – one, two, three, four — and they're all Mark 1 designs. In addition, there's another 35 in the world, including 23 here in America, that are the same design. A group of three engineers quit General Electric in 1976 because they realized the design was not safe. Two of the three are still alive and living here in California, and they are my personal heroes. They understood before any of us did how seriously we really didn't understand what it was that the engineers were doing.

Excerpt From Greenpeace Video With Dale Bridenbaugh

> **Bridenbaugh:** My boss said to me, that if we have to shut down all of these Mark 1 plants, it will probably mean the end of GE's nuclear business forever.
>
> I started with GE immediately after I got out of college as a mechanical engineer, and I started out as a field engineer responsible for supervising the construction and startup of power plant equipment across the United States.
>
> In the first ten or fifteen plants that GE sold of the large-scale commercial boiling water reactors, they did so on what's called a "turnkey" basis. They built the whole thing, get it operating, and then they turn the key over to the utility, and the utility then is theoretically capable of operating it to produce electricity.
>
> Fukushima 1 was basically a turnkey plant provided to TEPCO by GE. In 1975 the problem developed that became known at the Mark 1 plants – the some 24 Mark 1 units in the United States, and also those overseas, including the Fukushima units – had not taken into account all of the pressures and forces that are called hydrodynamic loads that could be experienced by the pressure suppression units as a result of a major accident. We didn't really know if the containments would be able to contain the event that they were supposedly designed to contain.
>
> Not only were there the containment problems that existed with the Mark 1s, which I was very familiar with, but there were a

> number of other problems with the GE boiling water reactors and with the nuclear program in general. And I got disillusioned with the speed with which these problems were being addressed, and then in the middle of the night I called my boss at GE and I said, "My recommendation is that we tell the U.S. utilities that GE cannot support the continued operation of these plants." And my boss said to me, "Well, it can't be that bad Dale, and keep in mind that if we have to shut down all of these Mark 1 plants it will probably mean the end of GE's nuclear business forever." That conversation occurred at about midnight on January 26, and that clinched my decision on resignation on February 2.
>
> The accident that occurred in Fukushima, it's some two years later now, and we don't really know the condition of the reactor core; we don't really know the condition of the containment. The radiation levels are so high inside the containment that it's very difficult to get in there. It will be years before that plant site is cleaned up.
>
> The damage that has been experienced at Fukushima is so great and so extensive that I don't think any one utility, certainly TEPCO, has the capability to be able to pay for all of that. So, it becomes a national issue. I think it would be a good idea to not have reliance on nuclear units. They're very risky enterprises. And I would like to see a world that is provided with electricity by alternative energy supplies.

Gundersen: When Maggie [Gundersen] and I were walking one day in February [a month] before the [Fukushima] accident, she said to me, "Where is the next accident going to be?" And I said, "I don't know where, but I know it's going to be in a Mark 1 reactor." And, I'm not alone. It's not like I was clairvoyant. The Nuclear Regulatory Commission had a report that they published in 1982, and they said there was an 85 percent chance, if there was a meltdown in a Mark 1 reactor, that the containment would explode. The writing was on the wall.

Urry: How many of these things are still out there in operation today?

Gundersen: In the U.S., all 23 continue to run, and as a matter of fact, the sta of the Nuclear Regulatory Commission recommended some pretty substantial improvements, and the politically appointed commissioners, who have no nuclear background, overrode the sta and said, "no, we're not going to do those changes." So, the Commission has been actively involved in thwarting the safety improvements that everybody knows are needed.

Script for General Electric Television Commercial

> "
>
> **Voice of Child Narrator:** My mom, she makes underwater fans that are powered by the moon. My mom makes airplane engines that can talk. My mom makes hospitals you can hold in your hand. My mom can print amazing things, right from her computer. My mom makes trains that are friends with trees. My mom works at GE.

Cunnings: If GE, a company that successfully weaseled its way out of paying any taxes whatsoever in the U.S. wants to boast night and day on the mainstream media airwaves the same mainstream media which it once nearly monopolized — that it "brings good th to life" and makes "underwater fans that are powered by the moon" and locomotives tha "talk to trees" perhaps the company should also bother to mention its own manufacture and sales of faulty nuclear power reactors that quite frankly, bring good things to an early death.

Oh, and by the way, the company not only builds the reactors that breed uranium into plutonium for bombs, oh no, its role goes much deeper. In fact, GE is in the business of manufacturing the actual bombs too. "We bring good things to life." Seriously? Let's get real.

Documentary Film Trailer for *Deadly Deception: General Electric, Nuclear Weapons and Our Environment*

> **Narrator:** The Hanford Nuclear Reservation, a massive 570-square-mile facility, where General Electric made plutonium for the U.S. military.
>
> **Subject #1:** I began loosing my hair, which I had long naturally curly hair.
>
> **Narrator:** [Of] 28 families who lived in a small area near Hanford, 27 of them had su ered severe health problems.
>
> **Subject #1:** … and the physician said that I had the most severe case of hypothyroidism he'd ever seen in his career…
>
> **Narrator:** … all of which are associated with exposure to high doses of radiation.
>
> **Subject #2:** We took twice the amount that the Children of Chernobyl took. There was absolutely no warning. They came and said, "You're safe."
>
> **Narrator:** According to the business press, General Electric is the most powerful company in the United States, and GE is rapidly expanding its control of markets worldwide.
>
> **Subject #3:** I'd like to wake Jack Welch up in the middle of his atomic power lab; let him explain why their husbands died of cancer related to the asbestos.
>
> **Subject #4:** I find their ads disgusting. I find that ad disgusting.
>
> **Narrator:** Four million individuals and 450 organizations in the U.S., Canada and around the world, have decided to join the GE boycott.
>
> **Subject #4:** Are you asking us to clean up your toxic waste again!?
>
> **Subject #5:** What GE does is not bring good things to life. They mislead the American public.
>
> **Subject #6:** General Electric is in this business of building weapons for profit – not for patriotism, not for the country, not for the ag, but for profit.
>
> **Ronald Reagan:** Until next week then, good night for General Electric.

Excerpt from Fairewinds Associates Video, Featuring Arnie Gundersen on the GE Mark 1 Reactor

Gundersen: This picture of a boiling water reactor containment is taken in the early 70s. It was taken at Browns Ferry [Nuclear Plant], but it's identical to the Fukushima reactors. Now, let me walk you through that as I talk about it.

There are two pieces to the containment, the top looks like an upside down light bulb, and that's called a "drywell." Inside there is where the nuclear reactor is. Down below is this thing that looks like a doughnut, and that's called the "torus," and that's filled almost all the way with water. The theory is that if the reactor breaks, steam will shoot out through the light bulb into the doughnut, creating lots of bubbles, which will reduce the pressure. Well, this thing's called a "pressure suppression containment." Now, at the bottom of that picture is the lid for the containment. When it's fully assembled, that lid sits on top. The containment's about an inch thick. Inside it is the nuclear reactor that's about eight inches thick, and we'll get to that in a minute.

Well, this reactor containment was designed in the early 70s, late 60s, and by 1972 a lot of people had concerns with the containment. So, in the early 70s, the Nuclear Regulatory Commission recognized this containment design was awed. In the mid-70s, they realized the forces were in the wrong direction; instead of down, they were up, and large straps were put into place.

Well, then in the 80s, there was another problem that developed. After Three Mile Island engineers began to realize that this containment could explode from a hydrogen buildup. That hadn't been factored into the design in the 70s either. Well, what they came up with for this particular containment was a vent in the side of it.

Now, a vent is designed to let the pressure out, and a containment is designed to keep the pressure in. So, rather than contain this radioactivity, engineers realized that if the containment were to survive an explosion they'd have to open a hole in the side of it called a "containment vent."

Well, these vents were added in the late 1980s. And they weren't added because the Nuclear Regulatory Commission demanded it. What the industry did to avoid that was create an initiative and they put them in voluntarily. Now, that sounds really proactive, but in fact, it wasn't. If the Nuclear Regulatory Commission required it, it would have opened up the license on these plants to citizens and scientists who had concerns. Well, by having the industry voluntarily put these vents in it did two things: One, it did not allow any public participation in the process to see if they were safe. And the second thing is that it didn't allow the Nuclear Regulatory Commission to look at these vents and say they were safety related. In fact, it sidetracked the process entirely.

Well, these vents were never tested until Fukushima. This containment was never tested until Fukushima. And it failed three times out of three tries. In retrospect, we shouldn't be surprised.

Looking at the procedures for opening these vents, in the event electricity fails, requires someone fully clad in radiation gear to go down to an enormous valve in the bowels of the plant and turn the crank 200 times to open it. Now, can you imagine, in the middle of a nuclear accident, with steam and explosions and radiation, expecting an employee to go into the plant and turn a valve 200 times to open it?

So, that was the second Band-Aid fix that failed, on a containment that 40 years earlier, was designed too small.

Well, with all this in mind, I think we really need to ask the question: should the Mark 1 containment even be allowed to continue to operate? The NRC's position is: well, we can make the vents stronger. I don't think that's a good idea.

Now, all those issues that I just talked about are related to the Mark 1 containment. The next thing I'd like to talk about is the reactor that sits inside that containment. So, that light bulb and that doughnut are the containment structure; inside that is where the nuclear reactor is.

Now, on a boiling water reactor, the nuclear control rods come in at the bottom; on a pressurized water reactor they come in from the top. All of the reactors at Fukushima, and 35 in the world in this design, have control rods that come in from the bottom. Now, that poses a unique problem and an important di erence that the NRC is not looking at right now.

If the core melts in a pressurized water reactor, there's no holes in the bottom of the nuclear reactor, and it's a very thick eight to 10-inch piece of metal that the nuclear reactor core would have to melt through. But that didn't happen at Fukushima.

Fukushima was a boiling water reactor; it's got holes in the bottom. Now, when the nuclear core lies on the bottom of a boiling water reactor like Fukushima, or the ones in the U.S., or others in Japan, it's easier for the core to melt through because of those 60 holes in the bottom of the reactor. It doesn't have to melt through eight inches of steel. It just has to melt through a very thin-walled pipe and scoot out the hole in the bottom of the nuclear reactor. I'm not the only one to recognize that holes at the bottom of a boiling water reactor are a problem.

Last week an email came out that was written by the Nuclear Regulatory Commission right after the Fukushima accident, where they recognize that if there's a core meltdown, and it's now lying as a blob on the bottom of the nuclear reactor, these holes in the bottom of the reactor form channels, through which the hot molten fuel can get out a lot easier and a lot quicker than the thi pressurized water reactor design. Now, this is a aw in any boilir water reactor, and the Nuclear Regulatory Commission is not recognizing that the likelihood of melting through a boiling water reactor like Fukushima, is a lot more significant than the likelihood of melting through a pressurized water reactor.

The third area is an area we've discussed in-depth in a previous video, and that's that the explosion at Unit 3 was a detonation, not a de agration. It has to do with the speed of the shockwave. The shockwave at Unit 3 traveled faster than the speed of sound, and that's an important distinction that the Nuclear Regulatory Commission, and the entire nuclear industry, is not looking at.

A containment can't withstand a shockwave that travels faster than the speed of sound. Yet, all containments are designed assuming that doesn't happen. At Fukushima 3 it did happen, and we need to understand how it happened and mitigate against it in the future on all reactors.

Now, I measured that. I scaled the size of the building versus the speed at which the explosion occurred, and I can determine that that shockwave traveled at around 1,000 feet per second. The speed of sound is around 600 feet per second. So, it traveled at supersonic speeds that can cause dramatic damage to a containment. They're not designed to handle it. Yet, the NRC is not looking at that. **[Editor's Note: Gundersen intended to say "miles per hour," not "feet per second" in this video.]**

So, we've got three key areas where the NRC, and the nuclear industry, don't want people to look, and that's: 1) should this Mark 1 containment even be allowed to continue to operate?

Cunnings: In America, when a vehicle, or even a part in a vehicle, is deemed unsafe for the population at large, the government forces automakers into costly and multi-billion dollar recalls – and the mainstream media does its part by shaming those culprit companies, relentlessly beating them to a bloody pulp for their negligence and their reckless endangerment of innocent American citizens.

The Mark 1 nuclear reactor is an extremely outdated model with obvious design aws. Apparently, it has so many problems, that as Mr. Gundersen pointed out, three of the engineers who originally designed it ended up resigning because they knew it wasn't safe – and that was well before Three Mile Island or Chernobyl ever happened – long before the public had experienced the fright, and health consequences of a full-scale nuclear meltdown.

Surely, after the triple meltdowns at Fukushima, Japan, it appears the Mark 1 is far from safe, yet here in the U.S., the government continues to let operators drive this faulty nuclear vehicle down the road – knowing full well that it could fall apart and crash, harming, or even killing innocent Americans at any time.

Perhaps the government should consider holding nuke-plant manufacturers, like GE, to the same standards it demands from automakers, and punish them with shameful recalls when they market a piece of faulty equipment that poses any danger to the public.

So, just what would a recall of the Mark 1 nuclear reactor look like, and who would issue enforce it? The Nuclear Regulatory Commission? And how could enough political will ev be mustered for such a massive undertaking? It would surely cost more than any auto recall ever has, but frankly, who should give a damn (except for General Electric's shareholders of course)? I mean, if it ain't safe, then it just ain't safe mate. Besides, after paying zero taxes, GE's pockets should be plenty deep enough to handle such an event — right? The concept of an all-out recall on the antiquated General Electric Mark 1 reactor is one that we will continue to explore. As a matter of fact, in tomorrow's show, we'll discuss the problems with the Mark 1 a little further.

Tune in then for episode six in our series of short films, *Nuclear Power In Our World Today*, with esteemed expert and whistleblower Arnie Gundersen.

Signing off for now – Josh Cunnings – *EnviroNews USA*.

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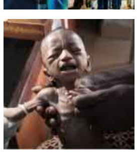
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Experts Had Long Criticized Potential Weakness in Design of Stricken Reactor

By Tom Zeller Jr.

March 15, 2011

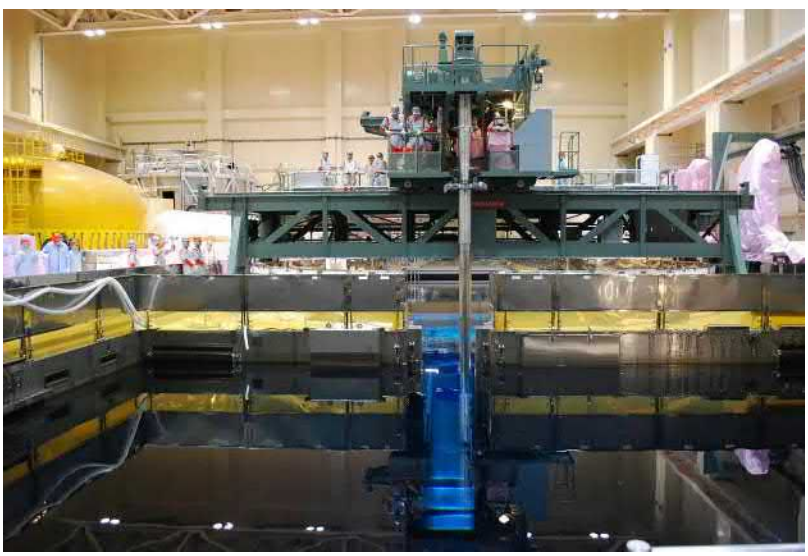
The warnings were stark and issued repeatedly as far back as 1972: If the cooling systems ever failed at a "Mark 1" nuclear reactor, the primary containment vessel surrounding the reactor would probably burst as the fuel rods inside overheated. Dangerous radiation would spew into the environment.

Now, with one Mark 1 containment vessel damaged at the embattled Fukushima Daiichi nuclear plant and other vessels there under severe strain, the weaknesses of the design — developed in the 1960s by General Electric — could be contributing to the unfolding catastrophe.

When the ability to cool a reactor is compromised, the containment vessel is the last line of defense. Typically made of steel and concrete, it is designed to prevent — for a time — melting fuel rods from spewing radiation into the environment if cooling efforts completely fail.

In some reactors, known as pressurized water reactors, the system is sealed inside a thick steel-and-cement tomb. Most nuclear reactors around the world are of this type.

But the type of containment vessel and pressure suppression system used in the failing reactors at Japan's Fukushima Daiichi plant is physically less robust, and it has long been thought to be more susceptible to failure in an emergency than competing designs. In the United States, 23 reactors at 16 locations use the Mark 1 design, including the Oyster Creek plant in central New Jersey, the Dresden plant near Chicago and the Monticello plant near Minneapolis.



A fuel storage pool in the Fukushima plant reactor building. Surrounding this and reactors like it is a containment vessel, the last line of defense if cooling fails. Jiji Press/Agence France-Presse — Getty Images

G.E. began making the Mark 1 boiling-water reactors in the 1960s, marketing them as cheaper and easier to build — in part because they used a comparatively smaller and less expensive containment structure.

American regulators began identifying weaknesses very early on.

In 1972, Stephen H. Hanauer, then a safety official with the Atomic Energy Commission, recommended that the Mark 1 system be discontinued because it presented unacceptable safety risks. Among the concerns cited was the smaller containment design, which was more susceptible to explosion and rupture from a buildup in hydrogen — a situation that may have unfolded at the Fukushima Daiichi plant. Later that same year, Joseph Hendrie, who would later become chairman of the Nuclear Regulatory Commission, a successor agency to the atomic commission, said the idea of a ban on such systems was attractive. But the technology had been so widely accepted by the industry and regulatory officials, he said, that "reversal of this hallowed policy, particularly at this time, could well be the end of nuclear power."

In an e-mail on Tuesday, David Lochbaum, director of the Nuclear Safety Program at the Union for Concerned Scientists, said those words seemed ironic now, given the potential global ripples from the Japanese accident.

"Not banning them might be the end of nuclear power," said Mr. Lochbaum, a nuclear engineer who spent 17 years working in nuclear facilities, including three that used the G.E. design.

Questions about the design escalated in the mid-1980s, when Harold Denton, an official with the Nuclear Regulatory Commission, asserted that Mark 1 reactors had a 90 percent probability of bursting should the fuel rods overheat and melt in an accident.

Industry officials disputed that assessment, saying the chance of failure was only about 10 percent.

Michael Tetuan, a spokesman for G.E.'s water and power division, staunchly defended the technology this week, calling it "the industry's workhorse with a proven track record of safety and reliability for more than 40 years."

Mr. Tetuan said there are currently 32 Mark 1 boiling-water reactors operating safely around the globe. "There has never been a breach of a Mark 1 containment system," he said.

Several utilities and plant operators also threatened to sue G.E. in the late 1980s after the disclosure of internal company documents dating back to 1975 that suggested that the containment vessel designs were either insufficiently tested or had flaws that could compromise safety.

The Mark 1 reactors in the United States have undergone a variety of modifications since the initial concerns were raised. Among these, according to Mr. Lochbaum, were changes to the torus — a water-filled vessel encircling the primary containment vessel that is used to reduce pressure in the reactor. In early iterations, steam rushing from the primary vessel into the torus under high pressure could cause the vessel to jump off the floor.

In the late 1980s, all Mark 1 reactors in the United States were also retrofitted with venting systems to help reduce pressure in an overheating situation.

It is not clear precisely what modifications were made to the Japanese boiling-water reactors now failing, but James Klapproth, the chief nuclear engineer for General Electric Hitachi, said a venting system was in place at the Fukushima plants to help relieve pressure.

The specific role of the G.E. design in the Fukushima crisis is likely to be a matter of debate, and it is possible that any reactor design could succumb to the one-two punch of an earthquake and tsunami like those that occurred last week in Japan.

Although G.E.'s liability would seem limited in Japan — largely because the regulatory system in that country places most liability on the plant operator — the company's stock fell 31 cents to $19.61 in trading Tuesday.

Fukushima: Mark 1 Nuclear Reactor Design Caused GE Scientist To Quit In Protest

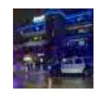
Damaged Japanese nuclear plant has five Mark 1 reactors.

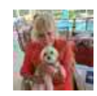
By MATTHEW MOSK
March 15, 2011, 2:34 PM • 4 min read

Preventing a Nuclear Meltdown

his colleagues at General Electric resigned from their jobs after becoming increasingly convinced that the nuclear reactor design they were reviewing -- the Mark 1 -- was so flawed it could lead to a devastating accident.

Questions persisted for decades about the ability of the Mark 1 to handle the immense pressures that would result if the reactor lost cooling power, and today that design is being put to the ultimate test in Japan. Five of the six reactors at the Fukushima Daiichi plant, which has been wracked since Friday's earthquake with explosions and radiation leaks, are Mark 1s.





"The problems we identified in 1975 were that, in doing the design of the containment, they did not take into account the dynamic loads that could be experienced with a loss of coolant," Bridenbaugh told ABC News in an interview. "The impact loads the containment would receive by this very rapid release of energy could tear the containment apart and create an uncontrolled release."

The situation on the ground at the Fukushima Daiichi plant is so fluid, and the details of what is unfolding are so murky, that it may be days or even weeks before anyone knows how the Mark 1 containment system performed in the face of a devastating combination of natural disasters.

But the ability of the containment to withstand the events that have cascaded from what nuclear experts call a "station blackout" -- where the loss of power has crippled the reactor's cooling system -- will be a crucial question as policy makers re-examine the safety issues that surround nuclear power, and specifically the continued use of what is now one of the oldest types of nuclear reactors still operating.

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GE told ABC News the reactors have "a proven track record of performing reliably and safely for more than 40 years" and "performed as designed," even after the shock of a 9.0 earthquake.

Still, concerns about the Mark 1 design have resurfaced occasionally in the years since Bridenbaugh came forward. In 1986, for instance, Harold Denton, then the director of NRC's Office of Nuclear Reactor Regulation, spoke critically about the design during an industry conference.

"I don't have the same warm feeling about GE containment that I do about the larger dry containments," he said, according to a report at the time that was referenced Tuesday in The Washington Post.

"There is a wide spectrum of ability to cope with severe accidents at GE plants," Denton said. "And I urge you to think seriously about the ability to cope with such an event if it occurred at your plant."

Bridenbaugh Believes Design Flaws Were Addressed At Fukushima Plant

Bridenbaugh told ABC News that he believes the design flaws that prompted his resignation from GE were eventually addressed at the Fukushima Daiichi plant. Bridenbaugh said GE agreed to a series of retrofits at Mark 1 reactors around the globe. He compared the retooling to the bolstering of highway bridges in California to better withstand earthquakes.

"Like with seismic refitting, they went back and re-analyzed the loads the structures might receive and beefed up the ability of the containment to handle greater loads," he said.

When asked if that was sufficient, he paused. "What I would say is, the Mark 1 is still a little more susceptible to an accident that would result in a loss of containment."

ABC News asked GE for more detail about how the company responded to critiques of its Mark 1 design. GE spokesman Michael Tetuan said in an email that, over the past 40 years, the company has made several modifications to its Mark 1 reactors in the U.S., including installing "quenchers" and fortifying the steel structures "to accommodate the loads that were generated." He said that GE's responses to modifications ordered by the Nuclear Regulatory Commission were also shared with the Japanese nuclear industry.

Bridenbaugh told ABC News that he is watching the events in Japan with a mix of anxiety and deep reflection. Many years have passed since he and fellow GE colleagues Gregory C Minor and Richard B. Hubbard publicly resigned, joined the anti-nuclear movement, and became known as the "GE Three."

Undoubtedly, he said, the containment structures at that Fukushima Daiichi plant are facing significant amounts of pressure -- and testing the very questions he was studying on paper more than three decades earlier. While he knew then that the Mark 1 had design limits, he said, no one knows now whether those limits will be surpassed.

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HAZARDS OF BOILING WATER REACTORS IN THE UNITED STATES

March 1, 1996

BACKGROUND

Of the 104 operational nuclear power reactors in the United States, thirty-five are boiling water reactors (BWR). General Electric is the sole designer and manufacturer of BWRs in the United States. The BWR's distinguishing feature is that the reactor vessel serves as the boiler for the nuclear steam supply system. The steam is generated in the reactor vessel by the controlled fissioning of enriched uranium fuel which passes directly to the turbogenerator to generate electricity.

LACK OF CONTAINMENT INTEGRITY DURING A NUCLEAR ACCIDENT

The purpose of a reactor containment system is to create a barrier against the release of radioactivity generated during nuclear power operations from certain "design basis" accidents, such as increased pressure from a single pipe break. It is important to understand that nuclear power plants are not required by the Nuclear Regulatory Commission (NRC) to remain intact as a barrier to all possible accidents or "non-design basis" accidents, such as the melting of reactor fuel. All nuclear reactors can have accidents which can exceed the design basis of their containment.

But even basic questions about the the GE containment design remain unanswered and its integrity in serious doubt. For example, 23 of these BWRs use a smaller GE Mark I pressure suppression containment conceived as a cost-saving alternative to the larger reinforced concrete containments marketed by competitors. A large inverted light-bulb-shaped steel structure called "the drywell" is constructed of a steel liner and a concrete drywell shield wall enclosing the reactor vessel–this is considered the "primary" containment.. The atmosphere of the drywell is connected through large diameter pipes to a large hollow doughnut-shaped pressure suppression pool called "the torus", or wetwell, which is half-filled with water. In the event of a loss-of-coolant-accident (LOCA), steam would be released into the drywell and directed underwater in the torus where it is supposed to condense, thus suppressing a pressure buildup in the containment.

The outer concrete building is the "secondary" containment and is smaller and less robust (and thus cheaper to build) than the containment buildings used at most reactors.

As early as 1972, Dr. Stephen Hanauer, an Atomic Energy Commission safety official, recommended that the pressure suppression system be discontinued and any further designs not be accepted for construction permits. Hanauer's boss, Joseph Hendrie (later an NRC Commissioner) essentially agreed with Hanauer, but denied the recommendation on the grounds that it could end the nuclear power industry in the U.S.

Here are copies of the three original AEC memos, including Hendrie's:

November 11, 1971: outlines problems with the design and pressure suppression system containment.

September 20, 1972: memo from Steven Hanauer recommends that U.S. stop licensing reactors using pressure suppression system

September 25, 1972: memo from Joseph Hendrie (top safety official at AEC) agrees with recommendation but rejects it saying it "could well mean the end of nuclear power…"

In 1976, three General Electric nuclear engineers publicly resigned their prestigious positions citing dangerous shortcomings in the GE design.

An NRC analysis of the potential failure of the Mark I under accident conditions concluded in a 1985 report that Mark I failure within the first few hours following core melt would appear rather likely."

In 1986, Harold Denton, then the NRC's top safety official, told an industry trade group that the "Mark I containment, especially being smaller with lower design pressure, in spite of the suppression pool, if you look at the WASH 1400 safety study, you'll find something like a 90% probability of that containment failing." In order to protect the Mark I containment from a total rupture it was determined necessary to vent any high pressure buildup. As a result, an industry workgroup designed and installed the "direct torus vent system" at all Mark I reactors. Operated from the control room, the vent is a reinforced pipe installed in the torus and designed to release radioactive high pressure steam generated in a severe accident by allowing the unfiltered release directly to the atmosphere through the 300 foot vent stack. Reactor operators now have the option by direct action to expose the public and the environment to unknown amounts of harmful radiation in order to "save containment." As a result of GE's design deficiency, the original idea for a passive containment system has been dangerously compromised and given over to human control with all its associated risks of error and technical failure.

As we have now seen at Fukushima, Japan, in March 2011, this containment design failed catastrophically when hydrogen built up in the outer containment buildings until three of them exploded. The outer containment building was neither large enough nor strong enough to withstand these explosions.

VULNERABILITY OF IRRADIATED FUEL POOLS

The irradiated (sometimes called "spent") fuel pools in GE Mark I reactors are above the reactor core and outside the primary containment system. This design was chosen for efficiency, not safety–the fuel rods in the reactor are lifted by crane and simply moved over to the fuel pool. The explosions at Fukushima that caused severe damage to the containment buildings (as can be seen in the above satellite photo taken March 18, 2011) also exposed and compromised the fuel pools providing a direct pathway for release of radioactivity into the air. While there was substantial amounts of fuel in the Fukushima pools, in the U.S. pools are typically packed even more densely, meaning even higher potential radiation risks if they are compromised.

DETERIORATION OF BWR SYSTEMS AND COMPONENTS

It is becoming increasingly clear that the aging of reactor components poses serious economic and safety risks at BWRs. A report by NRC published in 1993 confirmed that age-related degradation in BWRs will damage or destroy many vital safety-related components inside the reactor vessel before the forty year license expires. The NRC report states "Failure of internals could create conditions that may challenge the integrity the reactor primary containment systems." The study looked at major components in the reactor vessel and found that safety-related parts were vulnerable to failure as the result of the deterioration of susceptible materials (Type 304 stainless steel) due to chronic radiation exposure, heat, fatigue, and corrosive chemistry. One such safety-related component is the core shroud and it is also an indicator of cracking in other vital components through the reactor made of the same material.

Core Shroud Cracking

The core shroud is a large stainless steel cylinder of circumferentially welded plates surrounding the reactor fuel core. The shroud provides for the core geometry of the fuel bundles. It is integral to providing a refloodable compartment in the event of a loss-of-coolant-accident. Extensive cracking of circumferential welds on the core shroud has been discovered in a growing number of U.S. and foreign BWRs. A lateral shift along circumferential cracks at the welds by as little as 1/8 inch can result in the misalignment of the fuel and the inability to insert the control rods coupled with loss of fuel core cooling capability. This scenario can result in a core melt accident. A German utility operating a GE BWR where extensive core shroud cracking was identified estimated the cost of replacement at $65 million dollars. The Wuergassen reactor, Germany's oldest boiling water reactor, was closed in 1995 after wary German nuclear regulators rejected a plan to repair rather than replace the reactor's cracked core shroud.

Rather than address the central issue of age related deterioration, U.S. BWR operators now opt for a dangerous piecemeal approach of patching cracking parts at least cost but increased risk.

Paul Gunter, NIRS, March, 1996, updated by Michael Mariotte, NIRS, March 2011

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SAFETY DEFICIENCIES AT BROWNS FERRY NUCLEAR POWER COMPLEX

The Tennessee Valley Authority's (TVA) Browns Ferry nuclear power complex is composed of three aging reactors of obsolete design replete with safety deficiencies. Despite having spent $1.8 Billion to restart the long-shuttered Browns Ferry-1 reactor in 2007, TVA could not address the fundamental design problems with these reactors.

Perhaps even worse, TVA did not address the safety deficiencies it could have addressed: namely the ability to meet fire protection regulations promulgated by the Nuclear Regulatory Commission (NRC) in 1981 because of a near-catastrophic fire in 1975 at the same Browns Ferry-1. Inexplicably, the NRC did not require Browns Ferry-1 to meet its legal obligations to comply with the fire protection regulations before allowing it to restart. Indeed, a critical document demonstrating this NRC negligence was not released to the public until it was discovered by NIRS after the restart had been approved.

FIRE PROTECTION

Fire risk and fire code violations were overlooked by NRC in its approval of the restart of Browns Ferry-1, which was site of the original March 22, 1975 fire--the same fire that was responsible for promulgation of the safe shutdown fire code (10 CFR 50.48 and 10 CFR 50 Appendix R, section iii.g.2)

A prescriptive fire code was put in place for U.S. nuclear power stations following the fire at Alabama's Browns Ferry nuclear power station on March 22, 1975 to provide the best assurance that no single fire can destroy the reactor control room's ability to safely shutdown the reactor following a significant fire.

The Browns Ferry fire was started by an employee using a candle flame to check for air leaks along electrical cable trays under the reactor control room, initially igniting polyurethane foam insulating material around electrical cable used for control, power and instrumentation equipment to shut down the reactor from the control room, the preferred method for controlling the reactor. The fire quickly spread from the cable spreading room into the reactor building. The fire burned out of control for seven and half hours destroying over 1600 electrical cables including 628 safety-related cable systems.

The fire demonstrated that a high number of electrical circuit failures can occur in a relatively short period of time--in this case within 15 minutes from the ignition of the foam material. It further demonstrated that the federal government's hands-off approach for enforcement policy contributed to the non-regulation of fire protection requirements at nuclear power stations and was a principle contributing factor to the seriousness and near catastrophe of the fire. Station nuclear engineers privately confided a catastrophic release of radiation was avoided only by "sheer luck."

NRC began promulgating stricter fire protection codes as result of the Browns Ferry fire and, in a rulemaking highly contested by the nuclear industry, codified detailed and prescriptive fire protection requirements in 1981. The new rule, among other requirements, specifically required passive fire protection features (qualified and rated fire barriers, minimum separation requirements and automated fire suppression and detection) to limit fire damage done to electrical circuits for equipment so that capability to shut down the plant safely from the control room is ensured.

By 1992, well after Browns Ferry-1's shutdown in 1985, the industry was in widespread non-compliance with the fire code because of bogus fire barriers materials that did not meet requirements and failure to incorporate the minimum separation requirement.

NRC's permission to restart Unit I was based on "enforcement discretion" of these fire protection violations. Instead of protecting the safe shutdown electrical cable with qualified fire barriers, smoke detectors and automated sprinkler systems or minimum separation requirements between redundant electrical circuits when they appear in the same fire zone, NRC is allowing TVA (and other reactor operators) to proceed in violation of fire code by substituting largely unreviewed and unapproved compensatory actions that would allow the operator to conduct "operator manual actions." These allow circuits to burn in a fire with subsequent loss of control room operation and instead send plant employees throughout the reactor complex to those end pieces of safe shutdown equipment to manually pull switches, circuit breakers, open or close valves. These operators could encounter and even be delayed or halted by smoke, fire, radiation, even bad guys in case of sabotage, which make completion of their tasks uncertain and not an appropriate substitute for preferred control room operation preserved through qualified passive design.

A document not released by the NRC prior to restart indicates that NRC staff notes that TVA mischaracterized fire zones where redundant electrical circuits appear in the same fire zone. The document states "Manual actions are also permitted when using alternate shutdown in accordance with III.G.3." This corresponds to federal fire protection law for nuclear power stations 10 CFR 50 Appendix R III.G.2 and III.G.3) III.G.2 requires and prioritizes that when electric circuits for redundant safe shutdown equipment appear in the same fire zone of a nuclear power station, one train is required to be protected by one of three passive fire protection features 1) a qualified three-hour rated fire barrier; 2) a qualified 1-hour rated fire barrier used in conjunction with smoke detectors and automated suppression or; 3) a minimum separation of 20-ft between redundant circuitry with no intervening combustible used in conjunction with automated suppression and smoke detectors.

This is to assure that no single fire will knock out control room operations for the safe shutdown of the reactor as occurred during the Browns Ferry fire on March 23, 1975.

The operator can provide NRC with an alternate shutdown strategy through the formalized exemption process for a safety evaluation. TVA did not submit the proposed operator manual actions to the exemption and safety review process as required by law.

Section 3.1.5 of this document states "Section 3 of the licensee FPR (fire protection report) proposes to use the same safe shutdown methods used in Units 2 and 3." It goes on to say later in that paragraph that Unit 1 relies on OMA (operator manual actions) to accomplish post fire safe shutdown. In other words, TVA has abandoned bringing the unit into compliance with fire code as required. They did not apply for the exemption and receive the staff scrutiny for safety and ability to pull off these operator manual actions successfully.

As a result, NRC allowed them to restart under "enforcement discretion" as has already been applied to Browns Ferry Units 2 and 3. However, these unapproved and largely unreviewed operator manual actions are illegal.

THE BROWNS FERRY DESIGN IS DANGEROUSLY ANTIQUATED

All three Browns Ferry units use a General Electric Mark 1 containment design that has long been controversial. In 1976, three top GE engineers publicly resigned from the company and testified before Congress that the GE BWR was "dangerous" and not a "quality product."

http://www.time.com/time/magazine/article/0,9171,918045,00.html

The GE BWR Mark I containment was mistakenly designed and constructed to be undersized. As a result if there is an accident the containment system is very likely to fail and rupture. This could very easily be compared as "America's Chernobyl" design. According to NRC's then Director of Nuclear Reactor Regulation Harold Denton in 1985, there is something like a 90% chance of containment failure of this containment under accident conditions. The chances were high enough that NRC advised and industry back-fitted the Mark I with a vent system to deliberately defeat containment from the control room in order to save it. In the event that Browns Ferry has an over-pressurization accident, operators are faced with the decision to deliberately vent the containment structure through the Direct Torus Vent System (DTVS) which bypasses the radiation filtration system and sends radiation directly to the atmosphere through a "controlled release." They then preserve the option to close the controlled release rather than blow the roof off.

The Atomic Energy Commission (now the NRC) abandoned licensing the Mark I in 1972.

VULNERABLE ELEVATED NUCLEAR WASTE STORAGE POOL

In the GE Mark I design, the irradiated fuel pool, containing billions of curies of high-level atomic waste, sits atop the reactor building, outside primary containment and vulnerable to attack according to both NRC documents (2001) and the National Academy of Sciences (2005).

The NRC paper documents that there are no significant structures that would prevent an aircraft from penetrating the high-level nuclear waste storage pool for the Mark I and Mark II BWR. The consequences of draining down the fuel pool would be a catastrophic nuclear waste fire outside containment spreading a radioactive pall out hundreds of miles and inducing tens of thousands of fatal cancers.

A coalition of groups petitioned the NRC in 2005 requesting emergency enforcement action on the vulnerability of the Mark I and II elevated nuclear waste storage pool. The coalition's petition to the NRC was denied. *–June 2007*

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Browns Ferry: Shrinking the safety margin at Alabama's largest nuclear plant

Updated Mar 07, 2019; Posted Jul 07, 2013

By Challen Stephens | cstephens@al.com

aerial.JPG

Browns Ferry Nuclear Plant on the north shore of Wheeler Reservoir in Limestone County. Browns Ferry was TVA's first nuclear plant and was the largest in the world when it commenced operations in 1974. (submitted file photo)

By Challen Stephens and Brian Lawson

ATHENS, Alabama – For more than two years, the largest nuclear plant in Alabama operated without a fully functioning failsafe system.

A massive cooling pump didn't work. Bearings were installed backwards. Emergency cooling lines sat blocked and unnoticed for years. The last was a safety lapse so dire **Browns Ferry Nuclear Plant in Athens** received the federal notice of a "red finding" – the final warning before being forced to shut down.

Now a TVA engineer tells *The Huntsville Times/AL.com* that both the mechanical and managerial shortcomings were worse than what has been reported by federal regulators. Joni Johnson, a 52-year-old who's been a TVA engineer for half her life, contends that a worst-case scenario – overlapping failures of a broken line and a rapid loss of coolant in Unit 1 – could have led to a meltdown.

What federal regulators have said in recent years:

• Browns Ferry received a red finding, the federal government's most serious warning before shutdown.

• Browns Ferry failed to notice a blocked low-pressure cooling line.

• Inspectors discovered wider problems with safety culture at Browns Ferry.

• The backup low-pressure line also malfunctioned.

• The high-pressure core spray was installed incorrectly.

• The Unit 1 reactor operated for years with overlapping, malfunctioning emergency cooling systems.

What a whistleblower alleges, and paperwork supports:

• TVA ignored or obscured failing safety tests for malfunctioning equipment.

• TVA hurried to install equipment based on managerial bonuses.

What TVA acknowledges in their own paperwork:

• The plant operated for years with a bias toward power production over safety.

The Federal Emergency Management Agency says the danger from a nuclear accident is public exposure to radiation caused by the release of radioactive material from the plant.

Johnson points to managerial bonuses for rapid installation of equipment. She also blames an emphasis on continuous running of three boiling water reactors, which need to be shut down to allow for major repairs. But Browns Ferry generates about $1 billion a year, or about 10 percent of TVA's annual revenue, and maintenance shutdowns cost money.

For the past two months, a 23-member Nuclear Regulatory Commission (NRC) inspection team has been poring over records at Browns Ferry. Federal scrutiny in 2011 over one blocked failsafe line soon led to concerns about TVA's broader safety culture, prompting the NRC to expand its investigation from Unit 1 to all three reactors at the Athens plant.

TVA, in preparing for federal inspections, acknowledged shortcomings.

Nuclear, perhaps more than any other industry, is built around a vocabulary of safety. Yet, in a recent newsletter preparing employees for the NRC visit, Keith Polson, site vice president at Browns Ferry, is quoted in large bold letters saying Browns Ferry had slipped.

"Our performance declined," Polson said. "Employee morale was low and because we were so wrapped in a production-first mentality, we didn't realize just how bad things had gotten. Even when outside experts told us we needed to get better, we really didn't listen."

Whistleblower

Johnson, who is trained to conduct a "root cause analysis" of plant malfunctions, said she's speaking out now to restore the focus on safety. She said initial concerns voiced at the plant drew retaliation, that she was labeled a "man-hater," pulled from assignments and given poor performance reviews.

She has since engaged in a failed mediation with TVA. She alleges she was discriminated against for raising safety concerns. Regulators with the NRC wrote her a letter in October saying her case met the standards for a federal investigation. Johnson said she has met with NRC investigators on multiple occasions.

Browns Ferry (Huntsville Times file)

TVA and the NRC won't discuss legal matters or an ongoing investigation.

Johnson said the basis for her complaints was that TVA officials attempted to manipulate her team's findings related to equipment failures and how those findings pointed to organizational failures. A report by TVA's own inspector general backs up Johnson's equipment concerns about overlapping failures in the emergency cooling system.

The discrimination investigation remains open.

"You retaliate enough and people aren't going to come forward, and that's the real safety significance," said Johnson, who declined to be photographed for this report.

Slot machine

It's not that Browns Ferry experienced an accident, explains David Lochbaum, a nuclear engineer with the Union of Concerned Scientists. It's that Browns Ferry had reduced the odds the plant could avoid an accident.

Imagine a slot machine, he says. You sit down to find that three cherries are already up. Five cherries win a million. You pull the arm.

With that head start, you get to watch just two dials spin.

That was Browns Ferry for three years, running with faults in three of five emergency cooling systems.

Worst-case scenario

The top floor of the reactor building at Browns Ferry Nuclear Plant shows the cover of Unit 1 and the spent fuel storage tank where 29 feet of water covers the rods. (Michael Mercier/ The Huntsville Times)

In 2007, TVA restarted Unit 1 at Browns Ferry. It was a massive undertaking. The reactor had gone online in the early 1970s, but had sat dormant since the mid-1980s after being shut down for safety reasons.

The five-year restart cost $1.9 billion and was completed in May 2007. President George W. Bush visited Browns Ferry in June 2007 to mark the recovery. But problems surfaced almost immediately, and the plant had five emergency shutdowns in six months in 2007.

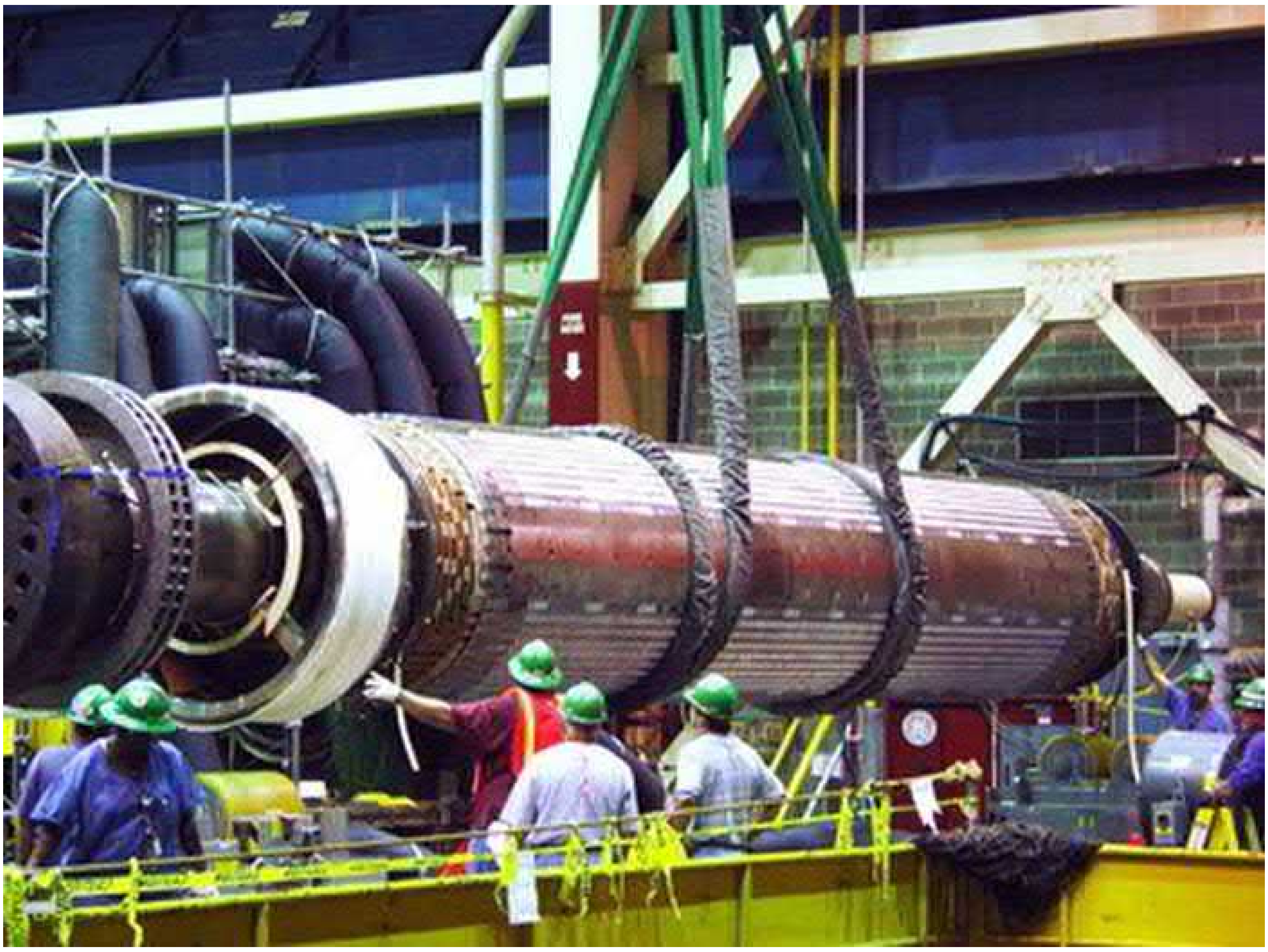
Three years later, a blocked cooling line would result in the costly federal probe and bring to light other equipment failures.

During a shutdown cooling in October of 2010, a 600-pound steel angle-wedge valve in Loop Two failed to open. Water could not reach the core. But safety calls for redundancy. Operators turned to the back-up low-pressure system, Loop One.

The NRC report in February of 2011 states that the residual heat removal pump in Loop One "had been in service for shutdown cooling for approximately 94 hours prior to experiencing a catastrophic failure of the motor on October 27" of 2010.

Redundant malfunctions

Johnson was on a team that studied the pump failure in the backup loop. She wrote the root cause analysis report.



Workers at Browns Ferry in 2004 move the Unit 1 main generator rotor from the generator on the turbine floor to the turbine access hatch. The 207-ton rotor was lowered through the access hatch to the main floor about three stories below. The restart of Unit 1 cost $1.9 billion. (Submitted photo)

TVA and NRC have said the second system was considered to have been functional up until the pump died.

But Johnson's team found the pump could never have cooled the core for its mission time of 30 days, that the van-sized motor had been installed hurriedly and incorrectly. The rotor was rubbing against a stationary part of the motor.

Again, nuclear safety relies on redundancy. There are two massive pumps in each loop. When the first one burned up, that left just one working pump in one back-up loop.

Polson at first said one pump would work. It was enough to complete shutdown. But one pump could not move enough water to control temperatures in a worst-case scenario.

Both pumps in a system must operate for containment cooling, according to Emergency Core Cooling specifications for Browns Ferry. Some of the worst scenarios, such as recirculation suction breaks, call for four working pumps.

Polson later acknowledged he was not talking about a worst-case scenario when commenting on the adequacy of one pump.

Backwards bearings

In addition to the low-pressure loops, there is also a high-pressure system, which can inject water into the core while it is under pressure. But during the restart, the bearings had been installed backwards in a turbine.

TVA officials say the high-pressure system would have worked. Polson said the high-pressure spray met its mission time of 14 hours after the April 27, 2011, tornado severed external power lines and forced the plant into shutdown. But Johnson said mission-time cooling is not as long as required for emergency cooling and the spray wouldn't have lasted long enough in a worst-case scenario.

Keith Polson, TVA Site VP for Browns Ferry Nuclear Plant, during an interview in 2012. (Huntsville Times file)

Polson said the plant has since stripped the high-pressure system and replaced all parts.

"Safety is the number-one priority," he said on the phone last month. Polson, who started at Browns Ferry in 2009, said perhaps TVA underestimated the extra work necessary to restart Unit 1, that the recovery took "a big toll on the trust of the people."

"I think the trust has been improved," he said, alluding to internal surveys that show improvements in morale last year. "Are we perfect? No, we're not perfect."

Catastrophe is just that, a plane crash, an earthquake, an EF-5 tornado like the one that just barely missed the Athens plant in 2011. A tsunami. The plant loses external power. Fire burns up control cables. The largest coolant pipe to the reactor breaks, requiring continuous operation of the low-pressure loops.

Nuclear plants are designed around such scenarios.

"It's not one broken pipe or one power outage away from disaster. It takes a lot of steps," said Lochbaum with the Union of Concerned Scientists.

Catastrophe assumes failure of the normal cooling system. Beyond the three problematic failsafe systems at Unit 1, there is also a pressure relief system, basically a steam release system. There is also a last-ditch, smaller core spray system.

But malfunctions in the high-pressure and both low-pressure failsafe systems represent an alarming drop in what the industry calls "safety margins." That's the three cherries up. And that invites federal scrutiny.

Winning performance

The inspector general for TVA, in a report requested by *The Times/AL.com*, backs up Johnson's mechanical concerns, as well as finding the same "unrealistic timetables" for installation.

A TVA worker in 2011 comes out of the reactor vessel while carrying out refueling operations on the Unit 2 reactor. (Michael Mercier/ The Huntsville Times)

The inspector general wrote that the pump in Loop One was installed in 2005 just one week before the deadline for a "winning performance" bonus. That was despite "dangerously high" readings on vibration tests, Johnson said. And that was despite the fact the pump wasn't needed for nearly two more years.

"Some personnel involved did not agree with the direction or findings of the root-cause analysis team," noted the TVA inspector general of Johnson's work, finding that Browns Ferry in general quickly reacts to broken equipment but "fails to perform the causal analysis necessary to understand why the problem occurred and how to prevent it."

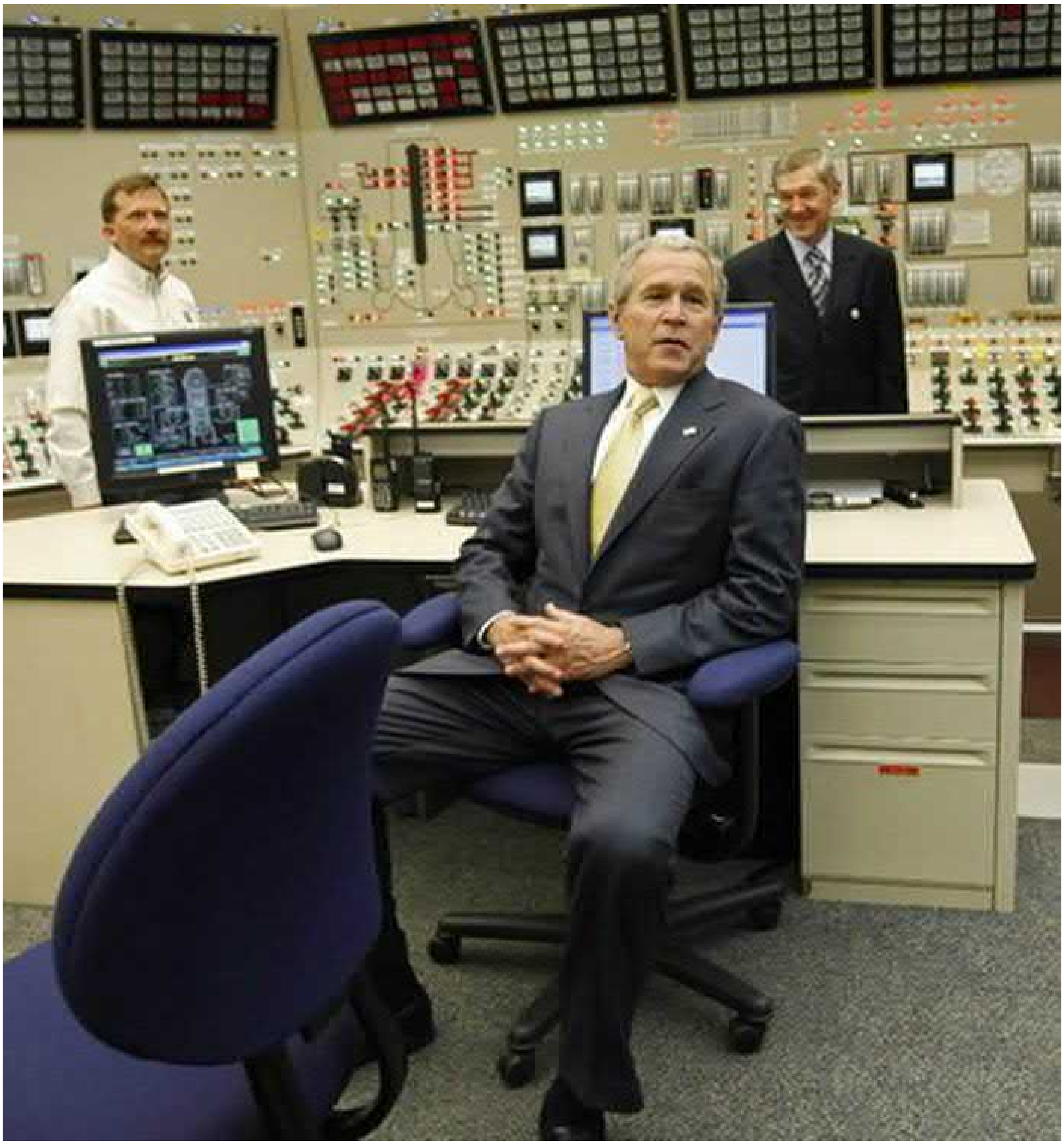
NRC inspectors last month told reporters that the pump failure in Loop One is not considered overlapping with the original blockage in Loop Two.

But NRC in its own lengthy 2011 inspection paperwork writes that the pump was required to be able to run for 720 hours to fulfill its safety role, and that the pump "had been incapable of meeting its required mission time, and thereby considered inoperable, since at least November 2007."

But that's not why the plant was given the costly red finding.

Bad bet

In the event of a fire or some unforeseen disaster, NRC inspectors say, TVA planned to kill power to other systems and flood the core using Loop Two. That means Browns Ferry would have, at least during crucial early steps, bet everything on a failsafe system that was blocked. That's why the red finding.



President George W. Bush sits in the control room at the Browns Ferry Nuclear Plant in Athens, Ala. Thursday June 21, 2007. His visit marked the restart of Unit 1. (AP Photo/Gerald Herbert)

TVA at first said the valve had separated from its stem due to poorly manufactured metal threads and undersized welds. TVA argued it couldn't be held accountable for a manufacturing defect. It also argued that, when needed, vibrations from massive amounts of water would have forced the valve to become unstuck.

NRC didn't buy any of what it labeled TVA's poor methodology and "unvalidated assumptions and calculations." Instead, NRC in a "final significance determination" in May of 2011 said TVA was at fault for inadequate testing of its own equipment. It also concluded the valve would never have opened. Johnson said it took two men with a jack hammer two days to free the valve.

Bill Baker, manager of the Browns Ferry Integrated Improvement Plan, spoke at length in the same employee newsletter ahead of the current NRC visit. The article says that, as Baker delved into historical data around the undetected valve failure, he came to a realization. "He needed to stop justifying continued operation and start putting nuclear safety first," reads the employee newsletter.

On April 27, 2011, a deadly EF-5 tornado crushed Independence Tube across the river from Browns Ferry. The tornado also flattened dozens of transmission towers, forcing a shutdown of the nuclear plant. (The Huntsville Times/ Michael Mercier)

Polson said eliminating "production bias" has been a priority in reshaping TVA's culture, and "that's changed 100 percent now."

But in April 2012, TVA seemed to remain focused on production, announcing that all three units at Browns Ferry had set records for continuous running without an outage.

With Unit 1 operating for 114 days, Unit 2 for 302 days and Unit 3 for 188 days, the site's record for continuous operation of all three units was three days longer than the previous best set in 2011, TVA said in a news release last year. Polson said at the time that the record reflected the overall health of the plant.

"Browns Ferry is a big plant. We account for about 10 percent of all TVA revenue," Polson told reporters last month. According to SEC filings, TVA grossed about $11.1 billion from selling power in 2012.

"They call it the cash cow," said Johnson of Browns Ferry.

As for the blocked line, Johnson said they didn't find it sooner because plant managers didn't do adequate testing. When testing the pump motor, according to the TVA inspector general, the vibration and oil tests didn't match expectations. "So they reset the set points," said Johnson.

Other equipment tests were not conducted, Johnson said. "You are encouraged to make it look better than it is," she said. "It's institutional bullying."

Selling power

On May 15, the NRC spoke to the press at Browns Ferry. It was not a flattering account. They said TVA initially challenged the findings related to the faulty angle-wedge valve.

NRC Engineering Area Assistant Lead Inspector Atif Shaikh examines pipes in May, 2013, at the Browns Ferry plant. (Photo courtesy NRC)

Federal regulators began to probe "overall issues," said Bill Jones with NRC, and those "were broader than we originally put down." NRC expanded its investigation from Unit 1 to the entire plant. "The more we looked, the more type of problems that were revealed."

Browns Ferry remains in Column 4 on the federal watch list. "Column 4 is as far to the right as you can get without being shut down," said Joey Ledford with NRC.

However, Jones appeared to disagree with Johnson's warnings, even though her charges are supported by some of the NRC paperwork. "Everything else was working. It was just that one valve," Jones said. "But that valve was important."

NRC representatives Joey Ledford, left, and Bill Jones (Brian Lawson /blawson@al.com)

Jones also acknowledged that the high-pressure system was malfunctioning due to backwards bearings.

"They are in business to sell power. It's not here for us," reminded Jones of the plant. He said it's the duty of NRC to ask cultural questions: "Do you run the plant even though it's compromised? What kind of tone does management set?"

In the end, despite the red finding and poor testing of failsafe equipment, Jones said: "Bottom line is even

een are

NRC is expected to release the results of its inspection during a public meeting on July 11.

For Johnson, speaking out has had consequences, as she said she ran up substantial legal bills without expectation of a resolution with TVA. But she became more concerned about the costs of not speaking out.

"I found myself in the position of becoming a whistleblower when TVA management altered root cause reports I authored to subdue their findings," she said last week. "I hope that bringing this story to public light will force TVA to address the safety significance of altering the findings of teams of engineers and experts for the sake of protecting production and their own bonuses."

Browns Ferry engineer never expected to be nuclear plant whistleblower

Updated Mar 07, 2019; Posted Jul 07, 2013

Nuclear Regulatory Commission inspectors during a May intensive inspection of the Browns Ferry Nuclear Plant in Athens. (NRC photo)

By **Brian Lawson**

By Brian Lawson and Challen Stephens

ATHENS, Alabama -- TVA engineer Joni Johnson is reluctant to talk about herself, and says she never expected to become a federal whistleblower.

Johnson's world changed when she ran into what she described as a flawed safety culture at the plant.

Johnson, 52, was used to going to work at the Browns Ferry Nuclear Plant where she's served since 1987.

She is a married mother of two sons, with an engineering degree from the University of Alabama in Huntsville.

Johnson worked full-time while finishing school, sometimes logging 60-hour work weeks while pursuing an electrical engineering degree. Her work at TVA has been recognized by colleagues and managers. She provided good performance reviews, internal awards and plenty of notes from co-workers thanking her for dedication and quality work.

Performance reviews note that Johnson "always accepts ownership," has strong technical knowledge, is detail-oriented and "provides excellent guidance."

Raised in a large family in Connecticut, Johnson is the daughter of an Army veteran of World War II and the Korean War. Her mom was born and raised in Carbon Hill. Her father worked on nuclear-related projects for the Army in Maryland and New Mexico late in his career and found the work fascinating, Johnson said.

Though engineering was not a booming career field for women in the 1970s, her father encouraged her to pursue technical work and she did. But in a male-dominated culture, it wasn't always easy.

"When you work so hard at something, achieve things nobody thinks you should be doing, it does a lot for your self-worth," Johnson said. "Being a field type person -- I don't like staying behind a desk, - that's when you get to the relationships especially with male engineers. I gained their respect. They saw I do know what I'm doing."

Johnson has been certified as a root cause analyst, charged with figuring out what went wrong with a system, a piece of equipment or process.

It was through work on a root cause analysis for a failed cooling system motor at Browns Ferry that Johnson first encountered what she said was troubling resistance to getting to the bottom of a problem and identifying what went wrong.

"It's a very detailed and scientific process," she said. "Your conclusions are based in fact and data. You accumulate them based on fact and data. There can be no unvalidated assumptions allowed in the root cause process."

Johnson said the completion of the root cause report and the issues it cited led to strong pushback from some managers, accusations against her and eventually poor performance reviews. She said a second root cause report she wrote on software problems affecting industrial safety led to similar responses, and her career suffered.

Nuclear Regulatory Commission investigators met with her last fall and agreed to look into her allegation that she was retaliated against by TVA for speaking out about safety concerns.

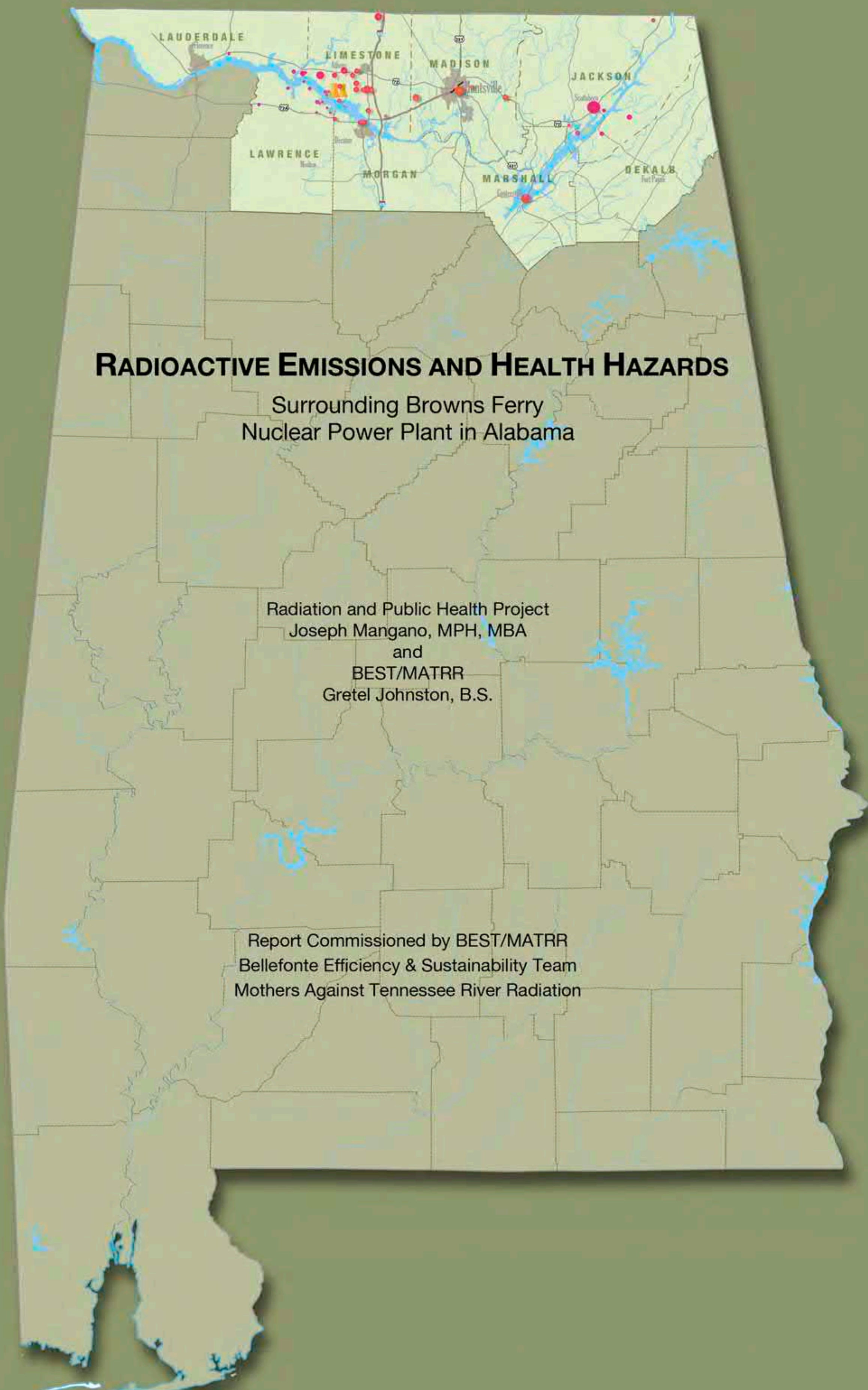
Officials with TVA and NRC would not discuss an ongoing investigation.

TVA has embarked on a substantial corrective action plan at Browns Ferry and said it has seen a major turnaround in the improvement of its safety culture.

Johnson hired an attorney to address her claims of discrimination. They pursued an unsuccessful mediation

Johnson said she remains "pro nuclear power."

"What we do is very important," she said. "We control the strongest form of energy on planet earth. I'm raising a family here. I don't take shortcuts when it comes to nuclear power. I'm sorry to have been around others that do."



Radioactive Emissions and Health Hazards

Surrounding Browns Ferry Nuclear Power Plant in Alabama

Radiation and Public Health Project
Joseph Mangano, MPH, MBA
and
BEST/MATRR
Gretel Johnston, B.S.

Report Commissioned by BEST/MATRR
Bellefonte Efficiency & Sustainability Team
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List of Acronyms

BEST	Bellefonte Efficiency & Sustainability Team
BREDL	Blue Ridge Environmental Defense League
BWR	Boiling Water Reactor
CRB	Control Rod Blades
GE	General Electric
MATRR	Mothers Against Tennessee River Radiation
NCI	National Cancer Institute
NPP	Nuclear Power Plant
NRC	U.S. Nuclear Regulatory Commission
PWR	Pressurized Water Reactor
RPHP	Radiation and Public Health Project
TVA	Tennessee Valley Authority

Gratitude

We are grateful to BEST/MATRR members and donors who have made this report possible, and especially to the Blue Ridge Environmental Defense League and the organizers of the Know Nukes Ya'll Summit, who generously donated legacy funds from the Summit to help support our local efforts. And special thanks go to our BEST Radiation Monitoring Project Manager, Garry Morgan, who called for local citizen radiation monitoring for many years, then with Lou Zeller's assistance, Garry equipped, organized and implemented systematic monitoring of areas near and downwind of Browns Ferry, creating videos and a graphic users manual to help empower other communities to monitor as well. The Tennessee Valley is fortunate to have Garry Morgan's concern, expertise and energy working for its citizens.

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EXECUTIVE SUMMARY

The Browns Ferry Nuclear Plant in northern Alabama runs three of the five operating nuclear reactors in the state. Nearly 1 million persons live within 50 miles of the plant.

Potential harm to local residents from Browns Ferry can be expressed in various ways:

1. Browns Ferry stores massive amounts of high-level radioactive waste, mostly in pools of water that must be constantly cooled to avoid a meltdown. **Browns Ferry has the 2nd largest waste storage of 71 U.S. nuclear power plants**.

2. Browns Ferry reactors have been closed for more than one year on six separate occasions due to mechanical problems, more than any U.S. nuclear plant. **The longest shutdown in the U.S. occurred at Browns Ferry 1, from 1985 to 2007.**

3. The 1975 near-miss accident at Reactor Unit 1 is considered the worst mishap at a U.S. nuclear power reactor, aside from the Three Mile Island meltdown; yet, Browns Ferry still does not comply with the fire safety regulations created after its 1975 fire.

4. **A 1982 federal estimate of 60,000 radiation poisoning cases and 3,800 cancer deaths per meltdown to a reactor core would be greater today**, due to higher population and effects beyond the 1982 study's geographic limits.

5. Amounts of tritium and beta-emitting radiation in drinking water near Browns Ferry are substantially greater than in Montgomery, which is far from nuclear plants.

6. Citizen-based monitoring has found higher levels of radioactivity (air, water, and land) close to, downwind, and downriver from Browns Ferry, and highest after rain events.

7. **Infant mortality in the seven closest downwind counties from Browns Ferry is 22.3% above U.S. rate, a steady increase from the early 1990s**, when it was below U.S. rate. The excess is 40.3% for Hispanics and 32.6% for whites.

8. **Since Browns Ferry's startup in the mid-1970s, the local mortality rate (all causes) steadily rose from 1.7% to 20.5% above U.S. rate.** Significant excesses exist for both genders, all ages, whites, and nearly all major causes.

Data presented in this report suggests a possible link between Browns Ferry emissions and elevated health risks. This finding is particularly important at this time, as the plant's three reactors approach 40 years in operation. Aging reactors have corroding parts, which can increase the risk of a meltdown and of larger routine releases. Officials and the public should understand patterns of radioactive contamination near the plant, along with local health trends, to ensure that decisions are made that best protect public health.

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I. INTRODUCTION

A. BRIEF HISTORY OF NUCLEAR POWER IN ALABAMA

The discovery of nuclear fission, or creation of high energy by splitting uranium atoms, was first used for military purposes, i.e. the atomic bombs in Japan during World War II. Soon after, other uses of the fission process were introduced. One of these was the creation of electric power from the heat generated by fission. The "Atoms for Peace" speech given at the United Nations by President Dwight Eisenhower in 1953 opened the door for the development of reactors that would produce electricity, and the first reactor began operating at Shippingport, near Pittsburgh, PA in 1957.

Hundreds of reactors were proposed by electric utilities, who were interested based on the potential to produce clean and cheap energy. In 1974, the U.S. Atomic Energy Commission predicted that the nation would have 1,200 reactors by the turn of the century. In Alabama, formal applications were made by utility companies for 13 reactors in the state. Five (5) of these are in operation; all others were cancelled, except for Bellefonte 1, which is still being planned (Table 1).

TABLE 1

NUCLEAR POWER REACTORS IN ALABAMA

Reactor	City/Town	Announced	**Startup**
Browns Ferry 1	Decatur	6/17/66	8/17/73
Browns Ferry 2	Decatur	6/17/66	7/20/74
Browns Ferry 3	Decatur	6/22/67	8/ 8/76
Joseph M. Farley 1	Dothan	5/13/69	8/ 9/77
Joseph M. Farley 2	Dothan	6/30/70	5/ 8/81
Barton 1	Clanton	1/ 1/72	
Barton 2	Clanton	1/ 1/72	
Barton 3	Clanton	1/ 1/74	
Barton 4	Clanton	1/ 1/74	
Bellefonte 1	Scottsboro	1/ 1/70	
Bellefonte 2	Scottsboro	1/ 1/70	
Bellefonte 3	Scottsboro	9/ 1/05	
Bellefonte 4	Scottsboro	9/ 1/05	

Source: U.S. Nuclear Regulatory Commission, www.nrc.gov

The U.S. Nuclear Regulatory Commission (NRC) has never refused a license extension request and has granted 20-year license extensions, after the initial 40-year licenses expire, for 75 of the 104 U.S. reactors, including the five reactors in Alabama. Nuclear power in Alabama has been producing over 25% of the state's electricity in recent years. (Source: U.S. Nuclear Regulatory Commission, Information Digest, various years, www.nrc.gov.)

B. RADIOACTIVE WASTE STORED AT NUCLEAR PLANTS

To produce electricity, nuclear power reactors split uranium-235 atoms, generating high energy that is transformed into electrical power. This splitting process, known as fission, also produces over 100 chemicals not found in nature. These chemicals are the same as those found in the large clouds of fallout after above-ground atomic bomb tests.

Fission products, which take the form of gases and particles, include Cesium-137, Iodine-131, and Strontium-90. They are highly unstable atoms which emit alpha particles, beta particles, or gamma rays. When they enter the body, they affect various organs. Cesium seeks out the muscles (including the heart and reproductive organs), iodine attacks the thyroid gland, and strontium attaches to bone. Each causes cancer after breaking cell membranes and damages cell DNA creating mutations, and is especially harmful to the fetus, infant, and child. Some decay quickly (Iodine-131 has a half life of 8.05 days), while others remain for long periods (Strontium-90 has a half life of 28.7 years and Cesium-137 of 30 years, meaning it remains radioactive for over 300 years).

Most of the radioactivity produced in reactors is contained within the reactor building and stored as high-level waste in deep pools of water that must be constantly cooled. At Browns Ferry and other aging plants, the pools are becoming full and have no dedicated backup power. Only about 20% of the waste nationally has been transferred to safer above-ground outdoor casks. **As of the end of 2010, Browns Ferry maintained 1,932 metric tons of waste on site, the second largest of 71 U.S. nuclear plants.** The amount of radioactivity at the plant (**314,140,400 curies**), the 5th highest in the U.S., is equivalent to several times more than that released by the 1986 Chernobyl meltdown, and hundreds of times more than releases from atomic bombs at Hiroshima and Nagasaki in 1945. The list of U.S. nuclear plants with the largest amounts of high-level waste is given in Table 2:

TABLE 2

U.S. Nuclear Power Plants (Total = 71)
With Largest Amounts of High-Level Nuclear Waste, As of December 2010

Plant	State	Metric Tons	Curies
1. Dresden	IL	2,146	350,380,400
2. Browns Ferry	**AL**	**1,932**	**314,140,400**
3. Nine Mile Point	NY	1,865	355,269,600
4. Millstone	CT	1,709	445,230,400
5. Palo Verde	AZ	1,674	360,032,400
6. Salem/Hope Creek	NJ	1,659	216,050,800
7. Peach Bottom	PA	1,554	254,072,600
8. Edwin I. Hatch	GA	1,446	237,432,400
9. D.C. Cook	IL	1,433	286,914,600
10. San Onofre	CA	1,423	315,932,400

Source: Alvarez, Robert *Spent Nuclear Fuel Pools in the U.S.: Reducing the Deadly Risks of Storage*, Institute for Policy Studies, May 2011.

In 2002, after decades of investigation and debate, the federal government designated Yucca Mountain in Nevada as a permanent waste site, despite considerable opposition. In 2010, the Obama administration stopped all expenditures for building the inadequate site, and assembled a panel to further consider options for long term waste storage. Some experts believe a permanent repository will never open, leaving existing nuclear plants like Browns Ferry to maintain the waste indefinitely.

C. MARK I REACTOR DESIGN FAULTS

The Browns Ferry GE Mark I Boiling Water Reactors, the same model as Fukushima, had serious enough design flaws that three General Electric (GE) nuclear engineers working on the system publicly resigned their positions in 1976, citing dangerous shortcomings in the GE Mark I design. In 1986, top Nuclear Regulatory Commission (NRC) safety official, Harold Denton, stated that the WASH 1400 Safety Study revealed a 90% probability of the Mark I containment failing in the case of a significant malfunction, resulting in retrofit torus vent pipe installations for all Mark I's allowing the control operator to release unfiltered radiation into the atmosphere to save containment. (Source: Gunter, Paul; "Hazards of Boiling Water Reactors in the United States," NIRS, 1996 and 2011.)

D. BROWNS FERRY AGING ISSUES

During their first 10 to 15 years of operation, all three Browns Ferry Reactors had poor operational records with high numbers of SCRAMs (emergency nuclear reactor shutdowns), which thermally shock reactor containment structures, causing weakening, premature aging and metal fatigue of the reactor pressure vessels. Altogether, the three reactors have suffered over 270 emergency SCRAMs. The reactors are now reaching their 40 design-basis life span, but NRC extended their operating license for 20 more years – despite a 1993 NRC report which confirmed "age-related degradation in Boiling Water Reactors will damage or destroy vital safety related components inside the reactor vessel before the forty year license expires." It was determined that the reactor vessel cracks were the result of the deterioration of Type 304 Stainless Steel due to exposure to chronic radiation, heat, corrosive chemistry, and fatigue.

After 20 year over design-basis license extensions were granted by the NRC, GE issued warnings about control rods cracking, then inspected Browns Ferry and found cracking of the rods necessary for shutting down the reactor for SCRAMs or refueling. In addition, according to an Associated Press Investigative Report in 2011, "The AP found proof that aging reactors have been allowed to run less safely to prolong operations. As equipment has approached or violated safety limits, regulators and reactor operators have loosened or bent the rules."; and, "Last year, the NRC weakened the safety margin for acceptable radiation damage to reactor vessels — for a second time. The standard is based on a measurement known as a reactor vessel's "reference temperature," which predicts when it will become dangerously brittle and vulnerable to failure." (Source: AP report by Jeff Donn, "Safety Rules Loosened for Aging Nuclear Reactors," June 20, 2011, http://www.nbcnews.com/id/43455859/ns/us_news-environment/t/safety-rules-loosened-aging-nuclear-reactors/#.UYp50JVs3S8; and, NRC, Licensee Event Reports search of BFN SCRAMSs; https://lersearch.inl.gov/Entry.aspx.)

E. BROWNS FERRY LONG-TERM SHUT DOWNS

A 2006 Union of Concerned Scientists Report listed 51 instances when a U.S. nuclear reactor closed for over one year before restart. **Six year-long (or more) outages occurred at Browns Ferry – the largest number of any U.S. nuclear plant** (Table 3). Three shutdowns of over one year occurred at Peach Bottom PA and Sequoyah TN. The 22-year shut down at Browns Ferry 1, from 1975 to 2007, was by far the longest in the U.S., while the plant also has the 2nd and 3rd longest shut downs ever.

TABLE 3

BROWNS FERRY SHUT DOWNS OF ONE YEAR OR LONGER

REACTOR	DATE SHUT	DATE OPEN	
Browns Ferry 1	3/22/75	9/24/76	
Browns Ferry 1	3/19/85	6/ 2/07	**1st Longest in U.S.**
Browns Ferry 2	3/22/75	9/10/76	
Browns Ferry 2	9/15/84	5/24/91	**3rd Longest in U.S.**
Browns Ferry 3	9/ 7/83	11/28/84	
Browns Ferry 3	3/ 9/85	11/19/95	**2nd Longest in U.S.**

Source: Union of Concerned Scientists, *Unlearned Lessons of Year-plus Reactor Outages*, 2006

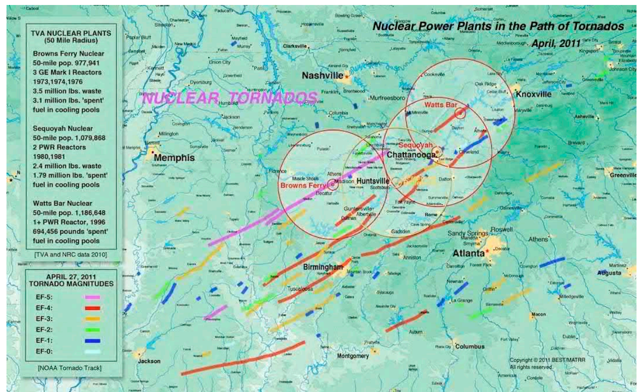
F. BROWNS FEERY I FIRE - 1975

On March 22, 1975, a fire broke out at Browns Ferry Unit 1 when a worker set a cable seal on fire with a candle. The fire caused significant damage to the cable room, burning about 1600 cables, and threatened the entire reactor unit, almost resulting in a core boiloff/meltdown accident, before it was extinguished seven hours later. The U.S. Nuclear Regulatory Commission made multiple changes to its fire prevention regulations after the incident, but Browns Ferry is still not in compliance (37 years later) with the regulations its own fire was responsible for creating, and the NRC has allowed the negligence. **The 1975 incident at Browns Ferry 1 is considered by many to be the most serious accident of any U.S. nuclear power reactor, with the exception of the Three Mile Island partial core meltdown in 1979.**

It seems worthy of note that David Dinsmore Comey (on whom the U.S, Environmental Protection Agency (EPA) bestowed its First Annual Environmental Quality Award in 1974 "for services that have immeasurably improved the design and safety review of nuclear reactors") writing in 1976 about the Browns Ferry fire said, "Every nuclear plant in the country uses a cable spreader room below its control room. Despite requirements for separation and redundancy of reactor protection and control systems, every reactor has been permitted to go into operation with this sort of configuration which lends itself to a single failure's wiping out all redundant systems." Source: David Dinsmore Comey, "The Fire at Brown's Ferry Nuclear Power Station," in *Not Man Apart*, Friends of the Earth, California, 1976, http://www.ccnr.org/browns_ferry.html

G. <u>Tornado Events of 2011</u>

The Tennessee Valley is in what locals call a tornado corridor, since the area periodically suffers the destruction of major tornados and they seem to return along familiar pathways. On April 27, 2011, fifteen EF-4 and EF-5 tornados crossed the southeastern U.S. (see Appendix 2) and one Category EF-5, the strongest tornado known to man, destroyed a row of incoming power towers right next to Browns Ferry Nuclear Power Plant, cutting power to the plant for seven days. Given over three million pounds (with over 314 million curies) of highly radioactive fuel is stored in pools requiring constant power for coolant circulation and raised 40 feet in the air with only sheet metal roofing overhead, this was a serious near-miss event. All but one line of incoming power was lost to the plant, and despite TVA reports to the public that all emergency systems performed as designed, numerous incidents occurred that were serious enough to require Event Reports (Nos. 46793, 46801, 46805) to the Nuclear Regulatory Commission (NRC). What they revealed was worthy of note:



Nuclear and Tornados Map (see Appendix 2)

1.) Only 12 of the required 100 off-site Emergency Sirens were functional on April 27.

2.) Two of eight Emergency Diesel Generators failed that day, one for the fire pump and one for the security station and sirens. A third generator was shutdown the next day – totaling a 37.5% failure rate for emergency backup power.

3.) On that day, a Main Steam Isolation Valve indicator failed on Unit 3 – so operators could not tell if the valve had closed as it should during the reactor emergency shutdown.

4.) On that day, April 27, hours after Unit 1 automatically shut down due to loss of the electrical grid, it received a second automatic shut down signal due to a low water level inside the reactor vessel. TVA later explained the operating crew was “distracted,” allowing the water level to boil down too low for safe reactor cooling.

5.) On April 28, an electrical part failure on Unit 1 initiated an automatic closer of Shutdown Cooling emergency valves. Power was restored after 47 minutes.

6.) On May 2, Unit 1 received an 'A' Emergency Generator output breaker trip, resulting in loss of Shutdown Cooling. Power was restored after 57 minutes.

H. ‘<u>Red Finding’ for Browns Ferry Nuclear Plant</u>

Nuclear Regulatory Commission inspectors were on-site reviewing existing safety issues when the tornados hit in 2011, and NRC issued Browns Ferry a rare ‘Red Finding’ (only four have ever been issued in nuclear history) for unrelated problems just eleven days after the tornados hit, a finding that still stands two years later. A ‘Red Finding’ is NRC’s worst rating, the most severe rating possible before a plant is shut down and forced into its decommissioning stage. The ‘Red Finding’ was given because of extended safety performance deficiencies and missed testing opportunities for a significantly degraded coolant injection valve, which meant an entire system could not be counted on to cool the reactor core, potentially leading to core damage. The faulty reactor cooling valve was found to have been inoperable for 18 months before the problem was discovered, and a jerry-rigged work-around was initially attempted to address the problem. A Professional Reactor Operator Society article also noted: "TVA provided incomplete and inaccurate information in a letter to the NRC. . . [which] referenced 18 valves. . . a Severity Level III violation." Source: Bob Meyer, "Most Significant NRC findings of 2012," Professional Reactor Operator Society, Feb.3, 2013, http://nucpros.com/content/most-significant-nrc-findings-2012

I. Control Room Fire - 2012

In January of 2012, Unit 3 control room operators noticed smoke and a flame under an annunciator panel. According to the Professional Reactor Operator Society, "The cause of the event was a failed power supply. An overcurrent was caused by an aged capacitor that had not received preventative maintenance to address its service life." The signifcance of this fire is that there had been three similar warning events of power failure in an annuciator panel – twice in 2008 and again in 2009, but the aged equipment was not monitored by the TVA or the NRC. Source: Professional Nuclear Reactor Operator Society "Browns Ferry Nuclear Plant, Unit 3 LER: Annunciator Panel Power Supply Fire in Unit 3 Control Room," July 9, 2012, http://www.nucpros.com/content/browns-ferry-nuclear-plant-unit-3-ler-annunciator-panel-power-supply-fire-unit-3-control-roo

J. Ongoing Radioactive Leaks and Releases

There have been sixteen reportable radioactive leaks at Browns Ferry Nuclear Power Plant (see Appendix 3), in addition to the routine radioactive releases. In 2010, a worker discovered an open test valve at Condensate Storage Tank 5, where 1,000 gallons of radioactively contaminated water had leaked, at concentrations of 2 million picocuries per liter which is 100 times the EPA drinking water contamination limit. So far, TVA reports drinking water test sites have not exceeded EPA limits. Sources: Jeff Donn, "Radioactive tritium leaks found at 48 US nuke sites," AP, June 21, 2011,http://www.nbcnews.com/id/43475479/ns/us_news-environment/t/radioactive-tritium-leaks-found-us-nuke-sites/#.UX7Aa5Vs3S8; and Union of Concerned Scientists, "Groundwater Events Sorted by Location," September 29, 2010, http://www.ucsusa.org/assets/documents/nuclear_power/Groundwater-Events-Sorted-by-Location.pdf (See Appendix 3)

II. HEALTH HAZARDS POSED BY REACTOR MELTDOWNS

A. Description

Much of the health concern posed by nuclear reactors focuses on major meltdowns. The radioactivity in a reactor core and waste pools must be constantly cooled by water, or the fuel will heat uncontrollably, causing a huge release of radioactivity. This release can be caused by mechanical failure (like at Chernobyl in 1986, when safeguard redundancy was deliberately shut off during testing), by an act of nature (like the earthquake/tsunami at Fukushima in 2011), or by an act of sabotage.

The experience at Hiroshima and Nagasaki demonstrated how exposure to high levels of radioactivity can harm humans. Those closest to the bombs were vaporized, literally melting from the intense heat. But many other victims who survived the initial blast developed acute radiation poisoning, marked by symptoms such as nausea, vomiting, diarrhea, skin burns, weakness, dehydration, bleeding, hair loss, ulcerations, bloody stool, and skin sloughing (falling off), according to the *Medical Encyclopedia of the National Library of Medicine* (Radiation Sickness, http://www.nlm.nih.gov/medlineplus/ency/article/000026.htm). In addition, a large number of bomb survivors in the two cities developed cancers over the next several decades; thyroid and breast cancer had the greatest excesses. (Source: Thompson DE et al. Cancer Incidence in Atomic Bomb Survivors. Part II: Solid Tumors, 1958-1987. Radiation Effects Research Foundation, Hiroshima Japan, 1994).

B. ESTIMATES OF CASUALTIES

If a meltdown resulting in large scale releases of radioactivity from the reactor core or the waste pools occurred at Browns Ferry, there would be no vaporizing of humans. However, many would suffer from acute radiation poisoning (in the short term) and cancer (in the long term). In 1982, the Sandia National Laboratories submitted estimates to Congress for each U.S. nuclear plant in the case of core meltdown. Estimates for Browns Ferry are given in Table 4.

TABLE 4

Estimated Deaths/Cases of Acute Radiation Poisoning and Cancer Deaths Near Browns Ferry, Following a Core Meltdown [1982]

Type of Effect	Unit 1	Unit 2	Unit 3
Deaths, Acute Radiation Poisoning	18,000	18,000	18,000
Cases, Acute Radiation Poisoning	42,000	42,000	42,000
Cancer Deaths	3,800	3,800	3,800

Note: Acute radiation poisoning cases and deaths calculated for a radius of 20 miles from the plant, cancer deaths calculated for radius 30 miles from the plant. Source: Sandia National Laboratories, *Calculation of Reactor Accident Consequences (CRAC-2) for U.S. Nuclear Power Plants*. Prepared for U.S. Congress, Subcommittee on Oversight and Investigations, Committee on Interior and Insular Affairs. November 1, 1982. Published in New York Times and Washington Post the following day.

The Sandia figures are known as CRAC-2 (Calculation of Reactor Accident Consequences). **CRAC-2 estimated casualties for a core meltdown per Browns Ferry Units 1, 2, or 3 are 60,000 cases of acute radiation poisoning (18,000 fatal) and 3,800 cancer deaths**. Estimates would be much larger today, since the local population has grown since 1982 when the calculations were made, and people beyond a 20 mile radius from the plant will also suffer adverse health consequences. Estimated costs from a meltdown after each unit ($67.3 billion, $69.1 billion, and $73.0 billion in 1980 dollars) would also be far greater today due to inflation. In the seven north Alabama counties immediately downwind of Browns Ferry (DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan), the population grew 47.7%, from 534,059 to 788,777 from 1980 to 2010.

Concerns about meltdowns near Browns Ferry are well founded. According to the 2010 Census, there are nearly 1 million residents living within 50 miles of Browns Ferry – up 11.0% from a decade earlier (Table 5):

TABLE 5

2010 Population and Change from 2000
By Distance from Browns Ferry

Distance	2010 Population	% Ch. From 2000
10 miles	39,930	+12.3%
20 miles	196,318	+14.8%
50 miles	977,941	+11.0%

Source: Bill Dedman, NBC News. "Nuclear Neighbors: Population Rises Near US Reactors", April 4, 2011

Despite the 1975 fire accident just two years after the plant began operating, Browns Ferry reactors may have become more vulnerable to a meltdown from mechanical failure in recent years because of their aging parts, and are decidedly more vulnerable to a meltdown from a terrorist attack. Finally, the March 2011 meltdown at four reactors in Fukushima, Japan is a reminder that these disasters can also occur from an act of nature.

III. RADIOACTIVITY RELEASED FROM BROWNS FERRY

A. OFFICIAL RADIOACTIVE RELEASES INTO THE ENVIRONMENT

Radionuclides created by fission disintegrate, releasing energy as they try to regain stability, and a curie is a unit of radioactivity corresponding to 3.7×10^{10} disintegrations per second. Utilities operating nuclear power plants are required to submit annual reports on radioactive releases to the federal government. From 1970-1993, the Brookhaven National Laboratories collected and disseminated data for each nuclear plant on airborne emissions of "Iodine-131 and effluents," or those radioactive chemicals with a half life of at least eight days, and most likely to enter the food chain and the body.

In this period, the three Browns Ferry reactors emitted 1.70 curies of Iodine-131, which is relatively typical of U.S. reactors. This total represents about 15% of the 14.20 official total from the 1979 Three Mile Island partial core meltdown. Comparisons of all U.S. plants were halted after 1993 by the U.S. government. (Source: Brookhaven National Laboratory *Radioactive Materials Released from Nuclear Power Plants*, NUREG/CR-2907, annual reports)

More recent data on radioactive emissions into the environment include the years 2000 through 2009, by quarter, for most U.S. reactors. The information is available online, but it is very resource-intensive to rank reactors and plants, since one must analyze each reactor's data. The data, posted by federal regulators, includes several types of airborne emissions, including fission and activation gases, iodine-131, particulates (half life over eight days), and tritium. The web site, operated by the U.S. Nuclear Regulatory Commission, also provides quarterly measurements of several types of liquid emissions, including dissolved/entrained gases, fission/activation products, and tritium. (Source: U.S. Nuclear Regulatory Commission, Effluent Database for Nuclear Power Plants, www.reirs.com/effluent).

An examination of the quarterly emission levels database, reveals a number of omissions and limitations in the data that make helpful analyses difficult, namely:

1. For the 10-year period, liquid releases are given only for 2005, 2007, 2008, and 2009

2. For the 10-year period, airborne releases are not given for 2006

3. For airborne releases of fission and activation gases, almost all of the quarterly measurements after 2003 are given as "N/D" (not detectable)

4. For liquid releases of fission/activation products, the number of curies from 2008 to 2009 jumped from 0.0114 to 34.8200, a 3054 times higher jump (which seems not likely)

5. Also for liquid releases of fission/activation products, the number of curies in the last three quarters of 2009 was 10.1, 10.1, and 10.1, respectively; the chance of these three being exactly equal is almost zero, and suggests these data are rough estimates

6. In 2008, while Browns Ferry emitted its highest amount of airborne tritium in the decade, it emitted its lowest amount of liquid tritium

TVA Photographs of Browns Ferry, Fair usage for Non-profit science and health report.

Without any further explanation from the Tennessee Valley Authority (TVA), which operates the plant and makes measurements, and the U.S. Nuclear Regulatory Commission (NRC), which regulates the TVA and publishes measurements, these unusual results have no obvious explanation. Because of these and other limits, precaution should be taken when analyzing these data for patterns and trends. Perhaps the most complete and most reliable type of radiation measure data is the airborne levels of tritium, a gas found in much greater amounts than many chemicals in reactors, and thus easier to measure.

Table 6. provides the quarterly and annual environmental releases of tritium from Browns Ferry 1, 2, and 3. All figures are given in curies.

TABLE 6

**Quarterly Airborne Releases of Tritium, 2000-2009
From Browns Ferry Nuclear Plant, in Curies**

Year	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	TOTAL
2000	8.25	12.00	16.40	11.90	**48.55**
2001	19.50	9.22	14.80	15.30	**58.82**
2002	31.00	13.20	10.60	63.80	**121.70**
2003	25.80	38.30	22.90	22.90	**109.90**
2004	23.60	10.30	12.00	8.61	**54.51**
2005	13.20	14.90	10.10	5.57	**43.77**
2006	No data	No data	No data	No data	-----
2007	1.90	14.30	11.30	7.13	**34.63**
2008	21.40	56.00	76.30	30.20	**183.90**
2009	39.10	19.20	19.50	17.70	**95.50**

Source: U.S. Nuclear Regulatory Commission, Effluent Database for Nuclear Power Plants, www.reirs.com/effluent.

In the decade, there are periods of increase and decline, from an annual low of 34.63 curies (in 2007) to a high of 183.90 curies (in 2008). There are even "hot" and "cold" quarters that sometimes follow one another. For example, there was a large increase from 10.60 to 63.80 curies from 3rd to 4th quarter 2002, before a decline back to 25.80 in 1st quarter 2003.

While acknowledging the limits of the data, Browns Ferry can be ranked among the 65 operating nuclear power plants in the U.S. In 2008, the year of its highest recorded airborne tritium emissions, Browns Ferry had the 8th highest amount in the nation:

TABLE 7

**U.S. Nuclear Power Plants (Total = 65 operational)
With Largest Airborne Tritium Released, 2008**

Plant	State	Curies
1. Palo Verde	AZ	1715.1
2. Brunswick	NC	296.2
3. Salem	NJ	278.9
4. Harris	NC	259.7
5. Catawba	SC	258.7
6. D. C. Cook	MI	242.7
7. McGuire	NC	226.4
8. Browns Ferry	**AL**	**183.9**

Source: U.S. Nuclear Regulatory Commission, Effluent Database for Nuclear Power Plants, www.reirs.com/effluent.

Curies of Tritium Released in Liquid Effluents		
Statistical Summary for 2003	**PWR**	**BWR**
Total	40,600	665
Minimum	0.1	0
Maximum	2,080	174
Average	725	27.7
Number of Data	56	24

An NRC example of typical annual liquid releases from nuclear power plants. Source: U.S. Nuclear Regulatory Commission, FAQs About Liquid Radioactive Releases, http://www.nrc.gov/reactors/operating/ops-experience/tritium/faqs.html#affect (Note: The EPA allows 20,000 picocuries per liter in drinking water, and one picocurie equals 0.000000000001 curie or one trillionth of one curie.)

B. Official Radioactivity Levels in the Environment

Nuclear power plants release tritium into the environment via routine and accidental releases into the air and water. The U.S. Environmental Protection Agency makes levels of environmental radioactivity at various sites in the U.S. publicly available. Measurements in air, water, and milk are included. The web site is called "Envirofacts," can be accessed at http://iaspub.epa.gov/enviro/erams_query_v2.simple_query, and covers measurements taken since 1978.

There are nine Alabama locations in the EPA web site. Two are relatively close to Browns Ferry. One is Muscle Shoals in Colbert County, about 20 miles west of the plant, and the other is Scottsboro, about 70 miles east of the plant, in Jackson County. Each of these locations contains periodic measurements of various types of radioactivity in drinking water, beginning in 1978.

Unfortunately, many measurements for some types of radioactivity are given as negative numbers. A single measurement has an error range, meaning that there is a 95% chance that the true concentration of radioactivity is within that range. Sometimes, when levels are relatively low, the number falls below zero, although the true number is a low, but positive value. Analyzing data with many negative numbers is not helpful; types of radioactivity in drinking water with many values below zero include Iodine-131 and gross alpha (sum of all radioactive chemicals emitting alpha particles).

However, measurements of other types of radioactivity show most or all positive values. Table 8 summarizes the results for (annual) gross beta and (quarterly) tritium in drinking water, for Muscle Shoals, Scottsboro, and also Montgomery (a "control" location, far from any reactor). Gross beta is given for the period 1978-2013, while tritium is given for 1996-2013 (from 1978-1995, only measurements to the nearest hundred were reported for tritium).

TABLE 8

Tritium and Gross Beta in Drinking Water, in Picocuries per Liter
Muscle Shoals, Scottsboro, and Montgomery AL, 1978-2013

Indicator	Muscle Shoals	Scottsboro	Montgomery
Tritium (quarterly), 1996-2013			
Measurements	66	66	60
Average	**88.52**	**78.53**	**11.08**
High Measurement	574	295	151
Number < Zero	9	10	25
Average (assume negative numbers equal zero)	**90.97**	**84.53**	**25.42**
Gross Beta (annual), 1978-2013			
Measurements	34	33	34
Average	**1.94**	**1.73**	**1.63**
High Measurement	2.67	2.99	3.07
Number < Zero	0	0	0

Note: EPA allows 20,000 picocuries in our drinking water. One picocurie is one trillionth of a curie. Source: U.S. Environmental Protection Agency. Radnet: Envirofacts, http://iaspub.epa.gov/enviro/erams_query_v2.simple_query.

The tritium data in drinking water show both Muscle Shoals and Scottsboro have much greater levels than Montgomery (3-4 times more, or 7-8 times more, depending on whether negative numbers are counted as negative or zero). There were 66 measurements at both Muscle Shoals and Scottsboro, and 60 in Montgomery. The Muscle Shoals average is slightly above Scottsboro (+12.7%, or 88.52 vs. 78.53). **The highest single concentration of tritium in drinking water since 1996 was 574 picocuries per liter, in Muscle Shoals on October 11, 2012.**

The gross beta readings also show Muscle Shoals has a higher 1978-2013 average than Scottsboro and Montgomery. Muscle Shoals is the highest, or 19.0% above Montgomery (1.94 vs. 1.63 picocuries per liter). None of the 101 measurements in the three locations were less than zero.

While these data show relatively higher environmental levels closer to Browns Ferry, they are quite limited. Both tritium and gross beta are present in natural background radiation, and are not just produced by nuclear reactors; however, tritium is produced by and routinely released from nuclear power plants – and then there are the accidental releases (see Appendix 3). Identifying levels of individual anthropogenic (man made) radioactive chemicals only produced in reactors or atomic bombs, by using spectrographs or radiation spectral analyzers, would be much more helpful to understand the additional radioactivity that Browns Ferry adds to the environment.

In addition, testing at more sites, especially those closer than 20 miles from the plant, would also provide more useful information. Finally, more frequent tests could better identify patterns; for example, **readings such as the very high October 11, 2012 tritium in Muscle Shoals drinking water (574 pCi/l) might be identified if more than quarterly measurements were made.**

C. Radioactivity in the Environment Measured by Citizens

Because of the limitations of official measurements of environmental radioactivity, interested local citizens near Browns Ferry embarked on a program of measurements in October 2012. The group, Bellefonte Efficiency and Sustainability Team (BEST), a chapter of the larger Blue Ridge Environmental Defense League (BREDL). The group's mission includes empowering communities through environmental education in the Tennessee River Valley, encompassing the Browns Ferry, Sequoyah, and Watts Bar nuclear reactors.

Lou Zeller, BREDL's Executive Director and the project's Quality Assurance Officer, began the group's training using EPA standards; and BEST Monitoring Project Manager, Garry Morgan (retired U.S. Army Medical Department), expanded protocol to include Homeland Security standards and created the *BEST Radiation Monitoring Manual*.

BEST project methods are based on models developed in 2005 by Russian scientist Sergey Pashenko and American scientist Norm Buske and published in *A Citizen's Guide to Radiation Monitoring*; and also the BREDL/Shell Bluff Draft QAPP of July 3, 2012. BEST purchased a Geiger counter (Inspector™, manufactured by Southeast International) to measure the total of alpha, beta, gamma, and X-ray radiation in the air, water, and land.

Background levels were always established first, since a portion of environmental radioactivity is from natural sources (spectrographs are needed to identify radionuclides). Background levels, in Counts Per Minute (CPM), were 26 in water and 36 to 40 on land.

Although these are preliminary, several findings became clear in the first few months of BEST project operations that were not identified by measurements posted by NRC and EPA regulators on their websites.

1. Elevated Levels Close to Plant Higher than background levels were generally found in locations close to Browns Ferry, i.e. those 1 to 10 miles from the plant's outer boundary. The high counts at these locations were about 125 CPMs, or 3-4 times above the background level of 36 to 40.

2. Elevated Levels Downwind of Plant Higher levels of airborne and land-based radioactivity were documented at locations downwind (east) of Browns Ferry. Measurements upwind (west) showed minor difference with background levels.

3. Elevated Levels Downriver of Plant Measurements taken in the Tennessee River downriver from the plant were roughly 2 times greater than those taken from upriver locations.

4. <u>HIGHEST LEVELS AFTER RAIN EVENT</u> The highest levels of radioactivity occurred just after precipitation brought particles to earth. The highest readings observed by BEST members occurred in Scottsboro AL, 70 miles east of Browns Ferry. The team wiped droplets of precipitation from the hood of a car with a paper towel; the droplets were observed to be black. It is possible that radioactive particles, which are invisible, might be trapped in blackened soot particles. The team made minute-by-minute tests for one hour holding the Inspector™ counter just above the sample, and observed a high reading of 1602 CPM at twelve minutes (at least 40 times above background levels); also performing simple paper and aluminum tests confirming beta and gamma radiation.

5. <u>HIGHEST LEVELS FOUND FAR FROM PLANT</u> The fact that the highest levels detected thus far were from Scottsboro, 70 miles downwind of Browns Ferry, indicates a possibility that dispersion of radioactive emissions from nuclear plants may be an inconsistent result of wind and precipitation patterns, and may travel relatively long distances from a plant; however, the source can not be pin-pointed without spectrometers.

BEST has made their users manual available online at RadiationMonitors.blogspot.com and many of their field test operations can be viewed through a series of internet-based videos at RadiationVideos.blogspot.com. (Also see Appendix 5.)

D. <u>RADIOACTIVITY LEVELS IN THE BODY</u>

In the 1950s and 1960s, Washington University and the Greater St. Louis Committee for Nuclear Information collected 320,000 baby teeth, and tested them for levels of radioactive Strontium-90, one of dozens of radioactive chemicals found only in atomic bomb tests and nuclear reactor emissions. It is chemically similar to calcium, seeking out bone and teeth, and resides in the body for many years (half-life of 28.7 years), making it possible to test in-body levels. Sr-90 impairs and kills cells in the bone and bone marrow (in which the immune system defenses are built) making it a risk factor for all cancers.

The St. Louis study found that for children born in 1964, just after above-ground bomb testing ended, the average Sr-90 level was **50 times greater** than for those born in 1950, just before testing began. After above-ground atom bomb tests were banned, Sr-90 averages declined sharply (about 50% from 1964-1969) until the federal government discontinued the study in 1970. (Source: Rosenthal HL. Accumulation of Environmental 90Sr in Teeth of Children. Hanford Radiobiological Symposium, Richland WA, May 1969, 163-171).

From 1961-1982, the U.S. Atomic Energy Commission (later the U.S. Department of Energy or DOE) operated a program measuring annual Sr-90 concentrations in the vertebrae of 100 healthy adults in San Francisco and New York City who had died in accidents. From 1965-74, after the Partial Test Ban Treaty reduced levels of fallout in diet, the average concentration of Sr-90 declined by 50% and at a lesser rate thereafter.

(Source: Klusek CS, Strontum-90 in Human Bone in the U.S., 1982. New York: Department of Energy Environmental Measurements Laboratory, 1982.)

The DOE terminated its program in 1982. Since then, the U.S. has been without a systematic government program of testing humans for radioactivity levels in their bodies.

From 1996 to 2006, the Radiation and Public Health Project (RPHP) research group conducted a baby tooth study measuring Sr-90 levels, known as the Tooth Fairy Project. The study is patterned on the St. Louis effort, which provides historical data on Sr-90 levels in the U.S. **The RPHP tooth project represents the only study in the U.S. of in-body radioactivity for persons living near nuclear reactors.**

RPHP collected and tested nearly 5000 teeth, mostly from California, Connecticut, Florida, New Jersey, New York, and Pennsylvania. It found a consistent pattern of elevated Sr-90 (30 to 50% higher) in baby teeth living in counties closest to reactors, and a 49% rise in Sr-90 for children born in the late 1990s vs. the late 1980s. (Source: Mangano JJ et al. An unexpected rise in strontium-90 in US deciduous teeth in the 1990s. The Science of the Total Environment 2003;317:37-51). Very few teeth from Alabama were collected and tested.

IV. HEALTH RISKS OF BROWNS FERRY

A. INTRODUCTION

Since the atomic era began in the 1940s, scientists have studied effects of exposures to man-made radioactivity. Elevated levels of illness and death are attributed to the Hiroshima and Nagasaki bombs; bomb tests in Nevada, the South Pacific, and the former Soviet Union; and the 1986 accident at the Chernobyl nuclear power plant. Each of these involved relatively high levels of exposure to radioactivity.

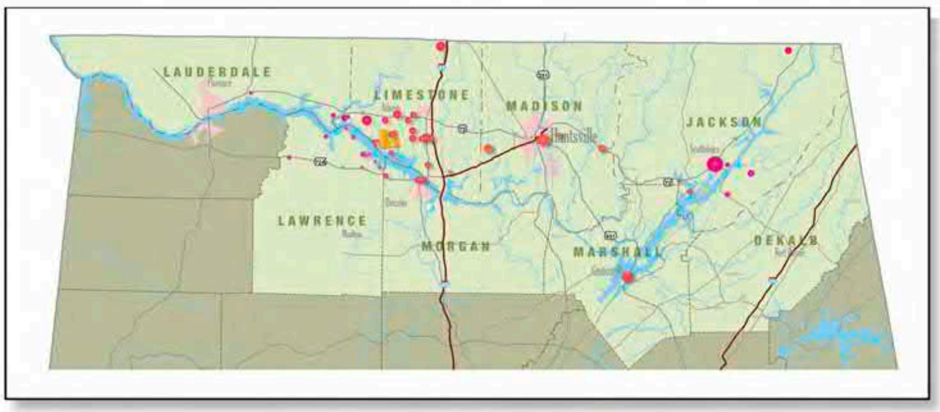
In addition, researchers have addressed effects of relatively low doses of radioactivity. The first to document hazards of low-dose exposures was British physician Alice Stewart. In the 1950s, Stewart showed that a pelvic X-ray to a pregnant woman nearly doubled the chance the baby would die of cancer before age 10. (Source: Stewart AM, Webb J, and Hewitt D. A Survey of Childhood Malignancies. British Medical Journal, 1958;i:1495-1508).

Studies of low-dose exposures have addressed many diseases, but often focus on cancer in children. Radioactive chemicals are known to be more harmful to the young, particularly the developing fetus and infant. Body growth and cell division is most rapid early in life, and thus a damaged cell is most likely to cause harm. **There are at least 19 medical journal articles that identify elevated child cancer rates near different nuclear plants**, mostly power plants (see Appendix 1).

B. DEFINING AREAS CLOSEST TO BROWNS FERRY

Defining which areas are most likely to be harmed by toxic emissions from Browns Ferry is an inexact process. The most affected are a result of proximity and downwind location, along with the source of food and water. The prevailing wind direction in the area is, similar to most of the continental U.S., from west to east (usually from the northwest in colder months and from the southwest in warmer months).

The seven Alabama counties closest to and downwind of Browns Ferry will be used for most analyses. These counties have a combined 2010 population of 788,867, including DeKalb (71,109), Jackson (53,227), Lawrence (34,339), Limestone (82,782), Madison (334,811), Marshall (93,109). The city of Huntsville is in Madison County. These counties are used because BEST citizens found the highest environmental radiation levels were detected in Scottsboro, 70 miles downwind. The map below shows monitored sites.



Map shows Browns Ferry and BEST radiation test sites. by Roy Simmons for BEST/MATRR

C. Breast Cancer Mortality Near Browns Ferry

RPHP's Jay Gould performed research on breast cancer near nuclear reactors. In his 1996 book *The Enemy Within*, Gould used National Center for Health Statistics data to show that women living within 100 miles of nuclear reactors are at the greatest risk of dying of breast cancer. (Source: Gould JM et al. The Enemy Within: The High Cost of Living Near Nuclear Reactors. New York: Four Walls Eight Windows, 1996).

Gould found that for most counties closest to Browns Ferry, the breast cancer death rate for white women rose substantially from the early 1950s to the late 1980s (Table 8). These include Limestone (+15%), Madison (+74%), and Morgan (+4%). The exception is Lawrence County (-37%). By contrast, rates for the U.S. only rose 1%.

Table 9

Breast Cancer Mortality Rates, White Females and All Ages
Alabama Counties Closest to Browns Ferry Nuclear Plant, 1950-54 and 1985-89

	Rate/100,000 (Deaths)		
County	1950-54	1985-89	% Change
Lawrence	20.4 (8)	12.9 (10)	- 37%
Limestone	18.8 (11)	21.7 (27)	+15%
Madison	15.9 (20)	27.6 (149)	+74%
Morgan	16.6 (17)	17.3 (50)	+ 4%
U.S.	24.4 (91932)	24.6 (178868)	+ 1%

Source: National Center for Health Statistics, in *The Enemy Within*, Gould JM et al. New York: Four Walls Eight Windows, 1996. Rates age adjusted to 1950 U.S. Standard.

D. Thyroid Cancer Incidence

Exposure to radioactive fission products constitutes a risk factor for all cancers. However, some cancers are considered more radiosensitive than others. One is childhood cancer, for reasons already explained. Another is thyroid cancer. One of the radioactive chemicals not found in nature, but produced only in atom bomb tests and nuclear reactor operations is radioisotopic iodine, which seeks out the thyroid gland when it enters the body, impairing and killing cells. Experts have not identified any true cause of thyroid cancer other than exposure to radioactive iodine; other risk factors, such as presence of another thyroid disorder, are not considered causes of the disease.

Thyroid cancer, of which radioactive iodine produced by nuclear power or bombs is the only known cause, is the fastest-rising type of cancer in the U.S., its rate having more than tripled from 1980 to 2009. The annual number of Americans diagnosed with the disorder has risen from 12,000 to 56,000 since 1991. While some contend that better diagnosis over time accounts for this increase, numerous researchers assert that there are other, still unknown factors. (Source: National Cancer Incidence, Surveillance, Epidemiology, and End Results program, http://www.seer.cancer.gov).

Because thyroid cancer is often treatable, and 97% of victims live more than five years after diagnosis, incidence is a much more useful measure of thyroid cancer than mortality. Table 10 lists the 10 Alabama counties (with at least 15 cases) with the highest 2005-2009 thyroid cancer incidence rates in the state:

Table 10

Highest Thyroid Cancer Incidence
Alabama Counties, 2005-2009

County	Rate/100,000	(Cases)
1. Winston	15.6	(20)
2. Walker	12.4	(45)
3. Lauderdale	11.7	(55)
4. Marshall	**11.4**	**(55)**
5. Escambia	10.7	(20)
6. Jackson	**10.3**	**(30)**
7. Etowah	9.7	(55)
8. Madison	**9.3**	**(150)**
9. Limestone	**9.2**	**(35)**
10. Tuscaloosa	9.1	(75)

Source: National Cancer Institute, State Cancer Profiles.
www.statecancerprofiles.cancer.gov. Age Adjusted to 2000 U.S. Standard Population

Black spot denotes Browns Ferry

U.S. Census Bureau
www.census.gov

Of the 10 Alabama counties with the highest thyroid cancer rates, four (4) are among the seven proximate/downwind counties in this analysis. Among the four is Madison, with nearly one-half of the residents in the area. It appears that thyroid cancer in the area is higher than most Alabama counties.

E. FEDERAL STUDIES OF CANCER NEAR U.S. NUCLEAR PLANTS

The federal government conducts no systematic tracking of disease and death rates among persons living near nuclear plants. The only large-scale federal study on cancer near nuclear reactors was a 1990 effort prepared by the National Cancer Institute (NCI), after Senator Edward M. Kennedy wrote to the National Institutes of Health director James Wyngaarden about an article on elevated leukemia rates near the Pilgrim plant in Massachusetts. NCI concluded there was no link between cancer risk and proximity to reactors, even though study methods have received criticism.

Browns Ferry was one of the 62 nuclear plants included in the NCI's 1990 study. The project analyzed cancer mortality in five-year periods before and after reactor startup in the period 1950 to 1984. It used the Standard Mortality Ratio (SMR), or the county rate divided by the U.S. rate, as a measure of mortality. The only cancer incidence (as opposed to mortality) data in the report was near reactors in Connecticut and Iowa, which were the only states with operating and reliable cancer registries before 1984.

The NCI selected Lawrence and Limestone counties as the "study" counties most proximate to Browns Ferry. Table 11 shows the change in SMR for all cancers before (1950-1973) and after (1974-1984) the startup of Browns Ferry.

TABLE 11

Standard Mortality Ratio, All Cancers Combined
Lawrence and Limestone Counties, 1950-1973 and 1974-1984

Type of Cancer	Std. Mortality Ratio (**Deaths**)		
	1950-73	**1974-84**	**% Change**
All+	0.78 (1497)	0.91 (1230)	+17**
Leukemia	0.98 (91)	1.00 (55)	+ 2
Hodgkins Disease	0.79 (18)	1.17 (9)	+48
Non-Hodgkins Lymphoma	0.46 (24)	0.75 (31)	+63
Multiple Myeloma	0.56 (13)	0.66 (15)	+ 9
Stomach	0.89 (132)	0.58 (30)	- 35*
Colorectal	0.58 (162)	0.75 (135)	+29**
Liver	0.84 (56)	1.54 (31)	+83*
Trachea, Bronchus, Lung	0.61 (189)	1.00 (343)	+64*
Female Breast	0.75 (131)	0.79 (96)	+ 5
Thyroid	0.71 (5)	0.30 (1)	- 58
Bone and Joint	1.37 (20)	1.20 (6)	- 12
Bladder	0.76 (42)	0.76 (25)	0
Brain/Other Nervous Sys.	0.97 (46)	1.04 (36)	+ 7
Benign/unspecified neoplasms	1.13 (7)	1.40 (15)	+24

+Excluding Leukemia, * Significant at p<.05, ** Significant at p<.001
Source: Jablon S. et al. Cancer in Populations Living Near Nuclear Facilities. Washington DC: U.S. Government Printing Office, 1990.

Of the 15 types of cancer, the Standard Mortality Ratio (SMR) increased in 11; decreased in 3; and was unchanged in 1. The SMR increase for all cancers of 0.78 to 0.91, or from -22% to -9% below the U.S. rate, was highly significant at p<.001. Increases were also significant for colorectal, liver, and lung cancer.

In May 2009, the U.S. Nuclear Regulatory Commission published a notice in the Federal Register, announcing it was pursuing another study of cancer near nuclear plants. After dropping its initial choice of subcontractor (Oak Ridge Associated Universities), the NRC selected the National Academy of Sciences to conduct the study. The NAS has convened a panel to judge the feasibility of such a study, and to conduct and present it. There will be no public release of the study, whether or not it is completed, until at least 2015.

F. Infant Mortality

In 2000 and 2002, this author, Joseph Mangano, published articles for the Radiation Public Health Project showing that when nuclear power plants shut down, deaths of infants under one year and cancer cases of children under five years in local downwind counties decline rapidly immediately after shutdown. Sources: Mangano JJ. Improvements in local infant health after nuclear power reactor closing. Environmental Epidemiology and Toxicology 2000;2(1):32-36. Mangano JJ et al. Infant death and childhood cancer reductions after nuclear plant closings in the United States. Archives of Environmental Health 2002;57(1):23-32.

Because the developing fetus and infant are especially sensitive to harmful biological effects of radiation exposure, any change in health status from adding or removing environmental radioactivity will first be observed in the youngest.

Table 12 shows the change in the infant death rate in the seven Alabama counties closest to and downwind from Browns Ferry, from the two-year period 1973-1974 (as the plant was running at limited power) to the two year period 1975-1976 (as the plant was operating at full power).

Table 12

Change in Local Infant Mortality, Age 0-1
Two Years Before 1973-74 and Two Years After 1975-76 Browns Ferry Startup

	Infant Deaths		Live Births		Deaths/1000		
Area	Before	After	Before	After	Before	After	% Ch
7 Counties	287	271	15213	14604	18.87	18.56	**- 1.6**
United States	108357	98790	6296923	6311986	17.21	15.65	**- 9.5**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Compares periods 1973-1974 and 1975-1976. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

The change in the death rate under one year in the seven counties closest to Browns Ferry was -1.6%, much less than the reduction in the United States (-9.5%). Even though the difference was not statistically significant, the change in local infant mortality supports studies showing the fetus and infant are more susceptible to radiation doses than adults. (See Appendix 1)

Another opportunity to evaluate changes after reactor startup was the re-start of Browns Ferry Unit 1 in June 2007, after 22 years of the reactor being offline (since 1985). The change in infant mortality in the two years after the Unit 1 reactor operated at full power (2008-2009) was also compared with the prior two years, for the same seven downwind counties: Lawrence, Limestone, Morgan, Madison, Marshall, Jackson, and DeKalb.

The local infant death rate fell just -0.4% after Browns Ferry Unit 1 re-start in 2007, compared to a nationwide decline of -4.9%. The Unit 1 restart infant mortality difference fell short of statistical significance. However, this followed the same pattern that was indicated when the plant began operating in the mid-1970s (Table 12).

With 43 years of infant mortality data available, it is possible to evaluate trends in local rates, compared to the U.S., over a long period of time. Table 13 shows the change in mortality among infants younger than one year for five-year periods, from 1968 to 2010. (The six-year period 1968-1973 is used to illustrate the period before Browns Ferry began operating; the two-year period 2009-2010 is used because it is the most current data available on the CDC web site as of spring 2013).

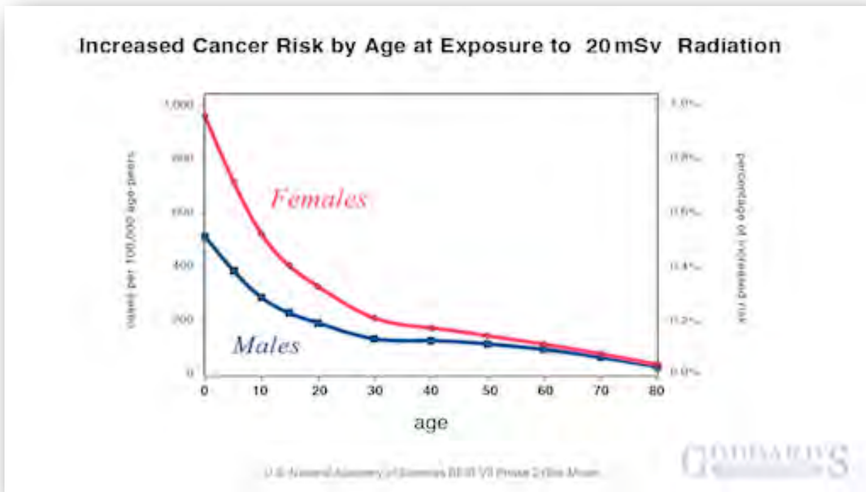
TABLE 13

Infant Mortality, Age 0-1
Seven-County Area in Northern Alabama vs. U.S.
Five Year Periods, 1968-2010

	Deaths/1000			
Period	Local	U.S.	Local Deaths	**% Local vs. U.S.**
1968-1973	20.99	19.71	1,084	**+ 6.5**
1974-1978	16.99	15.16	639	**+12.1**
1979-1983	12.73	12.05	501	**+ 5.7**
1984-1988	10.06	10.36	411	**- 2.8**
1989-1993	8.39	8.98	390	**- 6.5**
1994-1998	7.54	7.47	346	**+ 0.8**
1999-2003	7.76	7.14	352	**+ 8.7**
2004-2008	8.56	6.99	419	**+22.6**
2009-2010	7.80	6.42	154	**+21.6**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

After an initial jump in local vs. national infant mortality in the late 1970s, when Browns Ferry first began operating, the following years saw the local rate decline more rapidly, until it was below the U.S. But since the early 1990s, a steady increase has occurred in the local vs. national rate **(-6.5%, +0.8%, +8.7%, +22.6%, and +21.6%** for the latest two years available). With about 80 local infants dying each year in the seven counties, the numbers are large enough to merit further examination into potential reasons for this unexpected change, including exposure to emissions from Browns Ferry.



Source: National Academy of Sciences, *Biological Effects of Ionizing Radiation BEIR VII Phase 2 Report: Health Risks from Exposure to Low Levels of Ionizing Radiation*, National Academies Press, 2006, http://www.nap.edu/catalog/11340.html, (pg. 311), adjusted 100 mSv to 20 mSv by Ian Goddard according to BEIR instructions.

One way to further examine recent infant death rates is by race. Since 1999, the CDC web site classifies deaths into white non-Hispanics, black non-Hispanics, and white Hispanics, which make up nearly 100% of all deaths in the seven counties downwind of Browns Ferry. Table 14 shows local rates compared to the U.S. for each of these three racial/ethnic groups for the years 2004-2010, when local infant mortality was more than 20% greater than the U.S.

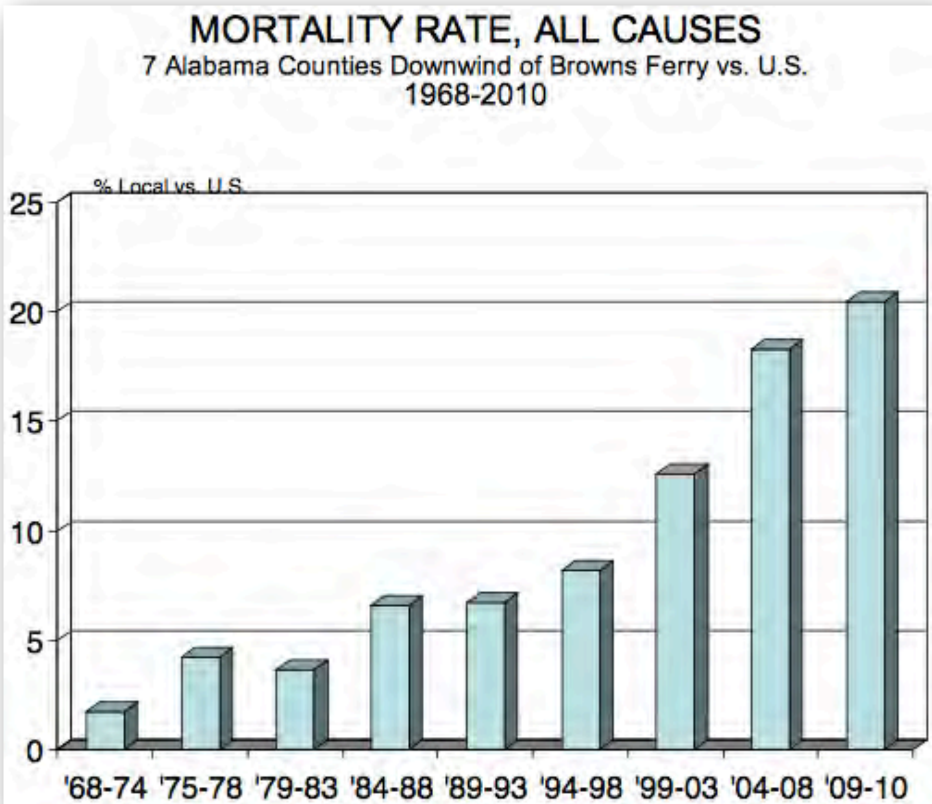
TABLE 14

Infant Mortality, Age 0-1, By Race, 2004-2010
Seven-County Area in Northern Alabama vs. U.S.

Group	Deaths/1000 Local	Deaths/1000 U.S.	Local Deaths	% Local vs. U.S.
White Hispanic	8.21	5.85	77	**+40.3**
White non-Hispanic	7.59	5.72	352	**+32.6**
Black non-Hispanic	12.71	13.46	135	**- 5.6**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

Local 2004-2010 infant mortality rates for whites greatly exceeded the U.S., both for Hispanics (+40.3%) and non-Hispanics (+32.6%). Both are statistically significant. The local rate for black non-Hispanics was actually 5.6% less than the nation, a non-significant difference.



G. Local Mortality Rate from All Causes

Another way to examine any potential health hazards from Browns Ferry radioactive emissions is to examine mortality. As mentioned, the U.S. Centers for Disease Control and Prevention maintains a data base on its web site of all deaths in the U.S. from 1968 to 2010, and adds the latest year's data annually.

Table 15 shows the local age-adjusted mortality rate compared to the U.S. rate for each five-year period beginning in 1968. The first period (1968-1974) is six years, as it represents the period before large-scale operations began at Browns Ferry, and the last period (2009-2010) is only two years pending the addition of future years. The table uses the seven closest counties located downwind (east) of the plant.

TABLE 15

Mortality, All Causes Combined, All Ages
Seven-County Area in Northern Alabama vs. U.S.
Five Year Periods, 1968-2010

Period	Deaths/100,000 Local	Deaths/100,000 U.S.	Local Deaths	**% vs. US**	Expected	**Excess**
1968-1974	1244.0	1222.8	26,426	**+ 1.7**	-	-
1975-1978	1113.1	1067.8	15,834	**+ 4.2**	15,438	396
1979-1983	1042.5	1005.9	21,079	**+ 3.6**	20,678	401
1984-1988	1043.4	978.5	23,883	**+ 6.6**	22,713	1170
1989-1993	990.6	927.9	25,836	**+ 6.7**	24,544	1292
1994-1998	965.4	892.5	28,650	**+ 8.2**	26,788	1862
1999-2003	968.6	860.3	31,515	**+12.6**	28,080	3435
2004-2008	939.0	793.7	34,234	**+18.3**	28,551	5683
2009-2010	901.9	748.3	14,405	**+20.5**	11,452	2953
Total 1975-2010	**(36 years)**		**195,436**		**178,244**	**17,192** (8.8%)

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Rates age adjusted to 2000 U.S. Standard Population. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

In 1968-1974, largely before operations at Browns Ferry began, the local mortality rate was just 1.7% above the U.S. Thereafter, the gap steadily increased, until by 2009-2010, the local rate was 20.5% greater – the largest elevation in at least 43 years.

Because the annual number of deaths in the seven counties is now over 7,000, this trend is highly significant. There is no obvious demographic change, such as race, ethnicity, age, or gender that explains such a dramatic difference. But while there are many potential factors that could contribute to this steady increase, exposure to emissions from Browns Ferry should be considered as one.

It is notable that a similar trend in local infant deaths occurred for all deaths, and that currently, local rates for both are more than 20% above the U.S. rate.

In 1999-2010, the most recent 12-year period, in which the greatest local-national gap in mortality rates was observed, it would be informative to examine the patterns for various demographic groups. Table 16 provides these data for four age groups, for racial/ethnic groups, and for each gender.

TABLE 16

Mortality, All Causes Combined, All Ages
Seven-County Area in Northern Alabama vs. U.S.
By Race/Ethnicity, Gender, and Age Group, 1999-2010

Group	Deaths/100,000 Local	Deaths/100,000 U.S.	Local Deaths	% Local vs. U.S.
All Persons	943.0	811.7	80,154	**+16.2**
Race/Ethnicity				
White non-Hispanic	951.0	808.0	71,039	**+17.7**
Black non-Hispanic	1006.0	1042.5	8,198	**- 3.5**
Gender				
Males	1128.9	971.1	40,132	**+16.2**
Females	799.9	687.9	40,022	**+16.3**
Age at Death				
0-24	88.0	69.1	2,595	**+27.4**
25-44	192.0	152.7	4,745	**+25.7**
45-64	728.8	613.9	16,677	**+18.7**
65+	5482.0	4790.5	56,137	**+14.4**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Rates age adjusted to 2000 U.S. Standard Population.. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

In the 12-year period, the local age-adjusted mortality rate for all deaths was 16.2% above the U.S., based on 80,154 deaths. Local rates exceeded the nation for each age group, males and females, and white non-Hispanics. All local-national differences were statistically significant. The only demographic group in which the local rate was less than the U.S. was for black non-Hispanics (-3.5% lower). This group accounted for 10% of the deaths in the seven counties from 1999-2010. The low rate for all deaths for black non-Hispanics was similar to the low rate for infant deaths in this racial/ethnic group.

Local death rates were especially high for young persons. The rates for persons who died at age 0-24 and 25-44 were 27.4% and 25.7% above the U.S., respectively.

Another way to examine mortality patterns in the seven closest counties downwind from Browns Ferry is by cause of death. Table 17 compares local and national 1999-2010 age-adjusted mortality rates for the 11 most common causes, which account for 98% of deaths, plus all others combined.

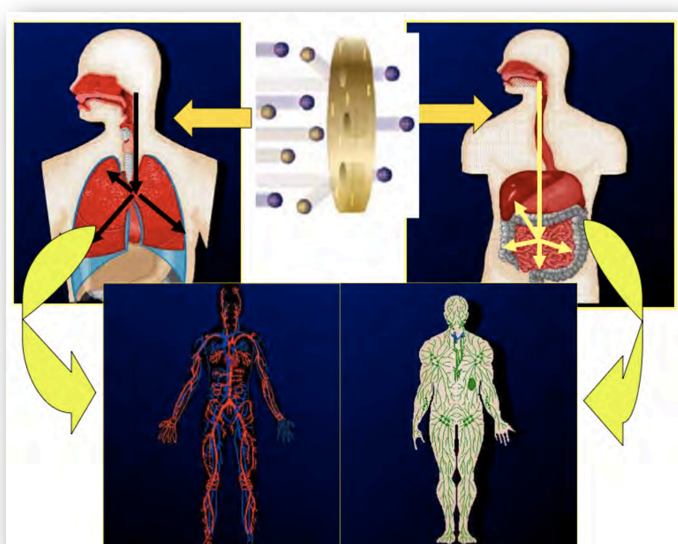
TABLE 17

Mortality, Most Common Causes, All Ages
Seven-County Area in Northern Alabama vs. U.S., 1999-2010

Cause	Deaths/100,000 Local	Deaths/100,000 U.S.	Local Deaths	% Local vs. U.S.
All Persons	943.0	811.7	80,154	**+ 16.2**
Circulatory System	354.0	289.0	29,511	**+ 22.5**
Neoplasms	199.7	190.5	17,865	**+ 4.8**
Respiratory System	95.8	78.4	8,079	**+ 22.3**
Homicide, Suicide, Accidents	68.2	57.6	5,922	**+ 18.4**
Nervous System	43.5	38.5	3,512	**+ 13.0**
Endocrine, Nutr., Metabolic	36.8	32.8	3,155	**+ 12.4**
Digestive System	31.6	29.0	2,778	**+ 9.1**
Genitourinary System	30.3	20.3	2,477	**+ 49.5**
Infectious/Parasitic Diseases	21.9	21.7	1,887	**+ 0.9**
Mental/Behavioral Diseases	23.3	25.1	1,817	**- 7.0**
Signs and Symptoms	19.7	11.1	1,625	**+ 77.9**
All Other	18.2	17.9	1,526	**+ 1.6**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Rates age adjusted to 2000 U.S. Standard Population.. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

The seven county mortality rate exceeded the U.S. rate for 11 of the above 12 categories. Of the 11 categories with excesses, 9 were statistically significant. The greatest excesses include signs and symptoms (+77.9%), genitourinary system disorders (+49.5%), circulatory system disorders (+22.5%), and respiratory system disorders (+22.3%).



Graphic Source: Antonietta M. Gatti et al, "Nanopathology: The Role of Micro and Nanoparticles in Biomaterial-induced Pathology", The European Commission, Project QLRT-2002-J47 (2002-2005), http://inchesnetwork.net/Fetal%20and%20embryological%20origin%20of%20diseases_Gatti.pdf

Analysts often point out that there may be limitations in geographic comparisons by cause of death. Categories are defined by the primary cause of death; in many cases, a decedent suffers from multiple disorders (such as heart disease and cancer). There are rules to define which cause is the primary cause, but they can be subject to interpretation by physicians completing death certificates and coders assigning a code to the primary cause of death. In other cases, a vague symptom might be assigned as the primary cause of death instead of a known disease entity; the seven-county death rate from signs and symptoms is nearly double that of the U.S. (19.7 vs. 11.1 deaths per 100,000 persons).

The local mortality rate from neoplasms, or cancers, is just 4.8% above the U.S. However, there is a possibility that a greater proportion of those local decedents who had cancer were assigned to another disease category than in the nation as a whole.

It is clear that the consistently high local death rates across various causes of death show an unusual pattern worthy of greater investigation, especially since the 1968-1974 local death rate was just 1.7% above the U.S, compared to the 2010 rate of 20.5%.

H. CHILD CANCER INCIDENCE

Another health condition sensitive to radiation is childhood cancer. As mentioned, a dose of radiation causes much more genetic and cellular damage to the fetus, infant, and young child than the same exposure does to an adult. However, it is not possible to examine long-term trends in cancer incidence in Alabama, since the state cancer registry only began in 1996, and the latest available data are for cases diagnosed in 2009.

In the most recent available period (2005-2009), cancer incidence among children age 0-19 for each Alabama county with at least 15 cases in the five year period is provided on the internet. Rates for two of the four counties closest to Browns Ferry exceeded the Alabama rate of 15.2 cases per 100,000 per year; Limestone County (21.8) and Morgan County (16.7). Madison County's rate (12.4) was below the state; and no figures are calculated for all 50 states combined. Given limited data, a precise cause and effect relationship between Browns Ferry and local childhood cancer cannot be made or rejected. Nevertheless, there are 26 children a year who contract cancer in Browns Ferry's Limestone County and 42 kids a year who get cancer in downwind Madison County for yet unknown reasons. Source: National Cancer Institute, State Cancer Profiles. www.statecancerprofiles.cancer.gov and census.gov.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This report has addressed patterns of radioactive emissions from the Browns Ferry Nuclear Power Plant, and potential links with adverse health effects among those living near or downwind of the plant. The plant has three of the five operating nuclear power reactors in Alabama. Nearly 1 million persons live within 50 miles of Browns Ferry.

The potential health consequences posed by Browns Ferry are massive. The plant contains 1,932 metric tons (containing 314,140,400 curies) of high-level radioactive waste, the highest of all U.S. nuclear plants except for Dresden IL. Most of this radioactivity is stored in deep pools of constantly-cooled water; loss of cooling water would result in a disastrous meltdown, which would poison many thousands of persons. A 1982 U.S. government panel estimated casualties from a core meltdown near all U.S. nuclear plants, and calculated 60,000 acute radiation poisoning and 3,800 cancer deaths per reactor near Browns Ferry. The numbers would be higher today because of increased population and additional casualties beyond the 20- and 30-mile limits of the study.

Browns Ferry has had a checkered safety record. The six shutdowns of at least one year is the highest number at any U.S. nuclear plant. The source of one of these shutdowns, the 1975 fire at Browns Ferry unit 1, is regarded by many as the most serious accident at a U.S. nuclear power plant other than the Three Mile Island partial meltdown. In addition, the 22-year outage at Browns Ferry 1 from 1985 to 2007 is easily the longest 'temporary' shutdown of any U.S. nuclear reactor.

The design of the Mark I reactor cooling pools at Browns Ferry are vulnerable to attacks by tornados as well as terrorists, since they are raised four stories in the air with no hardened overhead containment of these pools holding millions of pounds of highly enriched radioactive fuel in addition to nearly a million gallons of radioactive water. Browns Ferry is also one of the four nuclear power plant sites in history to receive a 'Red Finding' (the most severe short of plant shutdown) from the Nuclear Regulatory Commission in May, 2011 – a finding which still stands today.

While official measurements of radioactive emissions and environmental levels are often limited, some findings suggest that Browns Ferry is adding harmful radioactivity to the environment and food chain. For example, quarterly tritium levels taken since 1996 in drinking water at Muscle Shoals and Scottsboro were 3-4 times and 7-8 times greater than those in Montgomery, a control site far from any nuclear power plant.

Citizen-based monitoring, while only in operation for seven months, shows preliminary patterns indicating that Browns Ferry may be adding to environmental radioactivity levels, especially at downwind and downriver sites, and after rain events; however, spectrographic analyses of the offending radionuclides is required to determine specific identification of the radiation sources. BEST monitoring has recorded radiation levels from double to 40 times greater than background levels downwind and downriver from Browns Ferry, with only near background readings upwind and upriver. Since the highest levels recorded were found 70 miles downwind, early datum suggest the possibility that radioactivity from Browns Ferry may travel long distances before returning to earth.

The report also examined patterns of disease and death rates near Browns Ferry. For this purpose, the seven-county area immediately downwind (east) of the plant, with a population of about 800,000, was compared with the U.S. averages. Findings included:

1. Infant deaths changed little in the first two years after Browns Ferry startup in the 1970s, and the first two years after restart of Browns Ferry 1 in 2007.

2. The local infant death rate was below the U.S. in the late 1980s and early 1990s. However, the local rate has diverged steadily from the nation in the last decade (latest records are for 2010), until it has currently reached a level 22.3% above the U.S. These elevated infant death rates are even greater for whites (32.6%) and Hispanics (40.3%).

3. The mortality rate for all causes combined in the seven counties rose steadily from +1.7% above the U.S. in the early 1970s to +20.5% in the latest period (2009-2010). Elevated rates were observed for both genders, all age groups, whites (not blacks), and all major causes of death except for mental disorders.

4. Some of the highest current thyroid cancer rates in Alabama occurred in the seven-county area.

B. Recommendations

This report has provided information about the potential adverse health consequences that the Browns Ferry nuclear facility poses to many thousands of local residents. Some questions have been raised, especially the steadily rising mortality rate in the closest downwind counties.

While these data should be taken seriously, they also need to be followed up with additional studies. Continued citizen-based monitoring of environmental radioactivity levels should be encouraged, and results should be considered by EPA, TVA and NRC officials, who are responsible for the health and safety surrounding nuclear power facilities, and therefore must consider and implement improvements in current methods of measuring emissions and environmental radioactivity emanating from Browns Ferry.

The unusual and steady rise in local death rates should be taken seriously by health officials, who need to conduct their own studies to examine potential causes – among them, toxic releases from Browns Ferry.

Continued operations of the Browns Ferry reactors, which are aging and are now reaching their original design-basis age limit of 40 years, should include a “report card” of emissions performance, for which that they have not been held accountable in the past, so that sound decisions can be made to best protect the public health.

APPENDIX 1: JOURNAL ARTICLES (19) THAT IDENTIFY ELEVATED LEVELS OF CHILDHOOD CANCER NEAR NUCLEAR PLANTS

Sharp L, McKinney PA, Black RJ. Incidence of childhood brain and other non-haematopoietic neoplasms near nuclear sites in Scotland, 1975-94. *Occupational and Environmental Medicine,* 1999; 56(5): 308-314.

Busby C, Cato MS. Death rates from leukaemia are higher than expected in areas around nuclear sites in Berkshire and Oxfordshire. *British Medical Journal,* BMJ 1997; 315(7103): 309.

Black RJ, Sharp L, Harkness EF, McKinney PA. Leukaemia and non-Hodgkin's lymphoma: incidence in children and young adults resident in the Dounreay area of Carthness, Scotland in 1968-91. *Journal of Epidemiology and Community Health,* 1994; 48(3): 232-236.

Draper GJ, Stiller CA, Cartwright RA, Craft AW, Vincent TJ. Cancer in Cumbria and in the vicinity of the Sellafield nuclear installation, 1963-90. *British Medical Journal,* BMJ 1993; 306(6870): 89-94.43.

Goldsmith JR. Nuclear installations and childhood cancer in the UK: mortality and incidence for 0-9 year-old children, 1971-1980. *The Science of the Total Environment* 1992; 127(1-2): 13-35.

Kinlen LJ, Hudson CM, Stiller CA. Contacts between adults as evidence for an infective origin of childhood leukaemia: an explanation for the excess near nuclear establishments in west Berkshire? *British Journal of Cancer* 1991; 64(3): 549-554.

Ewings PD, Bowie C, Phillips MJ, Johnson SA. Incidence of leukemia in young people in the vicinity of Hinkley Point nuclear power station, 1959-86. *British Medical Journal,* BMJ 1989; 299(6694): 289-293.

Cook-Mozaffari PJ, Darby SC, Doll R, Forman D, Herman C, Pike MC, Vincent T. Geographical variation in mortality from leukemia and other cancers in England and Wales in relation to proximity to nuclear installations, 1969-78. *British Journal of Cancer* 1989; 59(3): 476-485.

Roman E, Beral V, Carpenter L, Watson A, Barton C, Ryder H, Aston DL. Childhood leukaemia in the West Berkshire and Basingstoke and North Hampshire District Health Authorities in relation to nuclear establishments in the vicinity. *British Medical Journal,* BMJ (Clinical Research Edition) 1987; 294(6572): 597-602.

APPENDIX 1

Forman D, Cook-Mozaffari P, Darby S, Davey G, Stratton I, Doll R, Pike M. Cancer near nuclear installations. *Nature* 1987; 329(6139): 499-505.

Heasman MA, Kemp IW, Urquhart JD, Black R. Childhood leukemia in northern Scotland. *Lancet* 1986; 1(8475): 266.

Gunay U, Meral A, Sevinir B. Pediatric malignancies in Bursa, Turkey. *Journal of Environmental Pathology, Toxicology, and Oncology* 1996; 15(2-4): 263-265.

McLaughlin JR, Clarke EA, Nishri ED, Anderson TW. Childhood leukemia in the vicinity of Canadian nuclear facilities. *Cancer Causes and Control* 1993; 4(1): 51-58.

Viel JF, Pobel D, Carre A. Incidence of leukaemia in young people around the La Hague nuclear waste reprocessing plant: a sensitivity analysis. *Statistical Medicine* 1995; 14(21-22): 2459-2472.

Hoffmann W, Dieckmann H, Schmitz-Feuerhake I. A cluster of childhood leukemia near a nuclear reactor in northern Germany. *Archives of Environmental Health* 1997; 52(4): 275-280.

Zaridze DG, Li N, Men T, Duffy SW. Childhood cancer incidence in relation to distance from the former nuclear testing site in Semipalatinsk, Kazakhstan. *International Journal of Cancer* 1994; 59(4): 471-475.

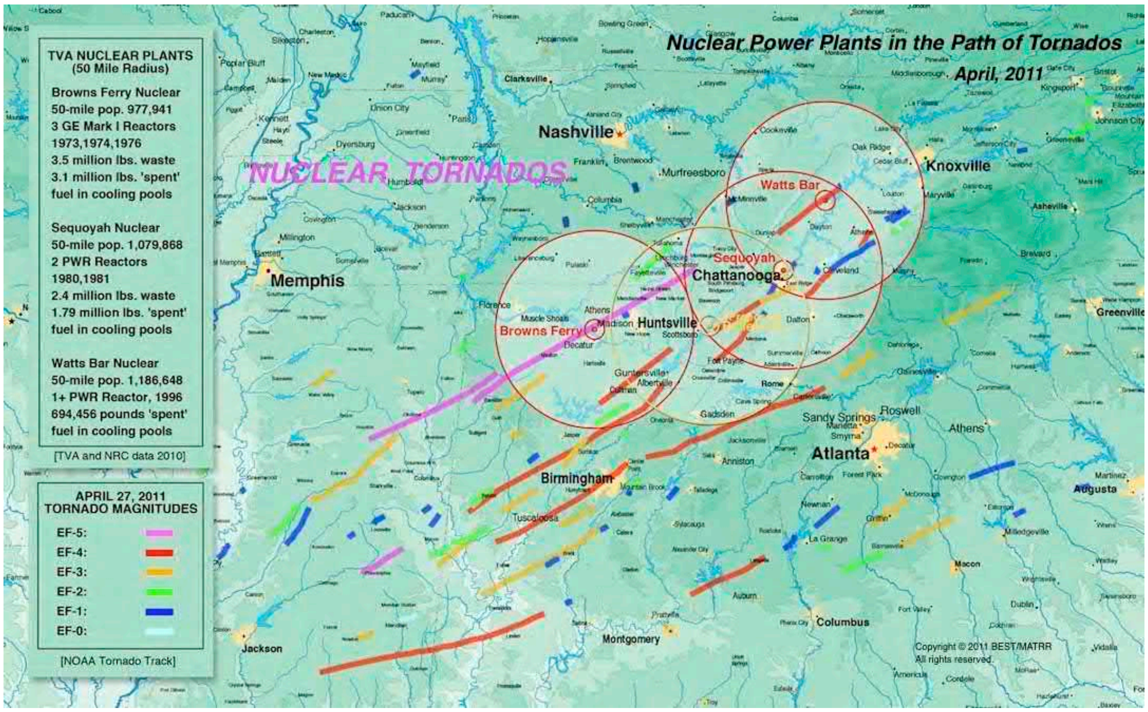
Mangano JJ, Sherman J, Chang C, Dave A, Feinberg E, Frimer M. Elevated childhood cancer incidence proximate to U.S. nuclear power plants. *Archives of Environmental Health* 2003; 58(2): 74-82.

Spix C, Schmiedel S, Kaatsch P, Schultze-Rath R, Blettner M. Case-control study on childhood cancer in the vicinity of nuclear power plants in Germany 1980-2003. *European Journal of Cancer* 2008; 44(2); 275-284.

Sermage-Faure C, Laurier D, Goujon-Bellec S, Chartier M, Guyot-Goubin A, Rudant J, et al. Childhood leukemia around French nuclear power plants – the Geocap study, 2002-2007. *International Journal of Cancer* 2012; 131(5): E769-E780.

APPENDIX 2: NUCLEAR POWER PLANTS IN THE PATH OF TORNADOS APRIL 27, 2011

50 Mile Radii of Nuclear Power Plants in the Tennessee Valley and 2011 Tornado Tracks



Sources: NOAA Tornado Tracks http://www.srh.noaa.gov/srh/ssd/mapping/; Bill Dedman, NBC News, "Nuclear Neighbors: Interactive Map," http://www.srh.noaa.gov/srh/ssd/mapping/; Pam Sohn, "Nuclear Waste Piling Up in Region," http://www.timesfreepress.com/news/2010/mar/22/nuclear-waste-piling-up-in-region/ Nuclear Tornados map created by Roy Simmons for BEST/MATRR, May 2011.

APPENDIX 3: RADIOACTIVE LEAKS AT BROWNS FERRY NUCLEAR PLANT

Record of leaks and spills at TVA's Browns Ferry Nuclear Power Plant near Decatur, AL.

In chronological order, 1973 - 2010

Sources: Union of Concerned Scientists (UCS), "Groundwater Events Sorted by Location," September 29, 2010, http://www.ucsusa.org/assets/documents/nuclear_power/Groundwater-Events-Sorted-by-Location.pdf

1. 1973, October 19

Browns Ferry Unit 1 About 1,400 gallons of liquid radwaste of unknown, unanalyzed concentration was inadvertently discharge to the river due to personnel error. The liquid radwaste tank was intended to be placed in recirculation mode but was mistakenly placed in discharge mode.

2. 1977, January 4

Browns Ferry Unit 1 A leak in a residual heat removal heat exchanger allowed radioactive water to be released to the river at levels exceeding technical specification limits.

3. 1978, July 15

Browns Ferry Unit 1 After the unit was shut down for maintenance, the residual heat removal system was placed in operation to assist shut down cooling of the reactor vessel water. Workers determined that a residual heat removal heat exchanger had a tube leak and that radioactively contaminated water was being discharged to the Tennessee River "at a rate above permissible limits."

4. 1983, January 16

Browns Ferry Unit 3 A leaking tube in a residual heat removal heat exchanger allowed radioactive water from the reactor coolant system to be released to the river at levels exceeding technical specification limits.

5. 2001, January 00

Browns Ferry Unit 3 Tritium levels greater than baseline values were detected in an onsite monitoring well west of the Unit 3 condenser circulating water conduit in the radwaste loading area.

6. 2005, March 00

Browns Ferry Unit 1 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

7. 2005, March 00

Browns Ferry Unit 2 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

8. 2005, March 00

Browns Ferry Unit 3 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

9. 2005, November 00

Browns Ferry Unit 1 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

10. 2005, November 00

Browns Ferry Unit 2 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

11. 2005, November 00

Browns Ferry Unit 3 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

12. 2006, February 00

Browns Ferry Unit 1 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

13. 2006, February 00

Browns Ferry Unit 2 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

14. 2006, February 00

Browns Ferry Unit 3 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

15. 2008, January 05

Browns Ferry Unit 3 The condensate storage tank overflowed due to failed tank level instrumentation. The spilled water flowed into the sump in the condensate piping tunnel, triggering a high level alarm that prompted workers to initiate the search that discovered the overflow condition. Some of the spilled water may have permeated through the pipe tunnel into the ground.

16. 2010, April 07

Browns Ferry Unit 3 Approximately 1,000 gallons of radioactively contaminated water leaked from Condensate Storage Tank No. 5 as workers were transferring water between condensate storage tanks. A worker conducting routine rounds observed water leaking from an open test valve near the top of CST No. 5.

APPENDIX 4: REQUEST TO SUSPEND BROWNS FERRY OPERATING LICENSE

Blue Ridge Environmental Defense League

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October 7, 2011

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RE: § 2.206 Request for Action to Suspend GE Mark I Boiling Water Reactors Operating Licenses due to Flawed Primary Containment and Unreliable Back-up Electric Power Systems for Cooling Spent Fuel Pools

Pursuant to 10 CFR § 2.206, the Blue Ridge Environmental Defense League ("BREDL" or "Petitioner") hereby submits written testimony regarding our June 7, 2011 joint petition request to the Nuclear Regulatory Commission for emergency enforcement action. The purpose of this request is to have NRC protect public health and safety through the prompt and thorough evaluation of safety problems at the Browns Ferry Nuclear Plant operated by the Tennessee Valley Authority near Athens, Alabama. BREDL is one of the co-petitioners ("Petitioners") to the Beyond Nuclear petition ("Petition") submitted on April 13, 2011. These remarks identify the enforcement action requested and the facts that BREDL believes are sufficient grounds for NRC to take enforcement action at Browns Ferry.

The Petitioners request that the NRC immediately suspend the operating licenses of General Electric (GE) boiling-water reactor (BWR) Mark I units to ensure that public health and safety is not unduly jeopardized. The Petition focuses on the unreliability of the GE BWR Mark I containment system to mitigate a severe accident and the lack of emergency power systems to cool high density storage pools and radioactive reactor fuel assemblies.

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Two items recommended by the NRC for further review; specifically, the possible overheating of radioactive fuel pools during an emergency and the loss of power such as the recent tornado-caused black outs. The GE Mark I irradiated fuel pools are located at the top of the reactor building and currently do not have backup power if offsite and onsite electrical power were lost simultaneously. Other petition items accepted by the NRC for review are: 1) the failure of the Mark I to prevent radioactive contamination of the atmosphere and ocean, 2) failure of the hardened vent system to cope with a severe accident and 3) the threats posed by rising river water at reactors located in flood plains.

Background

On April 13, 2011, Beyond Nuclear filed a petition for an enforcement action under 10 CFR 2.206. On April 19, 2011, the Petition Review Board denied the request for immediate action only. On or about June 7 BREDL and others submitted copetitioners requests. The PRB held a public meeting June 8. Over 3,000 co-petitioner requests were received by the NRC following the June 8 public meeting. On August 16, 2011, the Petitioners were informed of the Petition Review Board's decision to accept in part the petition for review.

Enforcement action requested

The Petition seeks to suspend the operation of the General Electric Mark I Boiling Water Reactors, which are almost identical to the Fukushima reactors that melted down in Japan. Petitioners ask that the Mark I reactors cease operations until several emergency actions are taken including: 1) that the NRC revoke the 1989 prior approval for all GE Mark I operators to voluntarily install the same experimental hardened vent systems on flawed containment structures that the Fukushima catastrophe demonstrates to

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have a 100% failure rate and; 2) that the agency immediately issue Orders requiring all U.S. Mark I operators to promptly install dedicated emergency back-up electrical power to ensure reliable cooling systems for the densely packed spent fuel pools. The GE BWR fuel pools are located at the top of the reactor building and currently do not have backup power if offsite and on-site electrical power were lost simultaneously.

Further, BREDL seeks the following specific actions: 1) NRC should order TVA to evaluate pressure suppression containment venting to determine whether the Browns Ferry Nuclear Plant should be allowed to continue operation. 2) NRC should issue an order to TVA to inspect control rod blades at Browns Ferry and not merely rely on the suggestion in an Information Notice; and 3) The NRC should order TVA to eliminate the existing unsafe irradiated fuel storage system at Browns Ferry and move the fuel to hardened storage in concrete structures.

In accordance with 10 CFR 2.202(e)(1), these orders would involve the modification of a part 50 license and are backfits; therefore, the requirements of § 50.109(a)(5) are to be followed; i.e., "The Commission shall always require the backfitting of a facility if it determines that such regulatory action is necessary to ensure that the facility provides adequate protection to the health and safety of the public and is in accord with the common defense and security." TVA is subject to the Commission's jurisdiction.

Facts Supporting Enforcement Action

- ***Reactor Containment***

The GE Mark I reactor was badly designed. To correct a fundamental flaw, pressure suppression containments systems were added to these plants in order to prevent high

pressures inside the reactor containment building during an accident. To do this, the direct torus vent system was designed to release steam—unfiltered and radioactive—directly to the atmosphere. Banning such dangerous pressure suppression methods and substituting safer dry containments was proposed by a few principled nuclear engineers, but their advice fell on deaf ears because it would, "[M]ake unlicensable the GE and Westinghouse plants now in review."[1] Today, some principled engineers persist in this quest to turn the NRC back from the dark side of promoting nuclear power to regulating it. This year, Arnold Gundersen stated the case most eloquently to the Advisory Committee on Reactor Safeguards:

Everyone sitting on the ACRS today knows that the pressure suppression

> containments on General Electric BWR's were inadequate when they were first designed. As a result of that design inadequacy, boiling water reactor containment vents were added in 1989 to prevent containment overpressurization. Currently there are 23 Mark 1 containment systems in operation. All 23 Mark 1's have vents that were added as a Band-Aid fix. It is time for the ACRS to evaluate containment venting to determine whether or not it any of these reactors be allowed to continue operation. [2]

The nuclear disaster at Fukushima Dai-ichi lends an urgency to the immediate question: What will it take to convince the NRC to prevents a similar disaster in the United States? Germany, when faced with the issue of providing energy with adequate protection to the health and safety of the public and in accord with the common defense and security said *no* to the nuclear power program in its entirety.

Further, it is just plain wrong to posit, as the NRC does, that no radioactive leaks are associated with the GE Mark I reactor pressure suppression containments systems. To avoid exceeding the primary containment pressure limit, that is what they are designed to

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1 Note from Joseph M. Hendrie to John F. O'Leary, September 25, 1972.

2 Statement of Arnold Gundersen, Advisory Committee on Reactor Safeguards Subcommittee on Fukushima, Official Transcript of meeting of May 26, 2011, NRC HQ, Rockville, MD, ADAMS Accession No. ML11147A075

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do in an accident. Based on his post-Fukushima findings, Gundersen served up crow to the committee:

> In December of 2010 I wrote to you again notifying you of a significant amount of additional information about containment failures and flaws because at the October 2010 ACRS meeting, the NRC staff informed the ACRS that the NRC's calculations assume that there is zero leakage in the Mark 1 design. Each time I have contacted you, the containment integrity data has been rebuffed and ignored. The accidents at the Fukushima Mark 1 BWR reactors have confirmed my belief that leakage of a nuclear containment cannot be based upon the assumption of a leakage rate of zero used by the NRC. This week, Tokyo Electric Power Company (TEPCO) has finally acknowledged that all three of the Fukushima Mark 1 containment systems are leaking significant radiation into the environment, and at least Units 1 and 2 began leaking on the first day of the accident. Unfortunately, the possibility of such containment failures, to which I have alerted you for the past six years, have been proven correct.[3]

If indeed United States were unable to license nuclear plants without pressure suppression containment Band-Aids, then perhaps Germany's example is correct. The NRC should order TVA to evaluate pressure suppression containment venting to determine whether the Browns Ferry Nuclear Plant should be allowed to continue operation.

- ***Control Rod Cracks***

Plant inspections done by the manufacturer indicate that the Browns Ferry Nuclear Plant suffers from cracking of the control rods necessary for shutting down the reactor. Based on this information, the manufacturer predicts that the control rods will fail sooner. An NRC Information Notice (IN) issued in June 2011 states:

> The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees that GE Hitachi Nuclear Energy (GEH) has discovered severe cracking in Marathon control rod blades (CRBs) near the end of their nuclear lifetime limits in an international BWR/6. As a result of investigations into the cracking, GEH has determined that the design life of

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3 Statement of Arnold Gundersen, Advisory Committee on Reactor Safeguards Subcommittee on Fukushima, Official Transcript of meeting of May 26, 2011, NRC HQ, Rockville, MD, ADAMS Accession No. ML11147A075

> certain Marathon CRBs may be less than previously stated and is revising the end-of-life depletion limits of these CRBs. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems.[4]

Not only did 100% of the control rods inspected suffer from cracking, the damage was more widespread and more serious than previously known. The Information Notice continued:

> In August 2010, GEH, as part of its surveillance program to monitor Marathon CRB performance, visually inspected four discharged CRBs at an international BWR/6 and found cracks on all four CRBs. The cracks were much more numerous and had more material distortion than those observed in previous inspections of Marathon CRBs. The cracks were also more severe in that they

> resulted in missing boron-carbide capsule tube fragments from two of the inspected CRBs.[5]

The list of suspect plants includes Browns Ferry 1, 2 and 3 and sixteen more GE Mark I BWRs: Cooper, Dresden 2 and 3, Duane Arnold, Fitzpatrick, Hatch 1 and 2, Monticello, Nine Mile Point 1, Oyster Creek, Peach Bottom 2 and 3, Pilgrim, Quad Cities 1 and 2, and Vermont Yankee.[6] Based on this evidence, 83% of the GE Mark I reactors in the United States are likely operating with cracked control rod blades.

Analysis of the missing fragments found in two of the four control rods inspected uncovered no negative effects on plant performance; however, to make this finding at Browns Ferry or the other affected plants would require individual reactor testing.

Browns Ferry was TVA's first nuclear power plant. The initial design life-span of nuclear plants is 30 to 40 years. All three Browns Ferry units are approaching the forty-year mark: Unit 1 began commercial operation on August 1, 1974, Unit 2 on March 1, 1975 and Unit 3 on March 1, 1977. NRC renewed the operating licenses for all three

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4 NRC Information Notice 2011-13: Control Rod Blade Cracking Resulting in Reduced Design Lifetime, June 29, 2011, ADAMS Accession No. ML111380019
5 *Id.*
6 The other four listed in the IN are Clinton, Grand Gulf, Perry and River Bend.

Browns Ferry reactors in May 2006, allowing TVA to continue operating them until 2033, 2034, and 2036, respectively. The new information regarding control rod cracks came after the renewal.

Control rod mismanagement was involved in at least two major nuclear accidents, at the Argonne Low Power Reactor and Chernobyl. The history of Chernobyl is familiar; less well known are events at Argonne, where the improper withdrawal of the control rod mechanism at the Army's experimental reactor in Idaho caused an explosion which killed three operators and released 1100 curies of fission products into the atmosphere.[7] In four milliseconds this small reactor went from 200 kilowatts power to 20 million kilowatts.[8] Although the NRC Information Notice includes no specific enforcement, it does point to the NRC's expectation that plant operators will act to avoid control rod problems caused by these flaws. NRC should issue an order to TVA to check these components and not merely rely on the IN suggestion.

- ***Irradiated Fuel Pool Danger***

TVA stores Browns Ferry's radioactive fuel rods in pools on upper levels of the plant. Over 1,415 metric tons of irradiated fuel in three pools is covered by a heavy metal sheet buildings on a concrete pad above the plant. As with most plants, water in the fuel pools is circulated by electric pumps. If the plant is scrammed and off-site power and electric back-ups fail, the fuel would heat the water, turning it to steam.

The area above the spent fuel pool is not designed to withstand high winds from tornadoes and hurricanes. As stated by an NRC spokesman, "The design of the Browns

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7 Horan, J. R., and J. B. Braun, 1993, *Occupational Radiation Exposure History of Idaho Field Office Operations at the INEL*, EGG-CS-11143, EG&G Idaho, Inc., October, Idaho Falls, Idaho (retrieved 10/6/11 from Wikipedia).
8 Steve Wander (editor) (February 2007) "Supercritical" *System Failure Case Studies* (NASA) **1** (4). http://pbma.nasa.gov/docs/public/pbma/general/sl1_sfcs.pdf (retrieved 10/6/11 from Wikipedia)

Ferry spent fuel pool has blowout panels. In case of a tornado where you have differential pressure across the wall, the panels would blow off and minimize any damage."[9]

On April 27, 2011 tornadoes knocked out TVA's electric power transmission lines in Mississippi and northern Alabama, causing an emergency and automatic cold shutdown of the Browns Ferry Nuclear Plant. The plant was forced to rely on diesel backup power for seven days.

> One NRC inspector told the audience that those containments were upgraded for assaults such as that on the heels of the Sept. 11, 2001, terrorist attacks. But David Lochbaum, a former TVA nuclear engineer and a former NRC training instructor, took that answer to task. "That's not accurate," said Lochbaum, a Chattanoogan who now works for the Union of Concerned Scientists. "It may be reassuring, but it's not accurate." The 9/11 changes "were only about airplanes," not multiple problems such as what the tornadoes caused or could

have caused if one had made a direct hit on the plant, he said. [10]

The NRC should order TVA to eliminate the existing unsafe irradiated fuel storage system and move the fuel to hardened storage in concrete structures.

• ***Need for Action Indicated by Record of Violations***

During the last few years, TVA has compiled an unenviable record of compliance at Browns Ferry.

On May 9, 2011, the NRC issued to TVA a violation (EA-11-018) for failure to implement an In-Service Training program for its engineers at Browns Ferry. More than a training exercise, this management failure led to an operational failure in which the RHR loop II subsystem was unable to fulfill its safety function due to a failure of LPCI

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9 NRC Region II Administrator Victor McCee, "Tornado Concerns Raised At Browns Ferry Nuclear Plant" WHNT-TV, Huntsville, AL, May 31, 2011, retrieved 10/6/11 from http://www.whnt.com/news/whnttornado- concerns-raised-at-browns-ferry...
10 "Regulators say TVA's Browns Ferry Nuclear Plant safe to operate" *Times-Free Press* October 4th, 2011

Outboard Injection Valve. The malfunctioning valve was not discovered for a year and a half. The violation was of Red Significance. The system is necessary for reactor core cooling during accidents and the valve failure left that system inoperable, potentially leading to core damage had an accident involving a certain series of events occurred.

On April 19, 2010, NRC issued Notice of Violations (EA-09-307) to TVA at Browns Ferry for failure to meet the requirements of 10 CFR 50, Appendix R, III.G, fire protection of safe shutdown capability. The violations were of Yellow and White Significance. There were multiple examples of TVA not providing fire protection capable of limiting damage to the plant. In 1974 a worker using a candle to check for air leaks started a fire that disabled safety systems at Browns Ferry Nuclear Plant.

On May 12, 2004, NRC issued to TVA a Notice of Violation (EA-04-063) for Severity Level III violations at Browns Ferry. Numerous problems in the Long-Term Torus Integrity Program were cited for failures to perform numerous weld repairs; omission of welds requiring repair; and failure to verify the location of repaired welds.

These violations support our request that regulatory action by the NRC is necessary to ensure that operations at Browns Ferry provide adequate protection to the health and safety of the public and are in accord with the common defense and security.

Respectfully submitted,

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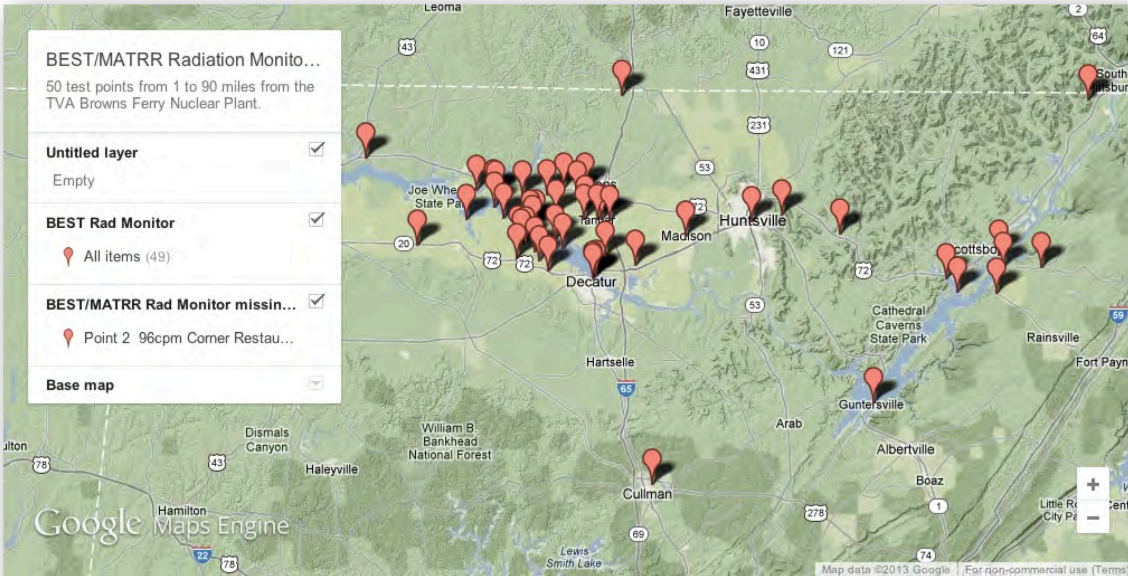
Esse quam videre

APPENDIX 5: BEST RADIATION MONITORING TEST SITES



As of publication, June 2013, the BEST/MATRR Radiation Monitoring Project had established 50 field test sites around Browns Ferry Nuclear Power Plant, and had recorded readings of radiation counts per minute (CPM) at each of the sites, some multiple times and under varying weather conditions. Test sites circled the plant and worked outward to determine plume paths. The distances range from under one mile to over 90 miles from the plant, and the readings on the Inspector™ geiger counter ranged from backgrounds of 32 to over 1600 CPM.

BEST/MATRR is a chapter of the Blue Ridge Environmental Defense League (BREDL), whose Executive Director, Lou Zeller, began group project training using EPA protocols and is BEST monitoring project Quality Assurance Officer. The Project Manager, Garry Morgan, is retired from the Army Medical Department with experience and training in Radiation Protection, Nuclear, Biological and Chemical Decontamination and Emergency Response in military and civilian medical care settings. Mr. Morgan expanded the training and procedures to include Department of Defense, Department of Homeland Security and State of Alabama Department of Health Radiation Control protocols.

BEST/MATRR Radiation Monitoring Project information and downloadable copies of *A Citizen's Guide to Monitor Radioactivity,* and our intended companion manual, *BEST Radiation Monitoring Manual* are available online at http://RadiationMonitors.blogspot.com. In addition, BEST project director, Garry Morgan, recorded several videos of field tests which are also available online at http://RadiationVideos.blogspot.com. The above map of BEST Radiation Monitoring Test Sites, also created by Morgan, may be viewed online using an interactive Google map showing CPM readings at https://mapsengine.google.com/map/edit?mid=zUriF2xNKAQ4.kc_DIj9TCDyM

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Susquehanna Spent Fuel Pool Concerns, and How I Ended Up at UCS

April 21, 2011

Dave Lochbaum
Former contributor

In November 1992, Don Prevatte and I submitted a report to the NRC regarding our concerns with spent fuel pools at boiling water reactors (BWRs), of which 35 are operating in the US. We had been consultants working on a team to evaluate the proposed increase in the maximum power level of the two BWRs at the Susquehanna nuclear plant in Pennsylvania. My assignments included the spent fuel pool cooling and cleanup system while Don's assignments included the reactor building ventilation system. While reviewing each other's work, we uncovered a problem.

system was designed to cool rooms and areas in event of an accident to protect emergency equipment from damage caused by high air temperatures.

The design calculation for the reactor building ventilation system considered heat emitted by operating motors, heat emanating from piping filled with hot water, and heat given off by incandescent light bulbs. Collectively, these heat sources amounted to 5.2 million BTUs per hour (a British Thermal Unit, or BTU, is defined as the amount of heat needed to increase the temperature of one pound of water by one degree Fahrenheit).

The cooling system for the reactor building ventilation system was sized to accommodate this amount of heat removal, thus ensuring that emergency equipment would not overheat and fail.

But the design heat load from irradiated fuel stored in the spent fuel pool was 12.6 million BTUs per hour, meaning the spent fuel could emit up to that much heat. Under normal operation, that heat would be carried out of the building by the cooling system. However, safety analyses assume the spent fuel pool cooling system will not be operating during a reactor accident. In that case there would be no heat added to the reactor building from the spent fuel pool pump motors and piping, but without cooling the spent fuel pool water would heat up, boil, and release heat into the reactor building air. A lot of heat—considerably more heat than that present in the reactor building from all other sources, and far more than the cooling system could handle.

The water boiling off the spent fuel pool would condense and drain down into the basement of the building where it would submerge and disable emergency equipment—at least the emergency equipment that had not already been disabled accident would prevent workers from entering to open the manual valves that supply makeup water to the spent fuel pool.

Hence, a reactor accident would lead to a spent fuel pool accident. And the boiling spent fuel pool would create conditions inside the reactor building that would disable the emergency equipment needed to cool the reactor core.

As Don and I investigated further, more problems surfaced. Susquehanna's owner initially justified the situation by saying that the non-safety-related spent fuel pool cooling system would remove the heat, even though it was not credited as doing so in the safety studies. Indeed, we found that emergency procedures directed the operators to open two electrical breakers within an hour of an accident to shut down all non-emergency systems inside the reactor building.

We also found that the standby gas-treatment system—a ventilation system located inside the reactor building that processes air discharged to the atmosphere to reduce its radiation levels by a factor of 100—would shut down if the spent fuel pool water approached boiling because the warm vapor evaporating from the pool would trick sensors into thinking there was a fire, causing inlet dampers to close. And we found that if the spent fuel pool cooling system was not operating, the operators would have no indications of the level or temperature of the water in the spent fuel pool.

The NRC failed to take our report seriously. They didn't even read it. We had attached all the relevant correspondence between us and the plant's owner to the report. I made two-sided copies of many of the 35 attachments to save postage costs. But when I took the original report to a copy shop, they mistakenly made single-sided copies and left out every other page. The NRC dismissed our concerns at

Don and I wrote letters summarizing the spent fuel pool problems to the governors and US senators in the states with BWRs like Susquehanna. We also sent letters to the three congressional committees that oversee the NRC. Congressmen Phil Sharp wrote several letters to the NRC about our concerns, as did several governors and US senators. The NRC granted our request for a public meeting for us to communicate our concerns to the agency. About 15 minutes into that meeting on October 1, 1993, the NRC project manager for Susquehanna was sound asleep and snoring in the first row.

The issues were resolved at Susquehanna by the owners' commitment to always operate with the spent fuel pools connected to each other. In case of an accident involving the Unit 1 reactor core, the systems on Unit 2 could be used to cool both spent fuel pools without adversely affecting conditions inside the Unit 1 reactor building, and vice-versa. The owner also took steps to install additional instrumentation to enable operators to monitor spent fuel pool water levels and temperatures and resolve the standby gas treatment system design issues.

However, little to nothing has been done to address the spent fuel pool vulnerabilities at other BWRs in this country.

Following this incident, I authored *Nuclear Waste Disposal Crisis*, a book about spent fuel storage issues. It was released by PennWell Publishing in January 1996. Chapter 8 outlined spent fuel pool safety issues. Chapter 9 detailed our spent fuel pool concerns at Susquehanna. And Appendix A summarized actual spent fuel pool problems that occurred at U.S. nuclear power reactors.

The tragedy at Fukushima Dai-Ichi involved many of the same concerns Don and I raised at Susquehanna. It appears

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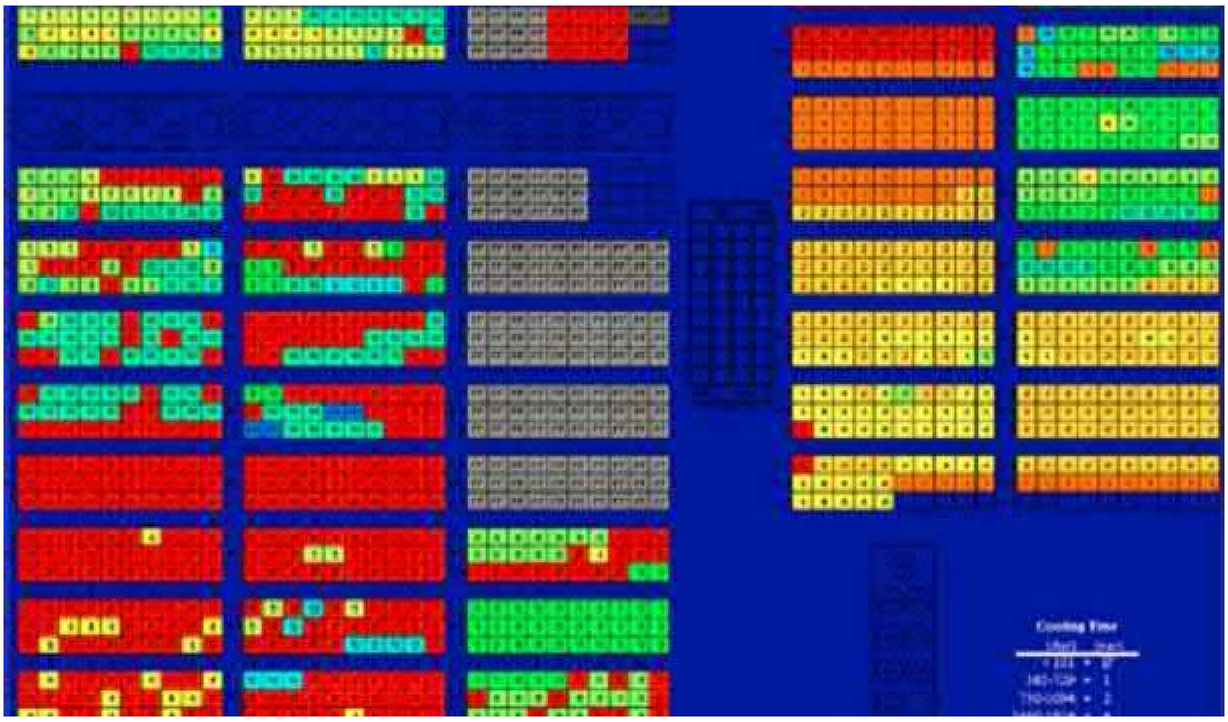
RISKS OF DENSELY PACKED SPENT FUEL POOLS



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by Allison Macfarlane
May 19, 2017

I. INTRODUCTION

This essay by Allison Macfarlane argues that "the back end of the fuel cycle, especially at reactors, has not received the attention to safety and management it needs. Management of spent fuel after discharge from the reactor requires careful thought and safety analysis. Surprisingly, regulators in some countries have taken a laissez-faire attitude to the back end of the fuel cycle at reactors."

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This Special Report was prepared for the *Project on Reducing Risk of Nuclear Terrorism and Spent Fuel Vulnerability In East Asia*. It was presented at a Nautilus Institute Workshop at International House, Tokyo, September 14-15, 2015, funded by The Macarthur Foundation.

The views expressed in this report do not necessarily reflect the official policy or position of the Nautilus Institute. Readers should note that Nautilus seeks a diversity of views and opinions on significant topics in order to identify common ground.

Banner Image Credit: Decay Heat of Fuel Inventory Fukushima Spent Fuel Pool 4, from Nuclear Energy Agency, 2015, Status on Spent Fuel Pools under Loss-of-Colling and Loss-of-Coolant Accident Conditions, Nuclear Safety NEA/CSNI/R(2010)2, May 2015, OECD, p.72, here.

II. SPECIAL REPORT BY ALLISON MACFARLANE

RISKS OF DENSELY PACKED SPENT FUEL POOLS

May 19, 2017

Introduction

Nuclear reactors need spent fuel pools to safely store spent nuclear fuel after discharge from a reactor core. Once discharged, the spent fuel is both thermally and radioactively hot and needs the cooling, shielding, and criticality protection provided by the pool.

The pools themselves are similar to very deep swimming pools. In fact, in some reactors divers "swim" in the pools to perform maintenance on them. In some countries, once spent fuel has cooled at least 5 years, it can be transferred to dry casks for passive cooling. Until then, the spent fuel needs the active cooling provided by the circulation of cool water in the pool. As a result, spent fuel pools are necessary equipment at nuclear power reactors.

At the same time, in a number of countries, spent fuel management practices over time have pushed the envelope of pool performance, packing in more and more spent fuel into the same small volume in an effort to deal with large quantities of used fuel. No country has yet developed and operationalized a "final solution" for its high-level nuclear waste, but experts agree that some kind of deep geologic repository will be the solution. Sweden and Finland are furthest along the path to building and eventually opening a mined geologic repository. In the meantime, spent fuel continues to pile up at reactor sites around the world. Some countries largely keep spent fuel in pools at reactors, such as the U.S., some move spent fuel into dry storage, like the U.S. and Germany, some operate away-from-reactor centralized storage sites such as Germany and Sweden, and a few send spent fuel to reprocessing facilities like the U.K. and France.

As spent fuel pools are central to the operation of a nuclear power plant, as large quantities of spent fuel have accumulated in these pools, and given recent safety and security concerns, it is reasonable to address the safety of these facilities. The question addressed here is to what degree and in which circumstances spent fuel pools pose potential threats. I will place this issue in the larger issue of spent fuel management practices in general and discuss spent fuel management practices in a variety of countries.

Technical Background

Spent Fuel Pools

Spent fuel pools in light water reactors are usually located outside of containment, the thick concrete and steel reinforced structure that provides an additional line of defense in preventing radioactive contamination from a reactor accident (Figures 1-4). This is true for all designs except Russian VVER-1000's, AREVA's EPR, and the German KONVOI or pre-KONVOI designs, in which the pool is located within the containment (Nuclear Energy Agency, 2015). As a result, for most operational power reactors, in the event of a spent fuel pool accident, radioactivity would be more likely to reach the surrounding environment than with a reactor accident.[1] Additionally, many spent fuel pools are located at or above grade at the site. In the case of General Electric Boiling water reactors of the Mark I and Mark II designs, pools are located at the top floor of the reactor building, often 4 or 5 stories in the air (Figures 1-2).

Figures 1 and 2: GE Boiling water reactors. Figure 1 on left is Mark I design, Figure 2 on right is Mark II design. In Mark I, spent fuel pool into upper right of reactor vessel; in Mark II, spent fuel pool is to the upper left of the reactor. Containment in both is the flask-shaped area outside of the red/orange reactor vessel. From NRC, undated.

Figure 3: GE Boiling water reactor, Mark III design. Spent fuel pool is to the right of the reactor, number 20, outside the main containment. From NRC, undated.

Figure 4: Pressurized water reactor and pool. Pool is to the right in the cartoon – outside the containment. From http://www.nucleartourist.com/images/refuel-bldg.gif.

Pools are made from thick reinforced concrete and have stainless steel liners to prevent leaks. Pool size varies widely between and among reactor designs. In some cases two or more reactors share a single pool. Some reactor sites have more than one storage pool on site. Pool depth is in the 12 m range and fuel is loaded in racks in the lower portion of the pool and has about 7 m of water above it (Nuclear Energy Agency, 2015). Boiling water reactors (BWRs) and pressurized water reactors (PWRs) differ in types of pool racks and method of radiation or reactivity control.

Racks in both PWR and BWR spent fuel pools can be open or closed designs (Figures 5-6). The open frame racks (often the original design) depend on water flow and distance between fuel assemblies in part for criticality control.[2] As space to store more spent fuel was required over the reactor's lifetime, racks were converted to higher and higher density designs. In PWRs, for instance, they went from a 41-53 cm spacing between the centers of two fuel assemblies in a open frame rack to a 26 cm spacing in a high density rack (Nuclear Energy Agency, 2015). In the high-density PWR and BWR racks, criticality control is done by borated absorber (a metal plate impregnated with boron, an element that captures stray neutrons) between or within the stainless steel rack wall. These high-density racks do not allow for lateral or cross-flow of water between fuel assemblies. Water flow is vertical, convective within each separate fuel assembly cell. PWR pools use borated water in the pools while BWR pools use demineralized water. And unlike PWRs, BWR assemblies are gathered in a metal sheath that directs the water up the channel and provides support to the assemblies and the associated control rods (NRC, undated) (Figure 7).

Figure 5: High density storage racks for PWRs. From NEA, 2015.

Figure 6: Storage racks for BWRs. From NEA, 2015.

Figure 7: BWR fuel assemblies, showing the metal sheath surrounding the assemblies. From NRC, undated.

Most spent fuel pools are actively cooled with a system of heat exchangers and pumps. The water lines into the pools tend to enter the pools near the top to avoid the potential to inadvertently drain the pool (Nuclear Energy Agency, 2015). These systems are usually attached to backup diesel generators in the case of offsite power loss. Moreover, additional pumps and heat exchangers may be located on site in the case of emergency.

Spent fuel pools usually have instruments that measure water level and temperature and feed this information to the control room operators. Usually, the maximum allowable temperature in spent fuel pools during operation (and especially refueling outages) is 60 °C (Nuclear Energy Agency, 2015). As a result of the Fukushima accident, the US Nuclear Regulatory Commission (NRC) now requires all spent fuel pools in the US to have independent water level controls that can provide water level measurements under station blackout conditions.

Spent Fuel Loading

Spent fuel is loaded into pools after use in the reactor via use of overhead cranes. Fresh fuel is often also stored in pools, awaiting use in reactors. BWRs, VVERs, and German PWRs use transfer canals to move spent fuel from the reactor to the pool, allowing fuel to be moved in a vertical manner. If water is lost from the transfer canal, this can directly affect water level in the pool itself. For PWRs, fuel is transferred horizontally using a transfer tube (Figure 4), which uses a much smaller volume of water and as a result, leaks from the transfer tube won't affect the spent fuel pool water level very much (Nuclear Energy Agency, 2015).

Many reactor pools maintain space to offload the entire contents of the reactor core (or in the case that one pool is shared by two or more reactors, two or more full cores) in the case of emergency or necessity. The US NRC does not require this of their licensees, and a handful of reactors in the U.S. do not have this capability.

Spent fuel loading patterns may directly affect the potential for an accident in the case of a loss of cooling or coolant accident.

Emplacing newly discharged spent fuel assemblies next to each other in one portion of the pool can concentrate heat and pool heat load is highest just after a full core is loaded into the pool, but sometimes it is easier and cheaper to place spent fuel in one location in the pool (in the place where the fresh fuel was stored, for instance).

Some plants, such as the Koeberg nuclear power facility in South Africa use special reinforced racks for freshly discharged spent fuel. Others disperse newly discharged spent fuel into 1 x 4 or 1 x 8 patterns, in which a hot, newly discharged assembly is surrounded by 4 or 8 old cold assemblies (Figure 8). The US NRC, in a recent modeling study, showed the benefits of 1 x 4 and 1 x 8 dispersal patterns over other patterns (NRC, 2014a). The study showed that in the case of the Peach Bottom reactor in Pennsylvania, dispersing hot fuel into a 1 x 8 pattern provided the best pool heat management over surrounding the hot assembly with only 4 cold assemblies or even no assemblies or open rack space. The cold fuel surrounding the hot assembly provides a cold sink for the heat, dissipating the heat in the pool. The 1 x 8 pattern does not decrease time needed in the pool, which is controlled by the decay of short-lived radionuclides.

Figure 8: Alternative spent fuel loading patterns for pools. From NEA, 2015.

In the US, for instance, reactors are encouraged to achieve a 1 x 4 pattern, but are not required to do so. US reactors will tend to disperse permanently discharged fuel into at least a 1 x 4 pattern, though this information is not actually tracked by the US NRC. On the other hand, many U.S. PWRs, when discharging a full core, do not do so into a dispersed pattern, opting instead to discharge into a single area of the pool. They will keep the full core in the same location in the pool for the duration of the outage (NRC, 2014b).

Pool Management Practices

Spent fuel pool management practices vary by country. I include a few countries here to illustrate the variety of ways to manage spent fuel in the nuclear fuel cycle.

Canada: Unlike all other countries listed, Canada operates CANDU reactors that use heavy water as a coolant and moderator. As a result, spent fuel cannot go critical in spent fuel pools filled with “light” water, so the spent fuel pool’s function is to maintain thermal and radiation control only. Spent fuel bundles are discharged to spent fuel pools and cooled there for 7-10 years, then transferred to dry storage facilities at reactor sites. In response to the Fukushima accident, Canadian operators have added equipment to reactor sites that can be transported to the pools to add water if needed. They have also installed hydrogen removal equipment to pools that can operate without external electrical power (Canadian Nuclear Safety Commission, 2015).

France: France reprocesses its spent fuel. As a result, it transfers its spent fuel from reactor sites within a few years after discharge to the La Hague reprocessing facility via train. At La Hague, the spent fuel is stored in large cooling pools for another few years before it is reprocessed. Spent MOX spent fuel is also transported back to La Hague after a longer period of cooling in reactor pools, but this fuel is not currently reprocessed (IPFM, 2011).

Germany: Germany reprocessed much of its spent fuel in the facilities in France and the UK until 2005. Since then, it has stored spent fuel at reactor sites and in centralized storage facilities. Most spent fuel is in dry storage at reactor sites (GAO, 2012).

Japan: Japan has managed spent fuel by a variety of methods. Much spent fuel is stored at reactor sites in spent fuel pools, centralized pools at reactors, and in a modest amount of dry storage. Some spent fuel has been shipped to Japan’s Rokkasho reprocessing plant, whose pool is almost at capacity. Other spent fuel was shipped to reprocessing facilities in the United Kingdom and France for reprocessing.

Sweden: Sweden has an off-site interim storage facility, the CLAB facility located in Oskarshamn. CLAB is an underground storage pool facility, 50 m deep, with 2 large storage pools. Spent fuel is transferred to CLAB about 18 months after discharge from reactors. As a result, reactor pools do not maintain large inventories of spent fuel.

United States: Spent fuel remains at reactor sites in the United States. As a result, all spent fuel pools have high-density racks, many of which are almost full. There is no requirement to discharge into a dispersed pattern, although, according to an incomplete survey done by the US NRC, many licensees do use such a pattern.

Past Accidents

Though there have been no major accidents in which spent fuel pools feature, a few smaller-scale accidents or near misses provide interesting benchmarks to understand how such a spent fuel pool accident might progress. The most notable recent near miss was the Fukushima accident that began March 11, 2011, at the Fukushima Dai'ichi plant in Japan. Three boiling water reactor cores eventually melted down, but much concern focused on the condition of unit 4's spent fuel pool.

Unit 4's entire core was moved into its spent fuel pool for maintenance work during a routine shutdown in November 2010. At that time, the pool water temperature was 27 °C (Wang et al., 2012). When the accident occurred on March 11, the facility lost all power and entered a state of "station blackout." At this time unit 4's spent fuel pool lost active cooling. After a hydrogen explosion in unit 4's reactor building on March 15, 2011, concerns arose that the spent fuel in the pool had become so hot that the fuel cladding had reacted with steam to form hydrogen. In fact, the source of the hydrogen was unit 3's reactor, piped in via connections between the two closely spaced buildings. At the time though, many thought unit 4's spent fuel pool had lost significant water and efforts became focused on adding water to the pool. Since the reactor pool was at the top of the building, now under debris from the explosion, and radiation levels were extremely high, it was inaccessible to humans. So, alternative methods were conceived to add water to the pool. This was done most dramatically by helicopter, which flew over the unit and attempted to drop water into the pool (little of this water actually reached its target). On March 20, cranes to the pool lifted hoses from Japanese Defense Forces fire trucks and water was sprayed into the pool. By June 16, water was added to the pool with a temporary injection facility, providing a more stable form of water addition (Wang et al. 2012).

The fuel in unit 4's pool was loaded into high-density racks and the fuel discharged from the entire core was inserted into positions adjacent to each other. Measured temperatures show a marked increase after the accident – to 84 °C on March 14 to 90°C on April 12 (30 °C over the desired maximum pool temperature). By mid June, water temperatures had dropped to about 70 °C (Wang et al., 2012). No water level readings were available until mid April, when measurements show water levels of 1.8 – 2.0 m above the top of the spent fuel (Wang et al., 2012). If water level were to drop below the top of spent fuel, it could ignite and catch fire, releasing radioactivity. Modeling done by Wang and others (2012) suggests that water levels began to drop in the pool beginning around March 13 and dropped about 0.7 m/day, based on local meteorological conditions and estimated evaporation rates. If water addition had not begun by March 20, at that predicted rate of decrease, the fuel would have been uncovered by March 23, just under two weeks from loss of active cooling. This suggests that loss of cooling events at spent fuel pools are not dire emergencies that need to be addressed within hours, but slower-moving events that do require backup systems and a variety of alternative approaches to resolve.

Another spent fuel pool accident sheds light on how fuel can be damaged in a pool. The Paks nuclear power plant in Hungary experienced an INES level 3 accident on April 10, 2003 in the spent fuel pool of the unit 2 reactor. The Paks reactors are VVER-440 designs, and the fuel develops magnetite corrosion during use. The corrosion – called crud – is removed from the fuel assemblies, 30 at a time, in a tank placed at the bottom of the spent fuel pool (Figure 9). On April 10, 2003, after the assemblies were cleaned, they were not removed from the tank because the crane used to lift them was being used elsewhere. As a result, they stayed in the cleaning tank. The fuel was cooled by a pump with a low flow rate, which allowed the fuel to heat up and form steam. The steam pushed most of the water out of the cleaning tank and the fuel assemblies then, over a matter of hours, heated to over 1000 °C and were severely damaged (IAEA, 2009). The spent fuel heated so quickly in part because the tank it was kept in was small, and the water, once turned to steam, was forced out of the tank. Once the tank was discovered, it was opened, and cool pool water rushed in, quenching the overheated fuel rods, fracturing them, and releasing noble gases (the non-reactive gases like helium, neon, argon, krypton, xenon, radon) into the atmosphere around the plant. Volatile and non-volatile radionuclides, like cesium-137, were retained in the pool water and collected on filters in the pool (Hozer et al, 2009). Fission product noble gases released were xenon-133 (10^{13} Bq released per 10 min.), krypton-85 (10^{12} Bq released per 10 min.), and iodine-131 (10^{9} Bq released per 10 min.) with 99% of the total release occurring in the first 24 hours of the accident (Hozer, 2009). These products didn't stay in the pool because of their low solubility in water, but instead went out of the stack and into the surrounding atmosphere (Hozer, 2009).

Figure 9: Diagram of the Paks 2 spent fuel storage and treatment systems. From Hozer, 2009.

The Paks 2 accident suggests that even in the event of a loss of cooling or coolant accident in which spent fuel is not uncovered but damaged, some amount of radioactive release can occur. Since many spent fuel pools contain hundreds of assemblies, this release of noble gases could be significant.

Threats

Spent fuel pools must be designed to defend against three main potential threats: criticality accidents, loss of cooling accidents, and loss of coolant accidents. As explained above, criticality mitigation has become more of an issue with the rise of high-density racks. Open frame racks load fuel assemblies far enough apart so that criticality is not an issue. High density racks place fuel assemblies close enough so that neutron absorbers must be added to the rack material to prevent criticality. Some neutron absorbing materials used previously in the U.S., such as boraflex, have degraded in the spent fuel pools due to radiation damage and have caused concern about the ability to maintain reactivity control in spent fuel pools. Some pools use borated water to aid in controlling criticality. In the case of a loss of boron input and circulation in the pool, criticality may also be compromised.

Loss of cooling accidents, in which the *cooling function is lost*, and loss of coolant accidents, in which pool *water or coolant is lost* through leakage or sloshing both can pose significant problems. Spent fuel pools at "mature" power reactors pose a potential threat because of the possibility of radionuclide contamination in the event of a loss of cooling or coolant accident that involves a self-propagating zirconium cladding fire. Pools contain much higher "source terms" than reactor cores simply because, at plants that have been operating for many years, they can contain many reactor cores' worth of spent fuel. The source term for a high density pool like that of the Peach Bottom reactor in the U.S. ranges from 40 to 140 million curies of cesium-137. For perspective, the amount released by the Fukushima accident was between 0.2 to 0.8 million curies of cesium-137 (Macfarlane, 2014). The US NRC's recent modeling of a fire at the Peach Bottom pool suggested that in a high density configuration with no mitigation, the accident would affect 9,400 square miles of land, displacing over 4 million people, and result in a collective dose of 350,000 person-sieverts (NRC, 2014a).

Most studies, including the ones mentioned in this report, analyze a total loss of coolant. Few studies examine a partial loss of coolant in which there is a slow leak and the fuel becomes uncovered but the pool does not drain. In this case, fuel assemblies may not be able to take advantage of convective cooling up the cells in the high-density racks. An open-frame rack may provide cooling of fuel through convection in the case of partial drain down (Alvarez et al, 2003).

Loss of coolant accidents can result from a few scenarios: massive earthquake, cask drop, accidental plane crash, or terrorism. When analyzed by the US NRC, all events precursor events were found to have a very low probability of occurrence (see for example, NRC 2001, 2014a), even though the consequences of an accident would be high. Spent fuel pools are built robustly, and in seismically active areas, are reinforced to withstand shaking from earthquakes. Of course, they are only built to withstand the expected earthquakes and have additional margin added, and sometimes, as happened in Fukushima in 2011, at the North Anna plant in Virginia, US in 2011, and at the Kashiwaszaki-Kariwa plant in Japan in 2007, seismic building standards are exceeded by Mother Nature.

Loss of coolant accidents from cask drops need some explanation. Spent fuel is often transferred via a canister or small cask out of the pool for either dry storage or storage elsewhere (for instance, at a reprocessing facility). This is done by loading the spent fuel into a cask under water in the pool. Water is later drained and the cask removed from the pool via crane. Damage to the pool's integrity may result were the cask to drop into the pool while suspended by the crane. Casks can be heavy and if dropped from a height may exert significant force on the pool bottom or walls.

Inadvertent or deliberate plane crash could also damage spent fuel pools. Most spent fuel pools lie outside of containment and do not have the additional protection provided by such a structure. The US NRC performed a classified study of plane crashes into spent fuel pools after the attacks of September 11, 2001. They also completed classified studies of terrorist attack with high-energy weapons or explosive charges. The National Academy of Sciences (2006) reviewed these studies and, "Concluded that there are some scenarios that could lead to the partial failure of the spent fuel pool wall, thereby resulting in the partial or complete loss of pool coolant. A zirconium cladding fire could result if timely mitigative actions to cool the fuel were not taken." (National Research Council, 2006, p. 49). A recent National Academies report (National Academy of Sciences, 2016) reviewed these previous findings and noted that there are additional threats such as unmanned aerial vehicles and cyberattacks that could provide additional pathways to an accident scenario.

Security at nuclear power plants is not governed by any international standards, unlike safety, for which the International Atomic

Energy Agency, among others, sets example standards for countries to consider. In the U.S., security at nuclear power plants is governed by regulations set by the NRC, which has responsibility for ensuring safety and security at reactors. As a result, nuclear power plants are well-guarded facilities[3] that have considered and practiced scenarios of terrorist attack that affects the operation of the reactor and associated safety systems. In other countries, security is provided by the local police force. Recently, a number of plant breaches by anti-nuclear activists in Sweden and France have made clear some vulnerabilities at these plants.

Loss of cooling accidents can result from loss of offsite electric power and backup diesel generators, a situation referred to as station blackout, similar to what Fukushima Dai'ichi suffered during the March 2011 accident. Cooling loss can also occur when a pump fails or is inadequate, so coolant is no longer circulated, as happened in the Paks 2 accident.

Loss of cooling can also occur from lack of heat removal – especially in the case of higher heat loads in the pool. Higher heat loads might result from higher fuel burnup or the presence of spent MOX fuel. Burnup refers to the number of atoms that have fissioned in the fuel or the energy released by the fuel and is expressed in mega (or giga-) watt – days per metric tonne heavy metal. In the 1970s and 1980s, a typical burnup for light water reactors were in the 33-40 MWd/MTHM range. Now burnup averages 50 MWd/MTHM (Xu et al., 2005). Some in the nuclear industry are pushing to use even higher burnup, in the 70 MWd/MTHM range in the near future. Higher burnup results in less spent fuel to manage and squeezes more energy out of a single fuel rod, potentially allowing reactor operators to extend times between outages and therefore run a leaner operation. Higher burnup requires higher enrichment of fresh fuel in uranium-235. To achieve a burnup of 50 MWd/MTHM, enrichments of 4.5% U-235 are needed; to achieve a burnup of 70 MWd/MTHM, enrichments of 6.3 % are needed (Xu et al, 2005).

Higher burnup fuel generates spent fuels that produce more heat. For instance, according to models of PWR spent fuel discharged 10 days previously, a burnup of 35 GWd/MTHM generates 5.5×10^4 W/MTHM versus 9×10^4 W/MTHM for a burnup of 50 GWd/MTHM (ORNL, 2011). As a result, as more high-burnup spent fuel assemblies are added to a pool, overall heat loads will increase in the pool and will decrease more slowly over time. These increased heat loads may be accompanied by a reduction in the absolute number of spent fuel assemblies, but this benefit has yet to be realized.

MOX or mixed oxide fuel poses a similar problem. MOX is formed by mixing plutonium oxide with uranium oxide to fuel reactors. Currently, France, Germany, Switzerland, and Japan are among the countries using MOX fuel as well as uranium oxide fuel. MOX spent fuel, because of its initial plutonium content, has higher decay heat than its uranium dioxide equivalent. For instance, for models of PWR spent fuel with a 35 GWd/MTHM burnup, 10,000 days after discharge, uranium oxide fuel produces 8×10^2 W/MTHM versus 2.4×10^3 W/MTHM for MOX spent fuel, almost 50% more heat (ORNL, 2011). Spent fuel pools have to be able to manage this additional heat and have necessary backup equipment to handle the load in case of accident.

Mitigation

A number of measures can be taken to avoid or mitigate potential accidents. First, though, it is important to understand which factors heighten the potential for loss of cooling or coolant accidents. The amount of spent fuel in the pool, the time since discharge of that spent fuel, the type of racks in the pool, and the loading pattern of spent fuel in the pool are all factors that can affect the potential for accident in the case of loss of cooling or coolant. A number of these factors are interrelated.

Reducing the amount of spent fuel in cooling pools, in particular moving all fuel older than 5 years from discharge into dry storage, suggested by Alvarez and others (2003) as a strategy to deal with the potential for accidents, would reduce the source term by a factor of four and would reduce the heat load in the pool. Reducing the amount of spent fuel in the pool would also allow for the use of open frame racks, which, in the case of loss of coolant, allow for air cooling of spent fuel rods. The high-density racks in use today in many pools are closed-cell racks that allow for little air access and depend largely on vertical water circulation to provide cooling.

Transfer of spent fuel from the pool to dry storage is not without costs. Transfer capability must exist[4] and casks and cask storage areas – either concrete pads or buildings – must be available as well. Transferring large quantities of spent fuel will increase the potential for cask drop – a possible initiating event for a loss of coolant accident. Moreover, workers transferring the spent fuel would be exposed to more radiation (GAO, 2012). Finally, of course, are the actual costs of dry storage – the facilities, the casks, and the security and monitoring required once it is in place.

The period of highest vulnerability during the operation of a spent fuel pool is shortly after spent fuel is discharged into the pool. The recent NRC models (NRC, 2014a) suggest that for the first 3-4 months after discharge from the reactor, spent fuel can ignite within 72 hours, if the fuel is uncovered and no mitigative measures are taken. Over the 20-year life of a reactor, these 3-4 month blocks add up to a significant period of time – between one and five years (Macfarlane, 2014). This period of vulnerability is exacerbated if recently discharged spent fuel is placed adjacent cells, instead of using a loading pattern that can absorb some heat, like the 1 x 4 or better, the 1 x 8 pattern. Therefore, it is important to require nuclear power plant operators to discharge spent fuel – and especially full cores – into a dispersed loading pattern in the pool, such as the 1 x 4 or 1 x 8 patterns.

Other mitigative measures include ensuring the ability to add water in the case of loss of coolant. This can be done with fixed and transportable equipment. Examples of fixed equipment are water cannons mounted near the pool and hose bibs attached to building walls near the pool. Transportable equipment can be similar to that used in the Fukushima accident – hose trucks to spray water into the pool. Additional pumps, heat exchangers, piping and wiring can also be located at the reactor site in case of cooling or coolant failure. Connections to on-site diesel generators are essential in the case of off-site power loss.

In the aftermath of the Fukushima accident a number of regulators in various countries have required the addition of equipment (both fixed and transportable) to ensure safety of the spent fuel pools. Some have gone beyond adding water addition and cooling equipment to requiring hydrogen mitigation equipment in the case of hydrogen generation from the oxidation of the zirconium cladding on spent fuel. Build up of hydrogen can result in massive explosions, as occurred in Fukushima.

Unknowns

By their nature, loss of coolant or cooling accidents at spent fuel pools are low probability, high consequence events. These events are generally difficult for society to deal with: as they may never occur, the need for investment in prevention is often questioned. At the same time, were an accident to occur, with little or no attempted prevention, the consequences could be dire, with potentially millions of people affected, and blame laid squarely on the nuclear industry.

All is not currently understood about the progression of an accident in a spent fuel pool. The ability of open-frame racks to mitigate an accident has not been investigated in detail, for instance. In its recent modeling of a spent fuel pool accident (NRC, 2014a), the NRC used two main scenarios, both using high density-type closed-cell racks: one with the cells completely full, and one with the cells partially full. They did not model the response of fuel assemblies in open-frame racks that allow significant water and air circulation.

Another area ripe for investigation is potential alternative loading patterns of recently discharged spent fuel into pools. Recent NRC analysis (2014a) suggests the advantages of using a 1 x 8 pattern where one hot fuel assembly is surrounded by 8 cold ones that provide a cold sink. The question remains whether there are other loading patterns that may be even more helpful in reducing risk of spent fuel fires in pools.

Loss of coolant accidents should be examined more closely, in particular the case where enough of the coolant is lost to uncover the spent fuel but not completely drain the pool. This situation impedes air-cooling of fuel because water blocks the circulation of air around the entire fuel assembly. As a result it is important to understand how much time it would take for spent fuel to heat up to ignition temperatures.

Over the longer term new more accident-tolerant fuels should be investigated, including cladding materials that would resist reactions with steam that produce hydrogen. Spent fuel management can be made safer, but first it is necessary to understand the range of options to promote safe spent fuel pool storage.

Conclusions

Spent fuel pools are a necessary part of nuclear reactor operation. They very simply provide the necessary thermal cooling, criticality control, and radiation protection needed for spent nuclear fuel. But they are not without risk. I would argue that the back end of the fuel cycle, especially at reactors, has not received the attention to safety and management it needs. Management of spent fuel after discharge from the reactor requires careful thought and safety analysis. Surprisingly, regulators in some countries have taken a laissez-faire attitude to the back end of the fuel cycle at reactors. For instance, the U.S. NRC does not require its licensees to report quantities of spent fuel, spent fuel pool loading patterns, loading patterns directly after discharge, whether full-core offload is maintained in the pool, and other pertinent information.

With the back end of the fuel cycle there are straightforward options for managing spent fuel to ensure safety. Spent fuel pools at reactors could be used as in Sweden and France – for recently discharged fuel, which is moved offsite quickly. They can also be used to hold fuel less than 5 years old. After 5 years of cooling, spent fuel can be transferred to passive dry storage. Spent fuel can be discharged into rack loading patterns that ensure the safest configuration in the case of loss of cooling or coolant accidents. Finally, open frame racks can be used to maximize the potential for air circulation in a loss of coolant accident.

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ENDNOTES

[1] In the Three Mile Island accident in 1979, even though the reactor suffered a partial meltdown, radioactivity generated did not contaminate the surrounding area because the containment operated as planned and contained the radionuclides. Conversely, the Chernobyl reactor that melted down in 1986 did not have containment and as a result contaminated a huge swath of land.

[2] PWR spent fuel pools also use borated water for criticality control (Nuclear Energy Agency, 2015).

[3] At some US nuclear power plants, the guard force makes up one third of the entire workforce at the plant.

[4] Transferring spent fuel from the pool to dry storage requires a crane strong enough to lift the loaded cask, space in the pool to emplace the cask, facilities at the reactor site to decontaminate and seal the cask, a specially-designed transfer vehicle to move the filled cask to the storage site. As a case in point, the Indian Point power plant in New York did not have the capability until 3 years ago to remove spent fuel from unit 3's pool because it could not accommodate the large crane needed to lift loaded casks. To resolve the problem they added a smaller crane to lift a small, water-filled transfer cask with 12 fuel assemblies. This transfer cask is brought to unit 2's spent fuel pool where a full-size storage cask can be loaded (Entergy, 2012).

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Criteria and Planning Guidance for Ex-Plant Harvesting to Support Subsequent License Renewal

December 2017

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R Devanathan
RM Meyer
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K Knobbs

Prepared for the U.S. Nuclear Regulatory Commission
under a Related Services Agreement with the U.S. Department of Energy
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Abstract

As U.S. nuclear power plants look to subsequent license renewal (SLR) to operate for a 20-year period beyond 60 years, the U.S. Nuclear Regulatory Commission and the industry will be addressing technical issues around the capability of long-lived passive components to meet their functionality objectives. A key challenge will be to better understand likely materials degradation mechanisms in these components and their impacts on component functionality and safety margins. Research addressing many of the remaining technical gaps in these areas for SLR may greatly benefit from materials sampled from plants (decommissioned or operating). Because of the cost and inefficiency of piecemeal sampling, there is a need for a strategic and systematic approach to sampling materials from structures, systems, and components (SSC) in both operating and decommissioned plants. This document describes a potential approach for sampling (harvesting) materials that focuses on prioritizing materials for sampling using a number of criteria. These criteria are based on an evaluation of technical gaps identified in the literature, research needs to address these technical gaps, and lessons learned from previous harvesting campaigns. The document also describes a process for planning future harvesting campaigns; such a plan would include an understanding of the harvesting priorities, available materials, and the planned use of the materials to address the technical gaps.

Summary

The decommissioning of some nuclear power plants (NPPs) in the United States after extended operation provides an opportunity to address a number of materials degradation questions that add to confidence in the aging management systems used by the nuclear industry. Addressing these questions is expected to provide reasonable assurance that systems, structures, and components (SSCs) are able to meet their safety functions. Many of the remaining questions regarding degradation of materials will likely require a combination of laboratory studies as well as other research conducted on materials sampled from plants (decommissioned or operating).

Evaluation of material properties of SSCs from operating or decommissioned NPPs can provide a basis for comparison with results of laboratory studies and calculations to increase confidence that long-lived passive components will be capable of meeting their functional requirements during operation beyond 60 years. A strategic and systematic approach to sampling materials from SSCs in both operating and decommissioned plants will help reduce costs and improve efficiency of materials harvesting. In turn, the ability to efficiently harvest materials is expected to lead to opportunities for benchmarking laboratory-scale studies on materials aging, identifying constraints on materials/components replacement in operating plants, and determining condition assessment methods that may be applied to these components in the field.

This document describes a potential approach for prioritizing sampling (harvesting) materials using a number of criteria that incorporate knowledge about the specific technical gaps closed through the sampling process. At the highest level, the major criteria are:

- Unique field aspects, if any, that drive the importance of harvesting the material
- Ease of laboratory replication of material and environment combination
- Applicability of harvested material for addressing critical gaps (dose rate issues, etc.)
- Availability of reliable in-service inspection techniques for the material
- Availability of materials for harvesting.

A number of information sources on materials degradation in NPPs were reviewed to assess key technical gaps that may be relevant for SLR. Information from these sources were cross-referenced (where possible) and collated to assess harvesting priority. In this document, several examples of this process are described, along with experiences from harvesting materials at several operating and closed plants. Using these lessons learned from previous harvesting campaigns, a harvesting process is defined that includes many of the criteria that should be taken into account during any harvesting campaign.

The use of information tools can assist with this harvesting process, and one concept for such a tool is described in this document. This tool is expected to provide a mechanism for easily sorting and searching through information from multiple sources, integrate subject matter expert input into the technical gaps assessment and prioritization process, and generate the appropriate prioritized harvesting plan. In theory, such a tool could be extended to include a mechanism for collating the findings from any research conducted using the harvested material and enable a seamless way for accessing the necessary information for any subsequent decisions.

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Acronyms and Abbreviations

ALARA	as low as reasonably achievable
AMP	aging management program
ASME	American Society of Mechanical Engineers
BWR	boiling water reactor
CASS	cast austenitic stainless steel
CM	condition monitoring
Code	ASME Boiler and Pressure Vessel Code
DBE	design basis event
DMW	dissimilar metal weld
dpa	displacements per atom
EAB	elongation-at-break
EMDA	enhanced materials degradation assessment
EPR	ethylene propylene rubber
EPRI	Electric Power Research Institute
GALL	Generic Aging Lessons Learned
IASCC	irradiation-assisted stress corrosion cracking
ISI	in-service inspection
LWR	light water reactor
NDE	nondestructive evaluation
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
OE	operating experience
OMB	outside the missile barrier
PMDA	proactive materials degradation assessment
PWR	pressurized water reactor
RPV	reactor pressure vessel
RRIM	Reactor Reliability and Integrity Management
SCC	stress corrosion crack
SLR	subsequent license renewal
SME	subject matter expert
SSC	structures, systems and components
XLPE	crosslinked polyethylene
XLPO	crosslinked polyolefin

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1.0 Introduction

The nuclear power fleet in the United States currently consists of approximately 98 operating reactors, of which 87, as of October 2017, have received licenses to operate beyond the original license period of 40 years (NRC N.D., Appendix A). The license renewal for these plants extends their operating life to 60 years and the U.S. nuclear power industry is now looking at a further extension of this operating license period.

The U.S. Nuclear Regulatory Commission (NRC) regulations in 10 CFR 54.31(d) allow nuclear power plants (NPPs) to renew their licenses for successive 20-year periods. The biggest challenges for the NRC and the industry will be addressing the major technical issues for this second (“subsequent”) license renewal (SLR) beyond 60 years. As summarized in SECY-14-0016 (SECY-14-0016 2014; Vietti-Cook 2014), the most significant technical issue challenging power reactor operation beyond 60 years is assuring long-lived passive components are capable of meeting their safety functions. In particular, the accumulation of degradation in four classes of systems, structures, and components (SSCs) is of concern (INL 2016):

- Reactor pressure vessel (RPV)
- Reactor internals and primary system components
- Concrete and containment degradation
- Electrical cables.

Understanding the causes and control of degradation mechanisms forms the basis for developing aging management programs (AMPs) to ensure the continued functionality of and maintenance of safety margins for NPP SSCs. The AMPs, along with the appropriate technical basis, are used to demonstrate reasonable assurance of safe operation of the SSCs during the SLR period.

Addressing many of the remaining technical gaps for SLR may require a combination of laboratory studies and other research conducted on materials sampled from plants (decommissioned or operating). Evaluation of materials properties of SSCs from decommissioned NPPs will provide a basis for comparison with results of laboratory studies and calculations to determine if long-lived passive components will be capable of meeting their safety functions during operation beyond 60 years. Because of the cost and inefficiency of piecemeal sampling (i.e., harvesting materials on an ad-hoc basis), there is a need for a strategic and systematic approach to sampling materials from SSCs in both operating and decommissioned plants.

This document describes a potential approach for sampling (harvesting) that focuses on prioritizing materials using a number of criteria. These criteria also help define the specific problems that will be addressed and the knowledge gained/technical gaps closed through the sampling process. Using a number of lessons learned from previous harvesting campaigns, a harvesting process is defined that includes many of the criteria that should be taken into account during any harvesting campaign.

2.0 Nuclear Plant Materials Harvesting

A key challenge to addressing the gaps in materials aging and degradation through 80 years of operation is the ability to perform tests that mimic the aging process in operating plants. Often, such tests are performed (and materials performance data obtained) through accelerated aging experiments, where the material under test is subjected to higher stresses (mechanical, thermal, and/or radiation) than those seen in operation. Such tests enable the experiments to be completed in a reasonable timeframe but need to be benchmarked with performance data from materials that have seen more representative service aging.

Where available, benchmarking can be performed using surveillance specimens. In most cases, however, benchmarking of laboratory tests will require harvesting materials from reactors.

Over the past several years, a number NPPs (both within the United States and elsewhere) have either permanently ceased operation or have indicated that they will shut down in the next few years. These shutdown plants provide an opportunity to extract materials that have real-world aging and provide an avenue for benchmarking laboratory-scale studies on materials aging. The resulting insights into material aging mechanisms and precise margins to failure will be essential to provide reasonable assurance that the materials/components will continue to perform their safety function throughout the plant licensing period. The extracted materials could also help in determining specific methods for condition assessment or non-destructive evaluation (NDE) that may be applied to these components in the field to assess component aging.

Note that while shutdown nuclear plants provide an unparalleled opportunity for ex-plant harvesting, similar harvesting opportunities may exist in operating plants. Scheduled repairs or replacements may provide opportunity to extract materials to address specific knowledge gaps associated with materials performance during SLR. In other instances, specific but unusual operational experience may dictate the need to harvest materials to better understand the observed phenomena.

Harvesting is not the sole answer to addressing knowledge gaps. In some cases where harvesting is most needed, such as the RPV, internals, and concrete in the shield walls, the components exist in areas with high radiation doses. Because of the need to minimize personnel radiation doses to levels as low as reasonably achievable (ALARA), worker access to these areas is stringently controlled. The benefits of harvesting may not be enough to overcome the costs of procurement, evaluation, and subsequent disposal of the materials.

Given the advantages and disadvantages associated with harvesting, there is a need for processes to identify, assess, and prioritize harvesting opportunities. The next section discusses criteria for harvesting and provides examples of applying these criteria.

3.0 Materials and Harvesting Prioritization

This section describes the sources of information used in the assessment and proposes several criteria for use in the prioritization of harvesting decisions. Several examples are included that show the application of these criteria to provide a qualitative assessment of harvesting priority.

3.1 Literature Sources

There are two general classes of degradation mechanisms that are of interest (Cattant 2014). The first class is mechanisms that lead to failure (such as corrosion, fatigue, or wear) while the second class concerns materials aging (such as irradiation embrittlement and thermal aging). In general, the second class of degradation mechanisms results in a change in material properties (reduction in toughness, increase in hardness, etc.) that can facilitate failure through one of the failure mechanisms. In this document, this distinction is not strictly followed and the terms “degradation mechanism” and “aging” are used somewhat generically to refer to either of the two classes.

A wide variety of literature exists with information on materials degradation that may be relevant to life extension of NPPs. Early materials aging insights for light water reactor components were summarized in a number of documents (Blahnik et al. 1992; Shah and MacDonald 1993; Livingston et al. 1995; Morgan and Livingston 1995; NRC 1998). More recently, the literature in this area includes the NRC Generic Aging Lessons Learned (GALL) reports (NRC 2010a, 2017b, a); *Expert Panel Report on Proactive Materials Degradation Assessment (PMDA)* (Andresen et al. 2007); *Proactive Management of Materials Degradation - A Review of Principles and Programs* (Bond et al. 2008); and *Expanded Materials Degradation Assessment (EMDA)*, NUREG-7153:

- Volume 1 (Busby 2014)
- Volume 2 (Andresen et al. 2014)
- Volume 3 (Nanstad et al. 2014)
- Volume 4 (Graves et al. 2014)
- Volume 5 (Bernstein et al. 2014)

The GALL report is the NRC staff's generic evaluation of the acceptable aging management for the period of extended operation based on the technical basis developed in the EMDA and PMDA. Based primarily on the operating experience from the fleet of operating plants in addition to EMDA and PMDA, GALL assesses the acceptable aging management approach for passive SSCs, based on material type and operating environment. The Electric Power Research Institute (EPRI) has also documented materials aging issues in the form of Materials Degradation Matrix and Issue Management Tables (EPRI 2013a, b, c). The matrix is used to document potential degradation mechanisms for primary system components, while the tables provide the basis for determining the consequence of component failures along with possible mitigation options. Further, a number of technical gaps have been identified in the understanding of degradation growth in specific materials; these are the current focus of active research by a number of organizations (IAEA 2012; McCloy et al. 2013; INL 2016).

Two factors play an important role in the ability to detect and mitigate materials degradation. First is an understanding of the materials degradation processes that contribute to the progression of degradation and, if not detected and mitigated, an eventual loss of structural integrity. The second factor is the availability of NDE methods and associated condition monitoring (CM) techniques that are capable of detecting the degradation in a timely fashion (before it grows to the point where loss of structural integrity occurs).

It is important to note that these two factors are connected and advances in one may help address any perceived deficiencies in the other. For instance, lack of a comprehensive understanding of the mechanism (how it develops and grows) may be mitigated somewhat if adequate methods for detecting the degradation are available. Likewise, lack of adequate methods for detection may be mitigated if improved understanding of the mechanisms exists.

Note that the sources of information for these two factors are not always connected. A number of studies have examined the ability to detect degradation in a timely manner. These studies have generally focused on assessing the reliability of NDE methods and the factors impacting reliability. Current techniques such as ultrasonic testing and eddy current testing that are applied for NPP in-service inspection (ISI) tend to focus on detecting signatures from mechanisms (such as cracking) that lead to failure. These studies are usually based on a comprehensive round-robin assessment of the technique, instrumentation, or personnel (Crawford et al. 2015; Meyer and Heasler 2017; Meyer et al. 2017; Ramuhalli et al. 2017). These types of studies have led to changes in the American Society of Mechanical Engineers (ASME) Boiler and

Pressure Vessel Code (hereafter the Code) around the implementation of techniques to assure reliable detection of cracking in the field (Doctor et al. 2013).

It is important to note that current NDE techniques have not seen real-time or in situ application for the detection and characterization of general materials aging. However, there is a rich set of literature that is examining the applicability of these same techniques as well as new techniques for this purpose, although the work has stayed largely in the basic research phase (Bond et al. 2009, 2011; Meyer et al. 2012; IAEA 2013; Ramuhalli et al. 2014; Fifield and Ramuhalli 2015).

3.2 Literature Assessment

The literature identified above, especially for materials degradation mechanisms, cover a broad range of materials, mechanisms, and environments, for both pressurized water reactor (PWR) and boiling water reactor (BWR) plants.

From the perspective of SLR, a number of studies, such as the EMDA and PMDA, have identified technical gaps associated with understanding the contributing factors for materials degradation development and growth. These studies, typically conducted as expert elicitations, have resulted in phenomena identification and ranking tables listing the susceptibility of materials to specific degradation mechanisms and the level of knowledge available. The tables also include general information on the environment that these materials operate in, as the specific degradation mechanisms are intimately tied to the environmental conditions in which the material operates.

It is important to note that the information in the literature sources identified in Section 3.1, while similar in form, differs in specificity. Studies such as the EMDA and PMDA have focused on specific materials (alloys, specific compositions, etc.) while other studies may refer to generic materials while recognizing that differences in material composition and grade may exist. As an example, different grades of stainless steel are used in the current nuclear power fleet and while there may be similarities in how they behave under different environmental conditions, differences that are related to specific compositional variations may drive their behavior over the long term under specific operating conditions.

A specific example of this is the structural steels used in RPVs, where compositional variations may be a driving force in the loss of fracture toughness (Sokolov and Nanstad 2016). Concern now focuses on the possibility of late-blooming phases (Malerba 2013) that may cause changes in fracture toughness over longer operating periods. However, the development of such phases appears to be a function of the specific composition and the operational environment.

Materials degradation analyses, as well as inspection methods, have tended to focus on metals and pressure boundary components, such as the phenomenon identification and ranking table analysis conducted under the PMDA effort (Andresen et al. 2007). As plants consider SLR out to 80 years of operation, concerns about non-metallic passive components are increasing. These long-lived components, broadly divided into concrete and electrical cables, are generally difficult (if not impossible) to replace and would require a significant investment if across-the-board replacement is considered. As a result, recent assessments such as the EMDA have included a significant emphasis on identifying knowledge gaps related to these long-lived non-metallic components (Bernstein et al. 2014; Graves et al. 2014). At the same time, there is increased attention being focused on developing CM and NDE methods for concrete and electrical cables, with the objective of defining methods and acceptance criteria that would provide reasonable assurance that degradation would be detected before it reaches a state where it begins to affect the safe operation of the plant.

Collectively, these studies point to several potential knowledge gaps regarding specific materials and degradation mechanisms. These knowledge gaps are related to an understanding of the conditions leading to degradation initiation and growth, and to methods for detecting and mitigating such degradation in a timely fashion. Note that this is not a blanket statement about all materials and all mechanisms; in many instances, sufficient knowledge exists about the mechanism and methods for detection such that appropriate AMPs may be used successfully to manage these mechanisms of aging and degradation out to 80 years of operation.

The implication of the foregoing discussion is that certain mechanisms and materials, within the context of SLR, may be considered as a high priority when it comes to addressing technical gaps in degradation initiation, growth, and detection; however, a systematic approach is needed to objectively identify these materials and mechanisms. This systematic approach could also identify one or more criteria that can be used in the prioritization process. From the perspective of materials harvesting, priorities may also need to account for the connection between materials degradation and CM/NDE, and include an assessment of available NDE or other CM techniques. Assuming such a prioritization can be made, the materials identified would then become the target of activities related to ex-plant harvesting.

There have been similar studies in the past, where the objective has been to develop a systematic methodology for prioritizing harvesting opportunities (Johnson Jr. et al. 2001). This study builds on these previous efforts, focuses on harvesting needs for increasing confidence in aging management for SLR, and incorporates lessons learned from harvesting efforts in the years since these previous studies.

The next several subsections describe potential criteria and provide several examples of the analysis that can be conducted using these criteria for identifying high-priority components/materials for ex-plant harvesting.

3.3 Criteria for Prioritizing Harvesting

3.3.1 Criteria

Criteria for prioritizing harvesting of components/materials need to be relevant to the organization's specific needs. For example, one of the questions that will need to be addressed is whether for a given material within a specific environment, the failure mechanisms are understood sufficiently. If so, the harvesting priority for the material exposed to this environment is likely lower. Likewise, if there are sufficient options for monitoring, mitigation, and repair, and these have been validated in representative materials/conditions, harvesting priority may be low. Uncertainty in any of these factors may drive up the priority for harvesting in an effort to reduce the uncertainty. For CM/NDE, the needs are generally about the mechanism and geometry but not how the degradation was created (accelerated vs. real time). A need also exists in simulating "realistic" degradation, and this is where limited harvesting may be useful for benchmarking purposes.

Given this background, criteria for prioritizing harvesting may be broken into five major categories, with several other lower level criteria for fine-tuning the information. At the highest level, the major criteria are:

- Unique field aspects, if any, that drive the importance of harvesting the material. This focuses on materials that are not easily available presently, such as legacy material formulations and fabrication methods that may be outdated. Also within this category would be operating experience (OE) associated with a specific class of materials in a relevant environment. If OE is available, especially for materials considered to be low in susceptibility to a specific degradation mechanism, for instance stress corrosion cracking (SCC), it may be worth harvesting the material if possible.

- Ease of laboratory replication of material and environment combination. This criterion focuses on conditions that are not easily reproducible in a laboratory environment. Of the environments of interest, radiation environments are likely to be the most challenging to duplicate. This is more so for low-dose, long-term irradiation and is a concern if dose rate effects exist that may influence the mechanism initiation and growth.
- Applicability of harvested material for addressing critical gaps. The focus of this criterion is on the ease with which the harvested material may be used in laboratory studies to address gaps in knowledge. Ideally, research plans for use of harvested materials would be in place prior to the actual harvesting. A related question would be whether, in addition to laboratory studies using characterization tools, the material can be used in degradation initiation and growth studies. In this context, re-aging of harvested materials under accelerated conditions may provide additional insights. In cable aging, such studies have been proposed (wear-out aging).
- Availability of reliable CM/NDE techniques for the material and degradation mechanism. Such techniques may compensate for any uncertainties in knowledge about the formation and growth of degradation, and enable sufficient defense in depth. Note that, even with reliable CM/NDE methods being available, harvesting may be warranted in some instances if the degradation mechanism is likely to be a generic fleet-wide issue. In these cases, the harvested material may provide insights for repair/mitigation decision-making and improving the economics of plant operation. Further, it is possible that the harvested material may be useful for developing or improving CM/NDE techniques.
- Availability of material for harvesting. Knowledge of materials used in different operating and shutdown plants as well an understanding of which materials may be available for harvesting over different time horizons (short, medium, long) is necessary.

Note that the focus of this document is on identifying harvesting needs; other parallel activities are underway (and are expected to continue into the future) to identify material availability.

These high-level criteria focus on the ability of harvested materials to address gaps in materials performance knowledge for SLR. In tabulating the answers to these criteria, a variety of information will need to be gathered, possibly using one or more of the sources identified earlier. These include expert elicitation studies (EMDA, Materials Degradation Matrix, etc.) on the susceptibility of various materials in relevant environments to a number of degradation mechanisms. In addition to the susceptibility information from these expert panels, knowledge and confidence may be gained in the specific combination of material, degradation mechanism, and environment. In parallel, information in the GALL documents associate similar combinations with relevant AMPs, while other available documents provide insights into specific knowledge gaps.

Specific information from these studies that would be needed include:

1. Whether the material, degradation mechanism, and environment combination rated “high susceptibility” in expert elicitation reviews such as EMDA.
2. Whether the material, degradation mechanism, and environment combination rated “low knowledge” in the expert elicitation reviews such as EMDA.
3. AMPs that may be applicable to address the combination of the material, degradation mechanism, and environment.
4. Presence of OE associated with the material, degradation mechanism, and environment combination.

5. The level of understanding of the mechanism (ranges of environmental factors, initiation times and growth rates, other factors such as compositional variations, etc.). In effect, this is related to identifying the critical gaps in knowledge and also the ease with which the material, degradation mechanism, and environment combination may be simulated in the laboratory.
6. Options for mitigation, if any. Effective mitigation techniques (including a relatively easy and inexpensive path to replacement of the component) point to a relatively high level of understanding of the degradation mechanism. As a result, the added benefits from harvesting may be limited in these instances.
7. Amount of material use (plant-wide and fleet-wide). In addition to addressing the criterion on material availability, this information also plays into an assessment of the harvesting benefit. Widespread use of a specific material under similar environmental conditions could point to a large (potentially fleet-wide) benefit from harvesting.

It is important to determine whether the expected benefits from the harvested materials will clearly reduce any uncertainty associated with the materials' performance through 80 years of operation of the plant. If so, this potentially provides benefits from the regulatory perspective, while reducing any uncertainty around safety margins in these components.

3.4 Examples

In the interest of developing the process for prioritizing harvesting further, several examples are considered in this subsection. These examples are not intended to be comprehensive, but were selected to cover the potential range of priorities as well as highlight specific aspects of harvested materials that may be considered in the harvesting decision process. In each case, the criteria described above are assessed, with the additional information listed. The result is an assessment of the priority for harvesting should the material become available due to plant retirements or planned repairs.

The first example is of a non-metallic material (electrical cable insulation), illustrating the complexity of the problem and the unknowns in aging mechanisms and performance. This is followed by an example of cast austenitic stainless steel (CASS), which highlights several unknowns in aging mechanisms and the potential limitations of accelerated laboratory aging-based tests. This provides an example of a potential medium- to high-priority harvesting need. The next example (SCC in dissimilar metal welds [DMWs]) is evaluated for two specific scenarios and is considered a low priority for harvesting. The final example of vessel internals highlights unique aspects of field-aged materials (radiation damage) that makes harvesting a valuable but perhaps expensive proposition.

3.4.1 Electrical Cables

The issues associated with aging of electrical cables are generally complicated by the diversity in materials and formulations that were used in vintage cables. Given the qualification methods used when they were put into service, utilities were able to perform time-limited aging analyses to show with a reasonable assurance that electrical cables would be able to perform their necessary function under a design-basis event through a first round of license extension. However, as utilities approach a decision on SLR, there is a general consensus that available data on long-term performance of cables is sparse and in some instances contradictory.

Generally, utilities have adopted a CM approach to aging cable management. Given the uncertainties and knowledge gaps, they do not necessarily expect the cable to last for 80 years. Rather through their CM program, they are assured that they can detect damage before it becomes critical. The damaged cables or cable sections may then be repaired or replaced.

Harvesting cables has benefits and drawbacks. On one hand, it is possible to accelerate aging in a laboratory environment; this is likely to be informative for tracking and correlating inspection techniques over a full degradation lifecycle. On the other hand, such a study is not possible with a snapshot in time of a cable from a plant where the actual temperature and dose level is not known.

However, there is concern that the aging seen in accelerated tests may not always correlate well with field aging. In particular, dose rates and total dose effects, synergistic effects of thermal and radiation aging, and diffusion-limited oxidation are all concerns for the applicability of accelerated aging. Further, there are many instances where the formulations of cable insulation material (polymers) in plants (vintage material) are different from what is available today. In these cases, harvested vintage cables can be used for studies to provide the necessary data and plug the knowledge gaps.

From a CM perspective, the most interesting harvested cable samples will have failed some in-plant test (such as walkdown, indenter, withstand test, and time and frequency domain reflectometry [TDR and FDR]). These cables can then be subjected to alternative tests (like capacitance and higher-frequency FDR) and autopsy with laboratory tests like diffusion-limited oxidation and elongation at break (EAB).

Both operating and decommissioned plants may be sources of material, particularly if there is some indication of dose and/or elevated temperature exposure. A key advantage of material from these plants is the ability to compare laboratory and NDE tests of artificially aged cable to the naturally aged cable for verification of equivalency.

Harvested cables, when subjected to laboratory aging studies (wear-out aging) may be used with destructive and NDE tests (EAB, line resonance analysis, gel-swell, micro-indenter, atomic force microscopy, indenter, etc.) for increasing confidence in the ability to detect aging of concern and provide assurance that the insulation/jacketing material has not reached its end of life (defined as 50% EAB). While some of this has been done (Bernstein et al. 2014), there are still knowledge gaps that could benefit from this work.

The Cable EMDA includes the following classifications of material:

1. Cables at 35°C–50°C (95°F–122°F) and zero dose
2. Cables at 35°C–50°C (95°F–122°F) and up to 0.01 Gy/hr. (1 rad/hr.)
3. Cables at 45°C–55°C (113°F–131°F) and up to 0.1 Gy/hr. (10 rad/hr.)
4. Cables at 45°C–55°C (113°F–131°F) and up to 1 Gy/hr. (100 rad/hr.)
5. Cables at 60°C–90°C (140°F–194°F) and zero dose
6. Medium voltage cables in long-term wet conditions

For the above categories, material considerations were:

1. Crosslinked polyethylene (XLPE) (wet cables)
2. Crosslinked polyolefin (XLPO) (not for wet conditions)
3. Modern tree retardant XLPE
4. Flame-retardant ethylene propylene rubber (EPR)
5. EPR/neoprene

6. EPR/chlorosulphonated polyethylene (CSPE)
7. Black EPR
8. Pink EPR
9. Brown EPR
10. Butyl rubber
11. Neoprene
12. CSPE
13. Chlorinated polyethylene
14. Silicone rubber (not suitable for wet conditions)

For low-temperature, low-dose cases, susceptibility to embrittlement due to radiation and thermal aging was 0 to 2 (low susceptibility), and this is a well understood issue with knowledge consistently ranking at 3 (on a scale of 0–3). As the environmental exposure exceeds 45°C and up to 0.1 Gy/hr., susceptibility increases particularly with Neoprene, silicone rubber, and CSPE and the knowledge falls to 2–3. Thus, harvesting materials (especially Neoprene, silicone rubber, and CSPE) exposed to temperatures in excess of around 45°C and low-doses is likely to be of value. Table 1 provides a summarization for one type of cable in a specific environment, as a single example of non-metallic materials. Given the critical gaps and widespread nature of their use, these are considered a high priority.

Table 1. Assessment of Electrical Cable Insulation Harvesting Priority. Insulation and jacket materials considered are EPR and CSPE, at temperatures between 45°C–55°C and dose between 0.1–0.01 Gy/hr. (1–10 rad/hr.)

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	Vintage formulations, depending on manufacturer, real-world conditions.	10–12 manufacturers of vintage cable in U.S. fleet. Within a single plant, cable types and manufacturers can vary.
Ease of laboratory replication	Low-medium (long-term aging studies necessary)	
Applicability of harvested material for addressing critical gaps	High – Wear-out aging a possibility. Evaluation of CM for field degradation.	Requires knowledge on plant conditions
Condition monitoring/ISI for detection and sizing	Low to medium. Unclear how well proposed techniques would perform for low dose rate, low temperature aging of insulation.	Access limited; long-range methods are not fully understood
Availability of material for harvesting	TBD	Needs input from utilities
EMDA susceptibility score	Generally High (2–3)	
EMDA knowledge score	Medium (mostly 2)	Some data exist on long-term aging. Inverse temperature and synergistic effects are a concern. Inverse temperature effects apply and CSPE is formulation-specific.
GALL-SLR	Documented as a potential issue	AMP updates ongoing
OE	Yes	Documented in industry publications
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium	See knowledge gaps below
Options for mitigation	Low	
Ease of replacement	Medium	Possible but can get expensive depending on specific locations
Amount of Use (in a plant and fleet-wide)	High	Low-voltage and medium-voltage cables extensively used in plants
Critical gaps in knowledge	Contribution to database for dominant effects, synergistic effects, dose rate effects for understanding accelerated aging vs. field aging, develop and qualify CM techniques	
HARVESTING PRIORITY		HIGH

3.4.2 Cast Austenitic Stainless Steel

CASS is used extensively in pressure boundary components in light water reactor (LWRs) coolant systems (Chopra and Rao 2016). Applications include piping, valves, vessel internals, pumps, support structures, brackets, and flow restrictors.

OE for material degradation has not been broadly encountered under 40 years of life. Under extended service life, the main concern is loss of fracture toughness due to aging (thermal and neutron embrittlement). Stress corrosion cracking and fatigue are not considered generic concerns for CASS. Under prolonged thermal aging, elements segregate and undesirable Cr-rich regions form within the ferritic phase, leading to degradation of mechanical properties. It is not known how radiation damage will interact with thermal aging.

At present, accelerated aging of CASS in the laboratory and computer simulations of microstructural changes are the main tools used to understand the aging of CASS in service. It would be useful to harvest reactor materials to validate the current accelerated aging program, computer models, and existing regulatory positions. Microscopy and mechanical testing of harvested materials will improve our understanding of aging behavior. In addition, accelerated aging of harvested materials will provide information on new degradation mechanisms that could crop up under extended life. While radiation damage has not been a concern in CASS, it would be prudent to harvest both unirradiated material (piping, pumps, etc.) and irradiated material (reactor internals) so that radiation effects on degradation under life extension can be reliably evaluated.

Below describes how the information on CASS may be mapped into the different criteria identified above.

1. The combination of material (CASS), degradation mechanism, and environment is rated high in the EMDA mainly for fracture of PWR piping in reactor water (no irradiation) and BWR vessel internals in primary water (radiation up to 1.5 dpa).
2. Both the knowledge and confidence scores are fairly high (~2, on a scale of 0–3) for CASS for all degradation mechanisms, because there have been limited instances of degradation in the OE and those were generally attributed to poor material quality or incorrect material processing.
3. The material, mechanism, and environment for thermal aging and loss of fracture toughness can be simulated in the laboratory. However, the relation between accelerated testing time and real-world service time is not clearly validated. Synergistic effects are difficult to reproduce in the laboratory. It would be valuable to look at the heat-affected zone in welded CASS material.
4. Knowledge gaps: There is data in the literature that suggests significant loss of fracture toughness for neutron exposures between 0.5 and 5 dpa due to the interaction of neutron and thermal embrittlement effects (Chopra 2015). This interaction needs to be understood for life extension.
5. Harvested materials can be used to address critical knowledge gaps in two areas: (1) calibration and validation of current accelerated testing procedures; and (2) assessment of the combined effects of thermal aging, coolant effects, and neutron irradiation. Degradation initiation and growth studies can be conducted with harvested materials. New/improved ISI procedures may be developed to detect degradation.
6. Reduction in fracture toughness as a result of thermal embrittlement can result in significantly increased crack propagation rates. While the delta ferrite content in CASS is one of the factors that controls crack (specifically SCC) initiation susceptibility, with higher delta ferrite generally resulting in lower SCC susceptibility but higher thermal embrittlement susceptibility, it is possible that other factors (such as fabrication irregularities or cold work) play a role in increasing the susceptibility to

SCC (Byun and Busby 2012). There is also active research to address potential gaps related to SCC initiation and thermal embrittlement during SLR.

The main microstructural mechanisms of thermal aging at less than 500°C are associated with the precipitation of additional phases in the ferrite: (a) formation of a Cr-rich α′-regions through spinodal decomposition, (b) precipitation of a γ-phase (Ni, Si-rich) and $M_{23}C_6$ carbide, and (c) additional precipitation and/or growth of existing carbides and nitrides at the ferrite/austenite phase boundaries (Ruiz et al. 2013). The formation of Cr-rich α′-regions by spinodal decomposition of δ-ferrite phase is the primary mechanism for the thermal embrittlement (Byun et al. 2016). The significant material signatures in the context of condition assessment for thermal aging appears to be the amount of Cr-rich α′-regions produced by spinodal decomposition of δ-ferrite and material hardness induced by thermal aging.

7. ISI methods are being evaluated to assess their ability to detect cracking in CASS. Currently, no technologies are deployed in the field for monitoring the thermally aged condition of CASS, nor does there appear to be an obvious immediate need for such technologies.

   In the event of a pressing need for such technology, the feasibility of monitoring the thermally aged condition of steels is suggested by the sensitivity of certain magnetic and ultrasonic NDE measurements to the precipitation and growth of second phases. It is reported that magnetic hysteresis loop analysis and magnetic Barkhausen noise emission can be used to estimate the amount of a non-ferromagnetic second phase material in a ferromagnetic material (Raj et al. 2003). Dobmann (2006) has investigated magnetic loop measurements for characterizing thermal embrittlement of WB36 low alloy steel. An estimate of the amount of copper phase precipitation is obtained from magnetic coercivity and results are presented that indicate a correlation between the coercivity measurements and Vickers hardness measurements. Similar studies are underway to assess precipitation of Cr-rich phases using magnetic measurements.

Harvested components are usually not necessary for condition assessment technology development as appropriate material conditions can be achieved and investigated by accelerated aging of laboratory specimens. Harvested materials may be useful to understand the interaction of radiation and thermal aging, to calibrate accelerated aging in the laboratory against long-term service in a reactor environment, and to estimate/predict the life time of CASS components for life extension. While the NRC is not currently funding research in this area, harvested CASS materials may help provide additional data to further inform the NRC’s regulatory decision-making.

The information above is summarized in Table 2.

Table 2. Summary of Harvesting Criteria for CASS, for All Mechanisms, in Reactor Water in Primary Loop Components

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	Vintage material, synergistic effects (especially radiation)	
Ease of laboratory replication	Low-medium	Gap relating accelerated aging studies to real-world service time
Applicability of harvested material for addressing critical gaps	Calibrate and validate accelerated aging procedures; assessment of the combined effects of thermal aging, coolant effects, and neutron irradiation; degradation initiation and growth studies; new/improved ISI procedures.	Potential need to validate methods for simulating SCC
Condition monitoring/ISI for detection and sizing	Limited (medium difficulty). Coarse-grained materials challenge ultrasonic testing. Challenge for meeting detection and sizing accuracy in thick-walled specimens.	Condition assessment methods for SLR may be unconventional. Access issues dictate probability of detection and sizing performance. Harvested materials useful to study issue and develop workarounds. Cases in the Code. Appendix to Section XI.
Availability of material	TBD	Needs input from utilities
EMDA susceptibility score	Generally high	BWR piping in reactor water (no irradiation), BWRs up to ~1.2 dpa, some PWR internals in primary water (up to 0.5 dpa)
EMDA knowledge, confidence score	Medium	All mechanisms
GALL-SLR	Variety of structures and similar components identified	No specifics on material composition
OE	Limited	Mostly due to poor material quality or incorrect processing
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium	See knowledge gaps
Options for mitigation	Low	
Ease of replacement	Low	
Amount of use (in a plant and fleet-wide)	High (use of highest susceptibility CASS – CF8M – is lower)	Diversity in material composition and microstructure across plants. CF8M used in about 1/3 of PWRs that use CASS for Class 1 piping.
Critical gaps in knowledge	Synergistic effects of radiation and thermal embrittlement on fracture toughness, relation between accelerated tests and real-world service time, in-service material composition and microstructure	Multiple studies available using accelerated tests
HARVESTING PRIORITY	MEDIUM-HIGH	

3.4.3 Dissimilar Metal Welds

DMW joints are extensively used in NPP primary systems, and encompass a host of materials and locations. DMW are generally used to join ferritic and austenitic piping components, and employ either austenitic or nickel-alloy materials as the weld material. The ferritic end is buttered with several layers of a material close in properties to the main (austenitic) weld material, with a post-weld heat treatment usually applied to reduce residual stresses (Taylor et al. 2006).

A challenge with DMW is the presence of different materials within the weld, resulting in different material properties. These differences can result in reduced material toughness near some of the interfaces. Localized high temperatures and residual stresses may increase susceptibility to SCC in certain environments. Operating experience has also shown the possibility of cracking in such welds.

Below briefly describes how information on DMW may be mapped into the different criteria identified above. The focus is on Alloy 82/182 welds in these examples, given their wide use.

1. For the combination of DMW and primary reactor water at temperatures between 100°–150°F, the susceptibility to SCC is low (1–2 on a scale of 0–3). With higher pressures and temperatures, the susceptibility increases.
2. Both knowledge and confidence scores are fairly high because OE and laboratory studies have shown numerous evidence of SCC in materials at high temperatures and pressures. In contrast, there is limited OE for cracking at lower temperatures and pressures.
3. There is general consensus on the combination of factors that leads to crack initiation in these materials. These conditions can be simulated in the laboratory in accelerated aging tests. Limited data on crack growth rates in DMW materials have been generated in accelerated aging tests but it is not clear how well the data matches field experience.
4. Crack initiation in these materials is a function of several factors including the residual stresses and welding temperature variations. There is limited data on crack initiation in DMWs in general and may require additional studies.
5. Harvested materials may be used to address technical gaps related to crack initiation susceptibility and crack growth rates. However, it is likely that only a limited set of harvested materials may be needed (if any), given the ease with which the environmental conditions in operating plants may be replicated in a laboratory.
6. Several studies have demonstrated the viability of using one or more NDE techniques for detecting, characterizing, and monitoring SCC growth in these materials. While the reliability of these methods is still a topic of active interest, preliminary data appear to indicate the possibility of detecting and sizing to ASME Code requirements.

Tables 3 and 4 show a similar analysis summary for SCC in 82/182 welds in different environments. In this case, given the level of knowledge available about the susceptibility of the material to cracking when exposed to the environment and the options for detecting such cracking, these materials are considered to be at a lower priority level.

Table 3. Example Assessment for SCC in DMW: 82/182 Welds, for SCC, in PWR Primary Environments (Borated Demineralized Water (normally stagnant), 100°F–150°F, 640 psia). Components: ECCS Accumulator Piping to Cold Leg.

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	Vintage material	
Ease of laboratory replication	Medium/high	
Applicability of harvested material for addressing critical gaps	Calibrate and validate accelerated aging procedures; degradation initiation and growth studies	
Condition monitoring/ISI for detection and sizing	Available techniques may be sufficient for reasonable assurance of detection	Detection and sizing capability TBD but generally capable of meeting acceptance criteria set in the Code
Availability of material	TBD	Needs input from utilities
EMDA susceptibility score	Low-medium	Temperatures considered too low for SCC to be concern. However, cracking is a generic concern for these materials.
EMDA knowledge, confidence score	Generally high	
GALL-SLR	Nothing obvious listed for environment for this example.	AMPs are for components similar to the one listed above
OE	No.	Nothing was identified in Licensee Event Report searches to date
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium-high	
Options for mitigation	Low	Given low susceptibility, this may not be an issue
Ease of replacement	Low	Given low susceptibility, this may not be an issue
Amount of use (in a plant and fleet-wide)	High	
Critical gaps in knowledge	Crack initiation time	Crack initiation probability considered low for the environment listed
HARVESTING PRIORITY	LOW	
ECCS = emergency core coolant injection system		

Table 4. Example of SCC in DMW: SCC in 82/182 Welds in PWR Primary Environment (reactor water, 653°F, 2250 psia) for Components: RCS Pressurizer DMWs, RPV DMWs, RCS SG, ECCS Accumulator Piping to Cold Leg, ECCS CVCS Piping to RCS Cold Leg

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	Vintage material	
Ease of laboratory replication	Medium/high	See gap on relating accelerated aging studies to real-world service time
Applicability of harvested material for addressing critical gaps	Calibrate and validate accelerated aging procedures, degradation initiation and growth studies, new/improved ISI procedures	Multiple studies available on SCC initiation and growth in nickel alloys and DMWs, mitigation proposals (overlay) also being studied.
Condition monitoring/ISI for detection and sizing	Available techniques appear sufficient for reasonable assurance of detection in pressure boundary components (ultrasonic testing, eddy current testing) and internals (visual testing). Generally easy to apply ISI (assuming access).	Potential need to validate methods for simulating SCC. Access issues dictate probability of detection and sizing performance. Detection and sizing generally capable of meeting acceptance criteria set in the Code.
Availability of material	TBD	Needs input from utilities
EMDA susceptibility score	Generally high	
EMDA knowledge score	Generally high	
GALL-SLR	Variety of structures and similar components identified, but no specifics on materials available	AMP XI. M7, M1, M2, M19: SG, Water Chem., ISI
OE	Yes	
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium-high	See knowledge gaps
Options for mitigation	Low	
Ease of replacement	Low	
Amount of use (in a plant and fleet-wide)	High	
Critical gaps in knowledge	Crack growth rates, crack initiation time	Multiple studies available on SCC initiation and growth in nickel alloys and DMWs, mitigation proposals (overlay) also being studied.
HARVESTING PRIORITY	LOW	Multiple ongoing studies, significant advances in degradation understanding, availability of NDE drive priority assessment.

ECCS = emergency core coolant injection system
RCS = reactor coolant system

3.4.4 Vessel Internals

Vessel internals comprise a wide range of structures and components, with one defining characteristic: they are all exposed to the highest fluences within a NPP. Vessel internals are generally made of austenitic stainless steels (typically 304 or 316L) and the materials may be subjected to several processing steps, including cold work and welding, to form the component. Given the potentially high fluences experienced by these materials, several degradation mechanisms may occur over time, including irradiation-assisted SCC (IASCC), as well as other irradiation-assisted processes.

In the case of austenitic stainless steel exposed to irradiation and the primary systems water environments in LWRs, the following generic assessments may be made:

1. Susceptibility and confidence scores for SCC and other degradation mechanisms are generally high.
2. Knowledge scores are generally low-medium but this is a function of the specific degradation mechanism and specific environmental information.
3. OE has shown a number of cracks initiating and growing in baffle former bolts.
4. Critical gaps in knowledge include the specifics of irradiation-assisted degradation mechanisms—factors contributing to initiation and growth. A number of microstructural changes are possible in the presence of radiation, including void swelling, segregation, and precipitation. Gaps exist in understanding the factors that contribute to these mechanisms and their impact on the material functional performance.
5. ISI methods exist that can detect the presence of cracking and dimensional changes in components. The reliability of these methods is a function of several factors, including the critical flaw size (i.e., flaw length and through-thickness depth beyond which the structural integrity of the component may be affected with continued operation), physical access for inspection, and a number of factors associated with the inspection deployment technology.
6. Internal components embody certain unique aspects that are hard to duplicate in the laboratory. Unlike DMW, and to some extent CASS, the environmental conditions (especially higher fluences) are hard to generate in the laboratory. Even with access to specialized facilities, there is concern that degradation mechanisms may be flux rate- and spectrum-dependent, indicating that accelerated aging conditions typically encountered in test facilities may not be representative of the field-aged component. In this respect, internal components resemble electrical cables in that there is some evidence that field aging results in different microstructural conditions than accelerated conditions; at the same time, like cables (but unlike most metallic components including DMW and CASS), at least some internal components may be amenable to replacement.

Collectively, these criteria drive the need for harvesting internal components if available and result in a prioritization of medium to high.

Table 5. Example of Vessel Internals for Degradation in Austenitic Stainless Steels for Vessel Internals

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	High-fluence irradiation; vintage material	
Ease of laboratory replication	Low	Accelerated aging tests vs field aging service time
Applicability of harvested material for addressing critical gaps	Mechanisms of irradiation-assisted degradation—microstructure and mechanical properties	Re-irradiation may assist with understanding materials performance at SLR fluences.
Condition assessment/ISI	Available techniques (ultrasonic, visual) may be sufficient for reasonable assurance of detection. Sizing – maybe. Ease of ISI can be low depending on access.	Access issues may dictate probability of detection and sizing performance. Challenging environment for continuous monitoring.
Availability of material	Some materials being harvested; closed plants may provide additional opportunity	
EMDA susceptibility score	Generally high	Based on OE primarily
EMDA knowledge score	Generally low	
GALL-SLR	Variety of structures and similar components identified, but no specifics on materials available	
OE	Yes	Baffle bolt cracking, cracking in other internal components
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Low-medium	See knowledge gaps
Options for mitigation	Low	
Ease of replacement	Depends on component	Some components (for instance, baffle bolts) can be replaced relatively easily.
Amount of use (in a plant and fleet-wide)	High	
Critical gaps in knowledge	Degradation mechanisms (IASCC, swelling, segregation, etc.), flux rate and irradiation spectrum effects, microstructural property changes, and links to mechanical properties.	
HARVESTING PRIORITY	HIGH	Unique field aspects and degradation mechanisms drive this prioritization.

4.0 Harvesting Plans

4.1 Ex-plant Harvesting Experience

4.1.1 Harvesting Projects

Harvesting activities have been carried out at a number of plants in years past. These have included decommissioned plants as well as cancelled or terminated plants. Of the cancelled or terminated plants, the harvesting effort appears to have been opportunistic and focused on accessing components that were fabricated, but not commissioned. Examples of these plants include Shoreham, River Bend Unit 2, and the Washington Public Power Supply System Units 1 and 3. In these cases, the focus was primarily on harvesting metallic components with a view to obtaining as-built materials for studies on crack growth, fracture toughness, and fabrication flaw density.

In recent years, harvesting efforts have generally focused on accessing materials from plants that have been decommissioned. The bulk of the effort appears to have been on three plants—Zion (both units) and Crystal River Unit 3 (all in the U.S.), and Zorita (in Spain). Zion is a decommissioned two-unit Westinghouse-designed four-loop PWR facility. The units were commissioned in 1973, permanently shut down in 1998, and placed into SAFSTOR in 2010 (Rosseel et al. 2016a). Crystal River Unit 3 is a PWR that ceased operation in 2013. Zorita is a 160-MWe PWR designed by the Westinghouse Electric Corporation, and operated for approximately 38 years (NRC 2010b). It was permanently disconnected from the national power grid on April 30, 2006. During this period, approximately 26.4 effective full-power years of reactor operation were accumulated and the highest fluence on the reactor vessel internals was estimated to be 58 dpa. A number of other plants that have ceased operations have been identified as potential sources of material for harvesting and include Kewaunee and San Onofre Generating Station (both units). At the same time, a limited amount of harvesting has been attempted at several other plants, usually in conjunction with a repair or replacement activity.

4.1.2 Cable Harvesting Experience

4.1.2.1 Background

The nuclear power cable community has long recognized the value of aged cable samples. For instance, EPRI developed a Cable Harvesting Users Guide website[(1)] that continues to accept recommendations from the community and provides guidelines to maximize the value of harvested cable. The guide indicates that the purpose of harvesting is to determine present condition, remaining life, and allow forensic analysis for insight into actual field-aging mechanisms and determine their influence on long-term performance. The guide is intended to benefit the utility in the following ways:

- If a utility identifies cables that are judged to be limiting by use, type, and/or operating environment, and the cables are shown to be acceptable with adequate remaining life, that utility may be able to demonstrate that work required by the regulatory authorities for other cables may be deferrable.

(1) EPRI. 2014. *Plant Engineering: Field Guide for Harvesting Service-Aged Cable (Cable Harvesting Guide) Version 2014*. EPRI Report 3002002994, Electric Power Research Institute (EPRI), Palo Alto, California. EPRI members may access this software at http://cableharvest.epri.com.

- Evaluation of service-aged cables is one strategy for determining the limits of remaining life for NPP cables. Equally important to understanding and managing aging of in-service cables is to gain practical insight into those cable material and construction systems that can be demonstrated to have performed well.

Key candidates for removal and harvesting are:

- Cables that have experienced unanticipated in-service failures
- Cables with observed aging degradation under specific service conditions
- Cables from systems identified by the plant as those with specific concerns (e.g., high safety significance or particular vulnerability)
- Cables from systems with plant-unique service or environmental conditions (e.g., salt water infiltration or water immersion, high operating temperature, high radiation)
- Cables that are examples from a large installed base; may include cables of particular construction and materials, from a single manufacturer, or of a single manufacturing vintage.

While it is recognized that cable harvesting may occur in conjunction with an environment where the task is secondary to either returning a plant to service or plant dismantlement, recognition of a best-practice removal protocol is helpful to maximizing the value of the harvested cable. Recommended cable removal protocol includes:

- Clearly identifying the cable to be removed
- Photographing the cable environment prior to removal
- Tagging or somehow unambiguously identifying the cable prior to or just after removal.

As long a section of cable as possible should be removed. Terminations, splices, and cable accessories should be retained as much as possible.

Identification of interesting parameters associated with the cable can include and should consider:

- Cable physical description
  - Cable category (instrumentation and control, low voltage, medium voltage)
  - Construction (configuration, number of conductors)
  - Manufacturer/date
  - Materials (jacket, insulation, conductor jacket)
  - Cable lengths and segments
- Service parameters
  - System
  - Service application
  - Current and voltage
  - Duty factor
  - Safety and maintenance rule significance
  - Age in service

- Installation data
  - Installation location (building, outside, buried)
  - Terminations
  - Supporting structures or conveyances
- Stressors
  - Installation
  - In-service mechanical and structural
  - Environmental degradation
  - Other damage potential
- Plant fleet cable experience
  - Testing interval and history
  - In-service failure or degradation
  - Other

4.1.2.2 Known Naturally Aged Harvested Cable Examples

On May 19, 2016, Zion Solutions harvested and placed into six steel drums, four sets of Zion Unit 2 cables with lengths up to 30 ft. of XLPO, low- or high-density polyethylene, EPR, silicone, Hypalon, etc., in collaboration with the NRC. Cables were harvested from:

- Accumulator discharge motor operated valve cabling, outside the missile barrier (OMB), lower level of containment
- Instrumentation cables – instrument racks, OMB, lower-level containment
- Air-operated valve cabling, OMB, lower level of containment
- Cables in electrical penetrations, OMB, containment; elevation 617 ft.

A test plan for these cables has been developed and tests such as EAB and additional aging/qualification tests have been initiated (as of the writing of this report).

Harvesting of cables was also recently performed at the Crystal River Unit 3 plant, which was shut down in 2009 for refueling and an uprate. The construction efforts caused damage to the containment structure that was ultimately determined to be too costly to repair. In 2013, it was announced that Crystal River Unit 3 would not restart and decommissioning activity was begun. Cables were harvested from the plant in 2015. Photographs were taken for many of these cables inside the plant just prior to their removal. Some of these cables have asbestos filler between the jacket and insulation; however, this is a recognized hazard that can be managed with minimal additional precautions as long as testing does not include jacket removal. A research plan has been developed for harvested high-priority cables (Fifield 2016) and is currently being executed.

Several cables were also removed from service from the Fermi nuclear station in 2015 for forensic examination. The cables were:

- 5C/#16AWG, 600V, Rockbestos XLPE/Neoprene (~ service from 1978–2010; 32 years)
- 4C/#12AWG, 600V, Okonite EPR-Neoprene/ Hypalon (~1977–2010; 31 years)

All XLPE insulations were determined to be like new based on indenter modulus and EAB. Neoprene jackets were approaching embrittlement level. The EPR-Neoprene/Hypalon jacket showed signs of aging based on both indenter modulus and EAB (Anandakumaran and Auler 2015).

In contrast to cables removed from (now closed) plants, there have been a number of examples of naturally aged cables harvested from storage. For instance, several warehouse-aged cables that had been purchased and stored for more than 20 years but not placed in service were made available to EPRI by the Palo Verde plant for evaluation. Testing at EPRI confirmed that cable insulation degradation when not exposed to severe environmental or operation stresses was limited.[(1)]

A third source has been cables removed from service due to failure of the cable (generally based on failing one or more tests conducted in the field). While such failures appear to be relatively rare in the field, removal of cables to prevent a future failure may occur after visual or electrical testing indicates a potential problem. In 2015, a 1000V three-phase cable with cracked Neoprene jacket and EPR insulation was removed from service at the Beaver Valley NPP after failing electrical test acceptance criteria. Forensic examination of the cable revealed tensile stresses in excess of ultimate yield strain. Chlorine and its compounds (probably hydrochloric and chloric acid) were found to contaminate the cable surface including crack walls, forming a conductive path between cable conductor and ground (Fryszczyn 2015). Several cables were also removed from the Kewaunee turbine building and sent to Analysis and Measurement Services Corp. for forensic evaluation in 2015. Cables included Boston Insulated Wire two-conductor 12 AWG CSPE jacket/CSPE insulation cable; Kerite three-conductor 12 AWG XLPO jacket/XLPO insulation cable; and Okonite four-conductor, 14 AWG Neoprene jacket/cloth wrap/EPR-Neoprene insulation. Of three naturally aged cables tested, two showed no signs of aging degradation and one showed signs of significant degradation for only the jacket (Toll 2015).

Several other harvested cables (from a number of plants) contributed to a series of reports on medium-voltage cable aging failure mechanisms mainly on butyl rubber and different types of EPR cables. It has been observed that the cables do not degrade homogeneously in water, but in discrete locations, enabling operators to isolate the degraded cable section, remove it, and splice in a new section (EPRI 2015).

4.1.3 Harvesting of Internals

4.1.3.1 Background

In recent years, OE has identified several examples of cracking in internal components, including baffle bolts, jet pump risers, core shroud, etc. A number of mechanisms are of interest, including IASCC. Given that the vessel internal components see some of the highest fluences, the acquisition of materials from these components is likely to provide a great deal of information about the behavior of these materials at high fluences. Some specific topics that are of interest include:

- Quantifying materials performance in the presence of irradiation-induced processes such as segregation, swelling, and precipitation
- Crack initiation and growth rates in the presence of irradiation-induced processes

(1) Andrew Mantey (EPRI), Personal communication.

4.1.3.2 Known Examples

A number of harvesting efforts have been initiated in the United States and elsewhere to acquire vessel internal components. In the United States, recent efforts have included the harvesting of baffle-former bolts. The harvesting, in this case, was focused on acquiring bolts that were withdrawn from service (and replaced with improved materials) for the purposes of post-service examination (Leonard et al. 2015). These were primarily used for laboratory studies to determine the degradation mechanism and if evidence of IASCC existed with some or all of the bolts.

Similar harvesting efforts are underway at Zorita (Hiser et al. 2015), with the objective being to acquire and test materials that have experienced a range of fluences. Planned studies in this case include mechanical testing of the samples as well as testing to determine crack initiation and growth rates. In the case of Zorita, the focus is on baffle plate materials and core-barrel weld materials. These materials have been exposed to different levels of irradiation, and welds and heat-affected zone. Additional studies are planned with post-harvesting irradiation of selected specimens.

Other baffle-bolt harvesting efforts have been based on industry OE (EPRI 2017; NRC 2017c; Smith and Burke 2017).

4.1.4 Harvesting of RPV Materials

4.1.4.1 Background

RPV-related materials harvesting has a long history in the nuclear power community. The harvesting has generally been to address several questions related to the performance of the pressure vessel in the presence of irradiation and assess its likely performance under abnormal conditions. RPV materials must withstand a harsh operating environment, including neutron irradiation and time at temperature, given their function as part of the pressure boundary. Specific questions that have been raised about RPV materials include:

- Improving understanding of mechanisms driving embrittlement in RPV steels and reducing predictive uncertainties for embrittlement
- Quantifying loss of fracture toughness due to irradiation embrittlement
- Quantifying fabrication and service-induced flaws (if any) in RPV materials
- Developing techniques for mitigating embrittlement.

Clearly, the harvesting of RPV material from an operating plant is unlikely. Instead, a significant amount of studies have focused on the use of surveillance specimens that are placed inside the reactor vessel and harvested during periodic plant refueling outages. This approach also allows for supplemental capsules to be inserted into an operating reactor for a relatively short time and still get meaningful results. The exception to this is harvesting materials from terminated or cancelled plants. These are briefly summarized below.

4.1.4.2 Known Examples

A number of specimens from the beltline weld region were harvested from cancelled or terminated plants, such as the Shoreham plant. In these instances, fabricated components (especially the RPV) were accessed for the harvesting effort. These were selected specifically for studies around fabrication flaw density in the beltline weld region, and knowledge gained on fabrication flaw size and distribution in

RPVs played a role in the development of 10CFR50.61a. The harvesting priorities in these cases were driven by the specific needs of the research and included sufficient material on either side of the weld to enable studies on the weld and adjacent material.

In recent years, harvesting from the Zion Unit 1 RPV has been the focus of the U.S. Department of Energy's effort (Rosseel et al. 2016b). An appropriate segmentation plan has been developed for the RPV to gather material from the beltline weld region, between the upper and lower vertical welds. Both base-metal regions and beltline weld regions are included in the harvested sections and are planned for use in laboratory studies. Comparisons with fracture toughness of surveillance specimens are expected to provide insights into the changes in fracture toughness over time.

4.1.5 General Lessons Learned from Harvesting Examples

The ability to harvest field-aged materials has generally proven to be successful, but a number of lessons can be learned from these experiences.

In general, information on the exact environment in which the material was operating may not be available. Often, all that is available (especially after a plant has closed and is in the decommissioning phase) is the total number of years the material was used while the plant was in operation and a general idea of the environment based on its location. While the environmental conditions for some components (such as RPV or internals) can be calculated relatively precisely based on plant operational data, the lack of such information can be problematic for components exposed to localized extreme environments. For instance in the case of cables, the possibility of localized hot spots (from uninsulated piping close by) may be a contributor to significant local thermal aging. This type of information is more readily available when the cable is harvested from an operating plant and additional measurements of environmental conditions may be taken prior to harvesting (for instance, through infrared thermography measurements).

Recent experiences (such as Zion and Crystal River Unit 3) showed the process of harvesting can be expensive. A related challenge was the complexity of securing engineering and labor support for a forensic harvesting task when the primary contractor in charge of the operation is primarily focused on dismantling the plant.

While harvesting materials with known degradation issues is always useful, in the case of harvesting post-plant closure, it may also be a challenge. Such information may not be readily available without performing some form of inspection. Given the challenges associated with securing engineering and labor support for harvesting, obtaining the necessary support is likely to be difficult.

4.2 Harvesting Plans General Requirements

With the experience to date harvesting materials from plants and the associated lessons learned, several best practices may be identified for future strategic harvesting exercises. Prior to developing a harvesting plan, the following will need to be addressed:

- Clearly identifying the need for harvesting the material. This will require defining the knowledge gaps that will be addressed and how these gaps are relevant to SLR.
- How the harvested material will be used. This will require development of a research plan (even if at a high level initially) that will be executed with the harvested material and how the studies are expected to close the knowledge gap. Several excellent examples exist for research plans (for instance, Leonard et al. 2015; Fifield 2016).

- Determine the necessary resources for harvesting. Use the justification and prioritization for harvesting to secure the necessary engineering/labor support prior to beginning the procedure. In discussions with technical staff who have been involved in harvesting activities, this was the number one item raised, especially when the harvesting activity is an adjunct to decommissioning the plant. In this case, the decontamination and decommissioning activities take precedence and the harvesting activity will need to accommodate any changes in schedules necessary to ensure that the primary activity is completed on schedule.
- Timeline for harvesting. A fall out of the resource planning issue above is the need for developing the harvesting plan, and, in consultation with plant personnel, a notional schedule for the harvesting.
- Post-harvesting receipt of material. The plan should also include information on where the material will be sent and in what form (complete component, segmented into smaller pieces, etc.), condition of the material after harvesting (contaminated, if cleaned to what extent, etc.).
  - Should include information on additional locations to which the material may be sent from its primary storage/use location to ensure appropriate planning can be initiated at the primary recipient facility as well as at any secondary recipient facilities.
  - A requirements document is mandatory that covers receiving and working with the material. In particular, if the material is to be handled as radioactive material, additional precautions will need to be taken for both shipping, storage, and use in research. Activated and/or contaminated material may require hot-cells for storage and use.
  - Note: Depending on the material and its condition (contaminated, activated), regulations for shipping (U.S. Department of Transportation regulations) will vary and need to be accounted for in scope, schedule, and budget for the harvesting activity.
  - Depending on its eventual end-use location, necessary approvals should be in place prior to executing the harvesting plan.
- Waste handling. Depending on the material and research plan for its use, provisions will need to be made to handle any waste streams generated during the process. This includes not only the waste generated during harvesting but subsequently during research. Specimens created from harvested material may need to be stored for longer terms, and provisions are necessary for long-term storage of the material if necessary.

Note the prioritization approach described earlier in this document provides a potential pathway to identifying the knowledge gaps, relevance to SLR, and defining the priority for harvesting the specific material. The associated research plan should include, in addition to a description of the specific research and expected outcomes that close the technical gaps, a pathway to using the information in a practical manner for addressing SLR needs. This may happen, for instance, through propagating the technical findings into the relevant technical literature and codes and standards.

A number of elements need to be kept in mind as the harvesting plan is developed. These include:

- Clearly identifying the component/material to be removed. Labels, tags, etc. are possible ways in which the component (or location on a component, if only a portion is being harvested) can be identified. Given the need to potentially coordinate the harvesting activity with other activities at the site, such identification can reduce the potential for mistaken harvesting of material.
- Documenting the environment in the vicinity of the component prior to removal. This includes not only the temperature, radiation, etc., but also the presence of other components in close proximity and how they interact with the component being harvested. For instance, vibration from a nearby pump may play a role in accelerating degradation in the component being harvested.

- Radiation surveys of materials may be needed before and after harvesting to determine if the material is contaminated or can be free-released. This also provides information on necessary decontamination activities that may be needed.
- The level of contamination and activation of the material will dictate the actual harvesting approach to meet ALARA requirements.

- Information about the condition (degradation and aging) should be documented if available. If possible, additional measurements should be taken before or after harvesting to confirm the condition of the material prior to its use in any aging-related studies.
- As large a section of material as possible should be removed. Note that this may be constrained by budget or dose to personnel. Any special features (such as terminations, splices, and cable accessories for the case of cable harvesting; welds, heat-affected zone, and base metal for similar and dissimilar welds) should be identified in the harvesting plan, and if necessary, retained.

Parameters that will need to be documented (if available) during this process include:

- Physical description
  - Category (examples: nozzle weld, instrumentation and control cable, medium voltage cable, baffle bolt)
  - Construction information (configuration, special processes used)
  - Manufacturer/date
  - Materials comprising the component to be harvested or composition
  - Dimensions and special features
- Service parameters
  - System
  - Service application
  - Usage parameters (how often was it used if intermittently used)
  - Safety/maintenance rule significance
  - Age in service
- Installation data
  - Installation location (containment, auxiliary building, other building, outside, buried)
  - Connected components
  - Supporting structures or conveyances
- Stressors
  - Installation
  - In-service mechanical and structural
  - Environmental degradation: temperature, pressure, fluence, humidity
  - Other damage potential
- Plant/fleet experience
  - Testing interval and history

– In-service failure or degradation

– Available data on inspections for degradation

Note that generating all the necessary harvesting plan information is time consuming and, where possible, should be assembled before any opportunities arise for harvesting. Critical details that will require knowledge about the harvesting plant/location are who will perform the harvesting, when will harvesting be performed, where is the material, what is its condition, and how much should be harvested? Having the rest of the information pre-assembled will provide a significant advantage towards speeding up the procedure. For this purpose, having the necessary information available, perhaps in a searchable database, will facilitate the process.

5.0 Information Tools for Harvesting Planning

The previous sections dealt primarily with approaches for prioritizing the needs for harvesting of materials from plants for addressing one or more issues. Identification of technical gaps and development of a harvesting plan to address some of these gaps will require other information. Such information can include the state of knowledge about materials performance, availability of materials for harvesting, and operational experience.

Key to efficient use of this information is an integrated tool set that will enable rapid assessment of technical gaps and well-informed decisions on harvesting. This section briefly describes a potential tool suite for this purpose.

5.1 Reactor Reliability and Integrity Management Library

5.1.1 Overview

The Reactor Reliability and Integrity Management (RRIM) Library is envisioned as a suite of integrated tools (Figure 1) that focus on providing decision makers with necessary information to deliver informed recommendations based on the available data. The following tools have been identified as critical to development of the RRIM Library:

- Generic plant framework
- Knowledge repository
- Harvesting management

Each of these tools is described below in greater detail. It is important to note that these are only envisioned tools at this time. As harvesting needs increase, it is likely the tool sets described here will be augmented or modified to account for emerging requirements for a decision-making tool suite in this area.

5.1.1.1 Generic Plant Framework

Generic aging lessons learned plans are categorized by plant type (PWR or BWR), structure and/or component, material, environment, and aging effect/mechanism. From a RRIM tool suite perspective, this information is assigned to the Generic Aging Management Plans block in Figure 1; this block is merely intended to illustrate that the aging management plans are informed by insights from GALL as well as a variety of other literature sources on materials degradation. This categorization provides a construct that may be used to align information from other sources to define a high-level categorization of the various elements that are of concern in a plant. This construct will be the basis for the generic plant framework in RRIM. Input from subject matter experts (SMEs) will be needed to map the knowledge elements to the framework, as each of the sources provides differing levels of granularity on the descriptions of the structure and/or components, environment, and materials. The framework will be used to further align data from other sources, which may have varying levels of detail, into a similar higher level categorization. Sources of information include the PMDA and EMDA documents.

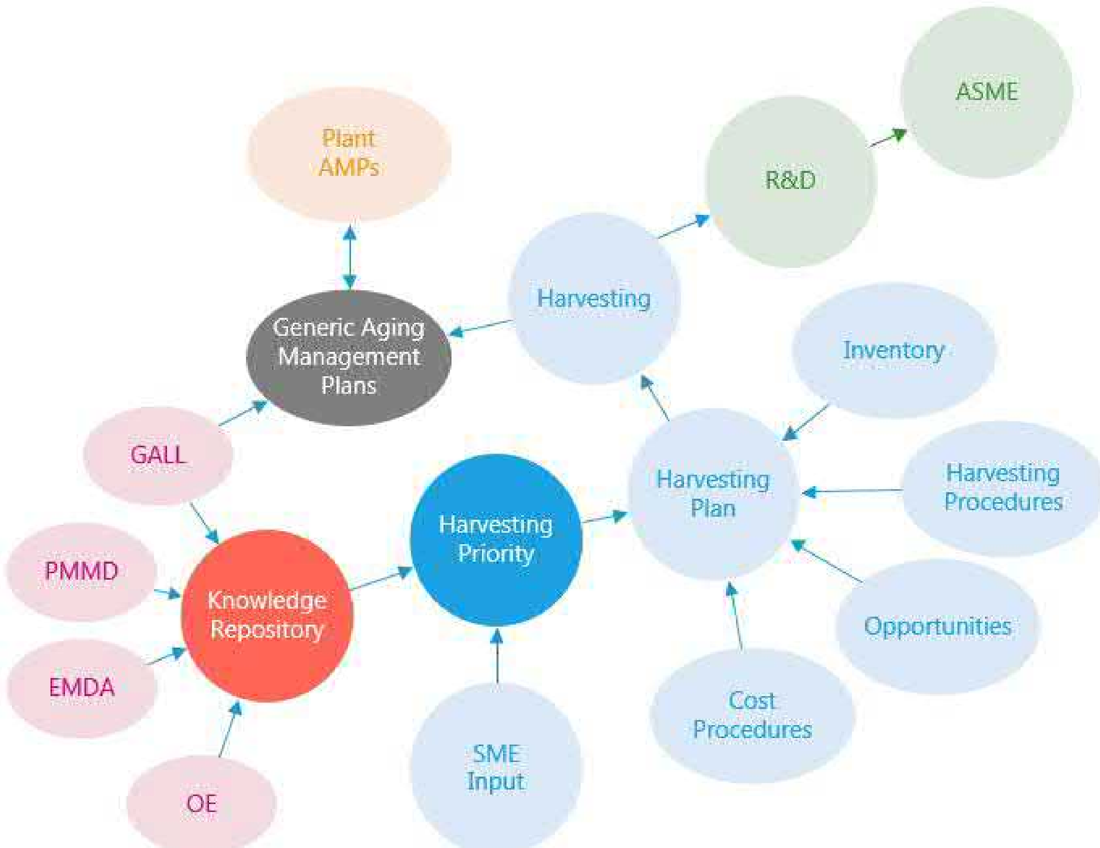

Figure 1. Reactor Reliability and Integrity Management Library Concept

5.1.1.2 Knowledge Repository

The knowledge repository will enable the correlation of a variety of information sources by mapping the data to the generic plant framework and providing searching capabilities.

The tool is envisioned to contain static content, such as information from the PMDA or EMDA. For example, the current proactive management of materials degradation tool (http://pmmd.pnl.gov) provides searching capabilities to visualize the susceptibility, confidence, and knowledge and search by the parts and degradation mechanisms as defined in the document; however, EMDA defines the parts differently.

The knowledge management tool will align the content of sources such as the EMDA and PMDA and map them into to a common structure and component list that would enable searching across both documents. The tool will also contain capabilities to automatically extract information from publicly available relevant sites, such as the Licensee Event Report, so that new information (particularly about relevant operational experience) is automatically added. The system will provide a best attempt at mapping to the generic plant framework; however, SME input may be required to validate these mappings.

5.1.1.3 Harvesting Management

As described earlier, harvesting has several phases, including determining the priority, developing a plan to complete the harvesting, conducting the actual harvesting of materials, and eventual use of the material (including the dissemination of results from research conducted on the material). The harvesting management tool is envisioned to support the lifecycle of the process.

This tool can be used to facilitate the harvesting prioritization as shown in the previous sections. We envision the tool as being capable of generating the unique combinations of materials, degradation mechanisms, and environments to create an entry for each unique combination within the harvesting management tool. The tool is expected to include the capability for automatically augmenting the entries with knowledge from the repository. After harvesting priorities have been determined by an SME, the tool will identify new knowledge that may impact the priorities. The tool will provide a mechanism to facilitate development of a justification, which is a key element in the preparation of harvesting plans.

The tool will also need mechanisms to capture costs, inventory, procedures, and opportunities related to harvesting. This information, augmented with priority and justification, will be the elements that provide the basis for the decision to develop a plan. The tool is also expected to facilitate capturing the results, including images and observations about the materials harvested.

5.1.2 Work to Date

A demonstration website[(1)] was set up to model what the knowledge repository may look like (Figure 2). The demonstration site only contains OEs as a sample data set; SME expertise would be needed to incorporate documents such as the proactive management of materials degradation tool, EMDA, and GALL into discrete knowledge elements. The visualization below provides an example of publicly available information about plant OE, along with the ability to search and sort the information (from more than one source, including public websites and a subset of EMDA information) by SSC type, material, environment, and degradation mechanism. The demonstration site for the knowledge repository would be one starting point for a detailed analysis of the required capabilities for the RRIM tool suite described earlier.

[1] http://hagar.pnl.gov/srs/dev/latest/v3/src/nrc/. Note: Website is only available to NRC.

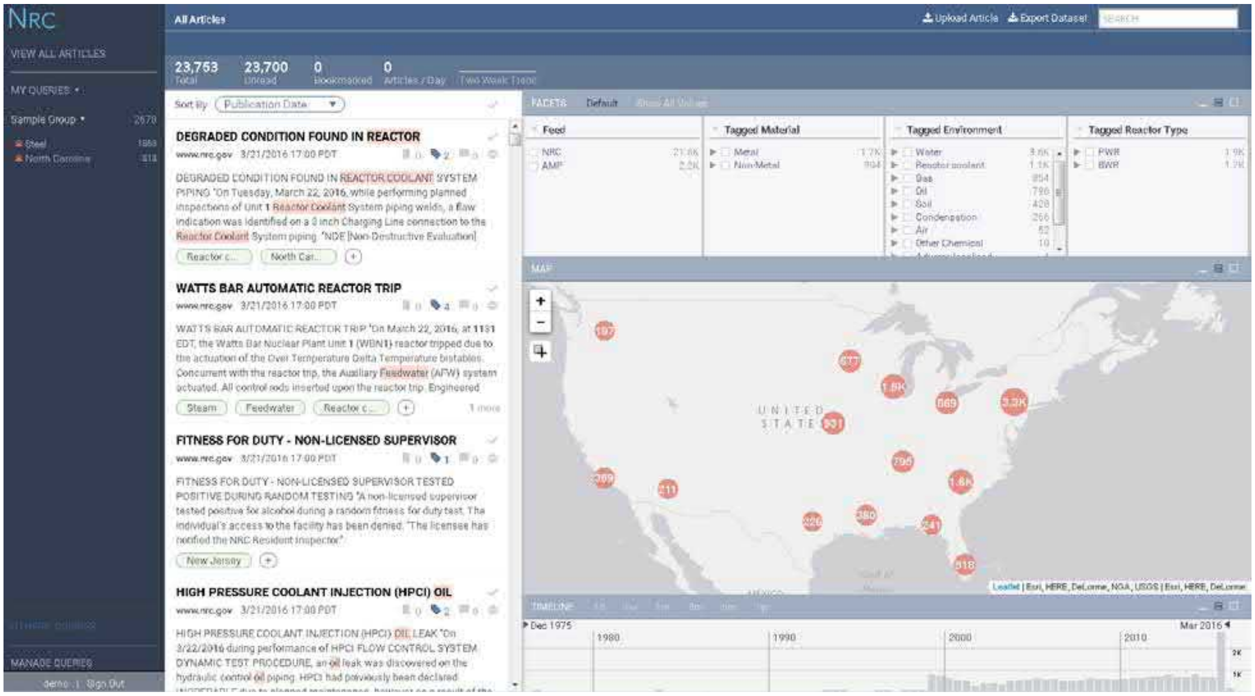

Figure 2. Example Visualization of Knowledge Repository to Support Harvesting Decision-Making

6.0 Summary and Path Forward

Addressing many of the remaining technical gaps identified in the EMDA for SLR may require accessing materials sampled from plants (decommissioned or operating). Such materials may be used to better understand actual material property changes with plant age and improve understanding of the initiation and growth of degradation mechanisms of relevance to SLR. Evaluation of material properties in SSCs from actual decommissioned NPPs will also provide a basis for comparison with results of laboratory tests and calculations.

Given the costs associated with any harvesting effort, potential approaches will need to prioritize materials using a number of criteria, including:

- Unique field aspects that drive the importance of harvesting the material
- Ease of laboratory replication of material and environment combination
- Applicability of harvested material for addressing critical gaps (dose rate issues, etc.)
- Availability of reliable ISI techniques for the material
- Availability of an inventory for harvesting.

These criteria help define the specific problems that will be addressed and the knowledge gained and technical gaps closed through the use of the harvested materials. A number of other factors (such as access to the material for harvesting, ability to work with the potentially contaminated material, and the plan for research using the material) play a role in defining the harvesting plan. A number of lessons may be learned from previous campaigns and these lessons can be used to develop a generic harvesting plan that can be customized for the specific needs and opportunities at hand.

A number of open questions remain in this context and will need to be addressed in follow-on research. These include:

- Requirements definition for an information tool such as RRIM. In the near term, such a tool can help as a searchable repository for identifying technical gaps. In the longer term, the tool can also assist as a repository of harvesting opportunities and with the prioritization using the criteria defined.
- Gaps assessment with respect to applying harvested materials for research and development.

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With climate change, aging nuclear plants need closer scrutiny. Turkey Point shows why.

By Caroline Reiser | September 14, 2020

A Google Maps 3-D view of Turkey Point Nuclear Generating Station, situated on the Florida coast just south of Miami. The plant relies on a 168-mile network of man-made canals to release excess heat from the reactors. Image credit: Google Maps.

Disclosure statement: The author is a legal fellow at the Natural Resources Defense Council, which is currently involved in a legal case appealing the subsequent license renewal at Turkey Point.

Last December, two nuclear reactors at Florida's Turkey Point Nuclear Generating Station, located 25 miles south of Miami, became the first reactors in the world to receive regulatory approval to remain operational for up to 80 years, meaning reactors that first came online in the 1970s could keep running beyond 2050.

The ages of the Turkey Point reactors are not unusual; of the 95 reactors currently licensed to operate in the United States, only five are less than 30 years old, while more than half are 40 or more years old. The Turkey Point reactors are a bellwether, just the first of possibly many aging nuclear reactors that will seek permission to stay online well into the middle of the century. Not long after the December decision, in March 2020, the US Nuclear Regulatory Commission granted two more reactors, located in Pennsylvania, the same extensions that it gave Turkey Point.

In pursing these extensions, the US commercial nuclear industry and its supporters collide with the realities of the aging US nuclear fleet and climate science projections. Existing safety and environmental requirements fail to provide the oversight necessary to ensure communities and the environment are protected. As nuclear reactors receive permission to operate for twice as long as originally envisaged, and in a world that, because of climate change, is drastically different from the one they were built for, the insufficiency of the existing regulatory framework is daunting.

A 40-year lifespan? At the beginning of its commercial nuclear power program, the United States designed and licensed reactors with a 40-year projected lifetime. Once the 40-year license is set to expire, regulations require the reactor owner to apply for a renewed license in order to continue operating for an additional 20 years. What the regulations don't make clear, however, is the number of times a reactor license can be renewed. What Turkey Point received last year was not its first, but its second extension—what regulators call a subsequent renewed license.

While the timeframe for the initial license was originally an economic decision, the 40-year projected life cycle reflects engineering realties. Throughout the lifetime of a reactor, the metal and concrete that make up and contain the reactor take a constant beating from the neutrons being released through nuclear fission. This causes the metal to lose flexibility, become brittle, and develop cracks and fissures. The concrete, designed to protect humans and the environment from a radioactive release, may also deteriorate over time. To ensure reactors continue to operate safely, those parts that were designed with a 40-year lifetime often must be replaced. While this may be technically achievable for some reactor parts, replacement can only go so far.

And even when it is technically conceivable to replace old reactor parts, economically it often is not. Already, nuclear reactors are closing well before their current licenses expire because of economic constraints. In today's electricity market, nuclear power struggles to compete with cheap natural gas and renewable energy. Many reactors can only stay in business with significant additional government or ratepayer subsidies. These economic constraints have led to cost-cutting measures, including reducing health, safety, and environmental safeguards.

Even more bizarre, under current regulations, nuclear operators can take up to 60 years to decommission a closed plant. Decommissioning is the process by which a nuclear reactor is dismantled to the point that it no longer requires radiation protection measures. In the case of Turkey Point, if the reactors stay online beyond 2050, decommissioning could extend into the next century, when sea level rise due to climate change is predicted to inundate southern Florida.

Nuclear plants and climate change don't mix. While proponents of nuclear energy often argue that nuclear power is a necessary tool against the climate crisis, nuclear power itself is at risk from climate change. Because reactors need huge amounts of water to operate, most existing plants sit on an ocean, lake, or riverfront. But this means that sea level rise, warmer water temperatures, and amplified droughts will all affect the ability of nuclear reactors to produce electricity. Last summer in Europe, several nuclear plants had to temporarily shut down because of increased temperatures and decreased water supplies. Such occurrences are bound to become more common as the climate becomes warmer and weather events become more extreme.

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It is especially ironic, then, that the Turkey Point reactors, perched on the southern tip of Florida, were the first to receive a subsequent renewed license. Close to half a million people live just north of the plant in Miami, and 2.7 million live in the wider Miami-Dade County. The plant sits 20 miles east of the Everglades National Park, on a piece of coastline carved out of Biscayne National Park. These surrounding natural lands are a unique, sensitive ecosystem, home to threatened and endangered species like the manatee and the American crocodile. While climate change is already stressing these people and resources directly, it is also compounding the challenges of safely running the nuclear plant.

Turkey Point is the only nuclear power plant in the United States that relies on an extensive network of cooling canals. Visible from space, the network comprises 168 miles of man-made canals spanning 5,900 acres, through which water used to cool the nuclear reactors circulates in order to release excess heat. In recent years, evaporation, coupled with reduced rainfall, has caused the canal water to become hypersaline, and that water is leaking into the groundwater, upsetting the delicate freshwater–saltwater balance and creating a plume of saltwater that threatens Miami's fresh groundwater drinking source.

Climate change is already affecting the plant in other ways, too. In 2014, increased temperatures and decreased precipitation caused canal water temperatures to rise to 99 degrees Fahrenheit, just one degree shy of a federal limit that would require the reactors to shut down—right at a time when electricity was in high demand. The plant was only able to remain open after receiving special permission from the Nuclear Regulatory Commission to exceed the 100-degree limit.

Further, in the coming decades, sea level rise is projected to reach Turkey Point's cooling canals. If the canals become flooded, then the plant cannot operate. In the meantime, increased ocean temperatures and higher sea levels will exacerbate the hypersaline plume and the threat it poses to Florida drinking water and the local ecosystem.

Perhaps even more concerning, the climate crisis is also predicted to increase the frequency and intensity of hurricanes and storm surges. While Hurricane Andrew hit Turkey Point in 1992 and Hurricane Irma just missed it in 2017, the hurricanes of the future will be very different storms from those of the past. According to a 2020 study published in Proceedings of the National Academy of Sciences, global warming has increased the chances that a hurricane will reach Category 3 or higher, meaning that the risk that a hurricane will dangerously damage the reactors is only increasing.

One might expect that these climate impacts would have given the plant's operators—and the regulators at the Nuclear Regulatory Commission—pause before granting permission to operate for an additional 20 years. Instead, the owners glossed over climate concerns in their application, and the Nuclear Regulatory Commission approved the extension without an in-depth consideration of the climate impacts.

The enfeebled license renewal process. The 20-year license renewal in the United States differs from most countries with commercial nuclear capacity, which often only approve extensions for 10 years at a time, or require extensive safety reviews to ensure that old reactors' safety functions remain "as close as possible" to those of newer reactors. In the United States, applicants simply go through a limited license renewal process that involves submitting a truncated safety and environmental application, one that the Nuclear Regulatory Commission has crafted to be virtually impossible for states, local governments, and communities to challenge.

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In this process, major safety and environmental issues have been declared off limits by a regulatory sleight of hand known as the Generic Environmental Impact Statement. In 1996, the Nuclear Regulatory Commission drafted a generic analysis of those environmental impacts it deemed would be the same for every nuclear reactor license renewal. Because the commission determined that this statement addresses a set of designated "generic" impacts, and put the result of that analysis in law, individual applicants for renewed nuclear reactor licenses are not required to address those safety and environmental issues. Rather, applicants only need to supplement that generic impact statement with an analysis of issues categorically designated "site-specific."

The only way for a state or local government or the public to challenge whether the commission's Generic Environmental Impact Statement analysis and conclusions in fact make sense to apply to a specific plant is to either ask for a rule waiver—and no waiver has ever been granted—or to wait to catch the next impact statement rewrite and challenge the agency's determination then. But while the generic impact statement is supposed to be updated every 10 years, 17 years passed before the commission finally published the first update to the statement in 2013—severely limiting the usefulness of this route for addressing concerns about specific reactors.

So, for example, the commission determined it could generically analyze the impacts of renewing a nuclear reactor's license on water quality. If someone is concerned with how climate change might exacerbate water quality impacts from the renewal of a specific reactor license, the only way to do so is by hoping the commission grants them the first ever waiver, or by waiting until the commission decides it's time to update its generic impact statement, though that will probably be years too late.

Moreover, for the site-specific environmental analysis, it is the license applicant, not the government agency, that completes the first draft, giving the reactor operator the ability to frame the analysis to its wishes. And in order to challenge any of the environmental review, a party must petition to intervene in the license proceeding as soon as the applicant submits this first draft. If a petitioner fails to raise an issue at this early point, which can be a decade before the current license expires, that party will be precluded from challenging the environmental analysis later unless they can prove that new information has become available. Finally, even if a party successfully brings a challenge before the commission, the commission can still grant the renewed license before the challenge has been fully adjudicated—as happened in the case of the Turkey Point license renewal.

The broader deregulatory binge. This paltry license renewal process is worrisome enough on its own, but it's even worse in the current atmosphere of deregulation. Nuclear safety is under assault in the United States. The Nuclear Regulatory Commission has successfully rolled back important safety initiatives and is pursuing more degraded regulatory standards. Rejecting the majority of its own staff's recommendations, in 2019 the commission implemented severely scaled down regulations based on lessons learned from the Fukushima Daiichi disaster. The commission is also proposing to decrease reactor safety inspections; allow for self-inspection and reporting by the reactor operator on a host of safety issues; require fewer "force on force" drills that test nuclear power plants' defenses against terrorist attacks; and reduce requirements for notice to the public and to state governors when problems arise.

And the Nuclear Regulatory Commission isn't the only federal agency on a deregulatory binge. The White House Council on Environmental Quality has overhauled its regulations interpreting the foundational environmental law, the National Environmental Policy Act. These changes could significantly limit the scope of projects to which the act applies, the public participation in assessing those projects (including nuclear plants), and the impacts of those projects that an agency must analyze (including climate impacts).

Obtaining a second 20-year license renewal, especially for a reactor built in the 1970s, must be a serious endeavor that considers the reasonably foreseeable safety and environmental implications. Given the risk to people and the environment, if a nuclear reactor cannot rigorously demonstrate safe functioning well into middle of the century, nearby communities must be given the time and opportunity to plan for safer and less expensive alternatives.

Keywords: Nuclear Regulatory Commission, Turkey Point, climate change, nuclear energy, nuclear safety
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5 COMMENTS

Oldest

Charley Bowman 9 months ago

Will the rising temperatures eventually compromise the cooling ability of the pools of spent nuclear fuel? High burn-up fuel use and rising temperatures will likely increase the time to cool the spent fuel, and expose the Turkey Point infrastructure to increasingly more powerful hurricanes. Turkey Point needs to be closed ASAP.

-5 Reply

Arnie Gundersen 9 months ago

I would also note that the storm surge for the proposed TP6/7 is higher than the storm surge from TP3/4 due to more improved modeling of global warming effects. The NRC has not modified the storm surge for TP3/4 in light of global warming.

-6 Reply

Russell Lowes 9 months ago

Thank you for bringing up these issues. However, in once sense, the whole issue of whether to have nuclear energy as an option lies in its economics and how it undermines solutions to global warming. This is how nuclear energy works against the solutions to global warming, on economic grounds. Every time you spend a dollar on nuclear energy, the utility company only delivers 4 kilowatt-hours (kWhe) or less; it is 25¢ per kWhe or more, with prices increasing. If you instead put that dollar into the solar blend (solar, wind, energy efficiency and storage), you get 8 kWhe at… Read more »

-6 Reply

Victor Gilinsky 9 months ago

The author refers in boldface to the enfeebled license renewal process but only discusses in detail environmental reviews. The so-called license extension safety review is a scandal. Although the whole thing is bureaucratically elaborate, and a bonanza for industry consultants and lawyers, the only question the NRC safety reviewers address is whether the plant owners have a plan for dealing with aging equipment so that the plant can meet its current "licensing basis." The NRC reviewers are specifically forbidden by regulation from questioning that licensing basis, that is, the basis on which safety depends, even though it was set many… Read more »

-3 Reply

Erin Stanton 7 months ago

I completely understand the author's concern, but we need to flip the narrative on nuclear. The industry is making leaps and bounds when it comes to creating more economically sound, and safe, reactors and replacements. Yes, nuclear power does compete with fossil fuels and renewable energy sources, but when comparing all options, nuclear energy is far superior. Especially when trying to solve climate change, which is the main goal for every energy provider. Nuclear releases less radiation into the environment than any other major energy source and their power plants operate at much higher capacity factors than renewable energy sources… Read more »

3 Reply

Caroline Reiser

Caroline Reiser is a Nuclear Energy Legal Fellow at the Natural Resources Defense Council. A graduate of University of California Santa Barbara and... Read More

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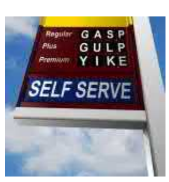

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